

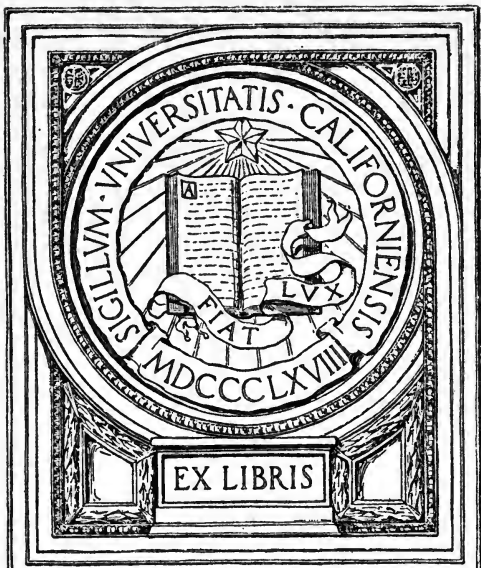
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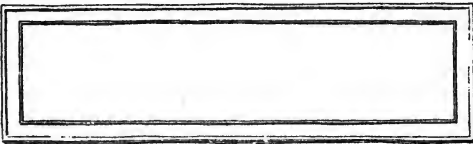
NAVIGATION

HAROLD JACOBY



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NAVIGATION



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NAVIGATION

BY

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PREFACE

THE present volume was undertaken with certain very definite aims. In the first place, it is intended to be complete in itself, so that it should be possible to navigate a ship in any ocean not very near the north or south pole without other books or tabular works, excepting only the nautical almanac for the year in which the voyage is made. To attain this end without unduly extending the size of the volume, certain essential nautical tables have been abridged; but all are given in sufficiently extended form to permit of actual navigation with their aid; and they are especially suitable for beginners, who can here attain the necessary knowledge with less effort than would be necessary with more bulky volumes. In cases where very extended tables are convenient, they are mentioned in the text.

In the second place, the author has not assumed that the reader possesses formal mathematical and astronomical knowledge, or desires to possess such knowledge. Whenever methods of navigation require for their demonstration an understanding of spherical trigonometry, or some other branch of formal mathematical science, such demonstrations have been replaced with incomplete or "outline" demonstrations designed for the non-mathematical reader. Practical methods are fully explained; and an attempt has always been made so to word the explanations that the reader, even the beginner, will understand his problem, and will know what he is doing, and why he does it.

The requirements of those who may study without a teacher have received constant and special attention. To meet these requirements the whole subject is presented in

a somewhat informal manner; such topics as the use of logarithms, or the principles on which all mathematical tables are constructed — these less attractive parts of the subject are not presented in a special chapter, but are described in a sort of digression, when needed in the discussion of an actual navigational problem.

Finally, to further simplify and condense his material, the author has made no attempt to include every method that can possibly be used to navigate a ship, or that ever has been used to navigate a ship; his purpose has been rather to limit the volume to the methods at present thought best by the most reliable modern authorities.

Other books on navigation have been used freely, especially in the preparation of the tables. Among these, that admirable encyclopedia of navigation, known as "Bowditch," published by the Hydrographic Office, United States Navy, and Kelvin's "Tables for Sumner's Method at Sea" have been found of the greatest help.

Miss Dorothy W. Block, Instructor of Astronomy in Hunter College, New York, has helped with great energy in the preparation of the tables and the correction of the text. It is hoped that such errors as may now remain in the book are few in number.

H. J.

COLUMBIA UNIVERSITY,
August, 1917.

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LIST OF ABBREVIATIONS

USED IN THE PRESENT VOLUME

| | |
|-----------------|---|
| Alt. | for altitude ; |
| App. | for apparent ; |
| Arg. diff. | for argument difference ; |
| Cf. | for compare ; |
| Chron. | for chronometer ; |
| Comp'd | for computed ; |
| Cos | for cosine ; |
| Cot | for cotangent ; |
| Csc | for cosecant ; |
| C. - W. | for chronometer <i>minus</i> watch ; |
| Dec. | for declination ; |
| Dep. | for departure ; |
| Dist. | for distance ; |
| D. R. | for dead reckoning ; |
| Eq. | for equation of time ; |
| G. A. T. | for Greenwich apparent time ; |
| G. M. T. | for Greenwich mean time ; |
| Hav. | for haversine ; |
| H. D. | for hourly difference ; |
| Int. diff. | for interpolation difference ; |
| Lat. | for latitude ; |
| Lat. diff. | for latitude difference ; |
| Log | for logarithm ; |
| Long. | for longitude ; |
| Long. diff. | for longitude difference ; |
| Mer. lat. diff. | for meridional latitude difference ; |
| Obs'd | for observed ; |
| <i>p</i> | for polar distance ; |
| R. A. | for right ascension ; |
| <i>s</i> | for half sum ; |
| Sec | for secant ; |
| Sin | for sine ; |
| <i>T</i> | for ship's apparent solar time (or star's hour-angle) ; |
| Tab. diff. | for tabular difference ; |
| Tan | for tangent. |



NAVIGATION

CHAPTER I

THE FUNDAMENTAL PROBLEM OF NAVIGATION

To find one's way in a ship across the trackless ocean is our problem. Most people would like to know how it is solved; nor is the solution very difficult to understand when set forth in simple language and without too great wealth of technical detail. We hope the reader will find this to be the case after a study of the following pages.

Our fundamental problem can be more fully stated quite easily. It consists in the determination of a ship's location on the earth's surface at any given moment. If this location can be determined, it becomes a comparatively easy matter to ascertain the direction (north, south, northeast, southeast, etc.) in which the ship must be steered in order to reach her port of destination. For the location of the port of destination on the earth's surface is of course also known: and if we know where the ship and her destined port both are, we can easily find the right course for the helmsman.

With the fundamental problem stated in this way, it would almost seem as if there were really no such problem in existence. For when the ship begins her voyage, she is necessarily in a known port. Knowing also the port to which she is to go, we should be able to determine her proper course from the one known port to the other. This course being then steered, no further navigational proceedings would be required. But this reasoning is incorrect, because a ship

does not actually advance across the ocean in exactly the direction in which she is steered. Ocean currents deflect her; and the action of a strong wind blowing against one of her sides will have a similar effect. Currents and winds cannot be predicted with accuracy: and so it becomes necessary to re-determine the ship's position frequently at sea. This should be done at least once daily if possible; and when it has been done, the mariner can take a new "departure," as he calls it, and lay a new course for his intended port. Thus the effect of ocean currents, etc., can be eliminated, and the voyage made as safely as if they did not exist.

Now this determination of the ship's position at sea, and when out of sight of land, is strictly an astronomical problem. It can be solved by means of astronomical observations, and in no other way. But before giving an outline of how this is done, let us first see what is meant by the words "ship's position at sea." How can we describe a ship's position so that one mariner could tell another where she is located, and thus enable the second mariner to find her?

To thus indicate the point on the earth's surface occupied by the ship has a certain similarity with giving the address of a house in a city. Such a city address always consists of two separate statements; as, for instance, the name of a street and the number of the house. An address cannot be given completely unless two different facts are stated. They need not necessarily be a street name and a street number: we can equally well designate such an address by stating that the house is at the corner of a certain street and a certain avenue. But here also the address is made up of two separate facts.

This form of stating an address as the intersection of a certain street and avenue is the form having the closest resemblance to the method of the navigator. If the city avenues are supposed to run north and south, and the streets

east and west, as they do in New York (approximately), the analogy with navigation will be almost perfect.

For the navigator imagines the earth covered with a network consisting of "avenues," running north and south, and "streets," running east and west. He calls the "avenues" meridians of longitude, and the "streets" parallels of latitude. Then he designates the position of a ship on the ocean by stating that it is at the intersection of a certain meridian of longitude and parallel of latitude. There are 360 such meridians of longitude: each begins at the terrestrial equator, and runs north and south from there to the north and south poles of the earth. Of the latitude parallels there are 180.¹ They all run east and west, parallel to the terrestrial equator; 90 are between the equator and the north pole, and the other 90 between the equator and the south pole.

One of the longitude meridians (that passing through Greenwich, England) is chosen arbitrarily as the starting point for counting longitude meridians. To this initial meridian is assigned the number 0, and the other meridians are numbered successively 1, 2, 3, etc. So numbered, the meridians are called "degrees" of longitude; the third one, for instance, being written 3°. The meridians may be counted either eastward or westward from Greenwich, a ship on the 20th meridian west of Greenwich, for instance, being in longitude 20° west.

The latitude parallels are similarly counted north and south from the equator; and if the above ship were on the 40th latitude parallel north of the equator, her complete "address," or position at sea, would be long. 20° W.; lat. 40° N.

Of course a ship would only rarely be located exactly at the intersection of a meridian and parallel. Therefore, the space between any two successive meridians and between any two successive parallels is subdivided into 60 parts, called minutes of arc. Thus the above ship, if halfway

¹ Including the equator twice, but excluding the two poles.

between a pair of meridians and also halfway between a pair of parallels, might be in longitude $20^{\circ} 30'$ west, and in latitude $40^{\circ} 30'$ north. This would be written long. $20^{\circ} 30' W.$; lat. $40^{\circ} 30' N.$

Each minute of longitude and latitude is further subdivided, when extreme accuracy is required, into 60 seconds; so that if the ship were a little to the north and a little to the west of the above position, she might, for instance, be in long. $20^{\circ} 30' 26'' W.$; lat. $40^{\circ} 30' 10'' N.$

These meridians and parallels, or longitude and latitude lines, appear on many maps and charts as straight lines, or at least as lines only slightly curved. But being all lines imagined drawn on the earth, which is almost an exact sphere or round ball, they must really all be circles. Thus, the terrestrial equator is really a big circle, girdling the earth, and divided into 360 equal parts, or degrees. At each of the division points a meridian starts northward toward the pole. This meridian is also a big circle perpendicular to the equator. The distance along the meridian from the equator to the pole is divided into 90 equal parts or degrees, and the whole distance from equator to pole is one quarter of a complete circumference of the earth. The 90 degrees, from equator to pole, thus representing one quarter of a circumference of the earth, a complete circumference contains 4×90 , or 360 degrees, the same as the equator. So the degrees measured along the meridians are equal to the degrees measured along the equator. The former are degrees of latitude, the latter degrees of longitude; and degrees of latitude are equal to degrees of longitude, when the latter are measured along the equator. The length of each degree is then 60 nautical miles.

Having thus indicated what is meant by a ship's position in latitude and longitude, we shall next describe in outline how such a position may be determined by observation. If the ship is within sight of a coast-line, there will probably

be some lighthouse, or other "aid to navigation," in view, from which the navigator can ascertain where he is. Methods for doing this are described later (p. 53). But when the ship is really at sea, with no land in sight, real deep-sea methods must be employed.

These methods, when the weather is clear, always include an observation of the sun or some other heavenly body. When the weather does not permit such observations, the mariner can still find his position approximately by means of "dead reckoning" (abbreviated, D. R.). This process will be described in detail in the next chapter; but we can already state that it consists in a calculation based on his astronomic observation of latest date. Knowing where the ship was the last time he observed the sun, and also knowing both the direction in which he has steered and the (approximate) speed of the ship, the navigator can calculate (also approximately) the location of the point he has reached.

Even when astronomical observations are made, the D. R. calculation is always carried out, because the navigator is always anxious to know how nearly correct his D. R. result would have been, if the day had been cloudy. Furthermore, this result also acts as a check on the astronomical work, and tends to increase the navigator's confidence in the correctness of his final result as to the ship's location.

The manner in which the ship's position is found from astronomic observations will of course be explained in detail later. It is all done with an instrument called a sextant. This is merely a contrivance with which the navigator can measure how high the sun (or other heavenly body) is in the sky at any moment. The sun is highest in the sky daily at noon, but it is not equally high on different days in the year. Nor is it equally high on the same date in different latitudes. Thus, by measuring with the sextant how high it is on any particular date at noon, as seen from the ship, the navigator learns the terrestrial latitude in which the ship is located.

Similar sextant observations made at other suitable times during the day, when combined with exact readings taken from an accurate chronometer such as every ocean-going ship carries, will similarly make the ship's longitude known. All this will of course be explained in full detail in later chapters.

CHAPTER II

DEAD RECKONING WITHOUT LOGARITHMS

As we have seen (p. 5), this is a process by means of which the mariner can calculate a ship's position in latitude

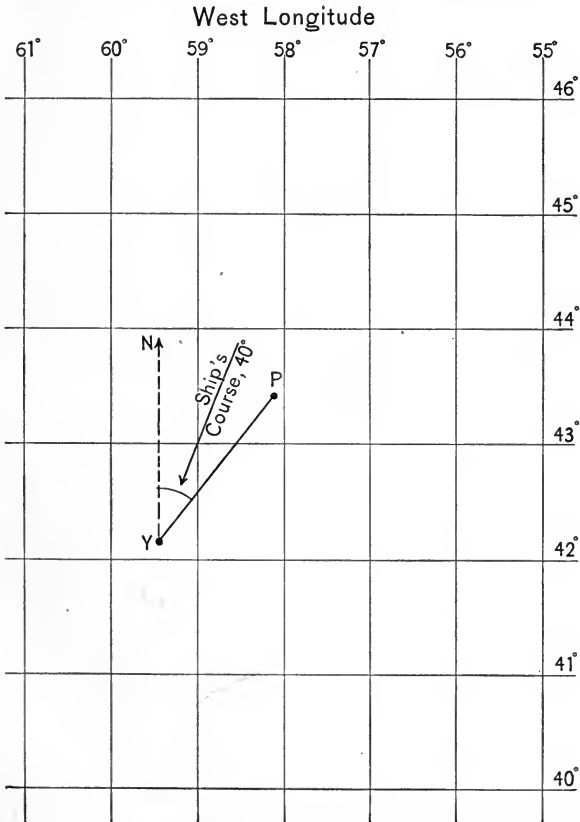


FIG. 1. — Dead Reckoning. (Diagram not drawn to scale.)

and longitude, without special astronomic observations of any kind. In the accompanying Fig. 1, which represents a portion of a chart of the North Atlantic, a ship's position at noon is shown at the point Y . This point we will call the ship's "initial position," in discussing our present problem. We will suppose that it was correctly obtained by astronomic observations, and that these showed the ship at Y to be in lat. $42^{\circ} 11'$ N. and long. $59^{\circ} 28'$ W. from Greenwich. Sometime in the afternoon, having traveled a distance estimated from the known speed of the ship as 63 miles, and having "made good" this distance in the direction YP , the ship arrives at P . This point P we will call the ship's "final position"; and our problem now is to find its latitude and longitude.

This problem may be called the first fundamental dead-reckoning problem. The second and remaining fundamental problem is the converse of the first, and may be stated as follows: having given the latitude and longitude of the initial point Y , as occupied by the ship, and also the latitude and longitude of the final point P , it is required to find the distance from Y to P in miles, and also the direction of the line YP .¹

To understand these two problems properly it is next necessary to explain how we may define the words "direction YP ." This is done by referring the line YP to the direction of the arrow shown in the figure. This arrow is parallel to the longitude meridians on the chart, and therefore points due north. The angle between the arrow YN and the line YP is marked in the figure, and is called the "ship's course." This angle is really the difference in direction of the two lines YN and YP . The point Y is called the "vertex" of the angle, and all angles are designated

¹ We think it advisable to place these two important converse problems together, and to call them both problems of dead reckoning, though many writers on navigation confine the phrase "dead reckoning" to the first fundamental problem alone.

by three letters, the letter belonging to the vertex being placed between the other two; in this case the angle is called either *NYP* or *PYN*.

Now let us draw a line *PQ* (fig. 2), from *P* to *NY*, and perpendicular to *NY*. Then the motion of the ship from *Y* to *P* will have carried her north of the point *Y* by a distance equal to *YQ*, and east of the point *Y* by a distance equal to *QP*. This is not *strictly* true, unless the earth's surface, throughout the small area involved in the present problem, can be regarded as a flat surface. Such a flat surface is called in geometry a "plane" surface; and these calculations therefore belong to that part of navigation which is called "plane sailing." Plane-sailing calculations are easy calculations, and they are generally sufficiently accurate for the purposes of the navigator.

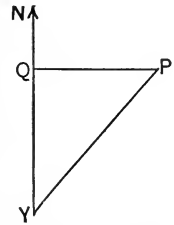


FIG. 2.—Dead Reckoning.

The ship's course, being thus an angle, must be designated

by means of a unit of measure suitable for measuring angles. For this purpose the degrees and minutes already used for longitude and latitude (p. 3) are usually employed. Fig. 3 shows that a latitude, for instance, is really an angle, and must therefore also be measured in degrees. *P* is the earth's pole, *PQ* a meridian, and the latitude of the observer at *O* is the angle *OCQ*, here about 40°.

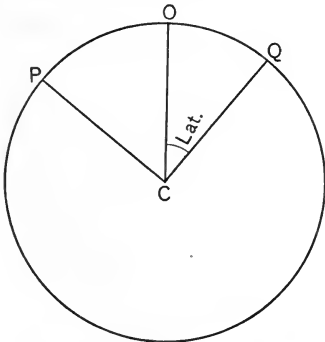


FIG. 3.—Latitude Angle.

So it is clear that the ship's course *NYP* (figs. 1 and 2) will be measured in degrees. Minutes are not really needed in measuring courses, as they are in measuring latitudes; the nearest whole degree is always accurate enough, because

it is never possible to steer a ship on her proper course with absolute exactness. In fact, many mariners use a still less precise method of measuring courses by means of "the points of the compass." (See p. 40.)

Resuming our two fundamental problems (p. 8), let us now begin with the first one, and proceed to find the latitude and longitude of the point P (figs. 1 and 2). To solve this problem, we must not only know the distance YP (63 miles), as traveled by the ship, but also the number of degrees in the course angle NYP . Let us suppose this course

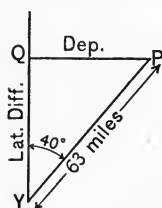


FIG. 4. — Dead Reckoning.

angle happens also to be 40° . The problem then appears as shown in Fig. 4. We now know the distance YP and the angle QYP . Evidently the next step is to find the distances QY and QP . QY , in our present problem, is called a "latitude difference" and QP is called a "departure."

To find the "latitude difference" and "departure" from the course angle and distance we may either use that branch of mathematics called plane trigonometry, or we may find them from a special navigation table, called a "traverse table." Our Table 1 (beginning p. 154) is such a table.

Before¹ beginning its use it will be well for the reader to note in general that *all* mathematical tables consist of two sets of numbers. The first set of numbers are called "arguments" of the table, and the second set are called "tabular numbers." The main object of the table is to furnish us with the proper tabular number when we know the proper argument.

The ordinary multiplication table is a good example of a mathematical table. It is usually written as follows and

¹ The beginner may find it advisable, on a first reading of the book, to omit this explanation of mathematical tables, returning later when he finds a reference to it in the text. The dead reckoning problem under discussion is resumed on p. 13.

it affords a good opportunity of studying the principles underlying all mathematical tables in a case so simple as to offer no difficulty.

MULTIPLICATION TABLE

(to illustrate "argument" and "tabular number")

| | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|-----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|-----------|-----------|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 |
| 3 | 6 | 9 | 12 | 15 | 18 | 21 | 24 | 27 | 30 | 33 | 36 |
| 4 | 8 | 12 | 16 | 20 | 24 | 28 | 32 | 36 | 40 | 44 | 48 |
| 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 |
| 6 | 12 | 18 | 24 | 30 | 36 | 42 | 48* | 54 | 60 | 66 | 72 |
| 7 | 14 | 21 | 28 | 35 | 42 | 49 | 56 | 63 | 70 | 77 | 84 |
| 8 | 16 | 24 | 32 | 40 | 48 | 56 | 64 | 72 | 80 | 88 | 96 |
| 9 | 18 | 27 | 36 | 45 | 54 | 63 | 72 | 81 | 90 | 99 | 108 |
| 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | 110 | 120 |
| 11 | 22 | 33 | 44 | 55 | 66 | 77 | 88 | 99 | 110 | 121 | 132 |
| 12 | 24 | 36 | 48 | 60 | 72 | 84 | 96 | 108 | 120 | 132 | 144 |

In this table the arguments are printed in heavy type and are contained in the left-hand column and the topmost horizontal line. In using the table, these arguments are given in pairs, being always the pair of numbers to be multiplied. In fact, in the case of most tables, the arguments are thus given in pairs, though there are some tables with but a single argument. In the present case one number from the pair of arguments will be found in the left-hand column, the other in the top horizontal line. Thus, if we wish to multiply 6 and 8, these two numbers constitute the pair of arguments. We find the right line (belonging to 6) and column (belonging to 8), and the tabular number 48 (marked with a *) occurs at the intersection of the 6-line and the 8-column. If the pair of arguments are taken in the order 8×6 instead of 6×8 , we should use the 8-line and the 6-column, again finding the required product (48) as the tabular number at the intersection.

Sometimes the given arguments cannot be found directly in the table. Thus we might wish to multiply $6\frac{1}{2}$ (written 6.5) by 8. Evidently the proper tabular number would be halfway between the 6×8 tabular number (48) and the 7×8 tabular number (56). The correct answer would therefore be 52. This process, by which the tabular number 52 is obtained, is called "interpolation." The example $6\frac{1}{2} \times 8$ is an extremely simple one. When less easy ones occur, the interpolation is best made as follows: we ascertain by subtraction how much the tabular number increases while the argument changes from 6 to 7. This increase is here 8, because the tabular number changes from 48 to 56 in the 8-column, while the argument in the left-hand column changes from 6 to 7. This increase of 8 in the tabular number is called a "tabular difference." We now compare the given argument (6.5) with the nearest argument (6) occurring in the left-hand column of arguments, and find an "argument difference" of 0.5 (being 6.5 *minus* 6). Since this "argument difference" is 0.5, we must evidently take 0.5×8 (8 being the tabular difference), and increase the tabular number 48 by 0.5×8 , or 4. This again brings us to 52. Similar examples are:

$$(1) 5.3 \times 4 = 21.2; \quad (2) 7.7 \times 8 = 61.6.$$

In example (1) the tabular numbers are 20 and 24; the tabular difference is 4. $0.3 \times 4 = 1.2$; $20 + 1.2 = 21.2$, the answer. Both examples may be verified, of course, by ordinary multiplication.

When both given arguments contain fractions, as, for instance, 5.3×8.4 , the resulting "double interpolation" is so complicated as to be of little practical use to the navigator.

To make this general explanation of mathematical tables complete, it remains to show how they can be used in an inverse manner; *i.e.* to find the argument from the tabular

number. Thus, if we were told that the tabular number is 48, and one argument 8, an inspection of the table would at once show that the other argument must be 6. In this way the table might be used for division as well as multiplication; and interpolation would evidently also be possible. Many mathematical tables must frequently be thus used in an inverse manner.

Having thus explained the peculiarities of mathematical tables, we return to our dead-reckoning problem and its solution by means of the traverse table (p. 154).

Referring to that table we find a column (p. 167), headed 40° , the course angle of our present problem. On the left-hand side of the page we find the given distance, 63. Then, opposite the distance 63, and under 40° , we find the latitude difference (abbreviated, "Lat.") and the departure (abbreviated, "Dep.") to be:

$$\text{lat.} = 48.3, \text{ dep.} = 40.5.$$

The following are additional examples for practice:

Given: dist., 84, course 26° ; *Ans.*, lat. = 75.5, dep. = 36.8.

Given: dist., 28, course 11° ; *Ans.*, lat. = 27.5, dep. = 5.3.

When the course is between 1° and 45° the course angle will be found in Table 1 at the head of the column: but when the course is between 45° and 90° , it appears at the foot of the column. In the latter case, the tabular lat. and dep. are to be taken from the columns having "Lat." and "Dep." at the foot instead of the top of the column. Examples follow:

Given: dist., 63, course 50° ; *Ans.*, lat. = 40.5, dep. = 48.3.

Given: dist., 84, course 64° ; *Ans.*, lat. = 36.8, dep. = 75.5.

Given: dist., 28, course 52° ; *Ans.*, lat. = 17.2, dep. = 22.1,

In addition to the course angles from 1° to 90° , three additional angles are given in parentheses at the top and foot of each column. Thus, with the course angle 30° appear also 150° , 210° , 330° . This simply means that the latitudes

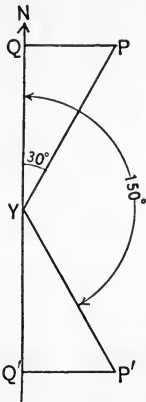


FIG. 5.—Departures for 30° and 150°.

and departures are the same for these four course angles. The accompanying Fig. 5 shows, for instance, that the departures QP and $Q'P'$ are equal for 30° and 150° courses if the two distances YP and YP' are alike.

It will be noticed also that our traverse table always gives distances from 1 to 50 on a left-hand page, and from 50 to 100 on a right-hand page. When distances larger than 100 occur, it is necessary to use the 100, 200, etc., given on the lower part of each page. If, for instance, we require the latitude and departure for a distance 363 miles, course 40°, we turn again to the 40° column, and find (near the bottom of the page):

| | | | |
|--------------------------------------|----------------|---------------|--------------|
| | For 300 miles, | lat. = 229.8, | dep. = 192.8 |
| and (in the usual way) for 63 miles, | lat. = 48.3, | dep. = 40.5 | |
| Sums, | 363 | = 278.1 | 233.3 |

Consequently, for dist. 363, course 40°, lat. = 278.1, dep. = 233.3.

Other examples are :

Course 25°, dist., 452; lat. = 409.6, dep. = 191.0.

Course 68, dist., 521; lat. = 195.2, dep. = 483.1.

Course 226, dist., 384; lat. = 266.8, dep. = 276.2.

When the given distances or course angles, which are really the "pairs of arguments" (p. 11) of the traverse table, contain fractions, interpolation can be used; but such close accuracy is seldom, if ever, required in navigation.

More extended traverse tables will be found in Bowditch's "American Practical Navigator," published by the Navy Department, Washington. They are also printed separately in Bowditch's "Useful Tables." Both volumes can be purchased at any "navigation shop" where instruments and books suitable for navigators are sold.

To complete this explanation of our traverse table, it is still necessary to mention that it also provides, with sufficiently close approximation, for the method of measuring

course angles in "points of the compass" (pp. 10, 41). This method is not now in use in the United States Navy, but it is still largely employed in merchant vessels. It is sufficient to state here that a course of 3 points, for instance, is very nearly equal to a course of 34° , and the traverse table column for 34° may properly be used for a 3-point course. Similarly, 31° may be used for $2\frac{3}{4}$ points, and the mariner desiring to use points can always find from the traverse table itself just what column to use. A special traverse table for points may also be found in Bowditch's Tables, already mentioned.

We have now shown how to find latitude difference and departure by means of the traverse table. But our problem is not yet completely solved. Our ship (p. 8) started from the point *Y* in lat. $42^\circ 11' N.$; long. $59^\circ 28' W.$ She traveled 63 miles on a 40° course, and the traverse table showed that she thus made good a latitude difference of 48.3 miles and a departure of 40.5 miles. It now remains to ascertain how much the ship changed her latitude in degrees and minutes from $42^\circ 11' N.$ and her longitude in degrees and minutes from $59^\circ 28' W.$ When we have found these last changes, we can learn the latitude and longitude of the point *P*, which we are required to find.

To get the latitude change in degrees and minutes from the latitude difference in miles offers no difficulty. If the miles used are nautical miles (and in navigation they always are nautical miles), each mile of latitude difference corresponds to $1'$ of angular measure (p. 9), and 60 miles correspond to 1° . Thus our ship must have changed her latitude $48'.3$, corresponding to a latitude difference of 48.3 miles. Her initial latitude having been $42^\circ 11' N.$, her final latitude at *P* will be $42^\circ 11' + 48'$ (if we omit the odd .3) or $42^\circ 59' N.$

The relation between departure and difference of longitude is not quite so simple. Our ship's departure of 40.5 miles might correspond to far more than 40.5 minutes of longitude. In fact, in very high latitudes near the north pole, the longitude meridians converge so closely that a person traveling

a few miles might change his longitude very greatly. At the pole itself a man might change his longitude 180° by simply stepping across the pole. So it follows that the longitude difference in minutes is *greater* than the departure in miles (however, cf. p. 4). The difference between the two increases rapidly as we approach high latitudes though it is *nil* at the equator; in Table 2 (beginning p. 168) we give this excess of longitude difference over departure for all latitudes under 60° , and for all longitude differences up to 100. When the longitude differences are greater than 100, it is necessary to use the numbers given for 100, 200, 300, etc., near the bottom of each page in the table, and to sum tabular numbers, precisely as we did with the traverse table.

It will be noticed that Table 2 gives "tabular numbers" for each degree of latitude in a separate column, and that these various latitudes are called "middle latitudes." Thus the middle latitude and the longitude difference are the pair of arguments (p. 11) for Table 2, and, as we shall see presently, the use of the middle latitude avoids any uncertainty in choosing the correct column for use. In our present problem we have at our disposal (p. 15) two different latitudes: the initial latitude at the point *Y*, $42^\circ 11' N.$, and the final latitude at the point *P*, $42^\circ 59' N.$ In this case, the two latitudes are so nearly equal that we might use either of them as an argument in Table 2 without material inaccuracy. In fact, in using Table 2 it is unnecessary to consider minutes of latitude, the nearest degree being sufficient.

But often the two latitudes available at this stage of the problem differ by many degrees. In such cases mariners always use the average of the two latitudes, and call it the "middle latitude." In the present case, the middle latitude would be found thus:

$$\begin{array}{r}
 \text{Initial latitude} = 42^\circ 11' \\
 \text{Final latitude} = 42^\circ 59' \\
 \text{Sum} = \underline{85^\circ 10'} \\
 \frac{1}{2} \text{ sum} = \text{middle latitude} = 42^\circ 35'
 \end{array}$$

The nearest even degree to $42^{\circ} 35'$ is 43° , and the problem would therefore be worked with the 43° column of middle latitude in Table 2.

Before completing our problem it is necessary to point out that while Table 2 is intended primarily for changing longitude differences in minutes into departures in miles, it can also be used (as stated at the foot of each page) for the inverse transformation of departures into longitude differences; and this is the transformation we must make in our present problem. It is merely necessary to use the departure (40.5) in the left-hand column, at the head of which are the words "Long. Diff. or Dep.," indicating that either of these two may be used as the argument in that column. Then, in the 43° column of middle latitude, we find (using interpolation) the tabular number 10.8.

This means that a longitude difference of $40'.5$ corresponds to a departure of $40.5 - 10.8$ miles, or 29.7 miles.

But when the table, as in the present case, is used for the inverse transformation, the tabular number 10.8 must, before use, be multiplied by the factor given at the bottom of the column. For the middle latitude 43° this factor is 1.37; and so the right tabular number becomes, in the present case:

$$10.8 \times 1.37 = 14.8;$$

and as the longitude difference is always greater than the departure, it follows that the departure of 40.5 miles gives a longitude difference of:

$$40.5 + 14.8 = 55'.3 = 0^{\circ} 55',$$

if we omit the odd tenths.

The initial longitude of the ship at the point *Y* was $59^{\circ} 28' W$. As her 40° course has carried her nearer to Greenwich, it follows that her final longitude at the point *P* is:

$$59^{\circ} 28' W. - 0^{\circ} 55' = 58^{\circ} 33' W.$$

We shall now discuss the following similar problem:

A ship takes her departure from a point about one mile

east of Navesink Highlands Light, New Jersey, in the initial lat. $40^{\circ} 24' N.$, initial long. $73^{\circ} 58' W.$, and travels 1377 miles on a course of 166° . What final latitude and longitude does she attain?

Entering the traverse table in the column headed 166° , which is the same as the 14° column, we find :

| | | | |
|----------------------------|--------------------|-------------|-------|
| For dist. 900, lat., | 873.2, | dep., | 217.7 |
| For dist. 400, lat., | 388.1, | dep., | 96.7 |
| For dist. <u>77,</u> lat., | <u>74.7,</u> dep., | <u>18.6</u> | |
| Sums, | 1377, | 1336.0, | 333.0 |

To make the large given distance (1377 miles) come within the range of Table 1, it has been necessary to enter the 166° column three times, with the arguments 900, 400, and 77, and then to sum the corresponding tabular numbers.

The latitude difference, 1336 miles, is equivalent to $1336'$, or $22^{\circ} 16'$, counting, as usual, $60'$ to 1° . Then, since the direction of her course (166°) carried the ship to the south of her initial position (cf. Fig. 5, p. 14, and p. 19), we have :

| | |
|---------------|---------------------------------------|
| Initial lat., | $40^{\circ} 24' N.$ |
| Lat. diff., | <u>$22^{\circ} 16' N.$</u> |
| Final lat., | $18^{\circ} 8' N.$ |
| Middle lat., | $29^{\circ} 16' N.$ |

Now turning to Table 2, in the proper column for middle latitude 29° :

| | |
|--------------------------------------|-------------------------------|
| For dep. 300 tabular number is | 37.6 |
| For dep. <u>33</u> tabular number is | <u>4.1</u> |
| Sums | 333 41.7 |

As in the former example, this 41.7 must be multiplied by the factor at the bottom of the column. This factor is 1.14. Multiplying, we have: $41.7 \times 1.14 = 47.5$. Consequently, long. diff. = $333 + 47.5 = 380'.5 = 6^{\circ} 20'.5$. Since the direction of her course (166°) carried the ship eastward, and therefore nearer to Greenwich, it follows that her final longitude is $73^{\circ} 58' W. - 6^{\circ} 20'$, or $67^{\circ} 38' W.$ The final position is therefore: lat. $18^{\circ} 8' N.$; long. $67^{\circ} 38' W.$

The point indicated by this final latitude and longitude is just off the entrance to the Mona Passage, between Haiti and Porto Rico; the given course and distance would therefore be correct for a voyage from New York to Mona Passage.

Additional similar problems are :

1. Initial lat., $40^{\circ} 28' N.$; initial long., $73^{\circ} 50' W.$; course, 119° ; dist., 2924 miles. This would take the ship from Sandy Hook to St. Vincent, Cape Verde Islands.

Ans. Final lat., $16^{\circ} 50' N.$; final long., $25^{\circ} 7' W.$

2. Initial lat., $40^{\circ} 10' N.$; initial long., $70^{\circ} 0' W.$; course, 75° ; dist., 2606 miles. This would take the ship from Nantucket Lightship to Fastnet, the nearest point of the Irish coast.

Ans. Final lat., $51^{\circ} 24' N.$; final long., $9^{\circ} 37' W.$

Before proceeding to our second fundamental problem (p. 8), it will be well to explain briefly two further points of interest. The first of these relates to the method of designating a ship's course. We have hitherto supposed it to be measured in degrees, from the north, around by way of the east, through the south and west, and so back to the north again. This is the best way to count courses, and is the way now in use in the United States Navy. Since a whole circle contains 360° , it follows that courses may contain any number of degrees from 0° to 360° .

But there is another quite convenient, although older, way of designating courses, in which a 60° course, for instance, is written $N. 60^{\circ} E.$, showing that the ship must be steered 60° east of north. In a similar way, a 120° course is written $S. 60^{\circ} E.$, showing that the helmsman should head her 60° east of south, which would be the same as 30° south of east, or 120° from the north toward the south by way of east.

The second further point of interest has to do with the relation between Tables 1 and 2. It is possible to avoid entirely the use of Table 2, and to transform longitude differences into departures, and *vice versa*, by means of Table 1

alone. It so happens that the relation between these two, for any given middle latitude, as, for instance, 29° , is identical with the relation between distance and latitude difference in Table 1 for the course 29° . In other words, if we have given a middle latitude and a longitude difference, and wish to find the departure, we :

Call the middle latitude a course, and
Call the longitude difference a distance ;

Then, corresponding to that course and distance, find from Table 1 the tabular latitude difference, and it will be the required departure. The same process can also be reversed, so as to find the longitude difference from the departure.

While this method with Table 1 is quite correct, we believe beginners (at least) will find the use of Table 2 advantageous in the solution of these problems, especially when the middle latitude is not very great.

Coming now to our second fundamental problem of dead reckoning, let us suppose a ship is required to proceed from the initial lat. $42^\circ 11' N.$ and long. $59^\circ 28' W.$ to a final lat. $42^\circ 59' N.$ and long. $58^\circ 33' W.$ We are to find the course she must steer, and the distance she must run.

We have at once the latitude difference of $0^\circ 48'$, or 48 miles, and the middle latitude $42^\circ 35'$, or nearest whole degree of middle latitude, 43° . The longitude difference is $55'$; and with this we find from Table 2 the correction 14.8 in the 43° column of middle latitude. Remembering that this time we are transforming a longitude difference into departure, and consequently do not need to use the factor at the foot of the column, we subtract this correction (14.8) from the longitude difference ($55'$) and obtain the departure as 40.2 miles.

Next we proceed to Table 1, to find the course and distance corresponding to lat. 48, dep. 40.2. To do this, we must find a place in Table 1 where this particular latitude and departure appear side by side. If this pair of numbers

cannot be found (exactly) side by side, we must take the pair which come nearest to them: in this case such a pair of numbers is found in the 40° course column, opposite dist. 63. So it appears that the ship must steer on a 40° course a distance of 63 miles, to proceed from the given initial to the given final latitude and longitude. This problem is the direct converse of the one first solved (pp. 15, 17).

As a second example, let us now calculate the course and distance from Sandy Hook, lat. $40^\circ 28' N.$; long. $73^\circ 50' W.$, to St. Vincent, lat. $16^\circ 50' N.$; long. $25^\circ 7' W.$ We have, by subtraction, lat. diff. = $23^\circ 38' = 1418' = 1418$ miles; long. diff. = $48^\circ 43' = 2923'$.

This $2923'$ must be turned into a departure, the middle latitude being $28^\circ 39'$, or, to the nearest whole degree, 29° . Turning to the column of Table 2 which belongs to 29° of middle latitude, we find the correction for $2923'$ of longitude difference thus:

$$\text{Tabular number for } \quad 900 = 113.0,$$

which being multiplied by 3, gives:

$$\begin{array}{r} \text{Tabular number for } \quad 2700 = 339.0 \\ \text{Also, tabular number for } \quad 200 = 25.1 \\ \text{Tabular number for } \quad \quad 23 = \quad 2.9 \\ \hline \text{Sums, tabular number for } \quad 2923 = 367.0 \end{array}$$

This must be subtracted from the longitude difference, and so we get:

$$\text{dep.} = 2923 - 367.0 = 2556 \text{ miles.}$$

We have now to seek a place in Table 1 where lat. 1418 and dep. 2556 appear side by side. No traverse tables are sufficiently extended to contain these large numbers, but we can at once obtain an approximate answer to the problem by dividing both numbers by 100. This reduces them to lat. 14.2, dep. 25.6; and the nearest numbers to these which can be found side by side in Table 1 are in the column belonging to course 119° and opposite dist. 29. This course (119°) is the same as would have been obtained if we had not been

forced to divide our latitude and departure by 100, to bring them within the range of Table 1. But the dist. 29 must now be multiplied by 100, to remove the effect of our former division of latitude and departure by 100. Thus we have the closely approximate information that the course and distance from Sandy Hook to St. Vincent are 119° and 2900 miles. The same problem (p. 19), when taken in its inverse form, starts with the numbers 119° and 2924 miles.

In discussing such a problem, many beginners have difficulty in choosing correctly the course number (119°) from the four (61° , 119° , 241° , 299°) to be found at the foot of the same column of Table 1. This choice is easily made with the help of our knowledge of elementary geography, or with any rough chart or map. From these, we know that St. Vincent is south and east of Sandy Hook, and the only one of the four possible courses that will carry a ship south and east is course 119° . The same course might be written in the other notation (p. 19) S. 61° E., which possibly makes the actual direction to be steered a little easier to understand.

The above result is approximate only, but higher accuracy is seldom required. When desired, it can be obtained by certain kinds of interpolations (p. 12); but these are always unsatisfactory, especially as complete precision can always be easily had by the use of logarithms, as explained in the next chapter.

CHAPTER III

DEAD RECKONING WITH LOGARITHMS

SINCE the publication in 1876 of Kelvin's tables for facilitating Sumner's method, it has been possible to navigate in the most approved way without using logarithms or trigonometry. Those who desire to study the subject in this manner may do so by simply omitting those parts of the book in which logarithmic or trigonometric formulas and calculations occur. But this method of study is not recommended, except perhaps for a first reading; for a knowledge of logarithmic processes always affords a most desirable check on the accuracy of the other method, and so makes for safety of the ship and peace of mind of the navigator.

Proceeding, then, with the subject of logarithms, we may define them as a mathematical device for facilitating calculations. They are merely numbers; but they are numbers having this peculiarity: every logarithmic number belongs to some ordinary number (like 1, 2, 3, 27, 800, etc.), and belongs to it alone. Its logarithm belongs to the number as a man's shadow belongs to the man.

For our present purpose it is unnecessary to enter into the theory of logarithms; we shall explain only the methods of using them in practice. Logarithms (abbreviated "log") always consist of two parts, a "whole number" part and a "decimal" part. Thus, 3.30103 is a logarithm, of which the whole number part is 3, and the decimal part .30103. The whole number part may even be zero: thus, 0.30103 is also a logarithm. The decimal part of the logarithm is found from a table of logarithms, such as our Table 3

(p. 178); but the whole number part is found by an inspection of the number to which the logarithm belongs.

We shall hereafter, to save space, always write "log 26" in place of "the logarithm belonging to 26": and, with the help of this abbreviation, we may now write the following tabular statement, which is fundamental in the matter of logarithms:

$$\begin{array}{ll} \log 1 = 0.00000, & \log 1000 = 3.00000, \\ \log 10 = 1.00000, & \log 10000 = 4.00000, \\ \log 100 = 2.00000, & \log 100000 = 5.00000, \text{ etc.} \end{array}$$

In other words, for these particular numbers, all "multiples" of 10, the decimal part of the log is zero. For numbers intermediate between 1 and 10, the whole number part of the log is 0, and the decimal part lies between .00000 and .99999. For those between 10 and 100 the whole number part is 1, and the decimal part again lies between .00000 and .99999.

The general rule is: the whole number part of a log is one *less* than the number of figures or "digits" in the number to which the log belongs. Thus, the number 26 has two digits: the whole number part of its log is 1. The number 2678 has four digits: the whole number part of its log is therefore 3.

If a number is itself partly decimal, we count only the number of digits to the left of the decimal point for the purposes of the present rule. Thus, 26.78 has two digits only; 2.678 has one; 267.8 has three, etc.

If, on the other hand, a number is wholly decimal, as 0.2678, the whole number part of its logarithm should be "negative," or *minus*, *i.e.* less than 0; and it will be one *greater* than the number of zeros immediately following the decimal point in the number. According to this, the whole number part of log 0.2678 should be -1 , because this number has *no* zeros immediately following the decimal point. But as these negative whole number parts are very inconvenient in actual work, it is customary to increase

all logs of decimal numbers arbitrarily by 10, which will avoid the negative sign. This arbitrary increase is always corrected again in the further or final procedure, so that it cannot possibly introduce error into the work.

In the case of $\log 0.2678$, the arbitrary increase of 10 changes the -1 to $+9^1$; and so 9 would be the whole number part of $\log 0.2678$. Similarly, $\log 0.002678$ would have 7 for its whole number part, because there are two zeros after the decimal point. This would make the whole number part of the log -3 , which, being increased by 10, gives $+7$.

In general, this matter of logs of wholly decimal numbers may be summarized as follows:

$$\begin{array}{ll} \log 0.1 & = 9.00000, & \log 0.0001 & = 6.00000, \\ \log 0.01 & = 8.00000, & \log 0.00001 & = 5.00000, \\ \log 0.001 & = 7.00000, & \log 0.000001 & = 4.00000, \text{ etc.} \end{array}$$

In all these cases the decimal part of the log is zero: and if the number lies, for instance, between 0.1 and 0.01, the whole number part of the log will be 8, and the decimal part will lie between .00000 and .99999.

The decimal part in the log of any number is taken from Table 3 without regard to the position of the decimal point in the number itself. The numbers 0.2678, 0.002678, 26.78, 2.678, 267.8, and 2678 all have precisely the same decimal part in their logs, so that such logs will differ in their whole number parts only. We can at once obtain this common decimal part from Table 3 (p. 181), where it is found to be .42781. In looking up this log, we again use (p. 11) a pair of arguments. The argument for the left-hand column consists of the first three digits of 2678 (267); and in selecting this argument we disregard any zeros that may immediately follow the decimal point, if the number is wholly decimal, like .002678. The other argument, in the top horizontal line of the tabular page is 8, the right-hand digit of the number 2678. In the horizontal line

¹ According to Algebra, 9 is greater than -1 by 10.

opposite 267, and in the column headed 8, appears 781; and these are the last three digits of the required log (.42781). The first two digits (.42) are common to a great many logs, and are therefore only printed in the column headed 0. The first two digits of every log are thus taken from the zero column, regularly from the same horizontal line that contains the last three digits of the log, or from some line above it. Only when there is an asterisk printed in the table with the last three digits do we make an exception, and take the first two digits from the line *below* the one containing the last three. Thus the decimal part of log 2691 is .42991, but the decimal part of log 2692 is .43008.

Having thus found the decimal part of log 2678 to be .42781, and the number 2678 having four digits, the complete

$$\log 2678 = 3.42781;$$

and here the reader should once more note that all tabular logs like .42781 are thus always decimals. The corresponding logs for the other numbers given above are:

$$\begin{aligned} \log 267.8 &= 2.42781, \\ \log 26.78 &= 1.42781, \\ \log 2.678 &= 0.42781, \\ \log 0.2678 &= 9.42781, \\ \log 0.002678 &= 7.42781. \end{aligned}$$

It is clear that Table 3 gives directly the decimal part of the logs of all numbers containing four digits. If the number contains less than four digits, as 26, we should look it up in the table as if it were 2600. We should find 260 as the argument in the left-hand column (p. 181); and in the corresponding line, in the column headed 0 (the fourth digit of 2600), is 41497. This is the decimal part, as usual, and the complete

$$\log 26 = 1.41497.$$

If, on the other hand, the number whose log is wanted contains more than four digits, as 26782, it is necessary to

resort to interpolation (p. 12). The number of digits being here 5, the whole number part of the log is 4 (p. 24). The decimal part of the log is to be found quite without regard to decimal points (p. 25). It may therefore be taken from Table 3 just as if we wanted log 2678.2 instead of 26782. Now the table tells us (p. 181):

$$\text{decimal part of log } 2678 = 42781,$$

$$\text{decimal part of log } 2679 = 42797.$$

The tabular difference (p. 12) of these two decimal parts is 16. As 26782 may, for our present purpose, be regarded as lying $\frac{2}{10}$ of the way from 2678 to 2679, it follows that the decimal part of log 26782 will lie $\frac{2}{10}$ of the way from 42781 to 42797. Evidently, we must multiply the tabular difference 16 by $\frac{2}{10}$ (giving 3.2) to find how much larger the decimal part of log 26782 is than the decimal part of log 2678. This 3.2 (or 3, in round numbers) must then be added to 42781; and we have, as the result of this interpolation:

$$\text{decimal part of log } 26782 = .42784.$$

As we have just found the whole number part to be 4, we have for the complete:

$$\text{log } 26782 = 4.42784.$$

This whole process of interpolation may perhaps be more clearly understood if we repeat (p. 10) that all tables furnish tabular numbers corresponding to given arguments. Interpolation is necessary when the given arguments are not to be found in the argument part of the table, but fall between two of the tabular arguments. Then we obtain by subtraction the difference between the given argument and the nearest smaller argument contained in the table. This difference is the "argument difference" (abbreviated, arg. diff.), and it should be expressed as a decimal fraction of the interval between two successive arguments (cf. $\frac{2}{10}$, above). The tabular difference (tab. diff.) between two successive tabular numbers being also obtained by subtrac-

tion, we have only to multiply the tabular difference by the argument difference to find the "interpolation difference" (int. diff.). This is then added¹ to the proper tabular number (belonging to the above-mentioned nearest argument given in the table) to obtain the tabular number required.

The multiplication of the tabular difference by the argument difference is facilitated by certain little auxiliary multiplication tables (called tables of "proportional parts") printed in the margins of many mathematical tables. In the example given above, the tabular difference was 16; and Table 3 contains on the proper page (p. 181) a proportional part table headed with this same number 16; and it shows that for an argument difference .2, and tabular difference 16, the interpolation difference is 3.2, just as we found above.

Other examples of logarithms are :

$$\begin{array}{ll} \log 427 = 2.63043, & \log 42765 = 4.63109, \\ \log 4276 = 3.63104, & \log 282374 = 5.45082, \\ \log 0.4276 = 9.63104, & \log 2 = 0.30103, \\ \log 0.42765 = 9.63109, & \log .0027 = 7.43136. \end{array}$$

The above considerations are preparatory only to the actual use of Table 3; and they are not yet quite complete. For it is still necessary to explain the inverse use (p. 12) of the table, or, in other words, the finding of the number to which a given log belongs. Thus, if the given log were 3.42781, we should begin by looking up its decimal part among the logs in the table. Finding it there, we take out the number to which it belongs, 2678. We then put in the decimal point according to the whole number part of the log. This being 3, we know (p. 24) that the number required must contain 4 digits. Therefore :

$$\text{number to which the log } 3.42781 \text{ belongs} = 2678.$$

¹ Except when a glance at the table shows that the tabular numbers are growing smaller, in which case the interpolation difference must be subtracted. This never occurs in Table 3, but happens frequently in Table 4.

If the given log had been 2.42781, the table would furnish the same number 2678, but the decimal point would be differently located. Because the whole number part of the given log is now 2, we know that the number to which it belongs has three digits, and so :

number to which the log 2.42781 belongs = 267.8.

When the given log is not to be found in the table exactly, a process of inverse interpolation is, of course, necessary. Thus, if the given log is 4.42784, we look for its decimal part in the table, and find it lies between

42781, which belongs to the number 2678, and

42797, which belongs to the number 2679.

The decimal part of the given log being 42784 is greater by 3 than the nearest tabular number 42781. This 3 is therefore the interpolation difference. The tabular difference is 16, obtained by subtraction between 42781 and 42797. We now divide the interpolation difference by the tabular difference, which gives $.2$ ($\frac{3}{16} = 0.2$, in round numbers). This $.2$ is the argument difference, and therefore the complete number belonging to the decimal part of the log (42784) is 26782. The whole number part of the given log being 4, the required number must have 5 digits, and will therefore be 26782. Had the given log been 2.42784, we should have arrived at the number 26782 in just the same way; but we should locate the decimal point differently. The whole number part of the log being now 2, there should be only 3 digits in the number, and we should have :

number to which the log 2.42784 belongs = 267.82.

Other similar examples are :

log = 2.71828, corresponding number = 522.73,

log = 4.26323, corresponding number = 18333,

log = 9.26323, corresponding number = 0.18333,

log = 0.21000, corresponding number = 1.6218.

The reader will perceive, from a consideration of these interpolated numbers, that work with logarithms is never

exact, *absolutely*. This is inherent in the nature of our log tables, which really contain only the decimal parts of the logs carried out to five places of decimals. Further decimals of course exist, but are here omitted, because five places always give sufficient accuracy for navigation calculations.

The simplest calculations which are facilitated by logarithms are the ordinary arithmetical processes of multiplication and division. These processes can be turned into addition and subtraction by the use of the following principle :

The log of a product is equal to the sum of the logs of the factors.

According to this principle, if we wish to multiply a series of factors, we simply add their logs. The sum is then a log and the number to which this log belongs is the product of the series of factors. Suppose, for instance, we wish to multiply the factors 2, 3, and 4. The product should be 24. Proceeding with logs, we have from Table 3 :

$$\begin{aligned} \log 2 &= 0.30103, \\ \log 3 &= 0.47712, \\ \log 4 &= \underline{0.60206}, \\ \log \text{ product} = \text{sum} &= 1.38021, \end{aligned}$$

and the number to which the log. 1.38021 belongs is, according to Table 3, 24.00, the correct product.

It is evident that the use of the log table is here of no advantage, because the factors are very small: but when large numbers are to be multiplied the advantage is very great.

Taking now a similar simple example of division, let us divide 6 by 3. In division, evidently, we must subtract the log of the divisor from the log of the dividend, to obtain the log of the quotient. We have

$$\begin{aligned} \log 6 &= 0.77815, \\ \log 3 &= \underline{0.47712}, \\ \log \frac{6}{3} = \text{difference} &= 0.30103, \end{aligned}$$

and the number to which the log 0.30103 belongs is 2.000, the correct quotient. Other examples are :

$$2.426 \times 42.78 \times 17.26 = 1791.3,$$

$$6.242 \times 87.24 \times 62.71 = 34149,$$

$$\frac{2802}{1726} = 1.6234,$$

$$\frac{18}{24} = 0.75.$$

In the last example, we have

$$\log 18 = 1.25527,$$

$$\log 24 = 1.38021.$$

The subtraction would lead to a negative log because 1.38021 is larger than 1.25527. Therefore we arbitrarily increase 1.25527 by 10, giving 11.25527, and then the subtraction gives

$$\log \text{quotient} = 9.87506,$$

which is the log belonging to the number 0.75, the correct quotient.

We come now to the solution of the two fundamental problems of dead reckoning (pp. 8, 10) by means of logs. For this purpose we must use our Table 4, in connection with Table 3. Table 4 is called a trigonometric log table and the tabular numbers in it are certain logs known as :

| | | | |
|----------|------------------|------------|------------------|
| sine, | abbreviated sin, | cotangent, | abbreviated cot, |
| cosine, | abbreviated cos, | secant, | abbreviated sec, |
| tangent, | abbreviated tan, | cosecant, | abbreviated csc. |

It is not our purpose to consider the theory of trigonometry, but it is necessary for the reader to have some understanding of its practical applications. If we have a triangle *QPY* (fig. 6), we notice that it is made up of six "parts," the three sides and the three angles. Now it is a fact that if we know any three of these six parts, we can calculate the other three parts, provided one of the known parts is a side.

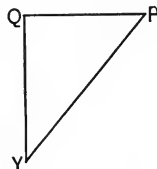


FIG. 6. — Trigonometry.

Trigonometry is the branch of mathematics which enables us

to do this, and the triangle QPY is the very triangle which occurs in the two problems of dead reckoning.

In trigonometry, every angle has belonging to it a sin, cos, etc., just as every number has its log. These sines, etc., can be taken out of Table 4 by means of a pair of arguments in the usual way. The two arguments are the number of degrees and the number of minutes in the angle (p. 9). The number of degrees is found in Table 4 at the top or bottom of the page, and the number of minutes in the right-hand or left-hand column. Each page (as, for instance, p. 229) has eight degree numbers, four, 33° , (213°), (326°), and 146° at the top, and four, 123° , (303°), (236°), and 56° at the bottom. The proper sines, etc., for all these degrees appear on the same page (p. 229). When the degree number is at the top or bottom of the left-hand column 33° , (213°), (303°), and 123° , the minutes must be taken from the left-hand column. But when the number of degrees is at the top or bottom of the right-hand column 146° , (326°), (236°), and 56° , the minutes must come from the right-hand column. And when the number of degrees comes from the top of the page, we must look for the proper sine, etc., in a column having the word sin, etc., at the top. But when the degree number comes from the bottom of the page, the sine, etc., will be taken from a column having the word sin, etc., at the bottom. Thus (p. 229):

$$\sin 33^\circ 26' = \sin 146^\circ 34' = \cos 56^\circ 34' = \cos 123^\circ 26' = 9.74113.$$

In this way, sines, tangents, etc., can be taken from Table 4. Examples are:

$$\begin{aligned} \sin 28^\circ 32' &= 9.67913, & \cot 117^\circ 10' &= 9.71028, \\ \cos 66^\circ 14' &= 9.60532, & \sec 12^\circ 40' &= 0.01070, \\ \tan 128^\circ 28' &= 0.09991, & \csc 111^\circ 11' &= 0.03038. \end{aligned}$$

These sines, etc., are really all logs. When the whole number part is 9, it indicates that the log belongs to a number which is wholly decimal (see p. 24), and that the log has been arbitrarily increased by 10.

Of course these trigonometric tables can also be used in the inverse manner. Thus, to find the angle corresponding to the sin 9.28190, we turn to p. 207, and finding 9.28190 in the sin column, we see that the corresponding angle is either $11^\circ 2'$, $191^\circ 2'$, $168^\circ 58'$, or $348^\circ 58'$. When the sin, etc., cannot be found in the table exactly, we may always take the nearest one: interpolation is never practically necessary in using the trigonometric tables in navigation.

Examples are:

- sec = 0.17177, angle = $47^\circ 40'$, $227^\circ 40'$, $132^\circ 20'$, or $312^\circ 20'$,
- tan = 0.17177, angle = $56^\circ 3'$, $236^\circ 3'$, $123^\circ 57'$, or $303^\circ 57'$,
- sin = 9.17177, angle = $8^\circ 32'$, $188^\circ 32'$, $171^\circ 28'$, or $351^\circ 28'$,
- cos = 9.17177, angle = $81^\circ 28'$, $261^\circ 28'$, $98^\circ 32'$, or $278^\circ 32'$,
- csc = 0.17177, angle = $42^\circ 20'$, $222^\circ 20'$, $137^\circ 40'$, or $317^\circ 40'$,
- cot = 0.17177, angle = $33^\circ 57'$, $213^\circ 57'$, $146^\circ 3'$, or $326^\circ 3'$.

Having thus explained the use of Table 4, we shall now apply it to the two problems of dead reckoning. These problems are:

1. To find latitude difference and departure from course and distance;
2. To find course and distance from latitude difference and departure.

These problems are solved by means of the following formulas, in which the letter *C* represents the course angle:

$$\begin{aligned}
 (1) \quad & \begin{cases} \log \text{ lat. diff.} = \log \text{ dist.} + \cos C, \\ \log \text{ dep.} = \log \text{ dist.} + \sin C. \end{cases} \\
 (2) \quad & \begin{cases} \tan C = \log \text{ dep.} - \log \text{ lat. diff.}, \\ \log \text{ dist.} = \log \text{ dep.} - \sin C. \end{cases}
 \end{aligned}$$

Sometimes it is preferable to find the distance from the latitude difference instead of the departure. We then use the following modification of formula (2):

$$(2') \log \text{ dist.} = \log \text{ lat. diff.} - \cos C.$$

Let us now solve with these formulas our former problem (p. 18), in which a ship traveled 1377 miles on a course of 166° . Applying formula (1) above, we have:

| | | | |
|--------------------------|-------------------------------|-------------------------|-------------------------------|
| log dist. (1377) | = 3.13893 | log dist. (1377) | = 3.13893 |
| cos C (166°) | = <u>9.98690</u> | sin C (166°) | = <u>9.38368</u> |
| sum = log lat. diff. | = <u>3.12583</u> ¹ | sum = log dep. | = <u>2.52261</u> ¹ |
| corresponding lat. diff. | = 1336.1 | corresponding dep. | = 333.1 |

These corresponding latitude difference and departure agree very closely with the results already found (p. 18) from Table 1.

If the departure and latitude difference were given, we could find the course and distance by means of formula (2). In the present case we have :

| | | | |
|-------------------------|------------------------|---------------------------|-------------------------------|
| log dep. (333.1) | = 2.52261 | log dep. (333.1) | = 2.52261 |
| log lat. diff. (1336.1) | = <u>3.12583</u> | sin C (166°) | = <u>9.38368</u> |
| by subtraction, tan C | = 9.39678 ² | by subtraction, log dist. | = <u>3.13893</u> ³ |
| corresponding C | = 166° | corresponding dist. | = 1377 |

These numbers, 166° and 1377 miles, are the same numbers with which we began this calculation; so it is clear that the log method of calculation agrees with the traverse table method. For accuracy the log method is superior.

The transformations of departure into longitude difference, and *vice versa*, are accomplished logarithmically with the following formulas :

- (3) log long. diff. = log dep. - cos middle lat.
 (4) log dep. = log long. diff. + cos middle lat.

Thus the longitude difference corresponding to dep. 333.1 would be calculated by formula (3) as follows :

| | |
|---|------------------------------|
| log dep. (333.1) | = 2.52261 |
| cos mid. lat. ($29^\circ 16'$, p. 18) | = <u>9.94069</u> |
| by subtraction, log long. diff. | = 2.58192 |
| corresponding long. diff. | = $381'.9 = 6^\circ 21'.9$. |

¹ These numbers have been diminished by 10, to allow for the fact that both cos C and sin C have been arbitrarily increased by 10 (p. 32; cf. also p. 25).

² This number has been increased by 10, and therefore is in accord with the usual practice of avoiding negative whole numbers in the trigonometric Table 4.

³ This subtraction is correct, if we remember that the 9.38368 is really too large by 10.

This is in close accord with the result on p. 18, where Table 2 gave $6^{\circ} 20' .5$. The logarithmic method is again the more precise, for it takes account of minutes in the course, which were neglected on p. 18. But either result is accurate enough for practical purposes.

Before finally leaving these problems of dead reckoning, we shall explain briefly two additional methods of solving them which differ from the method so far employed. These two additional methods are called "Mercator sailing" and "great circle sailing"; whereas, up to the present, we have been using "middle latitude sailing," so named because the middle latitude appears in the calculations.

Mercator sailing is based on a kind of chart first designed by Gerhard Mercator, a sixteenth century geographer. Such charts are still widely used for nautical purposes. In calculations based on them, every parallel of latitude is referred directly to the equator by means of a table of "meridional parts." Our Table 5 is such a table, and it gives the meridional part for every degree and minute of latitude from the equator to 60° . These meridional parts are really the distances from the equator to the several parallels of latitude, such as they would appear on a Mercator chart drawn to such a scale that 1' of longitude at the equator would occupy one linear unit on the chart. Thus the meridional part, for lat. 40° is given in Table 5 as 2607.6. Suppose the scale of the chart at the equator were 1 inch to the degree of longitude. That would be $\frac{1}{60}$ inch to the minute. The distance on the chart from the equator to the 40° parallel of latitude would then be $2607.6 \times \frac{1}{60}$ inches = 43.46 inches. It is needless to say that a chart on such a scale could not show a very large part of the ocean on a single sheet.

Calculations by Mercator sailing are of course only made when the distances involved are large and great accuracy is required. It is therefore best to do them by means of logarithms, although it is also possible to obtain Mercator results from the traverse table. In such calculations we do not

use the latitude difference of ordinary middle latitude sailing. In its place appears the "meridional latitude difference" (abbreviated mer. lat. diff.), defined as the difference between the meridional parts (Table 5) belonging to the two latitudes (initial and final) involved in the problem. With this definition in mind we may now give the Mercator formulas as follows:

- (5) $\log \text{ mer. lat. diff.} = \log \text{ long. diff.} + \cot C.$
 (6) $\log \text{ long. diff.} = \log \text{ mer. lat. diff.} + \tan C.$
 (7) $\tan C = \log \text{ long. diff.} - \log \text{ mer. lat. diff.}$

Let us now apply these formulas to the problem of pp. 18 and 33, in which a ship starts from the initial lat. $40^{\circ} 24' \text{ N.}$; long. $73^{\circ} 58' \text{ W.}$, and travels 1377 miles on a course, C , of 166° . What final latitude and longitude does she attain? The latitude difference is found in the ordinary way (p. 34), there being no special Mercator formula for it, and comes out 1336.1 miles, or $1336'.1 = 22^{\circ} 16'$. The final latitude (p. 18) is therefore $40^{\circ} 24' - 22^{\circ} 16' = 18^{\circ} 8'$. Then, from Table 5, we have:

for initial lat. $40^{\circ} 24'$, mer. parts = 2638.9
 for final lat. $18^{\circ} 8'$, mer. parts = 1099.4
 by subtraction,¹ mer. lat. diff. = 1539.5

Now, applying formula (6), we have:

$\log \text{ mer. lat. diff. (1539.5) (Table 3, p. 179)} = 3.18738$
 $\tan C (166^{\circ}) \text{ (Table 4, p. 209)} = \underline{9.39677}$
 by addition, $\log \text{ long. diff.} = 2.58415$
 corresponding long. diff. (Table 3, p. 183) = $383'.8 = 6^{\circ} 24'$

The final longitude is therefore $73^{\circ} 58' - 6^{\circ} 24' = 67^{\circ} 34' \text{ W.}$, whereas we obtained before $67^{\circ} 38' \text{ W.}$ (p. 18).

Finally, we shall apply the Mercator method to the example of p. 21. It is required to find the course and distance from

Sandy Hook, lat. $40^{\circ} 28' \text{ N.}$; long. $73^{\circ} 50' \text{ W.}$ to
 St. Vincent, lat. $16^{\circ} 50' \text{ N.}$; long. $25^{\circ} 7' \text{ W.}$

¹ If one latitude were in the southern hemisphere and the other in the northern, we should add the meridional parts.

We have from Table 5 :

| | |
|--|-----------------|
| for initial lat. $40^{\circ} 28'$, mer. parts | = 2644.2 |
| for final lat. $16^{\circ} 50'$, mer. parts | = <u>1018.1</u> |
| by subtraction, mer. lat. diff. | = 1626.1 |

The longitude difference is found by subtraction to be $73^{\circ} 50' - 25^{\circ} 7' = 48^{\circ} 43' = 2923'$. Now applying formula (7), we have :

| | |
|--------------------------------------|------------------|
| log long. diff. (2923) (Table 3) | = 3.46583 |
| log mer. lat. diff. (1626) (Table 3) | = <u>3.21112</u> |
| by subtraction, $\tan C$ | = 0.25471 |

and therefore (Table 4) $C = 119^{\circ} 5'$.

The distance is found in the ordinary way from the latitude difference (*not* mer. lat. diff.) by means of formula (2'), p. 33.

The latitude difference is $40^{\circ} 28' - 16^{\circ} 50' = 23^{\circ} 38' = 1418'$. Formula (2') then gives :

| | |
|---|-------------------------------|
| log lat. diff. (1418') (Table 3) | = 3.15168 |
| $\cos C$ ($119^{\circ} 5'$) (Table 4) | = <u>9.68671</u> ¹ |
| by subtraction, log dist. | = 3.46497 ¹ |
| corresponding dist. (Table 3) | = 2917 |

Course $119^{\circ} 5'$, distance 2917 miles is therefore the solution by Mercator sailing. On p. 22, we obtained 119° and 2900 miles; and on p. 19 we began with 119° and 2924 miles. The agreement is satisfactory.

Having thus briefly described Mercator sailing, we come next to "great circle sailing." This is a method of determining the ship's course toward her port of destination in such a way that the distance to be traveled will be as short as possible. If the earth's surface were flat instead of spherical, the shortest course would be a straight line, as used in plane sailing; but on the sphere the shortest course is a curve called a "great circle." Evidently, on all long voyages, the great circle course is the most advantageous one; that mariners do not more frequently use it is due to a peculiarity of their charts.

¹ This log is really too large by 10, so the subtraction is correct.

We cannot here enter into the details of chart "projections," as the theory of chart making is called. It is sufficient to remark that a straight line drawn on the ordinary nautical charts (which follow the Mercator system), between any two ports, will not represent the shortest (or great circle) course between them. On such a chart, the great circle course between the two ports will *appear* to be longer than the straight line course, although it is really shorter. This accounts for the use of the longer Mercator course by many navigators.

Now there is a kind of chart, called a "great circle sailing" chart, on which straight lines between ports really represent shortest (or great circle) courses. One would therefore naturally suppose that mariners would entirely discontinue the use of Mercator charts in favor of great circle charts. But there is a reason for not doing this.

On Mercator charts, all terrestrial longitude meridians are represented by parallel vertical straight lines. Consequently, if we draw another straight line on the Mercator chart joining two ports, that line will make the same course angle (p. 10) with all the meridians. In this way, a navigator can get from a Mercator chart, by simply drawing a straight line, and quite without calculation, a course angle which will carry him from one port to another. And because the course angle so obtained is the same with respect to all meridians to be crossed by the ship it follows that the voyage can be completed (theoretically at least) from the one port to the other with the great advantage of never changing the course to be steered.

On the other hand, the great circle track makes a different angle with every meridian it passes: so that the mariner must make very frequent changes in the course angle to be steered during the progress of a voyage. The simple Mercator track, without change of course, is called a "rhumb line"; the serious objection to it is that it sometimes leads to greatly (and unnecessarily) lengthened voyages.

The final conclusion is that Mercator charts, on account of their simplicity, are most convenient for short voyages, or for parts of long voyages when the land is not far away. But for shaping the main part of the course on a very long voyage, great circle sailing charts are to be preferred.

At times, in order to avoid very high latitudes, or to round some projecting point of land, navigators must substitute for a single great circle track one "composed" of two or more shorter arcs of great circles. This is called "composite" sailing.

Finally, for the sake of completeness, we shall merely mention two other kinds of sailing. "Parallel" sailing, which is simply middle latitude sailing when the latitude difference is zero; and "traverse" sailing, from which the traverse table gets its name. This is also the same thing as middle latitude sailing; but the special word "traverse" is used when the ship changes her course frequently, perhaps even during a single day. It is then possible to sum up the result of all the short courses which together make up the day's run. It is merely necessary to take from the traverse table the latitude difference and departure for each short course separately, and then to add¹ all the values of latitude difference for a "summed latitude difference," and all the values of departure for a "summed departure." With these a "composite course and distance" can be taken from the traverse table, or calculated with logs, and these will represent the motion of the ship, just as if she had steered an unchanged course during the entire day.

¹ It is necessary to sum separately latitude differences representing northward motion of the ship and those representing southward motion. The *difference* of the two sums is what we need to know. The same is true of departures representing eastward and westward motion of the ship.

CHAPTER IV

THE COMPASS

THE ship's course has been defined (p. 8) as the angle between the north and the direction in which the ship is sailing. To ascertain what this angle is, or, in other words, to steer the ship, mariners use the compass. The dial (or "card") of this instrument is divided, like any circle, into 360° . In the United States Navy these are numbered in such a way (fig. 7) that 0° appears at the north, 90° at the east, 180° at the south, and 270° at the west. The numbers therefore increase in a "clockwise" direction. There are also compasses in which the numbering begins with 0° at both the north and south points, and increases to 90° at the east and west points. But the United States Navy system of numbering is to be preferred.

In addition to the above division and numbering, the dial is also divided into 32 points (pp. 10, 15), each containing $\frac{360^\circ}{32}$, or $11\frac{1}{4}^\circ$. These points are then further subdivided into quarter points, all of which is shown clearly in Fig. 7.

The naming of the points has not been done by chance, but in accordance with a definite rule. The four principal, or "cardinal," points are north, east, south, and west. The remaining points are located by a continued process of halving. Halfway between the cardinal points are the "inter-cardinal" points; and each is named by combining the names of the two cardinal points adjacent to it. Thus northeast (abbreviated N.E.) is halfway between north and east. Again halving and combining names, we get points like E.N.E., S.S.E., etc. Still once more halving completes the tally of 32 points: but a combination of names would now be too complicated. However, since

each of these final points must necessarily be adjacent to a cardinal or inter-cardinal point, they are named by simply increasing the name of such adjacent cardinal or inter-cardinal point. This is accomplished with the word "by."



FIG. 7. — Compass Card.

Thus we find, adjacent to N.E., the points N.E. by E., and N.E. by N. In the light of the above, it is easy to "box" the compass, as seamen say, or to name the 32 points in order.

When the point system of division is used, and an accuracy

closer than a single point is required, the compass card is still further subdivided into quarter points. In naming these it is customary, in the United States Navy, to "box" from N. and S. towards E. and W. Thus the space between N.N.E. and N.E. by N. would be divided into four parts thus: N.N.E. $\frac{1}{4}$ E., N.N.E. $\frac{1}{2}$ E., N.N.E. $\frac{3}{4}$ E. But an exception is made to this last rule in the case of quarter points adjacent to a cardinal or inter-cardinal point. These last are always put first in naming the quarter points. Thus, between E. by N. and E., if we *always* boxed from N. towards E., we should have: E. by N. $\frac{1}{4}$ E., E. by N. $\frac{1}{2}$ E., E. by N. $\frac{3}{4}$ E. But it is customary, because shorter, to name these quarter points E. $\frac{3}{4}$ N., E. $\frac{1}{2}$ N., and E. $\frac{1}{4}$ N.

Inside the "bowl" of the compass, and adjacent to the card, a black line is marked on the bowl. This line is in plain view of the steersman, through the glass cover of the compass, and is called the "lubber line." When the ship is headed in such a way that this line comes opposite N.E., for instance, on the card, the ship will be on a N.E. course, which makes an angle of 45° with the north.

But would the ship really be traveling on a line making a 45° angle with the geographic meridian, or direction of the north pole of the earth? She would be doing so only if the compass were absolutely correct. This is practically the case with the "gyro-compass," a mechanical contrivance now much used in the navy, but not the case with the ordinary "magnetic" compass.

In Chapters II and III, concerning dead reckoning, we have always used the word "course" as if all compasses were absolutely correct. But since they are not correct, it is now necessary to make allowance for their errors. In other words, whenever we use a compass, we must first ascertain the difference between the "true course" and the "compass course." It must not be supposed from this statement that a ship can be steered on two different courses at the same moment. There is really only one direction along which

the ship is moving: but the angle between that direction and the true north may be different from the angle between it and the "compass north." It is the course measured from the true north that must be used in all dead-reckoning calculations, and that always results from such calculations: but for steering the ship by means of a compass the steersman must be furnished with the course as measured from the compass north. Therefore it is essential for the navigator to know the difference between the two. This difference is called the "error" of the compass.

Unfortunately, this error is made up of two parts. The first, called "variation" of the compass, is due to peculiarities in the earth's magnetism, and is quite different in different places on the earth. It also varies in different years at the same place. But at any one time, all ships in the same part of the ocean will have the same variation.

The mariner can always ascertain how great the variation is in his part of the ocean, because it is always marked on his chart. Certain curved lines are drawn on the chart; and if the ship is located on or near a line marked "variation 10° ," for instance, it follows that the navigator must on that day allow for 10° of variation. It is also important to take into consideration possible changes in the variation. Sometimes the annual change is marked on the chart; if not, it is important to use a chart of recent date.

The second part of the error is called "deviation" and is due to peculiarities in the magnetism always developed in the metallic parts of the ship itself. It is different in different ships, even in the same part of the ocean, and is even different in the same ship, when she is headed on different courses. Methods have been invented for "compensating" marine compasses, so as to remove the effects of deviation, and these methods are quite effective. But even when they are used, it is necessary, before beginning a long voyage, to have a "compass adjuster" visit the ship. He will then "swing" the ship on a number of different courses, and

adjust the compass so that it will be as nearly correct as possible. Finally, he will determine, by means of astronomic or other observations, just what the remaining compass deviation is on all the various courses, and give the navigator a table of these remaining deviations. This table must be taken into account in "shaping" the ship's course during the voyage. The navigator must also, from time to time, check these tabular deviations while at sea by means of astronomic observations of his own, to take care of possible changes.

Such astronomic observations are made with an instrument (the "azimuth circle"), which can be attached to the compass, and with which the "compass bearing" of the sun or any other object can be observed. The compass bearing is simply the compass direction of the object, as seen from the ship; or the compass course on which the ship would be steered, if she were moving directly toward the object. When the sun is used, its true bearing, measured from the true north, can be taken from astronomic tables which will be explained later; and it is called the sun's "azimuth." A comparison of this true bearing with that measured on the compass with the azimuth circle then makes the compass error known.

When it is not convenient to observe the sun, it is possible to substitute observations of a distant well-defined terrestrial object, whose true bearing can be measured on a chart for comparison with various compass bearings observed while the ship is being swung. Another method is to set up a compass on shore, away from any iron or steel, and use it to determine the bearing of the distant object. And there is still another method, if the above compass and the ship's compass are inter-visible. For the bearing of each may then be taken from the other, and these should differ by exactly 180° . If they do not, the variation from 180° must be due to deviation on board.

The "pelorus" is another instrument which may at times replace the azimuth circle. It is located anywhere on the ship, at a convenient point for observation, and not neces-

sarily close to the compass. It has a "dummy card" and a lubber line. The dummy card can be turned until the lubber line indicates the same course as the real compass. Observations of bearings with the pelorus will then obviously be the same as if made on the compass with the azimuth circle. The advantage of the pelorus is that it can be used anywhere on board, while the compass must be kept constantly in the exact place where it was "adjusted" before leaving port.

The error thus determined astronomically or otherwise is the *sum* of the variation and deviation. If we indicate by E the total compass error in that place, at that time, on that ship, and on that course; by D the deviation similarly described; by V the variation at that time and in that place; and if all three are counted from 0° in the usual direction around the compass card, then we have the formula :

$$(1) \quad E = V + D.$$

By counting in the usual direction, we mean counting from the north around to the east, as all courses are counted (p. 19); so that a compass error of 10° , for instance, would mean that the compass north pointed 10° east of the true north, or had a true bearing of N. 10° E. (p. 19). This is shown in Fig. 8, which also shows the ship's course, counted in the same way.

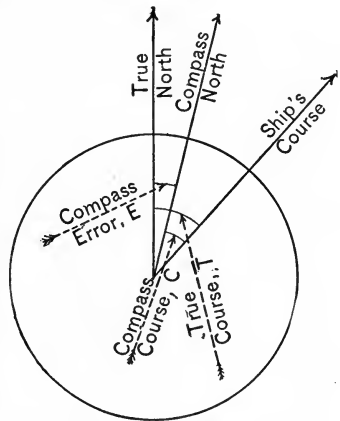


FIG. 8. — Compass Error.

It is clear from the figure that if we now indicate :
 by C , the ship's compass course,
 by T , the ship's true course,
 by E , the compass error,
 we shall have the formula :

$$(2) \quad T = C + E.$$

The simple formulas (1) and (2) enable the navigator to make all necessary compass calculations. The following are examples.

Suppose, for instance, that the error E has been determined by observation, and the variation V taken from the chart. Formula (1) then makes it possible to calculate the deviation D . For the formula shows that E is the sum of V and D ; and so D must be the difference of E and V , or:

$$D = E - V.$$

Thus the deviation D becomes known, as a check on the compass adjuster's work, and, while this value of D is correct only for the particular course on which the ship was headed at the time the observation was made, yet that course is the very one for which it is especially important to have correct information.

Again, suppose dead-reckoning calculations show that the ship is to sail on a 40° course. These calculations always furnish the true course (p. 43) so that $T = 40^\circ$. The variation being known from the chart, and the deviation from the adjuster's table, we know from (1) $E = V + D$. Then from (2) we see that $C = T - E$, which gives the compass course. Let us suppose in the present case, that V was 9° , D 1° ; then $E = V + D = 9^\circ + 1^\circ = 10^\circ$; and since $T = 40^\circ$, $C = T - E = 40^\circ - 10^\circ = 30^\circ$; and the helmsman would be directed to steer a 30° course by compass.

If, in Fig. 8, the compass north happened to be 10° on the left side of the true north, instead of the right, the error E would be 350° , instead of 10° (see also fig. 7, p. 40). This might be made up of a variation V of 349° and a deviation D of 1° , as before. If the true course is again to be 40° , the compass course would be $40^\circ - 350^\circ$, according to the formula $C = T - E$. This subtraction being impossible, we increase the 40° by a complete circumference of 360° , which is always permissible, and then have:

$$C = 360^\circ + 40^\circ - 350^\circ = 50^\circ.$$

The ship would be steered on a compass course of 50° .

An alternative way to take care of errors, variations, and deviations on the left side of the true north is to mark them with the negative or *minus* sign. Instead of calling V 349° , we might call it -11° . This is really the best way, and leads to the same result as before, if we remember that the subtraction of a minus quantity is always equivalent to an addition. In the example just given, calling V -11° , instead of 349° , we should have: $E = V + D = -11^\circ + 1^\circ = -10^\circ$; and $C = T - E = 40^\circ - (-10^\circ) = 50^\circ$, the same compass course as before.

An older way of designating variations, deviations, and errors is to call them east when the compass north points to the right of the true north, and west when it points to the left of the true north. This method leads to the necessity of providing various rules or diagrams with which to make compass calculations. We think the best way to avoid error (and such errors may lose ships and lives) is to use the method here given with its two simple formulas. When some other designation of the error, or some other method of numbering the card, is demanded by a captain, it is always possible to conform to that demand, but also to translate every problem into our method (in imagination at least) as a check against mistake.

The following is an example of a compass adjuster's "deviation table," taken from Bowditch's "Navigator" (1916 edition). The deviations are set down in degrees and tenths of a degree, instead of degrees and minutes, for convenience in the further calculations. The ship was swung so that her head bore successively around the horizon, and observations were made at intervals of 15° . This is a smaller interval than is usually necessary; and the deviations in the table are much larger than commonly occur in a modern well-compensated compass.

DEVIATION TABLE

| BEARING OF SHIP'S HEAD BY COMPASS | DEVIATION | BEARING OF SHIP'S HEAD BY COMPASS | DEVIATION | BEARING OF SHIP'S HEAD BY COMPASS | DEVIATION | BEARING OF SHIP'S HEAD BY COMPASS | DEVIATION |
|-----------------------------------|-----------|-----------------------------------|-----------|-----------------------------------|-----------|-----------------------------------|-----------|
| 0 | - 15.5 | 90 | - 9.1 | 180 | + 17.9 | 270 | + 9.9 |
| 15 | - 14.9 | 105 | - 9.0 | 195 | + 23.8 | 285 | + 1.9 |
| 30 | - 13.3 | 120 | - 7.8 | 210 | + 27.1 | 300 | - 4.2 |
| 45 | - 11.3 | 135 | - 5.9 | 225 | + 25.6 | 315 | - 10.3 |
| 60 | - 10.0 | 150 | - 2.3 | 240 | + 22.0 | 330 | - 13.6 |
| 75 | - 9.7 | 165 | + 8.5 | 255 | + 15.9 | 345 | - 16.0 |

To illustrate the use of this table, let us suppose the ship to be sailing on a compass course of 165° , in a part of the ocean where the variation is $+10^\circ$, or 10° E. Using formula (1) (p. 45), and finding from our table that the deviation D for 165° is $+8^\circ.5$, we have the compass error $E = V + D = +10^\circ + 8^\circ.5 = +18^\circ.5$. By formula (2) (p. 45) the true course of the ship is $T = C + E = 165^\circ + 18^\circ.5 = 183^\circ.5$. We should use this *true* course $183^\circ.5$ in calculating later the ship's position by dead reckoning (p. 10).

If the compass variation were everywhere the same, it would be more convenient to have a table of compass errors, instead of a table of deviations; but because the variation, as given on the chart, varies greatly, the table must be specially made for deviations only.

Equally important with the above use of our deviation table is its inverse use. When the navigator has calculated by dead reckoning the course he must steer, that course, as it comes from the calculations, will be a true course (p. 43); and it is necessary to turn it into a compass course for the use of the steersman.

To do this we must know the deviation; and we cannot get it directly from the deviation table above, because the use of that table presupposes a knowledge of the compass course, the very thing we are trying to find. The best

way to avoid this difficulty is to imagine the deviation to be non-existent, for the moment, and to make use of the "magnetic course," defined as the course which would be indicated by the compass, if deviation were thus totally absent. Under these circumstances, formula (1) gives $E = V$, since $D = 0$; and if we designate the magnetic course by M , we may write, in place of formula (2) (p. 45):

$$(3) \quad M = T - V.$$

Let us suppose a case in which the variation is $+10^\circ$, and the desired true course of the ship 175° . Then the magnetic course, allowing for variation only, will be, by formula (3):

$$M = T - V = 175^\circ - 10^\circ = 165^\circ.$$

This course is not really a compass course, because no account has yet been taken of the deviation. Nor can we yet find the deviation directly from the deviation table, because in that table we must still know the compass course to use as the argument (p. 10), whereas we know as yet only the magnetic course. Therefore navigators should always request the compass adjuster to furnish a "second deviation table," in which the argument is the magnetic course, instead of the compass course. Such a second table can always be calculated from the other. We here give one that has been calculated from the table on the preceding page.

SECOND DEVIATION TABLE

| MAGNETIC BEARING OF SHIP'S HEAD | DEVIATION | MAGNETIC BEARING OF SHIP'S HEAD | DEVIATION | MAGNETIC BEARING OF SHIP'S HEAD | DEVIATION | MAGNETIC BEARING OF SHIP'S HEAD | DEVIATION |
|---------------------------------|-----------|---------------------------------|-----------|---------------------------------|-----------|---------------------------------|-----------|
| 0 | 0 | 90 | 0 | 180 | 0 | 270 | 0 |
| 15 | - 14.9 | 105 | - 9.0 | 195 | + 11.0 | 285 | + 16.5 |
| 30 | - 13.4 | 120 | - 8.4 | 210 | + 16.9 | 300 | + 4.1 |
| 45 | - 11.7 | 135 | - 6.9 | 225 | + 21.3 | 315 | - 7.1 |
| 60 | - 10.4 | 150 | - 4.8 | 240 | + 24.9 | 330 | - 13.2 |
| 75 | - 9.8 | 165 | - 1.4 | 255 | + 26.8 | 345 | - 15.7 |
| | - 9.3 | | + 5.0 | | + 24.1 | | - 15.5 |

We also add as an example the calculation of one number in the second table from those given in the first. We shall find the deviation corresponding to the magnetic course 165° ; and we do it by a kind of interpolation (p. 12). From the first table we have the deviation $-2^\circ.3$ for the compass course 150° . Since the deviation is the only difference between compass and magnetic courses, it follows that $150^\circ - 2^\circ.3$, or $147^\circ.7$ magnetic, corresponds to 150° by compass. Similarly, $173^\circ.5$ magnetic corresponds to 165° by compass.

The magnetic course 165° for which we are making the calculation falls between $147^\circ.7$ and $173^\circ.5$, and exceeds the smaller of the two by $17^\circ.3$. The whole difference between $147^\circ.7$ and $173^\circ.5$ is $25^\circ.8$. Similarly, the whole difference between the two compass courses involved is 15° . Therefore we may write the proportion :

$$25^\circ.8 : 15^\circ = 17^\circ.3 : x^\circ,$$

where x is the excess over 150° of the compass course corresponding to 165° magnetic.

Solving this proportion by the ordinary rules of arithmetic, we have :

$$x = \frac{15 \times 17.3}{25.8} = 10^\circ.0.$$

The compass course belonging to 165° magnetic is therefore $150^\circ + 10^\circ.0 = 160^\circ.0$. The corresponding deviation is $165^\circ - 160^\circ.0 = +5^\circ.0$,¹ which is therefore the deviation for 165° magnetic, and appears as such in the second table. This entire table can be computed from the first table in an hour.

Sometimes the second deviation table gives compass courses instead of deviations. It is then often called a "table of

¹ A comparison of formulas (1), (2), and (3) shows that $D = M - C$; so that the deviation is obtained by subtracting the compass course from the magnetic course. This is also evident from the definition of a magnetic course (p. 49).

steering courses"; and in the example just calculated it would give the compass or steering course 160° for the magnetic course 165° , instead of giving the deviation $+5^\circ$.

We shall still further illustrate this important matter by an example, supposed to occur on board a ship for which our two deviation tables hold good.

What is the compass course to be given the helmsman at Sandy Hook, on a voyage to St. Vincent?

We have already found, from dead-reckoning calculations (p. 22) the course 119° . Being the result of a dead-reckoning calculation, this is a true course. The track chart of the north Atlantic gives the variation at Sandy Hook as 10° W., or -10° . The true course being 119° , we get the magnetic course, allowing for variation only, by formula (3), $M = T - V = 119^\circ - (-10^\circ) = 129^\circ$. The second deviation table shows that:

for magnetic course 120° , the deviation is $-6^\circ.9$, and
for magnetic course 135° , the deviation is $-4^\circ.8$.

Magnetic course 129° falls between 120° and 135° , so that an interpolation (to be extremely exact) between $-6^\circ.9$ and $-4^\circ.8$ makes the deviation for magnetic course 129° come out $-5^\circ.6$. Formulas (1) and (2) now give:

$$\begin{aligned} \text{Error} &= E = V + D = -10^\circ - 5^\circ.6 = -15^\circ.6 \\ \text{Compass course} &= C = T - E = 119^\circ - (-15^\circ.6) = 134^\circ.6. \end{aligned}$$

To check this, we can now solve the same problem in the inverse way with the first deviation table. For the compass course $134^\circ.6$, this table gives the deviation as $-5^\circ.9$. The variation being -10° , we have:

$$\begin{aligned} E &= V + D = -10^\circ - 5^\circ.9 = -15^\circ.9 \text{ and} \\ T &= C + E = 134^\circ.6 - 15^\circ.9 = 118^\circ.7, \end{aligned}$$

agreeing very closely with the true course 119° , with which we started. This shows that the two deviation tables are quite consistent in this case, and also checks the accuracy of the calculation.

We shall close this chapter with the following little table, showing the correspondence between the two methods of dividing the compass card into points, and into degrees.

COMPASS POINTS AND DEGREES

| | | | | | | | |
|------------|-------|------------|--------|------------|--------|------------|--------|
| North | 0 0 | East | 90 0 | South | 180 0 | West | 270 0 |
| N. by E. | 11 15 | E. by S. | 101 15 | S. by W. | 191 15 | W. by N. | 281 15 |
| N.N.E. | 22 30 | E.S.E. | 112 30 | S.S.W. | 202 30 | W.N.W. | 292 30 |
| N.E. by N. | 33 45 | S.E. by E. | 123 45 | S.W. by S. | 213 45 | N.W. by W. | 303 45 |
| N.E. | 45 0 | S.E. | 135 0 | S.W. | 225 0 | N.W. | 315 0 |
| N.E. by E. | 56 15 | S.E. by S. | 146 15 | S.W. by W. | 236 15 | N.W. by N. | 326 15 |
| E.N.E. | 67 30 | S.S.E. | 157 30 | W.S.W. | 247 30 | N.N.W. | 337 30 |
| E. by N. | 78 45 | S. by E. | 168 45 | W. by S. | 258 45 | N. by W. | 348 45 |

 $\frac{1}{2}$ pt. = 2° 49'

 $\frac{1}{3}$ pt. = 5° 38'

 $\frac{1}{4}$ pt. = 8° 26'

1 pt. = 11° 15'

CHAPTER V

COASTWISE NAVIGATION

BEFORE proceeding to a consideration of navigation by means of astronomic observations, as it is practiced on the high seas, we must first explain certain methods by which it is possible to ascertain a ship's position in latitude and longitude while she is in sight of land. Often such methods suffice to complete a long coastwise voyage in safety; they are always important for a last determination of the ship's position before a deep-sea voyage actually begins. Such a last determination is called "taking a departure" (cf. p. 2), and from such point of departure dead-reckoning calculations begin for the first day of the voyage.

Any determination or fixing of a ship's position, by astronomic observations or otherwise, is often called, for brevity, a "fix." To obtain one while in sight of land it is customary to make observations upon well-known objects ashore, such, for instance, as lighthouses, or other conspicuous objects marked on the chart. It is always possible to observe the bearings of such objects from the ship's deck with the compass, azimuth circle, or pelorus (p. 44).

When there is but one such object in sight, it is impossible to secure a fix with ordinary instruments, if the vessel is at anchor. But if she is running, it is merely necessary to take two bearings, and to estimate the distance run by the ship in the interval between the two. Figure 9 will make this matter clear. A lighthouse ashore is at *L*. *SS''* is the direction of the ship's course; *S* her position when the first bearing was observed, and *S'* her position at the time of the second bearing. *SN* is the direction of the north.

After taking the first bearing, the navigator must calculate the angle $S''SL$, between the ship's course SS'' and the lighthouse direction SL . Thus, if the ship's course angle NSS'' (p. 10) was 20° , and the bearing NSL was 42° , the angle $S''SL$ would be $42^\circ - 20^\circ = 22^\circ$. As the ship proceeds on her course, the angle $S''SL$ will become larger, and a second bearing must be taken at the moment when the ship reaches the point S' , where the angle $S''SL$ has become $S''S'L$. This point S' must be so chosen that the angle $S''S'L$ is just twice the angle $S''SL$ observed at S ; or, in this case, 44° . This is called "doubling the bearing from the bow," and it can

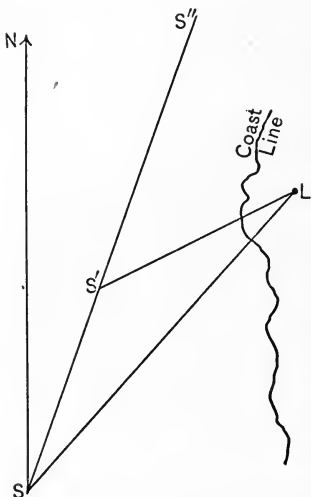


FIG. 9.—Ship's Position by Two Bearings.

easily be accomplished if we continue watching the compass bearing of L as the ship goes ahead, and catch the observation at the right moment. The ship's course not having been changed from 20° (this is important), the right moment will occur when L bears $20^\circ + 44^\circ = 64^\circ$ by the compass.

It can easily be proved by geometry that the distance $S'L$ between the ship at S' and the lighthouse at L will be equal to the distance SS' traveled by the ship in the interval between the two observations. This distance can be estimated quite accurately with an instrument called a "log," or "patent log," which is towed astern of the ship. It is so constructed that it turns as it is pulled through the water, and the number of turns is automatically counted by an attached contrivance on deck. The count is (also automatically) turned into miles of distance; so that the log on deck will indicate how far the ship traveled from S to S' .

As soon as we know the distance $S'L$ and the bearing of the line $S'L$, we can "lay down" or "plot" the position of S' on the chart; and this will be a "good fix." To do this, let us indicate by B' the bearing of the line $S'L$, and then draw on the chart, through the lighthouse L , a pencil line whose bearing from L is $B' + 180^\circ$, or " B' reversed." This can be done with a "course protractor," or with "parallel rulers," instruments to be purchased from any dealer in navigators' supplies. Next we measure or "lay off" on that line the distance $S'L$, equal to the run SS' as it came from the log. We always know the right "scale" of the chart (or fraction of an inch corresponding to one logged mile) which must be used in laying off the distance $S'L$; for we know that one mile always corresponds to 1 minute of latitude (p. 15), and the right- and left-hand edges of the chart are always divided into degrees and minutes of latitude.

Since the above bearings were observed by compass, it is now important to consider the compass error (p. 43). This will not affect the observations, because it will be the same for both ship's course and lighthouse bearing, so the angles $S''SL$ and $S''S'L$, which are obtained by subtraction, will be the same as if there were no compass error. But when we come to plotting on the chart, the compass bearing B' must be corrected by adding the deviation from the deviation table (pp. 48, 49). The resulting magnetic bearing (p. 49) must be used for B' , if the chart has printed on it a compass card (p. 41) showing magnetic bearings. If the printed card shows true bearings only, B' must be corrected for both deviation and variation (p. 43).

A specially important case of the foregoing occurs when the two angles $S''SL$ and $S''S'L$ are 45° and 90° . The second bearing B' will then put the light just abeam, and the distance by log, SS' , is the distance at which the ship passes the light abeam. This case is called a "bow-and-beam bearing." The navigator sights the light when it bears 45° or 4 points (p. 52) "broad" on the bow, "starboard,"

or "port." He then "reads" the log. When he brings the light abeam through the motion of the ship, he reads the log again, and the run in the interval, as taken from the log, is the light's distance abeam.

When sailing along the coast, it is particularly important so to shape the ship's course that lights and other prominent landmarks will be passed at the right distance abeam. The chart shows what the right distance is: if the navigator shapes a course which makes the distance abeam too small, he may fail to clear rocks or shoals extending seaward; and if he makes it too large, he may lengthen his voyage unnecessarily in rounding the light.

There are certain pairs of angles ($S''SL$ and $S''S'L$) which will make known the coming distance abeam long before the ship is dangerously near the light. These angles, $S''SL$ and $S''S'L$, are called "bearings from the bow" (see p. 54), since they are really measured from the ship's bow instead of the north. If the two bearings from the bow are either of the following pairs:

| | |
|--------------|--------------|
| 22° and 34°, | 32° and 59°, |
| 27° and 46°, | 40° and 79°, |

then the logged distance in the interval between the two observations is the distance at which the ship will pass the light abeam if she continues on her present course. This kind of observation will inform the navigator whether his course is safe in ample time to change it if necessary; and, since in this case no bearings are marked on the chart, no attention need be paid to compass error.

When two or more known and conspicuous landmarks are visible from the ship, it is possible to secure a fix by means of "cross-bearings." Observe the bearings of the objects as nearly simultaneously as possible. Allow for compass error in the manner just explained. Calculate for each object a reversed bearing by adding 180° to its observed bearing. Draw on the chart through each object

a pencil line having the proper reversed bearing and these lines will intersect at the point on the chart where the ship is located. Figure 10 illustrates this matter.

L, L', L'' are lights or landmarks ashore, visible from the ship, and also printed on the chart. The ship is at S . The lines intersecting at S represent the reversed bearings of L, L', L'' , as observed from S . Only two lines are necessary; and they should be chosen so that the angle between them is as near

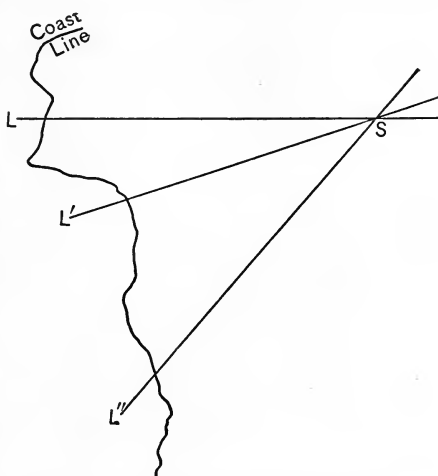


FIG. 10. — Ship's Position by Cross Bearings.

a right angle as possible, if high accuracy is required in the fix. The third object and line merely serve as an additional check or safeguard against error.

In addition to the foregoing methods of locating a ship by observations of objects ashore, there is a way to avoid sunken rocks or shoals without actually locating the ship on the chart. It is called the "danger angle," and is shown in Fig. 11. The small circle is supposed drawn on the chart around a rocky shoal K which must be cleared by the ship traveling along the course SS' . To make certain of clearing it safely, the navigator selects two visible objects ashore, and shown on the chart at L and L' . He draws on the chart a large circle passing through L and L' , and just touching the dangerous small circle at T . There is no difficulty in finding the center of the large circle, because it must be somewhere on the line PQ , which is drawn at right angles to the line LL' at its middle point P . A few trials with a

pair of compasses will locate the center. Next, the two lines LT and $L'T$ are drawn. Then the angle LTL' is called the danger angle.

Now it is a principle of geometry that if we select other points on the large circle, such as T' and T'' , the angles

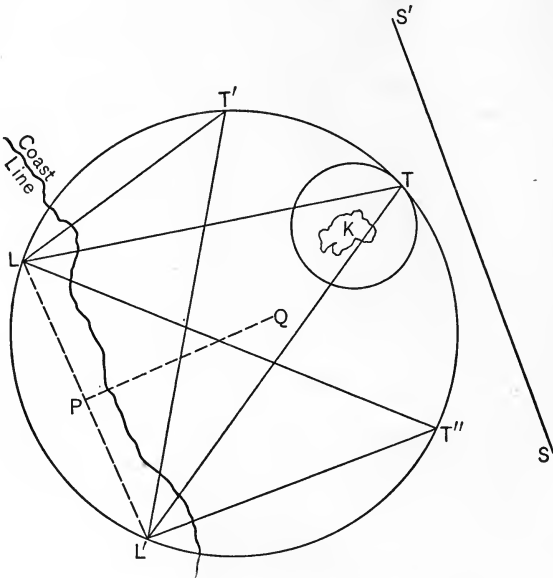


FIG. 11. — The Danger Angle.

$LT'L'$, $LT''L'$, etc., will all be equal, and will contain the same number of degrees as the danger angle LTL' . It follows that if the navigator measures from the deck the angle formed by two lines drawn to the ship from L and L' , and if he finds it equal to the danger angle LTL' , as measured on the chart with a protractor (p. 55), he then knows that the ship is somewhere on the large circle, and is therefore perhaps too near the small dangerous circle. If, on the other hand, the ship is entirely outside the large circle, and therefore surely safe from the dangers of the small circle,

the measured angle at the ship between the objects L and L' will always be smaller than the danger angle LTL' .

Angles can be measured from the deck by taking compass bearings of L and L' . The difference of the two will be the deck angle, which should be smaller than the danger angle measured on the chart. But the very best way to measure the deck angle is to use the sextant, an angle-measuring instrument to be described later (p. 61).

The danger angle can also be used when it is necessary to pass *between* a sunken danger circle and the shore. The large circle is then drawn through L and L' as before, but in such a way as just to touch the inside of the small circle instead of the outside. To pass inshore of the small circle it is then necessary for the navigator to keep his measured deck angle *larger* than the danger angle, instead of smaller.

Navigators also use at times a means of safety known as the "danger bearing," illustrated in Fig. 12. There is but one charted object in sight ashore at the point L . The ship at S must steer in such a way as to avoid sunken rocks at K . Evidently, she must pass outside the line SQ , of which the bearing from the north is the angle NSQ , which can be measured on the chart. This is the danger bearing, and the ship's course SS' , to

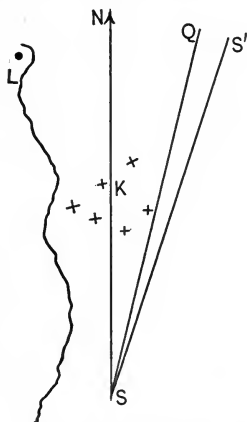


FIG. 12.—The Danger Bearing.

be safe, must be *greater* than the danger bearing. In the case shown in the figure, the danger bearing would be very useful long before a fix could be had by means of bearings from the bow or bow-and-beam bearings.

Finally, to complete this part of our subject, it is necessary to mention "soundings," which are a method of *feeling* the land, even when it cannot be seen. By means of

the "lead-line" the mariner can ascertain when he is in shoal water; and as depths of water are always marked on the chart, he can often get valuable information as to the ship's position. As she runs along her course, he can take a "line of soundings" and upon examining the chart he will often find but a single possible line on the chart where the charted depths correspond with those observed. It follows that the ship's course must have been along that line on the chart; and at an anxious moment, in a fog, such a check will be a great relief to the navigator. Even in the ocean, far from land, it is possible to take soundings with the "sounding machine" at great depths, and in some parts of the ocean quite accurate locating of the ship will result. Specimens from the ocean floor can also be brought up by attaching some sticky grease to the bottom of the lead, and at times these specimens also give information of value, for the charts always specify the kind of bottom existing in various parts of the ocean.

CHAPTER VI

THE SEXTANT

WE have twice made reference to this instrument — once (p. 5) as a contrivance for ascertaining by observation how high the sun is in the sky, and again (p. 59) in the measurement of the danger angle. These two uses of the sextant are not inconsistent, for it is really intended for the measurement of any angle (p. 8) formed at the observer's eye by two lines drawn to two distant objects. In the case of the danger angle these two distant objects are landmarks ashore; in the case of the sun they are the "horizon" line (where sea and sky seem to meet), and the sun itself. This height of the sun (or of any star) in the sky is called its "altitude"; and so the altitude is always an angle, to be measured in degrees and minutes. The point directly overhead is the "zenith"; the angle between lines drawn to horizon and zenith is 90° , or a right angle. An altitude of 40° , for instance, simply means that the distance from the horizon to the sun is $\frac{40}{90}$ of the total distance from horizon to zenith.

Figure 13 will give an idea of the construction of the sextant.¹ The essential parts are two small silvered mirrors, *M* and *m*; a telescope, *EK*; and a circle, *AA*, engraved with "graduations," by means of which angles may be measured upon it in degrees, minutes, and seconds. The mirror *m* and the telescope *EK* are firmly attached to the sextant; but the mirror *M* is pivoted in such a way that it

¹ Quoted in part from Jacoby's "Astronomy, a Popular Handbook," Macmillan, 1913; reprinted 1915.

can be turned, and the angle through which it is turned measured on the circle by means of the index *CB*. When the mirror *M* is turned until it is parallel to the fixed mirror *m*, the circle "reads" or indicates 0° , because the angle between the two mirrors is then 0° . In all other positions

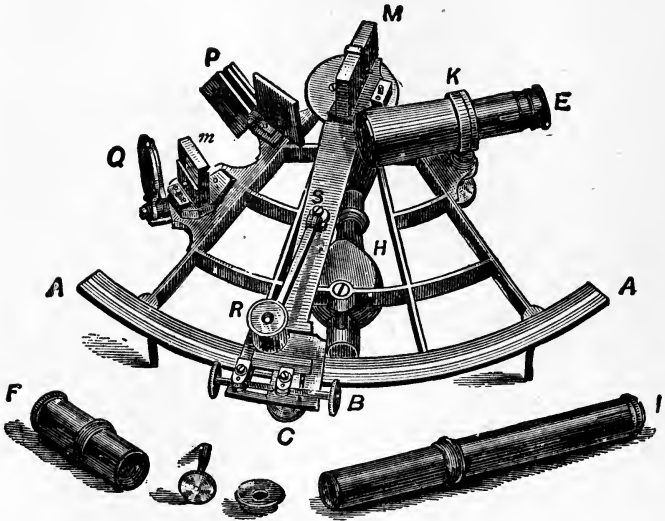


FIG. 13.—The Sextant.

of the mirror *M* the circle measures the angle between the two mirrors. *P* and *Q* are sets of colored glasses, which can be interposed temporarily, when the sun's rays are so brilliant as to be hurtful to the observer's eye. *R* is a small magnifying glass, pivoted at *S*, intended to facilitate the examination of the index *CB*. At *C* and *B* are shown the "clamp," by which the index can be fastened to the circle, and the "tangent screw," or "slow-motion screw" which will adjust it delicately, after it has been clamped. *I* and *F* are additional telescopes or accessories.

The mirror *m* has an important peculiarity. The silvering is scraped away at the back of the mirror from half its

surface. Thus only one half reflects; the other half is simply transparent glass. A navigator looking into the telescope at *E* will therefore look *through* the mirror *m* with half his telescope, and with the other half he will look *into* the mirror.

Now it is a fact that half a telescope acts just like a whole one. If a person using an ordinary spy-glass half covers the big end with his hand, he will see the same view he saw with the whole glass. Only, as half the "light-gathering" power is cut off, this view will be fainter, — less luminous. Applying this to the sextant telescope, it is clear that the observer will see *two* things at once: with half the telescope he will see what is visible *through* the mirror *m*; and with the other half he will see what is visible by reflection *from* the mirror *m*.

If he holds the sextant in such a position that the telescope is horizontal, while the frame of the instrument is vertical, he will see the visible sea horizon with half the telescope *through* the mirror *m*. If the other mirror *M* is then turned to the proper position, it is possible to see the sun in the sky at the same time, with the other half of the telescope, the solar rays having been reflected successively from *both* mirrors, *M* and *m*. To make this possible, the sextant telescope must be aimed at that point of the sea horizon which is directly under the sun. The solar rays will then strike the mirror *M* first; be thence reflected to the silvered part of the mirror *m*; and finally reflected a second time *into* the telescope. Therefore the observation consists in so turning the movable mirror *M*, that the sun and horizon can be seen coincidently in the telescope.

The angle between the mirrors can then be measured on the circle; and it is easy to prove by geometry that the angular altitude of the sun will be twice the angle between the two mirrors. Thus it should merely be necessary to double the mirror angle, as indicated by the sextant index, to obtain the solar altitude. But the sextant makers always

save the navigator the trouble of doubling the angle by the simple device of numbering half degrees on the arc AA as if they were whole degrees; so the angle as it comes from the sextant is already doubled for further use. The mirror m is called the "horizon glass," because the navigator looks through it at the horizon. The other mirror M is the "index glass," because it is attached to the index arm.

When the sextant is used for non-astronomical observations, such as the danger angle, the frame is held horizontally, instead of vertically, as in observations of the sun. The telescope is aimed at the left-hand object ashore, and that object is viewed *through* the horizon glass m . The index glass M is then turned until light from the right-hand object is also brought into the telescope, after successive reflections from the two mirrors M and m . The two objects will then be seen "superposed," and the sextant arc will give the angle between two lines drawn from the observer on board to the two objects ashore. This angle should be smaller than the danger angle to keep the ship safely off-shore of sunken dangers (p. 59).

Reading the sextant circle, or ascertaining from it the angle that has been measured, is accomplished by means of a "vernier." This is a short circular arc, engraved with graduations resembling those on the sextant circle, attached to the index CB (fig. 13) just under the little magnifier R . It is so placed that the graduations on the sextant circle and the vernier are close together and can be seen at the same time through the magnifier R . Figure 14 gives an idea of the vernier and a part of the sextant circle near the zero of its graduations. Numbers on both circle and vernier increase toward the left. On the circle, the largest spaces, marked by long lines, are whole degree spaces. Each is usually divided into two halves of $30'$ each indicated by shorter lines, and these are again subdivided into three small spaces of $10'$ each. The divisions on the vernier resemble those on the circle, except that the degree spaces

of the former are here called minute spaces, and the 10' spaces of the former are called 10'' spaces.

The real index of the instrument is the zero mark on the vernier, sometimes provided with an engraved "arrow." If this falls exactly on a degree mark of the circle, say the 1° mark, the reading of the instrument is exactly 1° 0' 0''. If it falls exactly on a small line of the circle, say the second to the left of the 1° mark, the reading is exactly 1° 20' 0''. But if it falls *between* two of the small lines, say between the 20' and 30' marks to the left of the 1° mark (as shown in the figure), the reading must be 1° 20' and a "bit." It is the business of the vernier to estimate the size of that bit. To do this look along the vernier until you find a line which is exactly opposite some line on the circle. There will always be such a line: in the figure it is the 6' line of the vernier. Pay no further attention to noting which line on the circle is the one thus "exactly opposite"; it matters not which line it is. But read carefully the number *on the vernier* belonging to the "exactly opposite" line you have found there. Being on this occasion the 6' line, it follows

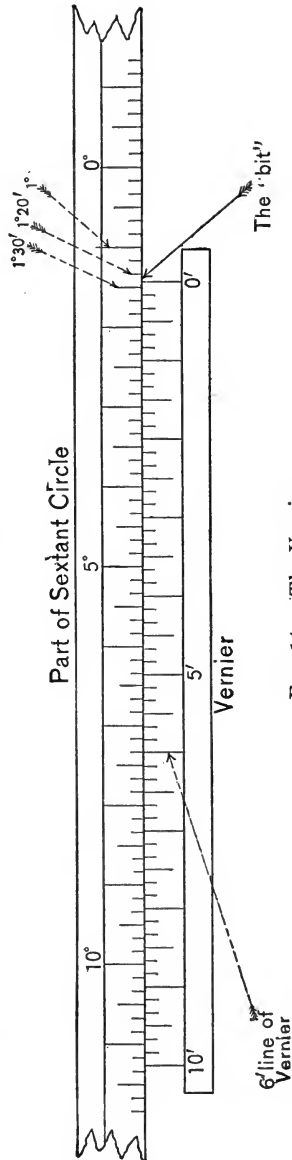


FIG. 14.—The Vernier.

that the bit is 6'; and as we found the reading to be $1^{\circ} 20'$ and a bit, the complete reading is $1^{\circ} 20' + 6' = 1^{\circ} 26'$.

If the vernier line that happened to be "exactly opposite" was not one of the ten long minute lines, but fell between two of them, it would indicate that the bit was made up of minutes and seconds, instead of being an exact number of minutes. For each space the "exactly opposite" vernier line happens to lie to the left of a long vernier minute line, 10" must be added to the bit. For instance, if in the figure the "exactly opposite" vernier line was the next short one to the left of the 6' long line, the bit would be 6' 10", and the complete reading $1^{\circ} 26' 10''$, instead of $1^{\circ} 26'$. But seconds are not really required when observing aboard ship, so that it will be sufficient; in using the vernier, to find the number of the long vernier line that comes nearest to being "exactly opposite."

It will also be noticed in the figure that the sextant circle has some additional graduations to the *right* of the 0° mark. These are called "off the arc" graduations, and it is sometimes necessary to read a small angle upon them, measuring from the 0° mark to the right instead of the left. This makes it necessary to read the vernier backwards, calling the 0' mark of the vernier 10' and the 10' mark 0'.

This backward reading of the vernier offers no particular difficulty, and it is especially useful in determining by observation the "index error" of the sextant. We have seen (p. 62) that when the two sextant mirrors are parallel, the index should read $0^{\circ} 0' 0''$. But it is seldom possible to adjust the instrument so that this condition will be satisfied exactly; nor would the adjustment remain perfect *very long*. A better plan is to determine by observation how much the reading differs from $0^{\circ} 0' 0''$, when the mirrors are parallel. This difference is the index error, and must be applied as a correction to all angles observed with the instrument.

It is easy to make the mirrors parallel: we have merely

to sight some distant well-defined terrestrial object like the gilt ball on the top of a flagpole (or the sea horizon, if aboard ship at sea), after clamping the index near 0° . We shall then see in the telescope two images of the distant object; one by direct vision through the unsilvered part of the horizon glass, the other after reflection from *both* mirrors. By means of the tangent screw, the observer, with his eye at the telescope, can bring these two images together, so that they will appear as a single image. Then the mirrors will be parallel, and the vernier should read $0^\circ 0' 0''$. If it actually reads $0^\circ 8'$, for instance, instead of $0^\circ 0' 0''$, it means that the reading is $8'$ too large on account of index error; and *every* angle measured with that sextant at that time will be $8'$ too large, and must be corrected by subtracting $8'$ from it.

If, on the other hand, the reading is $8'$ "off the arc," when it should be $0^\circ 0'$, the instrument reads $8'$ too small, and any angle measured with it must be corrected by adding $8'$ to it.

For accurate determination of the index error (and it should be checked frequently), navigators prefer to observe the sun, or at night, a star. If a star is used, the process is the same as just described for a flagpole ball. But if the sun is used, a slightly different method is required. The sun, as seen in the telescope, shows a round disk of considerable size, and it is not possible to superpose the two images accurately.

Therefore it is better to make them just touch, as shown in Fig. 15, when they are said to be "tangent" to each other. This must be done successively in two positions, *AB* and *BA*. In other words, after the first "tangency"

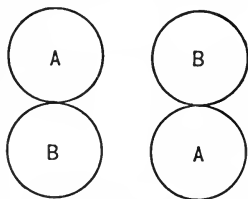


FIG. 15. — Index Error.

has been observed, the tangent screw (*B*, fig. 13) is manipulated until the image *A* passes across *B* from top to bottom, and gives a new tangency in the second position.

Each tangency will give a reading of the vernier. Unless

the sextant is greatly out of adjustment, one of these readings will be off the arc, the other on the arc. If there were no index error, the off-arc and on-arc readings would be equal; if they differ, half the difference is the index error. If the off-arc reading is the larger, all altitudes measured with that sextant must be *increased* by the amount of the index error; and if the on-arc reading is the larger, all such altitudes must be similarly diminished.

The following is an example of an index error determination:

| On-arc readings, | Off-arc readings, |
|------------------|-------------------|
| 31' 20" | 33' 20" |
| 31 40 | 33 50 |
| 30 50 | 34 0 |
| Means, 31' 17" | 33' 43" |

The difference is $33' 43'' - 31' 17'' = 2' 26''$. Half the difference, or $1' 13''$, is the index error; and because readings on the arc are the smaller, all angles read with this instrument must be *increased* by $1' 13''$, or, for ordinary purposes of navigation, by $1'$.

In addition to certain "adjusting screws" with which the index error can be reduced when it becomes unduly large, means are provided for three other sextant adjustments. These are:

1. To make the index glass perpendicular to the frame of the instrument.
2. To do the same with the horizon glass.
3. To set the telescope parallel to the frame of the instrument.

These adjustments are always completed by the maker before a sextant is sent out, nor does the navigator usually need to correct them himself. But it is important to know how to test them occasionally. Perpendicularity of the index glass can be examined by looking into the glass very obliquely with the index set near 0° . It is then possible to see the inner edge of the sextant circle both by looking at

it directly, past the edge of the index glass, and also by reflection in the glass itself. The inner edge of the circle should form a continuous line when so examined, if the glass is perpendicular; but if it is inclined, the line will appear broken, instead of continuous.

Secondly, perpendicularity of the horizon glass can be tested at the same time the index error is determined by observing a star or a distant terrestrial point (p. 67). The index glass having been properly adjusted to perpendicularity, the two mirrors can never be made parallel by moving the index, unless the horizon glass is also properly perpendicular. Any existing lack of adjustment will therefore betray itself in the index error determination, because the two images of the star or distant object will not be superposed in *any* position of the index.

Thirdly, the parallelism of the telescope to the frame of the instrument can usually be best tested with an ordinary pair of "calipers."

Having thus described the sextant, its adjustments, and its use from the deck, we have still to explain how it can be used ashore. Sometimes it is necessary for the navigator to make observations ashore, when it is not usually possible to see the horizon line (p. 61). Recourse must then be had to an "artificial horizon," which is simply an iron basin full of mercury covered with a glass roof. The mercury furnishes an almost perfectly horizontal mirror, and the glass roof prevents wind from ruffling the mercury surface, and thus destroying the mirror. Figure 16 explains the principle of the artificial horizon. HH is the mercury mirror, S the sun, and X the sextant. The observer aims the sextant telescope at the mercury where he can see a reflection of the sun. He then measures with the instrument the angle between a line

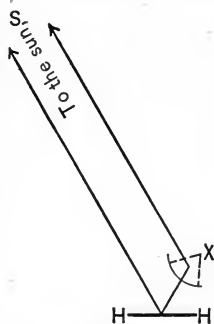


FIG. 16. — Artificial Horizon.

drawn to the sun as seen reflected in the mercury and another line drawn to the actual sun in the sky. It can be shown by geometry that this measured angle will be just twice the real altitude of the sun, such as it would be if observed from the sea horizon. Therefore, in using the artificial horizon, it is merely necessary to divide the sextant angle by 2 to obtain the correct altitude of the sun.

In observations of this kind two "suns" are seen at the same time in the telescope, just as is the case in index error observations (p. 67); whereas in observing from the sea horizon, the telescope shows only one solar image and the horizon line. When there are thus two solar images, they must be brought into tangency, just as we have already explained for index error (p. 67). When there is but one, it must be brought into tangency with the visible sea horizon line.

But this altitude is not yet ready to be used in the further calculations for obtaining the position of the ship in latitude

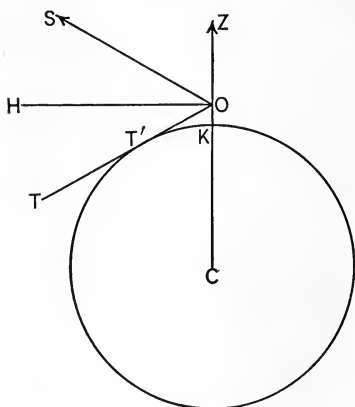


FIG. 17.—Dip of the Horizon.

and longitude. Further preparatory corrections must be applied, in addition to the index error (p. 66), which is always the first correction to receive attention. These preparatory corrections are:

1. "Dip" of the sea horizon, due to the elevation of the navigator on the ship's deck above the surface of the sea. Its cause is shown in Fig. 17. C is the center of the earth, K a point at sea level, and O the navigator, elevated

a distance OK above the sea. OZ is the direction of the zenith (p. 61), OS the direction of the sun, and OH a horizontal line from O . OT is a line drawn through O , and just touch-

ing the sea surface at T' . Evidently OT will be the direction of the sea horizon, where sky and sea seem to meet. Therefore, the altitude of the sun, as measured from the visible sea horizon, will be the angle SOT ; whereas the angle we require is the angle SOH , or the altitude of the sun above the true horizontal line OH . Therefore the angle HOT is a correction for dip which must be subtracted from all measured altitudes, and the amount of the correction depends on the height of the navigator's eye above the sea surface.

2. "Refraction" is a bending of the light rays as they come down to us from the sun through the terrestrial atmosphere. It always makes the sun seem higher in the sky than it really is, giving another subtractive correction for the observed altitude. The bending here involved is due to the passage of the sun's light rays through atmospheric strata of increasing density as the light approaches the earth's surface.

3. "Parallax" is a small correction which must be added to the observed altitude of the sun. In strict theory, all astronomical observations are supposed to be made from the earth's center instead of its surface where the ship floats; and the small parallax correction allows for this minor theoretic point. In the case of star observations this correction is zero.

4. "Semidiameter" is a correction depending on the choice by the navigator of a particular point on the sun's disk (p. 67) for observation. The sun's altitude, as used in the further calculations, should be the altitude of the sun's center; but it is impossible to locate the center of the disk accurately in the telescope, so the navigator always observes the lowest point of the disk. This is called the "lower limb" of the sun.

Beginners sometimes have difficulty in distinguishing the upper from the lower limb in the telescope. The best way to do this is to focus the telescope on some distant

object, and note whether it appears upside-down in the field of view. If so, the telescope is an "inverting" one, and the top of the sun must be observed, as it appears in the telescope, though it will really be the correct (or lower) limb, because of inversion by the telescope. When using the artificial horizon with an inverting telescope, the tangency must be made by bringing the bottom of the mercury image in contact with the top of the other image. The high-powered telescopes supplied with good sextants are usually inverting telescopes.

Evidently the measured altitude, as it comes from the sextant, must be increased by the amount by which the sun's center is higher than the lower limb, and this is the sun's semidiameter. The index correction, together with the above four additional corrections, will fully prepare a measured sextant altitude of the sun for further use in navigational calculations. In the case of a star, which appears in the telescope as a point of light only, without any perceptible disk, no semidiameter or parallax corrections are required; and in using the artificial horizon (p. 69), no correction for dip is necessary, either for the sun or a star.

It is possible to arrange these various corrections in convenient tables. Thus, in Table 6 (p. 247), we give a combination of corrections 2 (refraction), 3 (parallax), and 4 (semidiameter), to be used for observations of the sun's lower limb, and the same combination without the semidiameter and parallax¹ to be used for star observations. It will be noticed that the tabular corrections vary for different values of the observed altitude, which appears in the left-hand column of the table. This variation comes mainly from the refraction part of the combined correction, for the refraction is much greater when the sun or star is observed at a low altitude near the horizon than it is at a high altitude near the zenith. At the foot of the page is given a small supplementary correction depending on the date in the year.

¹ Which leaves refraction only.

This small correction is not important in navigation, but is given here for the sake of completeness. It arises from the semidiameter part of the combined correction, for the annual orbit of the earth around the sun is of such a shape that the earth is nearer the sun in January than it is in July, which makes the sun appear bigger in January. And when the sun appears big, the semidiameter will of course be large too.

Table 7 gives the dip of the sea horizon, the number in the left-hand column being the height (in feet) of the navigator's eye above sea level. This will be the height of the ship's deck, increased by the height of the man's eye above the deck. Unfortunately, the dip, as given in Table 7, at times varies considerably from the dip as it actually exists at the ship. The cause can be seen from Fig. 17 (p. 70), where it will be noticed that the line from the observer at O to the sea horizon at T' passes very near the surface of the ocean. It is therefore entirely in the lowest strata of the terrestrial atmosphere, and there quite irregular refractions sometimes occur. These have been known to produce errors in the dip amounting to $10'$ or $20'$, and it is principally the existence of these unavoidable errors that makes it unnecessary to read the sextant closer than the nearest minute (p. 66), when observing from the deck. But when observing ashore with the artificial horizon, which has no dip, the navigator may, if he chooses, read seconds, especially if he intends to use in his further calculations the "mean" or average of a considerable number of observations.

We shall now give an example of the complete correction of a sextant observation. Suppose the angle read from the sextant was $30^{\circ} 28'$, the index error (p. 68) $1'$, additive, height of observer's eye 26 feet. We should then have :

| | |
|-------------------------------------|--------------------|
| observed altitude, lower limb | = $30^{\circ} 28'$ |
| index correction | = $+ 1'$ |
| correction from Table 6 (p. 247) | = $+ 14'$ |
| correction from Table 7 (p. 247) | = $- 5'$ |
| corrected altitude, for further use | = $30^{\circ} 38'$ |

If the altitude had been observed ashore with an artificial horizon, it might have been desirable to retain seconds. The calculation might then have been as follows:

| | |
|---|--------------|
| observed <i>double</i> altitude (see p. 70), lower limb | = 63° 0' 20" |
| index correction (p. 68) | = + 1 13 |
| corrected double altitude | = 63 1 33 |
| resulting altitude | = 31 30 46 |
| correction from Table 6 (interpolated) | = + 14 31 |
| corrected altitude, for further use | = 31 45 17 |

CHAPTER VII

THE NAUTICAL ALMANAC

BEFORE beginning the further utilization of altitude observations in our navigation calculations, it is necessary to understand the use of the Nautical Almanac. This is an annual publication, issued in two different editions by the Nautical Almanac Office, United States Naval Observatory. Copies can be obtained from the Superintendent of Documents, Washington, D. C., or through any dealer in nautical supplies. Navigators do not need the larger edition, of which the title is "American Ephemeris and Nautical Almanac"; accordingly, all our references are made to the smaller edition for the year 1917. Parts of certain pages from that edition are reprinted in the present volume for convenience of reference, and we shall give a somewhat detailed explanation of the almanac page 29 (our p. 76).

Let us consider the date Monday, Dec. 17. We find for that date, and for every even hour (0^h , 2^h , 4^h , 6^h , etc.) of "Greenwich Mean Time" (abbreviated G. M. T.¹), two tabular numbers (p. 10) called "sun's declination" and "equation of time."

To understand these it is necessary to bear in mind that the kind of time in ordinary use is "solar time," as kept by the sun. The "solar day" begins at "noon," called 0^h in astronomic navigation, and it continues through twenty-four hours, without any confusing A.M. and P.M. In ordinary life the day begins twelve hours sooner, at midnight, and runs through two twelve-hour periods of A.M. and P.M. to

¹ The reader is requested to note carefully this abbreviation, as it will be used very frequently.

SUN, DECEMBER, 1917. *From Nautical Almanac, p. 29*

| G. M. T. | SUN'S DEC- LINATION | EQUATION OF TIME | SUN'S DEC- LINATION | EQUATION OF TIME | SUN'S DEC- LINATION | EQUATION OF TIME |
|----------|------------------------|---------------------|------------------------|---------------------|------------------------|---------------------|
| | Monday 17 | | Tuesday 25 | | Saturday 29 | |
| h | ° | m s | ° | m s | ° | m s |
| 0 | - 23 21.3 | + 3 56.8 | - 23 24.7 | - 0 1.6 | - 23 15.2 | - 1 59.7 |
| 2 | 23 21.5 | 3 54.4 | 23 24.6 | 0 4.1 | 23 14.9 | 2 2.1 |
| 4 | 23 21.7 | 3 51.9 | 23 24.5 | 0 6.5 | 23 14.6 | 2 4.6 |
| 6 | 23 21.9 | 3 49.5 | 23 24.4 | 0 9.0 | 23 14.3 | 2 7.0 |
| 8 | 23 22.1 | 3 47.0 | 23 24.2 | 0 11.5 | 23 14.0 | 2 9.4 |
| 10 | 23 22.2 | 3 44.5 | 23 24.1 | 0 14.0 | 23 13.7 | 2 11.9 |
| 12 | 23 22.4 | 3 42.1 | 23 24.0 | 0 16.5 | 23 13.4 | 2 14.3 |
| 14 | 23 22.6 | 3 39.6 | 23 23.8 | 0 18.9 | 23 13.1 | 2 16.7 |
| 16 | 23 22.8 | 3 37.1 | 23 23.7 | 0 21.4 | 23 12.8 | 2 19.1 |
| 18 | 23 22.9 | 3 34.7 | 23 23.5 | 0 23.9 | 23 12.5 | 2 21.5 |
| 20 | 23 23.1 | 3 32.2 | 23 23.4 | 0 26.4 | 23 12.2 | 2 24.0 |
| 22 | 23 23.2 | 3 29.8 | 23 23.2 | 0 28.8 | 23 11.9 | 2 26.4 |
| H. D. | 0.1 | 1.2 | 0.1 | 1.2 | 0.1 | 1.2 |
| | Tuesday 18 | | Wednesday 26 | | Sunday 30 | |
| 0 | - 23 23.4 | + 3 27.3 | - 23 23.1 | - 0 31.3 | - 23 11.6 | - 2 28.8 |
| 2 | 23 23.6 | 3 24.8 | 23 22.9 | 0 33.8 | 23 11.3 | 2 31.2 |
| 4 | 23 23.7 | 3 22.3 | 23 22.7 | 0 36.3 | 23 11.0 | 2 33.6 |
| 6 | 23 23.8 | 3 19.9 | 23 22.5 | 0 38.7 | 23 10.6 | 2 36.0 |
| 8 | 23 24.0 | 3 17.4 | 23 22.4 | 0 41.2 | 23 10.3 | 2 38.4 |
| 10 | 23 24.1 | 3 14.9 | 23 22.2 | 0 43.7 | 23 10.0 | 2 40.9 |
| 12 | 23 24.3 | 3 12.5 | 23 22.0 | 0 46.2 | 23 9.7 | 2 43.3 |
| 14 | 23 24.4 | 3 10.0 | 23 21.8 | 0 48.6 | 23 9.3 | 2 45.7 |
| 16 | 23 24.5 | 3 7.5 | 23 21.7 | 0 51.1 | 23 9.0 | 2 48.1 |
| 18 | 23 24.6 | 3 5.0 | 23 21.5 | 0 53.6 | 23 8.6 | 2 50.5 |
| 20 | 23 24.8 | 3 2.6 | 23 21.3 | 0 56.0 | 23 8.3 | 2 52.9 |
| 22 | 23 24.9 | 3 0.1 | 23 21.1 | 0 58.5 | 23 7.9 | 2 55.3 |
| H. D. | 0.1 | 1.2 | 0.1 | 1.2 | 0.2 | 1.2 |
| | Wednesday 19 | | Thursday 27 | | Monday 31 | |
| 0 | - 23 25.0 | + 2 57.6 | - 23 20.9 | - 1 0.9 | - 23 7.6 | - 2 57.7 |
| 2 | 23 25.1 | 2 55.1 | 23 20.7 | 1 3.4 | 23 7.2 | 3 0.1 |
| 4 | 23 25.2 | 2 52.6 | 23 20.5 | 1 5.9 | 23 6.9 | 3 2.4 |
| 6 | 23 25.3 | 2 50.2 | 23 20.3 | 1 8.3 | 23 6.5 | 3 4.8 |
| 8 | 23 25.4 | 2 47.7 | 23 20.1 | 1 10.8 | 23 6.1 | 3 7.2 |
| 10 | 23 25.5 | 2 45.2 | 23 19.8 | 1 13.2 | 23 5.8 | 3 9.6 |
| 12 | 23 25.6 | 2 42.7 | 23 19.6 | 1 15.7 | 23 5.4 | 3 12.0 |
| 14 | 23 25.7 | 2 40.2 | 23 19.4 | 1 18.1 | 23 5.0 | 3 14.4 |
| 16 | 23 25.8 | 2 37.8 | 23 19.2 | 1 20.6 | 23 4.6 | 3 16.7 |
| 18 | 23 25.9 | 2 35.3 | 23 19.0 | 1 23.1 | 23 4.3 | 3 19.1 |
| 20 | 23 26.0 | 2 32.8 | 23 18.7 | 1 25.5 | 23 3.9 | 3 21.5 |
| 22 | 23 26.1 | 2 30.3 | 23 18.5 | 1 28.0 | - 23 3.5 | - 3 23.9 |
| H. D. | 0.0 | 1.2 | 0.1 | 1.2 | 0.2 | 1.2 |
| | Thursday 20 | | Friday 28 | | SEMIDIAMETER | |
| 0 | - 23 26.1 | + 2 27.8 | - 23 18.3 | - 1 30.4 | | |
| 2 | 23 26.2 | 2 25.3 | 23 18.0 | 1 32.9 | | |
| 4 | 23 26.3 | 2 22.8 | 23 17.8 | 1 35.3 | | |
| 6 | 23 26.3 | 2 20.4 | 23 17.5 | 1 37.8 | | |
| 8 | 23 26.4 | 2 17.9 | 23 17.3 | 1 40.2 | | |
| 10 | 23 26.5 | 2 15.4 | 23 17.0 | 1 42.6 | | |
| 12 | 23 26.5 | 2 12.9 | 23 16.8 | 1 45.1 | | |
| 14 | 23 26.6 | 2 10.4 | 23 16.5 | 1 47.5 | | |
| 16 | 23 26.6 | 2 7.9 | 23 16.3 | 1 50.0 | | |
| 18 | 23 26.7 | 2 5.4 | 23 16.0 | 1 52.4 | | |
| 20 | 23 26.7 | 2 2.9 | 23 15.7 | 1 54.8 | | |
| 22 | - 23 26.8 | + 2 0.4 | - 23 15.4 | - 1 57.3 | | |
| H. D. | 0.0 | 1.2 | 0.1 | 1.2 | Dec. 1 | 16'26 |
| | | | | | 11 | 16'28 |
| | | | | | 21 | 16'29 |
| | | | | | 31 | 16'30 |

NOTE. — The Equation of Time is to be applied to the G. M. T. in accordance with the sign as given.

the following midnight ; but this "civil day," as it is called, does not for the moment concern us.

Solar time, as kept by the *visible sun*, is a very inconvenient kind of time, because there are certain peculiarities in the astronomic motion of the earth which make these solar days of unequal length. They are called "apparent solar days" and the corresponding kind of time is "apparent solar time."

To avoid the above inconvenience, an imaginary "mean sun" and a "mean solar day" have been invented. The mean sun conforms as nearly as possible to the average performance of the visible sun, and the length of the mean solar day is the average of all the apparent solar days throughout the year. The corresponding kind of time, kept by the mean sun, is "mean solar time"; and this is the kind of time recorded by all our watches and marine chronometers (p. 6).

The difference between these two kinds of solar time varies on different dates, and even at different hours on the same date. It is this difference which is called the "equation of time" and which is one of the tabular numbers in the nautical almanac page 29 (our p. 76).

This equation of time is of great importance in navigation, and it is easy to see how page 29 of the almanac may be used to find it. Suppose, for instance, we wish to know what the equation is on Dec. 17, 1917, on board ship, when the ship's chronometer indicates on its face 3 P.M., civil time, or (which is the same thing) 3^h, astronomical time (p. 75). Ship's chronometers are always set to Greenwich mean time, so that 3^h by the chronometer signifies that the time at Greenwich was 3^h.

We then look in the almanac page 29 (our p. 76), and find that the equation was + 3^m 54^s.4 at 2^h, G. M. T., and + 3^m 51^s.9 at 4^h, G. M. T. Its value at 3^h must be half-way between these two, or + 3^m 53^s.15. This we would call + 3^m 53^s.2, so as to avoid the use of hundredths of seconds, which do not need attention in navigation. And

since the equation is merely the difference between the two kinds of solar time, the + sign means that it must be *added* to G. M. T., to obtain Greenwich apparent time, in accordance with the "Note" at the foot of the almanac page 29. Consequently, the G. M. T. by chronometer having been $3^h 0^m 0^s$, the Greenwich apparent time at the same instant was $3^h 0^m 0^s + 3^m 53^s.2 = 3^h 3^m 53^s.2$.

It will be noticed that the process we have here used for obtaining the equation from the almanac is merely an interpolation (see p. 12). Let us, as another example, find the equation for Sunday, Dec. 30, at $10^h 26^m$ A.M., civil time by chronometer, and we have purposely here retained the civil method of reckoning time to make certain that the reader understands the difference between civil and astronomic (or navigation) time. The given time is $10^h 26^m$ A.M., civil time, Dec. 30. But the astronomic Dec. 30 does not begin until noon (p. 75), so that it is not yet Dec. 30 by astronomic reckoning. By that reckoning it is really only $22^h 26^m$ on Dec. 29. In other words, when the civil time is P.M., as in the first example, the astronomic time is the same as the civil time. But when the civil time is A.M., as in the present example, the astronomic time is found by adding 12^h to the civil time, and deducting 1 from the date. These complications emphasize the advantage of the astronomic count, which avoids A.M. and P.M. altogether.

We now have from the almanac (p. 76) :

equation of time, Dec. 29, 22^h , G. M. T. = $- 2^m 26^s.4$,
 equation of time, Dec. 30, 0^h , G. M. T. = $- 2^m 28^s.8$;

and the numbers in this example have been purposely so chosen that the above two tabular values of the equation (between which the required value falls) come from different dates in the almanac. This creates no confusion, for these two values of the equation are really consecutive tabular numbers, just as much as if they occurred on a single date.

The difference between the two values of the equation is

$2^s.4$; and as this difference corresponds to 2^h in the left-hand (or argument) column, it follows that the difference for 1^h is here $1^s.2$. This is the change of the equation per hour of time; it is called the "hourly difference" (abbreviated H. D.) and is printed in the almanac at the foot of each daily column.

Now we want the equation for Dec. 29, $22^h 26^m$, by the chronometer. The 26^m must next be changed into a decimal fraction of an hour. $26^m = \frac{26}{60}$ of an hour = $0^h.43$. So the time for which we want the equation becomes Dec. 29, $22^h.43$. The H. D. being $1^s.2$, the change in $0^h.43$ will be $1^s.2 \times 0.43 = 0^s.5$. The almanac shows that at 22^h the equation was $2^m 26^s.4$, and was increasing numerically. Therefore, at $22^h.43$, it was $2^m 26^s.4 + 0^s.5 = 2^m 26^s.9$. And this number has the *minus* sign. Therefore, the G. M. T. being Dec. 29, $22^h 26^m$, the Greenwich apparent time at the same instant will be Dec. 29, $22^h 26^m - 2^m 26^s.9 =$ Dec. 29, $22^h 23^m 33^s.1$.

Most of these minor interpolation calculations, which are here set forth in great detail for the benefit of the beginner, can be made with sufficient accuracy by a skilled navigator mentally.

In the foregoing two examples we have assumed that the chronometer was right, but these instruments practically never run quite correctly. Therefore, before leaving port, navigators always have their chronometers "rated" by a chronometer expert; and when the instrument is returned to the ship just before sailing, a "rate card" (or "rate paper") always comes with it. Let us suppose that in the present example this card stated that the chronometer was slow $8^m 22^s.5$ ¹ on Dec. 20, at noon, and was "losing" $2 1^s.8$ daily. The $8^m 22^s.5$ would then be the "chronometer error" on Dec. 20; and the $1^s.8$ would be its "daily rate."

¹ This number is here purposely chosen much larger than would ever occur in practice.

² The opposite kind of "rate" is called "gaining."

From Dec. 20, noon, to Dec. 30, 10^h 26^m A.M. is an interval of 9 days 22 hours 26 minutes. This interval must now be reduced to a decimal of a day. 26^m = $\frac{26}{60}$ of an hour = 0^h.43. The interval is therefore 9^d 22^h.43.

But 22^h.43 = $\frac{22 \cdot 43}{24}$ days = 0^d.93. Therefore, in days, the interval is 9^d.93. This transformation of hours and minutes into decimals of a day can be accomplished with less trouble by means of our Table 8 (p. 248).

Having a losing rate of 1^s.8 daily, the chronometer lost 1^s.8 \times 9.93 = 17^s.9 in the interval of 9.93 days. And as it was already slow 8^m 22^s.5 on Dec. 20, it was slow 8^m 22^s.5 + 17^s.9 = 8^m 40^s.4 at the time for which the equation is required.

Now the equation was required for Dec. 29, 22^h 26^m by the chronometer; and that instrument being slow 8^m 40^s.4, the correct G. M. T. was: Dec. 29, 22^h 26^m + 8^m 40^s.4 = Dec. 29, 22^h 34^m 40^s.4. Turned into a decimal fraction of an hour, this becomes Dec. 29, 22^h.58, instead of 22^h.43, as we found before, when the chronometer error was omitted from the calculation. The H. D. is 1^s.2, as before, and the change in 0^h.58 = 1^s.2 \times 0.58 = 0^s.7. Therefore, at 22^h.58 the equation is 2^m 26^s.4 + 0^s.7 = 2^m 27^s.1. This still has the *minus* sign, so that the correct Greenwich apparent time becomes Dec. 29, 22^h 34^m 40^s.4 - 2^m 27^s.1 = 22^h 32^m 13^s.3.

All the above calculations have been carried out here with unnecessary accuracy. There would be no harm if the result were in error by a few tenths of a second; and it is this circumstance that makes it possible to perform these interpolations largely mentally.

In the foregoing examples no account was taken of the ship's location on the ocean; yet this location may have an indirect influence on the calculations. To understand this, we must consider for a moment the time-differences which exist between different places on the earth. The sun rises in the east and travels across the sky toward the west; so that if we consider two places like Greenwich, England, and New York, for instance, the sun, because of this motion from east

to west, will pass Greenwich first. Consequently, when it is noon in New York, it has already been noon in Greenwich, and is afternoon there. Greenwich time is therefore always later than New York time. The same is true of any other two places; there is always a time-difference between them, and the easterly place has the later or "faster" time.

The amount of such time-difference of course depends on the relative location of the two places, and the relation is such that 15° of longitude-difference corresponds exactly to 1^h of time-difference. Thus Sandy Hook, which is in longitude $73^\circ 50'$ west of Greenwich, has a time-difference from Greenwich of $4^h 55^m 20^s$. This conversion of longitude into time-difference is best accomplished by means of our Table 9 (p. 249). According to that table:

$$\begin{array}{r} 73^\circ = 4^h 52^m 0^s \\ 50' = \quad \quad 3 \quad 20 \\ \hline 73^\circ 50' = 4^h 55^m 20^s \end{array}$$

The indirect influence of such time-differences upon the use of the almanac is that they may at times, especially when they are large, make the Greenwich date of the observation different from the date on board. Thus a vessel off Manila Bay, in longitude 120° east of Greenwich, would have her local time 8^h (120°) later than Greenwich time. If a sextant observation was made on board at 4 P.M., civil time, on a Thursday, the chronometer would indicate 8^h , and it would be 8 A.M. on Thursday, because Greenwich is 8^h earlier than the ship. This 8 A.M. would really be 20^h of the preceding Wednesday by astronomic time, and so the almanac date used would be one day earlier than the date of the observation. The chronometer will always give the right Greenwich time, but the navigator must be very careful to interpolate the almanac numbers on the right date.

We have now learned how to ascertain the equation of time from the almanac, and how to use it for transforming G. M. T. into Greenwich apparent time. The contrary transformation, from Greenwich apparent time to G. M. T.,

can be made by applying the equation in the opposite way: subtracting when it has the + sign in the almanac, and adding when it has the - sign.

The great importance of these time transformations comes from the fact that sextant observations must necessarily be made upon the *visible* sun. When they are made for the purpose of calculating the local time on board, this local time will therefore necessarily be local apparent solar time, as kept by the visible sun. At the instant of the observation (p. 6), the chronometer face (corrected for error and rate) tells us the G. M. T. If this is turned into Greenwich apparent time by applying the equation, we have only to compare the Greenwich and the ship's apparent times to get the time-difference between the ship and Greenwich. This time-difference can then be turned into degrees and minutes, and will be the ship's longitude. Examples of this calculation will be given in detail (p. 99). It is also worth noting here that the time-difference between any two places is precisely the same, quite irrespective of the kind of time in which it is counted.

To complete our explanation of the almanac page 29 (our p. 76), it remains to give an example of a calculation of the sun's declination. This is an angle in degrees and minutes, and it is interpolated just like the equation by the aid of its H. D. Thus, for Dec. 29, 22^h.58 (p. 80) the declination is obtained thus:

$$\begin{array}{rcl} \text{Dec. 29, 22}^h, \text{ declination} & = & 23^\circ 11'.9 \\ \text{H.D. (0'.1)} \times 0^h.58 & = & 0.1, \text{ declination decreasing;} \\ \text{by subtraction, at 22}^h.58, \text{ dec.} & = & 23^\circ 11'.8, \end{array}$$

and according to the almanac, this declination must be given the *minus* sign. When the sign should be +, that fact is indicated in the almanac. The use of the declination will be explained later; the accuracy required in the interpolation of it is not so great as we have used here, for the nearest minute suffices in practically all navigation work.

In addition to the sun's declination, navigators require

in their further calculations another number called the sun's "right ascension" (abbreviated, R. A.). This is obtained from pages like the almanac page 3 (reprinted in part below). It is always the R. A. of the "mean sun" that we need, and the almanac gives it for Greenwich mean noon of each day in the year. When needed in our further calculations, it is of course always required for the exact moment when a sextant observation was made. In fact, this statement applies also to the equation of time and declination. They must always be interpolated from the almanac for the moment when the navigator actually observed the sun; and

SUN, 1917. *From Nautical Almanac, p. 3*

| DAY OF MONTH | RIGHT ASCENSION OF THE MEAN SUN AT GREENWICH MEAN NOON | | | | | | | | | | | | | | | | | |
|--------------------|--|----|------|--------|----|------|-----------|----|------|---------|----|------|----------|----|------|----------|----|------|
| | July | | | August | | | September | | | October | | | November | | | December | | |
| | h | m | s | h | m | s | h | m | s | h | m | s | h | m | s | h | m | s |
| 1 | 6 | 35 | 52.2 | 8 | 38 | 5.5 | 10 | 40 | 18.7 | 12 | 38 | 35.3 | 14 | 40 | 48.4 | 16 | 39 | 5.1 |
| 2 | 6 | 39 | 48.8 | 8 | 42 | 2.0 | 10 | 44 | 15.2 | 12 | 42 | 31.8 | 14 | 44 | 45.0 | 16 | 43 | 1.7 |
| 3 | 6 | 43 | 45.3 | 8 | 45 | 58.6 | 10 | 48 | 11.8 | 12 | 46 | 28.4 | 14 | 48 | 41.5 | 16 | 46 | 58.2 |
| 4 | 6 | 47 | 41.9 | 8 | 49 | 55.1 | 10 | 52 | 8.3 | 12 | 50 | 24.9 | 14 | 52 | 38.1 | 16 | 50 | 54.8 |
| 5 | 6 | 51 | 38.4 | 8 | 53 | 51.7 | 10 | 56 | 4.9 | 12 | 54 | 21.5 | 14 | 56 | 34.6 | 16 | 54 | 51.3 |
| 6 | 6 | 55 | 35.0 | 8 | 57 | 48.2 | 11 | 0 | 1.4 | 12 | 58 | 18.0 | 15 | 0 | 31.2 | 16 | 58 | 47.9 |
| 7 | 6 | 59 | 31.6 | 9 | 1 | 44.8 | 11 | 3 | 58.0 | 13 | 2 | 14.6 | 15 | 4 | 27.8 | 17 | 2 | 44.5 |
| 8 | 7 | 3 | 28.1 | 9 | 5 | 41.4 | 11 | 7 | 54.5 | 13 | 6 | 11.1 | 15 | 8 | 24.3 | 17 | 6 | 41.0 |
| 9 | 7 | 7 | 24.7 | 9 | 9 | 37.9 | 11 | 11 | 51.1 | 13 | 10 | 7.7 | 15 | 12 | 20.9 | 17 | 10 | 37.6 |
| 10 | 7 | 11 | 21.2 | 9 | 13 | 34.5 | 11 | 15 | 47.6 | 13 | 14 | 4.2 | 15 | 16 | 17.4 | 17 | 14 | 34.1 |
| 11 | 7 | 15 | 17.8 | 9 | 17 | 31.0 | 11 | 19 | 44.2 | 13 | 18 | 0.8 | 15 | 20 | 14.0 | 17 | 18 | 30.7 |
| 12 | 7 | 19 | 14.3 | 9 | 21 | 27.6 | 11 | 23 | 40.8 | 13 | 21 | 57.3 | 15 | 24 | 10.5 | 17 | 22 | 27.2 |
| 13 | 7 | 23 | 10.9 | 9 | 25 | 24.1 | 11 | 27 | 37.3 | 13 | 25 | 53.9 | 15 | 28 | 7.1 | 17 | 26 | 23.8 |
| 14 | 7 | 27 | 7.4 | 9 | 29 | 20.7 | 11 | 31 | 33.9 | 13 | 29 | 50.4 | 15 | 32 | 3.6 | 17 | 30 | 20.4 |
| 15 | 7 | 31 | 4.0 | 9 | 33 | 17.2 | 11 | 35 | 30.4 | 13 | 33 | 47.0 | 15 | 36 | 0.2 | 17 | 34 | 16.9 |
| 16 | 7 | 35 | 0.6 | 9 | 37 | 13.8 | 11 | 39 | 27.0 | 13 | 37 | 43.6 | 15 | 39 | 56.8 | 17 | 38 | 13.5 |
| 17 | 7 | 38 | 57.1 | 9 | 41 | 10.4 | 11 | 43 | 23.5 | 13 | 41 | 40.1 | 15 | 43 | 53.3 | 17 | 42 | 10.0 |
| 18 | 7 | 42 | 53.7 | 9 | 45 | 6.9 | 11 | 47 | 20.1 | 13 | 45 | 36.7 | 15 | 47 | 49.9 | 17 | 46 | 6.6 |
| 19 | 7 | 46 | 50.2 | 9 | 49 | 3.5 | 11 | 51 | 16.6 | 13 | 49 | 33.2 | 15 | 51 | 46.4 | 17 | 50 | 3.2 |
| 20 | 7 | 50 | 46.8 | 9 | 53 | 0.0 | 11 | 55 | 13.2 | 13 | 53 | 29.8 | 15 | 55 | 43.0 | 17 | 53 | 59.7 |
| 21 | 7 | 54 | 43.4 | 9 | 56 | 56.6 | 11 | 59 | 9.7 | 13 | 57 | 26.3 | 15 | 59 | 39.5 | 17 | 57 | 56.3 |
| 22 | 7 | 58 | 39.9 | 10 | 0 | 53.1 | 12 | 3 | 6.3 | 14 | 1 | 22.9 | 16 | 3 | 36.1 | 18 | 1 | 52.8 |
| 23 | 8 | 2 | 36.5 | 10 | 4 | 49.7 | 12 | 7 | 2.8 | 14 | 5 | 19.4 | 16 | 7 | 32.6 | 18 | 5 | 49.4 |
| 24 | 8 | 6 | 33.0 | 10 | 8 | 46.2 | 12 | 10 | 59.4 | 14 | 9 | 16.0 | 16 | 11 | 29.2 | 18 | 9 | 46.0 |
| 25 | 8 | 10 | 29.6 | 10 | 12 | 42.8 | 12 | 14 | 55.9 | 14 | 13 | 12.5 | 16 | 15 | 25.8 | 18 | 13 | 42.5 |
| 26 | 8 | 14 | 26.1 | 10 | 16 | 39.4 | 12 | 18 | 52.5 | 14 | 17 | 9.1 | 16 | 19 | 22.3 | 18 | 17 | 39.1 |
| 27 | 8 | 18 | 22.7 | 10 | 20 | 35.9 | 12 | 22 | 49.0 | 14 | 21 | 5.6 | 16 | 23 | 18.9 | 18 | 21 | 35.6 |
| 28 | 8 | 22 | 19.2 | 10 | 24 | 32.4 | 12 | 26 | 45.6 | 14 | 25 | 2.2 | 16 | 27 | 15.4 | 18 | 25 | 32.2 |
| 29 | 8 | 26 | 15.8 | 10 | 28 | 29.0 | 12 | 30 | 42.2 | 14 | 28 | 58.8 | 16 | 31 | 12.0 | 18 | 29 | 28.7 |
| 30 | 8 | 30 | 12.4 | 10 | 32 | 25.6 | 12 | 34 | 38.7 | 14 | 32 | 55.3 | 16 | 35 | 8.6 | 18 | 33 | 25.3 |
| 31 | 8 | 34 | 8.9 | 10 | 36 | 22.1 | 12 | 38 | 35.3 | 14 | 36 | 51.9 | 16 | 39 | 5.1 | 18 | 37 | 21.9 |

CORRECTION TO BE ADDED TO R. A. M. S. AT G. M. N. FOR
TIME PAST NOON*From Nautical Almanac, p. 3, Continued*

| TIME | 0 ^m | | 6 ^m | | 12 ^m | | 18 ^m | | 24 ^m | | 30 ^m | | 36 ^m | | 42 ^m | | 48 ^m | | TIME |
|------|----------------|------|----------------|------|-----------------|------|-----------------|------|-----------------|------|-----------------|------|-----------------|------|-----------------|------|-----------------|------|------|
| h | m | s | m | s | m | s | m | s | m | s | m | s | m | s | m | s | m | s | h |
| 12 | 1 | 58.3 | 1 | 59.3 | 2 | 0.2 | 2 | 1.2 | 2 | 2.2 | 2 | 3.2 | 2 | 4.2 | 2 | 5.2 | 2 | 6.2 | 12 |
| 13 | 2 | 8.1 | 2 | 9.1 | 2 | 10.1 | 2 | 11.1 | 2 | 12.1 | 2 | 13.1 | 2 | 14.0 | 2 | 15.0 | 2 | 16.0 | 13 |
| 14 | 2 | 18.0 | 2 | 19.0 | 2 | 20.0 | 2 | 20.9 | 2 | 21.9 | 2 | 22.9 | 2 | 23.9 | 2 | 24.9 | 2 | 25.9 | 14 |
| 15 | 2 | 27.8 | 2 | 28.8 | 2 | 29.8 | 2 | 30.8 | 2 | 31.8 | 2 | 32.8 | 2 | 33.8 | 2 | 34.7 | 2 | 35.7 | 15 |
| 16 | 2 | 37.7 | 2 | 38.7 | 2 | 39.7 | 2 | 40.7 | 2 | 41.6 | 2 | 42.6 | 2 | 43.6 | 2 | 44.6 | 2 | 45.6 | 16 |
| 17 | 2 | 47.6 | 2 | 48.5 | 2 | 49.5 | 2 | 50.5 | 2 | 51.5 | 2 | 52.5 | 2 | 53.5 | 2 | 54.5 | 2 | 55.4 | 17 |
| 18 | 2 | 57.4 | 2 | 58.4 | 2 | 59.4 | 3 | 0.4 | 3 | 1.4 | 3 | 2.3 | 3 | 3.3 | 3 | 4.3 | 3 | 5.3 | 18 |
| 19 | 3 | 7.3 | 3 | 8.3 | 3 | 9.2 | 3 | 10.2 | 3 | 11.2 | 3 | 12.2 | 3 | 13.2 | 3 | 14.2 | 3 | 15.2 | 19 |
| 20 | 3 | 17.1 | 3 | 18.1 | 3 | 19.1 | 3 | 20.1 | 3 | 21.1 | 3 | 22.1 | 3 | 23.0 | 3 | 24.0 | 3 | 25.0 | 20 |
| 21 | 3 | 27.0 | 3 | 28.0 | 3 | 29.0 | 3 | 29.9 | 3 | 30.9 | 3 | 31.9 | 3 | 32.9 | 3 | 33.9 | 3 | 34.9 | 21 |
| 22 | 3 | 36.8 | 3 | 37.8 | 3 | 38.8 | 3 | 39.8 | 3 | 40.8 | 3 | 41.8 | 3 | 42.8 | 3 | 43.7 | 3 | 44.7 | 22 |
| 23 | 3 | 46.7 | 3 | 47.7 | 3 | 48.7 | 3 | 49.7 | 3 | 50.6 | 3 | 51.6 | 3 | 52.6 | 3 | 53.6 | 3 | 54.6 | 23 |

the Greenwich time of this event is of course always taken from the chronometer (duly corrected for error and rate).

Thus, if the R. A. of the mean sun is required for Dec. 29, 22^h 34^m 40^s.4, G. M. T. (p. 80), we find from the almanac page 3 (our p. 83) that the R. A. of the mean sun at Greenwich mean noon is 18^h 29^m 28^s.7.¹ This, according to the supplementary table quoted above from page 3, must be increased by a correction for "time past noon." In this case the time past noon is 22^h 34^m 40^s.4. The tabular correction for 22^h 30^m is 3^m 41^s.8, and for 22^h 36^m it is 3^m 42^s.8. Ours falls between these two, and an interpolation makes the correction 3^m 42^s.6. Consequently, the R. A. of the mean sun for Dec. 29, 22^h 34^m 40^s.4, G. M. T. is 18^h 29^m 28^s.7 + 3^m 42^s.6 = 18^h 33^m 11^s.3.

It will be noticed that the small supplementary table (quoted above from almanac page 3) only runs from 12^h to 24^h. The other half of the table, from 0^h to 12^h, is printed on the opposite page 2 of the almanac. There is also another longer table, printed near the end of the almanac, and there called Table. III, from which the supplementary correction can be taken without the necessity of interpolation.

It is not absolutely essential that the navigator learn what

¹ Right ascensions are always thus measured in hours, minutes, and seconds, like time, and they are counted from 0^h to 24^h.

the words "right ascension" and "declination" really mean. But for the benefit of those who are curious in such matters we may state that these numbers locate the position of the sun (or of a star) on the sky. The sky is a great globe, called by astronomers the "celestial sphere," and all heavenly bodies are located upon it precisely as points on the earth are there located by their latitudes and longitudes (p. 3). There is a "celestial equator" with two "celestial poles," corresponding accurately to the terrestrial equator and poles. Declination then corresponds exactly to latitude on the earth, and so it measures the distance of a heavenly body from the celestial equator. When the body is north of the celestial equator, the declination is called +.

Right ascension similarly corresponds to longitude; and for the beginning point of right ascensions on the sky there is a "celestial Greenwich," which is called the "vernal equinox."

After this brief digression into astronomy, we return to our subject. We have seen (p. 82) that observations of the sun will tell us only apparent solar time, because it is only the visible sun that we can observe. If the observations are made upon a star, the kind of time is different from any so far mentioned. It is called "sidereal time," or star time.

It is always possible to change mean solar time into sidereal time, and *vice versa*, by a simple process of calculation; but the only change of this kind required in navigation is the transformation of G. M. T. into Greenwich sidereal time. To make this transformation, we have only to take from the almanac, for the given G. M. T., the R. A. of the mean sun, and then to add it to the given G. M. T.

Thus, to find the Greenwich sidereal time corresponding to Dec. 29, $22^{\text{h}} 34^{\text{m}} 40^{\text{s}}.4$, G. M. T., we have already found (p. 84) that the R. A. of the mean sun $= 18^{\text{h}} 33^{\text{m}} 11^{\text{s}}.3$
 To this must be added the given G. M. T. $= 22 \ 34 \ 40.4$
 Sum = corresponding Greenwich sidereal time $= 17^{\text{h}1} 7^{\text{m}} 51^{\text{s}}.7$

¹ The number of hours was here really 41^{h} : but whenever it is larger than 24^{h} , we must drop or reject 24^{h} .

CHAPTER VIII

OLDER NAVIGATION METHODS

WE shall now explain in detail certain standard methods of determining a ship's latitude and longitude by means of sextant observations. An understanding of these methods is essential to a proper comprehension of the newer navigational processes to be described later; and the older methods are in fact still very widely used at sea, although most recent authorities believe they should be rejected in favor of the newer procedure.

The simplest of these older processes, and the one most frequently employed, is the determination of the ship's latitude by a noon or "meridian" observation ("noon-sight") of the sun's altitude (p. 61). Now the sun is higher in the sky at noon than it is at any other time during the day; and so it is possible to get the noon-sight by beginning to observe the sun with the sextant a few minutes before noon, and continuing the observation as long as the sun's altitude is increasing. The moment it begins to diminish, or the sun to "dip," as sailors say, the observation should be terminated, and the vernier read.

The altitude thus observed will be an altitude of the lower limb (p. 71); and before it is used further it must be fully corrected for index error; for refraction parallax and semi-diameter; and for dip; all as in the example on p. 73, where the observed altitude was $30^{\circ} 28'$, and we found the corrected altitude to be $30^{\circ} 38'$.

Next, the sun's declination must be taken from the almanac, being interpolated for the Greenwich time of the

observation, as in the example on p. 82, where we found the declination to be $-23^{\circ} 12'$ on Dec. 29, at $22^{\text{h}} 34^{\text{m}} 40^{\text{s}}.4$, G. M. T. We shall suppose the above altitude $30^{\circ} 28'$ to have been observed at the Greenwich time stated, so as to make use of the results of our former calculated examples. Nor is there any inconsistency in supposing a noon observation to have been made at $22^{\text{h}} 34^{\text{m}} 40^{\text{s}}.4$. For the noon observation is made when it is noon on board ship, while the $22^{\text{h}} 34^{\text{m}} 40^{\text{s}}.4$ is the G. M. T. at the same moment. The difference is simply the time-difference (p. 80) between Greenwich and the ship.

The calculation of the ship's latitude is now made by the following formula :

$$\text{Latitude} = 90^{\circ} + \text{Declination} - \text{Altitude.}$$

In this formula, the *plus* sign signifies that the declination must be *added*; and the *minus* sign signifies that the altitude must be *subtracted*. Furthermore, it is most important to remember that if the declination is itself a "*minus* declination," as in this example, the addition of it according to the formula is really a subtraction. Or, in other words, and in general, whenever a formula calls for an addition, and the number to be added is a *minus* number, then that number must be subtracted instead of added. And similarly, if the formula calls for a subtraction, and the number to be subtracted is a *minus* number, then that number must be added instead of subtracted. Two *minus* signs neutralize each other.

In the present case we have, omitting seconds :

| | |
|-----------------------------------|-----------------|
| | $90^{\circ} 0'$ |
| declination | $= -23 12$ |
| $90^{\circ} + \text{declination}$ | $= 66 48$ |
| altitude | $= 30 38$ |
| latitude | $= 36 10$ |

In considering this result it is of interest to inquire where this observation really locates the ship. Now we have not yet stated what the date was, on board, when the observa-

tion was made; but we have given the G. M. T. as Dec. 29, 22^h 34^m 40^s.4. The noon-sight was taken, as a matter of fact, at noon on Dec. 30, or at the moment when the date Dec. 30 commenced by astronomic reckoning. Therefore the ship's time was later than the Greenwich time by about 1^h 25^m; or 21° 15', allowing 15° to 1^h (p. 81); and the ship was (approximately) in 21° 15' east longitude from Greenwich. This, together with the latitude 36° 10', locates the ship in the Mediterranean, south of Greece, and west of Candia.

Although we have thus apparently located the ship completely in latitude and longitude from a single noon-sight, it must not be supposed that we have really accomplished this. The noon-sight is only suitable for ascertaining the ship's latitude; the longitude is determined so inaccurately as to be practically useless. The reason for this is that near noon the sun changes its altitude very slowly, because it is then near the turning-point where its upward morning motion is about to become a downward afternoon motion. For the sun's daily motion in the sky is upward in the morning and downward in the afternoon. Near noon it runs along horizontally, or very nearly so, for several minutes, so that its altitude change is insignificant during that time.

It follows from this temporary invariability of altitude that we cannot determine the exact moment when noon occurs by observing altitude changes with the sextant. But the latitude determination is not affected; because, for the latitude, we only need to know the noon altitude. And if we happen to measure it a little too soon or too late, on account of the difficulty of fixing the moment of noon, no harm will result, because the altitude very near noon is the same as it is at noon precisely, as we have just seen.

It is, in general, practically impossible to determine *both* latitude and longitude from a single observation. To determine *two* unknown things, at least two different observations must be made. Nor can any skillful method of planning the observation overcome this fundamental circumstance.

Returning now to our latitude formula (p. 87), it is necessary to modify it somewhat in case we happen to be in the tropics, where the sun may pass between the zenith and the celestial pole. Even in temperate latitudes a celestial body may do this, if we happen to observe a star instead of the sun. In such a case, if the ship is in the northern hemisphere, the navigator will observe the sun's altitude toward the north at noon instead of toward the south, as usual. Furthermore, in very high northern latitudes, the "midnight sun," as it is called, can be observed toward the north, and *below* the celestial pole. This is the minimum altitude during the day, instead of the maximum; but it is usable for a latitude determination. Such an observation is called a "lower transit"; and it can often be observed in the case of stars in temperate latitudes.

If we now remember to call northerly latitudes and declinations *plus*, and southerly ones *minus*, we have the following complete set of formulas for the present problem, including observations in both hemispheres. These formulas are so arranged that we can easily choose the right formula, by having regard to the + and - signs. But the right formula *once chosen*, the latitude is calculated without marking declinations with either the + or - sign.

| | | | | |
|-----------------------|---|----------------------------|--------------------------|-----|
| lat. ¹ and | { | if lat. greater than dec., | lat. = 90° + dec. - alt. | (1) |
| dec. both + | | if dec. greater than lat., | lat. = dec. + alt. - 90° | (2) |
| or both - | | if lower transit, | lat. = 90° + alt. - dec. | (3) |
| lat. and dec., | } | | | |
| one +, one - | | | lat. = 90° - alt. - dec. | (4) |

We shall now give some more examples; and to enable the reader to follow star observations correctly we reprint part of the upper halves of pages 94 and 95 (our pp. 91, 92) of the Nautical Almanac. These contain the right ascensions and declinations (p. 85) of a quantity of bright stars for various dates in the year. These numbers are correct for the moment of "upper transit," which is the moment when these

¹ Latitude and declination are abbreviated lat. and dec.

stars attain their maximum altitudes. This event cannot be called a noon-sight in the case of a star; but it is observable in a manner perfectly similar to a solar noon-sight.

These stellar right ascensions and declinations change so slowly that it is unnecessary to use interpolation when taking them from the almanac pages.

Proceeding now to our examples, suppose that on shore, at Sandy Hook Light, approximate latitude and longitude $40^{\circ} 28' N.$, $74^{\circ} 0' W.$, on Monday, Dec. 17, 1917, at noon, the double altitude of the sun's lower limb was observed with a sextant and artificial horizon, and found to be $51^{\circ} 48'$. The index correction required by the sextant was $+ 4'$; and the G. M. T. by chronometer was $4^h 56^m$ at the moment the observation was made. Find the latitude. We have:

| | | |
|---|------------------|------|
| Observed double altitude..... | $51^{\circ} 48'$ | (1) |
| Index correction..... | $+ 4$ | (2) |
| Adding (1) and (2) gives corrected double altitude | $51^{\circ} 52'$ | (3) |
| Halving (3) gives observed altitude..... | $25 56$ | (4) |
| Correction from Table 6 ¹ (p. 247)..... | $+ 14$ | (5) |
| Adding (4) and (5) gives fully corrected altitude..... | $26^{\circ} 10'$ | (6) |
| Now use formula (4) (p. 89) because latitude is + and declination is -. Write..... | $90 0$ | (7) |
| Subtracting (6) from (7) gives 90° - corrected altitude.. | $63 50$ | (8) |
| Interpolate declination from almanac (p. 76). This gives declination..... | $23 22$ | (9) |
| Subtracting (9) from (8) gives for the latitude..... | $40 28$ | (10) |

With regard to the foregoing example it is worth remarking that if there had been no available chronometer set to Greenwich time, it would still have been possible to calculate the observation. For the known approximate longitude, even if only a dead-reckoning (p. 5) longitude, would be quite accurate enough to make possible the interpolation of the declination from the almanac. And in the present example, the chronometer was only used in getting the declination printed in line (9) above.

¹Dip correction from Table 7 not needed because the artificial horizon was used.

APPARENT PLACES OF STARS, 1917

From Nautical Almanac, p. 94

FOR THE UPPER TRANSIT AT GREENWICH

| No. | CONSTELLATION NAME | RIGHT ASCENSION | | | | | | | | | | |
|-----|--------------------|-----------------|-------|--------|--------|--------|---------|--------|--------|--------|---------|-------|
| | | Jan. 1 | May 1 | June 1 | July 1 | Aug. 1 | Sept. 1 | Oct. 1 | Nov. 1 | Dec. 1 | Dec. 32 | |
| | | h m s | s | s | s | s | s | s | s | s | s | s |
| 1 | α Androm. | 0 4 | 6.3 | 6.4 | 7.4 | 8.4 | 9.4 | 10.0 | 10.3 | 10.3 | 10.0 | 9.6 |
| 2 | β Cassiop. | 0 4 | 44.8 | 44.4 | 45.7 | 47.3 | 48.7 | 49.7 | 50.1 | 49.9 | 49.3 | 48.4 |
| 3 | β Ceti | 0 39 | 26.5 | 26.3 | 27.0 | 28.0 | 28.9 | 29.7 | 30.0 | 30.1 | 29.8 | 29.5 |
| 4 | δ Cassiop. | 1 20 | 23.9 | 22.3 | 23.5 | 25.1 | 26.7 | 28.1 | 28.9 | 29.2 | 29.0 | 28.2 |
| 5 | α Urs. Min. | 1 29 | 89.0 | 22.9 | 45.5 | 77.6 | 112.8 | 142.4 | 161.2 | 166.4 | 155.3 | 129.0 |
| 6 | α Eridani | 1 34 | 39.1 | 36.8 | 37.6 | 38.8 | 40.3 | 41.5 | 42.3 | 42.4 | 41.9 | 41.1 |
| 7 | α Arietis | 2 2 | 31.0 | 30.1 | 30.8 | 31.7 | 32.7 | 33.6 | 34.3 | 34.6 | 34.7 | 34.5 |
| 8 | θ Eridani | 2 55 | 8.8 | 6.8 | 7.2 | 7.9 | 9.0 | 10.0 | 10.8 | 11.3 | 11.4 | 11.0 |
| 9 | α Persei | 3 18 | 25.9 | 23.9 | 24.4 | 25.5 | 26.8 | 28.2 | 29.3 | 30.2 | 30.6 | 30.5 |
| 10 | α Tauri | 4 31 | 11.7 | 10.3 | 10.5 | 11.0 | 11.9 | 12.8 | 13.7 | 14.5 | 15.0 | 15.2 |
| 11 | β Orionis | 5 10 | 35.1 | 33.7 | 33.7 | 34.2 | 34.7 | 35.6 | 36.5 | 37.3 | 37.8 | 38.1 |
| 12 | α Aurigæ | 5 10 | 36.5 | 34.5 | 34.6 | 35.2 | 36.2 | 37.5 | 38.7 | 39.9 | 40.7 | 41.1 |
| 13 | γ Orionis | 5 20 | 43.1 | 41.7 | 41.7 | 42.1 | 42.8 | 43.7 | 44.6 | 45.4 | 46.0 | 46.4 |
| 14 | ε Orionis | 5 32 | 2.4 | 1.0 | 1.0 | 1.3 | 2.0 | 2.8 | 3.7 | 4.5 | 5.2 | 5.5 |
| 15 | α Orionis | 5 50 | 43.1 | 41.8 | 41.7 | 42.0 | 42.7 | 43.5 | 44.4 | 45.3 | 46.0 | 46.4 |
| 16 | α Argus | 6 22 | 9.2 | 6.1 | 5.5 | 5.4 | 6.0 | 6.9 | 8.1 | 9.3 | 10.2 | 10.6 |
| 17 | α Can. Maj. | 6 41 | 31.6 | 30.2 | 30.0 | 30.1 | 30.6 | 31.3 | 32.2 | 33.1 | 33.8 | 34.3 |
| 18 | ε Can. Maj. | 6 55 | 24.1 | 22.6 | 22.2 | 22.2 | 22.6 | 23.3 | 24.2 | 25.2 | 26.0 | 26.5 |
| 19 | α Can. Min. | 7 34 | 59.7 | 59.0 | 58.7 | 58.8 | 59.1 | 59.8 | 60.5 | 61.5 | 62.3 | 63.0 |
| 20 | β Gemin. | 7 40 | 17.1 | 16.3 | 16.0 | 16.0 | 16.4 | 17.1 | 18.0 | 19.0 | 20.0 | 20.8 |
| 21 | ε Argus | 8 20 | 51.4 | 49.0 | 48.0 | 47.3 | 47.2 | 47.8 | 48.9 | 50.4 | 51.8 | 52.8 |
| 22 | λ Argus | 9 4 | 58.6 | 57.9 | 57.3 | 56.9 | 56.8 | 57.1 | 57.8 | 58.9 | 60.1 | 61.0 |
| 23 | β Argus | 9 12 | 20.6 | 18.1 | 16.4 | 15.1 | 14.5 | 14.8 | 16.0 | 17.9 | 20.0 | 21.7 |
| 24 | α Hydræ | 9 23 | 32.5 | 32.6 | 32.2 | 32.0 | 32.0 | 32.3 | 32.9 | 33.7 | 34.7 | 35.6 |
| 25 | α Leonis | 10 3 | 59.2 | 59.7 | 59.3 | 59.1 | 59.0 | 59.2 | 59.7 | 60.5 | 61.4 | 62.4 |

Had it been thus necessary to get the declination without using the chronometer, we should have proceeded as follows :

- Apparent solar time of noon (p. 75) 0^h 0^m (1)
- Approximate longitude = 74° 0' W. = (at 15° to the hour) 4 56 W. (2)
- Adding (1) and (2) (p. 81) gives approximate Greenwich apparent time 4 56 (3)
- Approx. eq. of time, Dec. 17, at 4^h 56^m (p. 76) + 4 (4)
- Subtracting ¹ (4) from (3) gives approximate G. M. T. 4 52 (5)
- Declination interpolated for G. M. T. in line (5) is - 23° 22' (6)

¹ The equation is additive to G. M. T., according to the note at the foot of p. 76, and therefore to be subtracted from Greenwich apparent time.

APPARENT PLACES OF STARS, 1917

From Nautical Almanac, p. 95

FOR THE UPPER TRANSIT AT GREENWICH

| No. | DECLINATION | | | | | | | | | | SPECIAL NAME | MAG. ¹ |
|-----|-------------|--------|--------|--------|-------|--------|--------|--------|---------|------|--------------|-------------------|
| | Jan. 1 | Feb. 1 | Mar. 1 | Apr. 1 | May 1 | Oct. 1 | Nov. 1 | Dec. 1 | Dec. 32 | | | |
| 1 | + 28 | 38.2 | 38.1 | 38.0 | 38.0 | 38.0 | 38.4 | 38.5 | 38.5 | 38.5 | Alpheratz | 2.2 |
| 2 | + 58 | 41.9 | 41.8 | 41.7 | 41.6 | 41.5 | 42.0 | 42.1 | 42.2 | 42.2 | Caph | 2.4 |
| 3 | - 18 | 26.5 | 26.5 | 26.5 | 26.4 | 26.3 | 26.0 | 26.1 | 26.2 | 26.2 | Deneb Kaitos | 2.2 |
| 4 | + 59 | 48.7 | 48.7 | 48.6 | 48.4 | 48.3 | 48.6 | 48.8 | 48.9 | 49.0 | Ruchbah | 2.8 |
| 5 | + 88 | 52.2 | 52.2 | 52.1 | 52.0 | 51.8 | 52.0 | 52.2 | 52.4 | 52.5 | Polaris | 2.1 |
| 6 | - 57 | 39.7 | 39.7 | 39.6 | 39.4 | 39.2 | 39.0 | 39.2 | 39.3 | 39.4 | Achernar | 0.6 |
| 7 | + 23 | 4.5 | 4.4 | 4.4 | 4.3 | 4.3 | 4.6 | 4.7 | 4.7 | 4.7 | Hamal | 2.2 |
| 8 | - 40 | 38.3 | 38.3 | 38.3 | 38.2 | 38.1 | 37.7 | 37.8 | 38.0 | 38.1 | Acamar | 3.0 |
| 9 | + 49 | 34.3 | 34.3 | 34.3 | 34.2 | 34.1 | 34.3 | 34.3 | 34.4 | 34.5 | | 1.9 |
| 10 | + 16 | 20.7 | 20.7 | 20.7 | 20.7 | 20.7 | 20.8 | 20.8 | 20.8 | 20.8 | Aldebaran | 1.1 |
| 11 | - 8 | 17.8 | 17.8 | 17.9 | 17.9 | 17.8 | 17.5 | 17.6 | 17.7 | 17.7 | Rigel | 0.3 |
| 12 | + 45 | 55.0 | 55.1 | 55.1 | 55.1 | 55.0 | 54.9 | 54.9 | 55.0 | 55.1 | Capella | 0.2 |
| 13 | + 6 | 16.6 | 16.5 | 16.5 | 16.5 | 16.5 | 16.7 | 16.7 | 16.6 | 16.6 | Bellatrix | 1.7 |
| 14 | - 1 | 15.2 | 15.3 | 15.3 | 15.3 | 15.3 | 15.0 | 15.1 | 15.1 | 15.2 | Alnitam | 1.8 |
| 15 | + 7 | 23.6 | 23.5 | 23.5 | 23.5 | 23.5 | 23.7 | 23.7 | 23.6 | 23.6 | Betelgeux | 1.0-1.4 |
| 16 | - 52 | 39.0 | 39.2 | 39.3 | 39.3 | 39.2 | 38.7 | 38.7 | 38.9 | 39.1 | Canopus | - 0.9 |
| 17 | - 16 | 36.1 | 36.2 | 36.3 | 36.3 | 36.3 | 35.9 | 36.0 | 36.1 | 36.2 | Sirius | - 1.6 |
| 18 | - 28 | 51.5 | 51.7 | 51.7 | 51.8 | 51.7 | 51.3 | 51.4 | 51.5 | 51.6 | Adhara | 1.6 |
| 19 | + 5 | 26.3 | 26.2 | 26.2 | 26.2 | 26.2 | 26.3 | 26.2 | 26.2 | 26.1 | Procyon | 0.5 |
| 20 | + 28 | 13.6 | 13.6 | 13.6 | 13.7 | 13.7 | 13.5 | 13.5 | 13.4 | 13.4 | Pollux | 1.2 |
| 21 | - 59 | 14.4 | 14.6 | 14.8 | 14.9 | 14.9 | 14.4 | 14.4 | 14.5 | 14.7 | | 1.7 |
| 22 | - 43 | 5.7 | 5.9 | 6.1 | 6.2 | 6.2 | 5.8 | 5.8 | 5.9 | 6.0 | | 2.2 |
| 23 | - 69 | 22.4 | 22.6 | 22.8 | 22.9 | 23.0 | 22.5 | 22.4 | 22.5 | 22.7 | Miaplacidus | 1.8 |
| 24 | - 8 | 17.9 | 18.1 | 18.1 | 18.2 | 18.2 | 18.0 | 18.0 | 18.1 | 18.2 | Alphard | 2.2 |
| 25 | + 12 | 22.2 | 22.2 | 22.2 | 22.2 | 22.2 | 22.2 | 22.1 | 22.0 | 21.9 | Regulus | 1.3 |

¹ When the number in this column is very small, and especially when it is *minus*, the star is very bright.

It is further to be noted that as we can thus obtain the approximate G. M. T., we really know in advance the approximate moment when the observation should be made. So it is unnecessary to get the sextant ready a long time before the observation; and it is, in fact, better to observe at the proper predetermined approximate moment rather than to wait for the maximum altitude (p. 86).

When the ship's position at noon can be predicted with fair approximation, it is thus possible to have the declination and other numbers for calculating the noon-sight also all ready

in advance, so that the latitude will be immediately available when the noon altitude has been read from the sextant.

We shall now consider the following example: Off St. Paul de Loando, West Africa, approximate latitude $8^{\circ} 55'$ south, approximate longitude $12^{\circ} 55'$ east, both predicted in advance by D. R. for noon on Monday, Dec. 31. The altitude of the sun's lower limb is to be measured. Index correction is $- 5'$. Height of eye, 26 ft.

To prepare for the observation, we have, as before :

| | | |
|--|-----------------|-----|
| Apparent solar time of noon | $0^h \quad 0^m$ | (1) |
| Approximate D. R. longitude = $12^{\circ} 55'$ east = (at 15° to the hour) | 52 E. | (2) |
| Subtracting (2) from (1) gives approximate Greenwich apparent time, Dec. 30 | 23 8 | (3) |
| Approximate equation of time, Dec. 30, at $23^h \ 8^m$ (p. 76) | - 3 | (4) |
| Subtracting (4) from (3), having regard to - sign of (4), gives approximate G. M. T. | 23 11 | (5) |

The navigator will then make the observation when the G. M. T. is $23^h \ 11^m$, as indicated by the chronometer, duly corrected for error and rate. This would of course also be noon, or the time when the sun attained its maximum altitude for the day.

Now the dials of chronometers are always divided into 12 hours, like ordinary watches, although navigators count time through 24 hours, as we have seen (p. 75). The reason is that the dial would be overloaded with numbers if there were 24 hour divisions. Therefore, when we speak of the chronometer indicating $23^h \ 11^m$, it must be understood that the actual chronometer indication, or "chronometer face," as it is sometimes called, would really be $11^h \ 11^m$; only, the navigator would call it $23^h \ 11^m$, astronomic time. In this manner civil time still forces its way into navigation, by way of the chronometer face.

To make the observation at the prearranged G. M. T. by chronometer it is not desirable to carry that instrument out into the sunlight, where the observer stands. It is much

better for the navigator to use his watch, and to calculate in advance the "watch time" of the observation. To do this, it is merely necessary to compare the watch with the chronometer, and thus ascertain how much the watch is slow or fast of the chronometer. This amount is called "chronometer *minus* watch" (abbreviated C. - W.); and when the watch is fast of the chronometer, C. - W. is marked with the *minus* sign.

To obtain the watch time for the observation, we subtract C. - W. from the G. M. T. In the present case we will suppose the watch was 47^m fast of the chronometer. Then C. - W. = - 47^m. To get the watch time for the observation we must subtract - 47^m from 23^h 11^m. Subtracting a minus number is equivalent to addition; and so the watch time is 23^h 11^m + 47^m = 23^h 58^m. The observation would be made as nearly as possible 2^m before noon, by the watch.

In this connection it also becomes of interest to inquire how the navigator's watch happened to be 47^m fast of the chronometer. It is customary aboard ship to set the deck and cabin clocks, and all watches, to the ship's local apparent time once a day at least. To do this, we proceed as follows:

- Take from chronometer the G. M. T., corrected for error and rate (1)
 Apply to this G. M. T. the eq. of time, giving Green'h app. time (2)
 Apply to (2) the approximate D. R. longitude, adding it if longitude is E., which gives ship's apparent time. (3)
 And set the watch to the time (3).

An example of this proceeding can be had from the data on p. 93. Suppose the watch was to be set; and the chronometer time was 23^h 0^m. We should then prepare to set the watch in about 5^m, when the

| | | | |
|--|-----------------|----------------|-----|
| G. M. T. by chronometer would be | 23 ^h | 5 ^m | (1) |
| Chronometer error (corrected for rate) say | - | 2 | (2) |
| Corrected G. M. T. by chronometer, (1) + (2) | 23 | 3 | (3) |
| Equation of time (p. 93) | - | 3 | (4) |
| Greenwich apparent time, (3) + (4) | 23 | 0 | (5) |
| Approximate longitude (p. 93) | | 52 E. | (6) |
| Ship's apparent time, (5) + (6) | 23 | 52 | (7) |

And the watch would be set to $23^h 52^m$, when the chronometer face was $23^h 5^m$; or, which is the same thing, the watch would be set at 8^m to 12 when the chronometer indicated 5 minutes past 11.

Sometimes the navigator wishes the watch to be correct by ship's apparent time at noon, but desires to set it right half an hour sooner, so as to be free at noon to make an observation. In that case he calculates by D. R. what the longitude will be at noon, and proceeds practically in the same way as before.

Resuming now the example of p. 93, we are still off St. Paul de Loando, and at 2^m before noon by the watch (p. 94) the altitude of the sun's lower limb was measured.

| | | |
|--|---------|-----|
| Suppose it was found to be..... | 75° 34' | (1) |
| The index correction was..... | - 5 | (2) |
| Adding (1) and (2), with regard to sign of (2), gives | | |
| corrected altitude..... | 75 29 | (3) |
| Correction from Table 6..... | + 16 | (4) |
| Correction from Table 7, for 26 ft. height of eye..... | - 5 | (5) |
| Adding (3), (4), (5) gives corrected altitude..... | 75 40 | (6) |
| Formula (2), p. 89, is the proper one, and the inter- | | |
| polated declination, disregarding sign, is..... | 23 8 | (7) |
| Latitude, by formula, is (6) + (7) - 90°, or..... | 8 48 | (8) |

The latitude of the ship is therefore $8^\circ 48'$ south, from the above noon-sight observation. The difference of $7'$ from the approximate latitude (p. 93) might easily be caused by ocean currents.

Our next example is a star observation. Position of ship by D. R. March 23, 1917, at $6^h 30^m$ ship's time is: latitude $40^\circ 25' N.$, longitude $46^\circ 52' W.$, so that she is near the turning point in the southern "lane route" followed by steamships bound from New York to Fastnet in summer. The upper transit (p. 89) of Sirius was observed; and the sextant altitude was $33^\circ 7'$. Index correction, $- 7'$; height of eye, 24 ft.

The calculation is as follows :

| | | | |
|--|-----|-----|-----|
| Observed altitude of Sirius | 33° | 7' | (1) |
| Index correction | | - 7 | (2) |
| Adding (1) and (2), having regard to <i>minus</i> sign of (2), gives corrected altitude | 33 | 0 | (3) |
| Correction Tables 6 and 7, combined | | - 6 | (4) |
| Adding (3) and (4) gives finally corrected altitude | 32 | 54 | (5) |
| Use formula (4), p. 89, because latitude is + and decli- nation of Sirius -. We have | 90° | | (6) |
| Subtract (5) from (6), giving (90° - altitude) | 57 | 6 | (7) |
| Declination of Sirius (p. 92), disregarding sign, is | 16 | 36 | (8) |
| Subtract (8) from (7), giving (90° - altitude - declina- tion), or the latitude | 40 | 30 | (9) |

Ship's latitude at the moment of observation was therefore 40° 30' N.

In making such a star observation, it is of course possible to follow the star with the sextant until it begins to dip (p. 86) toward the horizon exactly as we have explained for the sun. But it is preferable to prepare for the observation in advance, and to make it at a definite predetermined minute by the navigator's watch. To make such preparation, it is necessary to use pages 96 and 97 of the Nautical Almanac, parts of which pages are reprinted here (pp. 97, 98).

The almanac page 96 gives for all the bright stars the G. M. T. of upper transit (p. 158) at Greenwich, for the first day of each month. And it will be noticed that the upper transit is here called "meridian transit," which is practically another name for the same thing. Almanac page 97 (our p. 98) then gives a subtractive correction, applicable to the numbers on page 96, to make them correct on days of the month other than the 1st.

Another small correction is still required to make the numbers right in the approximate D. R. longitude of the ship, instead of the longitude of Greenwich, as used on almanac page 96. This correction is subtractive, if the ship is in west longitude, and additive, if she is in east longitude; and the

MERIDIAN TRANSIT OF STARS, 1917

From Nautical Almanac, p. 96

GREENWICH MEAN TIME OF TRANSIT AT GREENWICH

| CONSTELLATION NAME | MAG. | JAN. 1 | | FEB. 1 | | MAR. 1 | | APR. 1 | | MAY 1 | | SEPT. 1 | | OCT. 1 | | NOV. 1 | | DEC. 1 | |
|----------------------|---------|--------|----|--------|----|--------|----|---------------------|---------------------|-------|----|---------|----|--------|----|--------|----|--------|----|
| | | h | m | h | m | h | m | h | m | h | m | h | m | h | m | h | m | h | m |
| α Androm. | 2.2 | 5 | 21 | 3 | 19 | 1 | 29 | 23 | 23 | 21 | 25 | 13 | 22 | 11 | 24 | 9 | 22 | 7 | 24 |
| β Cassiop. | 2.4 | 5 | 22 | 3 | 20 | 1 | 30 | 23 | 24 | 21 | 26 | 13 | 22 | 11 | 24 | 9 | 22 | 7 | 24 |
| β Ceti | 2.2 | 5 | 56 | 3 | 54 | 2 | 4 | { ₂₃ 24} | { ₂₃ 24} | 22 | 0 | 13 | 57 | 11 | 59 | 9 | 57 | 7 | 59 |
| δ Cassiop. | 2.8 | 6 | 37 | 4 | 35 | 2 | 45 | 0 | 43 | 22 | 41 | 14 | 38 | 12 | 40 | 10 | 38 | 8 | 40 |
| α Urs. Min. | 2.1 | 6 | 47 | 4 | 45 | 2 | 54 | 0 | 52 | 22 | 50 | 14 | 49 | 12 | 51 | 10 | 49 | 8 | 51 |
| α Eridani | 0.6 | 6 | 51 | 4 | 49 | 2 | 59 | 0 | 57 | 22 | 55 | 14 | 52 | 12 | 54 | 10 | 52 | 8 | 54 |
| α Arietis | 2.2 | 7 | 19 | 5 | 17 | 3 | 27 | 1 | 25 | 23 | 23 | 15 | 20 | 13 | 22 | 11 | 20 | 9 | 22 |
| θ Eridani | 3.0 | 8 | 12 | 6 | 10 | 4 | 20 | 2 | 18 | 0 | 20 | 16 | 12 | 14 | 14 | 12 | 12 | 10 | 14 |
| α Persei | 1.9 | 8 | 35 | 6 | 33 | 4 | 43 | 2 | 41 | 0 | 43 | 16 | 35 | 14 | 38 | 12 | 36 | 10 | 38 |
| α Tauri | 1.1 | 9 | 47 | 7 | 46 | 5 | 55 | 3 | 54 | 1 | 56 | 17 | 48 | 15 | 50 | 13 | 48 | 11 | 50 |
| β Orionis | 0.3 | 10 | 27 | 8 | 25 | 6 | 35 | 4 | 33 | 2 | 35 | 18 | 27 | 16 | 29 | 14 | 28 | 12 | 30 |
| α Aurigæ | 0.2 | 10 | 27 | 8 | 25 | 6 | 35 | 4 | 33 | 2 | 35 | 18 | 27 | 16 | 29 | 14 | 28 | 12 | 30 |
| γ Orionis | 1.7 | 10 | 37 | 8 | 35 | 6 | 45 | 4 | 43 | 2 | 45 | 18 | 37 | 16 | 39 | 14 | 38 | 12 | 40 |
| ϵ Orionis | 1.8 | 10 | 48 | 8 | 46 | 6 | 56 | 4 | 54 | 2 | 56 | 18 | 49 | 16 | 51 | 14 | 49 | 12 | 51 |
| α Orionis | 1.0-1.4 | 11 | 7 | 9 | 5 | 7 | 15 | 5 | 13 | 3 | 15 | 19 | 7 | 17 | 9 | 15 | 7 | 13 | 9 |
| α Argus | -0.9 | 11 | 38 | 9 | 36 | 7 | 46 | 5 | 44 | 3 | 46 | 19 | 39 | 17 | 41 | 15 | 39 | 13 | 41 |
| α Can. Maj. | -1.6 | 11 | 57 | 9 | 55 | 8 | 5 | 6 | 3 | 4 | 5 | 19 | 58 | 18 | 0 | 15 | 58 | 14 | 0 |
| ϵ Can. Maj. | 1.6 | 12 | 11 | 10 | 9 | 8 | 19 | 6 | 17 | 4 | 19 | 20 | 12 | 18 | 14 | 16 | 12 | 14 | 14 |
| α Can. Min. | 0.5 | 12 | 51 | 10 | 49 | 8 | 59 | 6 | 57 | 4 | 59 | 20 | 51 | 18 | 53 | 16 | 52 | 14 | 54 |
| β Gemin. | 1.2 | 12 | 56 | 10 | 54 | 9 | 4 | 7 | 2 | 5 | 4 | 20 | 57 | 18 | 59 | 16 | 57 | 14 | 59 |
| ϵ Argus | 1.7 | 13 | 36 | 11 | 34 | 9 | 44 | 7 | 42 | 5 | 44 | 21 | 37 | 19 | 39 | 17 | 37 | 15 | 39 |
| λ Argus | 2.2 | 14 | 20 | 12 | 19 | 10 | 28 | 8 | 27 | 6 | 28 | 22 | 21 | 20 | 23 | 18 | 21 | 16 | 23 |
| β Argus | 1.8 | 14 | 28 | 12 | 26 | 10 | 36 | 8 | 34 | 6 | 36 | 22 | 28 | 20 | 30 | 18 | 28 | 16 | 31 |
| α Hydræ | 2.2 | 14 | 39 | 12 | 37 | 10 | 47 | 8 | 45 | 6 | 47 | 22 | 40 | 20 | 42 | 18 | 40 | 16 | 42 |
| α Leonis | 1.3 | 15 | 19 | 13 | 17 | 11 | 27 | 9 | 25 | 7 | 27 | 23 | 20 | 21 | 22 | 19 | 20 | 17 | 22 |

amount of it is 10^s for every 15° in the ship's longitude. After it has been applied, the result will be the ship's mean solar time of the star's upper transit.

As an example, let us take the preparation for the foregoing observation of Sirius, or α Can. Maj. We have :

| | | | |
|--|----------------|----------------|-----|
| G. M. T. of upper transit, March 1, from almanac page 96 above..... | 8 ^h | 5 ^m | (1) |
| Correction for 23d day of month, from almanac page 97 (our p. 98)..... | - 1 | 27 | (2) |
| Correcting (1) with (2), having regard to - sign of (2) | 6 | 38 | (3) |
| Further correction for longitude 46° 52' W., at 10 ^s per 15° of longitude, approximately..... | 1 | | (4) |
| Subtracting (4) from (3) gives ship's mean solar time of the observation..... | 6 | 37 | (5) |

MERIDIAN TRANSIT OF STARS, 1917

From Nautical Almanac, p. 97

CORRECTIONS TO BE APPLIED TO THE MEAN TIME OF TRANSIT ON THE FIRST DAY OF THE MONTH, TO FIND THE MEAN TIME OF TRANSIT ON ANY OTHER DAY OF THE MONTH

| DAY OF MONTH | CORRECTION | | DAY OF MONTH | CORRECTION | | DAY OF MONTH | CORRECTION | |
|--------------|------------|----|--------------|------------|----|--------------|------------|----|
| | h | m | | h | m | | h | m |
| 1 | - 0 | 0 | 11 | - 0 | 39 | 21 | - 1 | 19 |
| 2 | 0 | 4 | 12 | 0 | 43 | 22 | 1 | 23 |
| 3 | 0 | 8 | 13 | 0 | 47 | 23 | 1 | 27 |
| 4 | 0 | 12 | 14 | 0 | 51 | 24 | 1 | 30 |
| 5 | 0 | 16 | 15 | 0 | 55 | 25 | 1 | 34 |
| 6 | - 0 | 20 | 16 | - 0 | 59 | 26 | - 1 | 38 |
| 7 | 0 | 24 | 17 | 1 | 3 | 27 | 1 | 42 |
| 8 | 0 | 28 | 18 | 1 | 7 | 28 | 1 | 46 |
| 9 | 0 | 31 | 19 | 1 | 11 | 29 | 1 | 50 |
| 10 | 0 | 35 | 20 | 1 | 15 | 30 | 1 | 54 |
| 11 | - 0 | 39 | 21 | - 1 | 19 | 31 | - 1 | 58 |

NOTE. If the quantity taken from this Table is greater than the mean time of transit on the first of the month, increase that time by $23^h 56^m$ and then apply the correction taken from this Table.

The actual observation was made at $6^h 30^m$, ship's time, as indicated by the navigator's watch. The difference of 7^m between $6^h 30^m$, and $6^h 37^m$ in line (5) above, is due to the equation of time (p. 77), which is 7^m on March 23. This 7^m , if applied (with its proper sign from the almanac) to line (5) above, will give the ship's apparent time; and we have seen that watches and clocks on board are usually kept set to apparent and not mean ship's time (p. 94).

To complete this part of our subject, we have still to consider a few additional points of interest. For instance, a star chosen for observation may be one of the planets: Mars, Jupiter, or Saturn. These look like *very* bright stars in the sextant telescope; and calculations depending on them are similar to those described for stars. The planetary declinations and the G. M. T.'s of their upper transits are given in the almanac, but not on the pages reprinted here.

The moon is now so rarely observed that we have not given examples of lunar observations.

Sometimes an "ex-meridian" observation of the sun or a star is made at a time very near the upper transit, on a day when the actual transit observation could not be secured because of clouds. There are special tables¹ for calculating observations of this kind; but we have not included them here because all such observations can be satisfactorily treated by a new general method to be explained later (p. 108).

Having now fully treated the older standard method of determining the ship's latitude, let us next consider the older way of obtaining the longitude. This cannot be done when the sun (or a star) is near its maximum altitude, as already explained (p. 88). The most favorable opportunity occurs when the observed object bears (p. 44) east or west; but it is not always possible to get the observation on such a bearing. In that case, the longitude observation, often called a "time-sight," must be taken when the sun is near the desired bearing, but always avoiding, if possible, observations at very low altitudes. And if a very low altitude has been observed in an emergency, it can sometimes be checked by a later observation at a better altitude.

The principle on which the time-sight depends is simple. Calculations based on the measured altitude make known the ship's mean time at the moment of observation. At the same moment the chronometer face (p. 93), duly corrected for error and rate, tells us the G. M. T. The difference between the two times then gives us the longitude (see p. 82).

The calculations for this problem are made by means of Table 4 (trigonometric logarithms) and Table 10 ("haversines"). These haversines (abbreviated hav.) are really additional trigonometric logarithms; and Table 10 gives in every case not only the haversine itself, which is really

¹ Tables 26 and 27 of Bowditch's "Navigator," for instance.

a logarithm, but also, in the adjoining heavy type columns, the number (abbreviated No.) of which the haversine is the log. This additional heavy type number is not given throughout the entire table, but only when necessary for working Sumner line calculations (see Chapter IX, p. 108). It is not needed in working time-sights.

The argument (p. 10) of the haversine table is a double argument, not to be confounded with the pairs of arguments already explained (p. 11). In the haversine table, the argument is generally given in degrees and minutes, as well as (for convenience) in hours and minutes of time, allowing the usual 15° to each hour, etc.

We shall now solve our time-sight problem for the sun; and in doing so shall make use of two angles not hitherto employed: the "polar distance" (abbreviated p), and the "half sum" (abbreviated s). We shall also, for brevity, indicate the ship's apparent solar time by T . Then we have the following formulas:

If lat. and dec. are both + or both - . . . $p = 90^\circ - \text{dec.}$ (1)

If lat. and dec. are one + and one - . . . $p = 90^\circ + \text{dec.}$ (2)

In every case $s = \frac{1}{2} (\text{alt.} + \text{lat.} + p)$ (3)

If time-sight was made before noon, ship's time,

hav. $(24^h - T) = \text{sec lat.} + \text{csc } p + \text{cos } s + \text{sin } (s - \text{alt.})$ (4)

If time-sight was made after noon, ship's time,

hav. $T = \text{sec lat.} + \text{csc } p + \text{cos } s + \text{sin } (s - \text{alt.})$ (5)

In using these formulas, we have to choose between (1) and (2), and also between (4) and (5). Formula (3) is always used. No attention need be given to the signs of the declination or latitude except in choosing between formulas (1) and (2) for calculating p ; and in choosing between (4) and (5), we have merely to note whether the time-sight was taken in the forenoon or afternoon by ship's time.

We also desire to emphasize especially that these formulas presuppose the latitude to be known. This is merely another application of the principle (p. 88) that both lati-

tude and longitude cannot be determined from a single observation. It follows that in using this method we must first determine the latitude by a noon-sight before we can calculate the time-sight for longitude. If the time-sight was taken in the afternoon, the noon-sight will naturally have preceded it, and the ship's latitude at noon will be known. This noon latitude must then be carried forward to the moment of the afternoon time-sight by D. R. methods (p. 7); and the latitude thus obtained must be used for calculating the time-sight.

But if the time-sight was a forenoon observation, it cannot be properly calculated until noon, when the latitude will be determined. After that, the latitude can be carried *backwards* by D. R. to the moment of the forenoon time-sight, and the latter can be calculated.

But if the navigator, because of emergency, needs his longitude at once, after taking the forenoon time-sight, he must obtain the latitude by a D. R. calculation based on the last good noon-sight. Most navigators calculate morning time-sights in this way, and then repeat the calculation after the new noon-sight has been obtained. The latter calculation will be preferable to the former, because the further the latitude is carried along by D. R., the less accurate will it be. And any error in the latitude used in the calculation will impress a consequent error on the calculated longitude.

We shall now work some time-sight examples. On board ship, at sea, Dec. 18, 1917, in the afternoon, D. R. latitude $42^{\circ} 20' N.$, D. R. longitude $35^{\circ} 16' W.$, the altitude of sun's lower limb was observed to be $14^{\circ} 19'$. The time was taken with the navigator's watch, and was $2^h 29^m 58^s$. A comparison of the watch and ship's chronometer gave $C. - W. = 2^h 27^m 8^s$. The chronometer correction was $2^m 8^s$ slow of G. M. T. The index correction of the sextant was $+ 4'$; height of eye, 24 ft. Calculate the ship's longitude.

We have first to find, for the moment of the observation,

values of the declination and equation of time. To do this, we have:

| | | |
|---|--|-----|
| Watch time of observation..... | 2 ^h 29 ^m 58 ^s | (1) |
| C. - W..... | 2 27 8 | (2) |
| Adding (1) and (2) gives chronometer time of observation..... | 4 57 6 | (3) |
| Chronometer correction, slow..... | 2 8 | (4) |
| Adding (3) and (4) gives G. M. T. of observation | 4 59 14 | (5) |
| For the G. M. T. (5) we interpolate the declination (p. 76), finding..... | - 23° 24' | (6) |
| and for the same G. M. T. we interpolate the equation of time..... | + 3 ^m 21 ^s | (7) |
| Now, adding (5) and (7) gives Greenwich apparent time of observation..... | 5 ^h 2 ^m 35 ^s | (8) |

Next we inspect the formulas (p. 100), choosing (2) because latitude is + and declination -, and (5) because the sight was an afternoon one.

| | | |
|--|---------|------|
| We now have, from line (6), declination (disregarding sign)..... | 23° 24' | (9) |
| to which, by formula (2), we add..... | 90 0 | (10) |
| giving p | 113 24 | (11) |
| The observed altitude was..... | 14 19 | (12) |
| Index correction..... | + 4 | (13) |
| Adding (12) and (13) gives corrected altitude..... | 14 23 | (14) |
| Correction, Table 6..... | + 12 | (15) |
| Correction, Table 7..... | - 5 | (16) |
| Adding (14), (15), (16) gives finally corrected altitude | 14 30 | (17) |
| The latitude by D. R. is..... | 42 20 | (18) |
| Adding (11), (17), (18) gives..... | 170 14 | (19) |
| Halving (19) gives (by formula (3), p. 100) s | 85 7 | (20) |
| Subtracting (17) from (20) gives ($s - \text{alt.}$)..... | 70 37 | (21) |

Next we apply formula (5), p. 100. We have:

| | | |
|--|----------------------|------|
| sec lat. (18) from Table 4, page 238..... | 0.13121 | (22) |
| csc p (11) from Table 4, page 219..... | 0.03727 | (23) |
| cos s (20) from Table 4, page 200..... | 8.93007 | (24) |
| sin ($s - \text{alt.}$) (21) from Table 4, page 215..... | 9.97466 | (25) |
| sum (22) to (25) = hav. T , by formula (5)..... | 9.07321 ¹ | (26) |

¹This sum has been diminished by 10 arbitrarily (see p. 25), which must always be done when the sum of logs is larger than 10.

T ,¹ corresponding to (26) from Table 10, page 260, is $2^h 40^m 59^s$ (27)
 Greenwich apparent time (8) by watch and
 chronometer is..... 5 2 35 (28)
 Subtract (27) from (28), giving time difference
 between ship and Greenwich..... 2 21 36 (29)
 Turning (29) into degrees with Table 9, page 249,
 gives..... $35^\circ 24'$ W. (30)
 and (30) is the ship's longitude from this time-sight.

Upon comparing the D. R. longitude ($35^\circ 16'$ W.) with the result of the time-sight ($35^\circ 24'$ W.), we find that the ship is 8' west of her D. R. position. This means, of course, that there has been a westerly "set" of current in the interval between the last accurate determination of longitude and the present one. It would be proper for the navigator to calculate from this the amount of westerly drift per hour, and to allow for it in carrying forward his longitude by D. R. from the present time-sight. It is also clear that the northerly or southerly set of the current can be similarly measured and allowed for by comparing the D. R. latitude with the latitude from a noon-sight (cf. p. 95). It is the general custom of navigators to ascribe such differences to ocean currents, never to uncertainty in the astronomic results. Dead reckoning is never allowed any weight as against a sextant observation.

The reader will have noticed that the foregoing calculation has been made in great detail, so that a beginner may have no difficulty in understanding it. But a practiced navigator would of course work the calculation in a much more condensed form, in such a way as to bring the logarithms next to the numbers to which they belong. We shall therefore now repeat the same example in such a condensed form :

¹ If the observation had been made before noon, we should have used formula (4) and should here have obtained $24^h - T$, instead of T . This $24^h - T$ would then be subtracted from 24^h , to get T , before continuing the calculation. Thus the form of calculation would contain another line between (27) and (28), in the case of a forenoon observation.

TIME-SIGHT, CONDENSED FORM. SUN

| | | | |
|----------------------------|--|--------------|--------------|
| Watch time: | 2 ^h 29 ^m 58 ^s (1) | Obs'd alt.: | 14° 19' (12) |
| C. - W.: | 2 27 8 (2) | Index: | + 4 (13) |
| Chr. time: | 4 57 6 (3) | Table 6: | + 12 (15) |
| Chr. corr'n: | + 2 8 (4) | Table 7: | - 5 (16) |
| G. M. T.: 18 th | 4 59 14 (5) | Corr'd alt.: | 14 30 (17) |
| Eq. of time: | + 3 21 (7) | | |
| G. app. time: | 5 2 35 (8) | | |

| | | | |
|---|-------------|---|-------------------------------------|
| Decl. 18 th , 4 ^h : | 23° 23'7 | Eq. time, 18 th , 4 ^h : | + 3 ^m 22 ^s .3 |
| H. D.: | 0.1 | H. D.: | 1.2 |
| Decl. 4 ^h 59 ^m : | 23 24 (6) | Eq. time, 4 ^h 59 ^m : | + 3 21.1 (7) |
| <i>p</i> : | 113 24 (11) | | |

| | | | |
|------------------|---------------|-------------------------|---|
| Corr'd alt.: | 14° 30' (17) | | |
| Lat., D. R.: | 42 20 (18) | sec lat.: | 0.13121 (22) |
| <i>p</i> : | 113 24 (11) | csc <i>p</i> : | 0.03727 (23) |
| sum of 3: | 2)170 14 (19) | | |
| <i>s</i> : | 85 7 (20) | cos <i>s</i> : | 8.93007 (24) |
| <i>s</i> - alt.: | 70 37 (21) | sin (<i>s</i> - alt.): | 9.97466 (25) |
| | | sum of 4: | 9.07321 (26) = hav. <i>T</i> (or 24 ^h - <i>T</i>) ¹ |

| | |
|---------------------------------|---|
| <i>T</i> = ship's app. time: | 2 ^h 40 ^m 59 ^s (27) |
| By chron., Greenwich app. time: | 5 2 35 (8) |
| Longitude: | 2 ^h 21 ^m 36 ^s (29) |
| or: | 35° 24' W. (30) |

When the object observed is a star or planet, the choice between formulas (4) and (5), p. 100, is not quite the same as in the case of a solar time-sight. We must use (4) if there is any east in the star's bearing at the moment of observation; and (5), if there is west in the bearing. The more nearly the star bears due east or west, the more accurate will be the resulting longitude. The use of formulas (1), (2), and (3) is the same as for the sun; but *T*, in the case of a star, is no longer the ship's apparent solar time. Instead, it is called

¹ See p. 103, footnote.

the star's "hour-angle." To get the longitude, we must first (p. 85) calculate the Greenwich sidereal time corresponding to the G. M. T. of the observation, as taken from the chronometer, duly corrected for error and rate; and then use the following formulas:

(6) Greenwich sid. time - right-ascension of star = Greenwich hour-angle.

$$(7) \begin{cases} \text{West long.} = \text{Greenwich hour-angle} - T, \\ \text{East long.} = T - \text{Greenwich hour-angle.} \end{cases}$$

As an example of a star observation we shall take the following:

At sea, just before sunrise, Dec. 17, 1917, off Cape Agulhas, latitude by D. R. $35^{\circ} 20' S.$, longitude by D. R. $20^{\circ} 41' E.$, the altitude of Sirius was measured, and found to be $40^{\circ} 3'$. The star bore west, and the height of eye was 22 ft. Index correction was $+ 5'$. Time by watch, $16^h 29^m 48^s$, or $4^h 29^m 48^s$ A.M., civil time, Dec. 18; C. - W., $- 1^h 23^m 50^s$; chronometer fast of G. M. T. $2^m 28^s$.

The calculation would proceed thus:

| | | |
|---|------------------|------|
| Watch time of observation..... | $16^h 29^m 48^s$ | (1) |
| C. - W. | $- 1 23 50$ | (2) |
| Adding (1) and (2), having regard to - sign of (2), gives chronometer time of observation..... | $15 5 58$ | (3) |
| Chronometer correction, fast..... | $- 2 28$ | (4) |
| Adding (3) and (4), having regard to - sign of (4), gives G. M. T. of observation..... | $15 3 30$ | (5) |
| Right ascension mean sun, Greenwich mean noon, Dec. 17 (p. 83)..... | $17 42 10$ | (6) |
| Correction for "time past noon" (see p. 84).... | $2 28$ | (7) |
| Adding (6) and (7) gives right ascension of mean sun..... | $17 44 38$ | (8) |
| Adding (5) and (8) (see p. 85) gives Greenwich sidereal time of the observation..... | $8^1 48 8$ | (9) |
| Right ascension of Sirius, Dec. 17, is (p. 91).... | $6 41 34$ | (10) |
| Subtracting (10) from (9) gives Greenwich hour- angle (formula (6), above)..... | $2 6 34$ | (11) |

¹ This is really 32^h ; but 24^h is dropped arbitrarily.

Next we calculate T by formula (5), p. 100. We have:

| | | |
|---|-----------|------|
| Declination of Sirius, Dec. 17 (p. 92) | - 16° 36' | (12) |
| By formula (1), p. 100, subtract (12) from 90°, without attention to sign of (12), giving p .. | 73 24 | (13) |
| The observed altitude was | 40 3 | (14) |
| The index correction was | + 5 | (15) |
| Table 6 correction | - 1 | (16) |
| Table 7 correction | - 5 | (17) |
| Adding (14), (15), (16), (17), having regard to signs, gives corrected altitude | 40 2 | (18) |
| The latitude by D. R. was | 35 20 | (19) |
| Adding (13), (18), and (19) gives | 148 46 | (20) |
| Halving (20) gives s | 74 23 | (21) |
| Subtracting (18) from (21) gives (s - altitude) .. | 34 21 | (22) |

Now applying formula (5), page 100, we have :

| | | |
|---|--|------|
| see latitude (19) from Table 4, page 231 | 0.08842 | (23) |
| csc p (13) from Table 4, page 212 | 0.01849 | (24) |
| cos s (21) from Table 4, page 211 | 9.43008 | (25) |
| sin (s - altitude) (22) from Table 4, page 230 | 9.75147 | (26) |
| Summing (23) to (26) gives hav. T , by form. (5) .. | 9.28846 ¹ | (27) |
| T^2 corresponding to (27), from Tab. 10, p. 263 is .. | 3 ^h 29 ^m 14 ^s | (28) |
| Difference between (28) and (11) is the longi- tude by formula (7), page 105 | 1 22 40 E. | (29) |
| Turning (29) into degrees with Table 9, page 249, gives | 20° 40' E. | (30) |

The D. R. longitude, 20° 41' E., was therefore within 1' of the longitude from this time-sight, and this shows that the ship has not been affected by ocean currents since the last observation. It is also interesting to note how near sunrise the observation was made. The twilight must have been quite strong, and the star therefore dim. But star observations can be made best in twilight because the horizon line can then be seen distinctly.

¹ This sum has also been diminished by 10 (see footnote, p. 102).

² Might be 24^h - T , if the star bore E. instead of W. (see footnote, p. 103).

The foregoing example can of course also be arranged in condensed form, as follows :

TIME-SIGHT, CONDENSED FORM. STAR

| | | | | | |
|-------------------------|---|------|----------------------|----------|------|
| Watch time : | 16 ^h 29 ^m 48 ^s | (1) | Obs'd alt. : | 40° 3' | (14) |
| C. - W. : | -1 23 50 | (2) | Index : | + 5 | (15) |
| Chr. time : | 15 5 58 | (3) | Table 6 : | - 1 | (16) |
| Chr. corr'n : | - 2 28 | (4) | Table 7 : | - 5 | (17) |
| G. M. T. : | 15 3 30 | (5) | Corr'd alt. : | 40 2 | (18) |
| R. A. mean sun : | 17 42 10 | (6) | Lat. D. R. : | 35 20 | (19) |
| Corr'n, past noon : | 2 28 | (7) | <i>p</i> : | 73 24 | (13) |
| Greenw'h sid. time : | 8 48 8 | (9) | sum : | 2)148 46 | (20) |
| R. A. of Sirius : | 6 41 34 | (10) | <i>s</i> : | 74 23 | (21) |
| Greenwich hour-ang. : | 2 6 34 | (11) | (<i>s</i> - alt.) : | 34 21 | (22) |
| <i>T.</i> , from (27) : | 3 29 14 | (28) | | | |
| Long. : | 1 22 40 E. | (29) | | | |
| or : | 20° 40' E. | (30) | | | |

| | | |
|--------------------------|--|--|
| R. A. of Sirius : | 6 ^h 41 ^m 34 ^s | (10) |
| Dec. of Sirius : | - 16° 36' | (12) |
| <i>p</i> : | 73 24 | (13) |
| sec lat. : | 0.08842 | (23) |
| esc. <i>p</i> : | 0.01849 | (24) |
| cos <i>s</i> : | 9.43008 | (25) |
| sin (<i>s</i> - alt.) : | 9.75147 | (26) |
| sum of 4 : | 9.28846 | (27) = hav. <i>T</i> (or 24 ^h - <i>T</i>) ¹ |

Having now fully explained both the noon-sight and the time-sight, we shall close this chapter with a strong recommendation to young navigators to familiarize themselves with the observation of stars. These always furnish a valuable check on sun observations : and at times of danger may save the ship when clouds have obscured the sun for days, and clearing occurs after sunset. It is easy to learn to know the principal stars from Jacoby's "Astronomy," Chapter III, "How to Know the Stars."

¹ See footnote, p. 103.

CHAPTER IX

NEWER NAVIGATION METHODS

THE reader may have noticed in Chapter VIII that there is a very definite difference between the determination of latitude by a noon-sight and longitude by a time-sight: for the latitude is obtained without previous knowledge of the longitude; but to get the longitude, a previous knowledge of the latitude is essential. This is, of course, a decided disadvantage in determining longitude, nor is there any practicable direct way to get the longitude without first knowing the latitude.

We have also seen (p. 101) that any existing uncertainty in our knowledge of the latitude will produce an error in the longitude computed from a time-sight. In situations of danger it is important to ascertain how great this longitude error may be. Suppose, for instance, we have calculated a time-sight with a D. R. latitude that we suspect may be as much as 10' too small; and we wish to know how much our computed longitude may have been thereby put wrong. The obvious way to find out is to recompute the longitude with an assumed latitude 10' larger than the D. R. latitude. The resulting longitude will then show the extreme range of error that must have been produced if the D. R. latitude was 10' too small.

A third calculation, with an assumed latitude 10' smaller than the D. R. latitude, will similarly exhibit the extreme possible range of longitude error in the other direction. Thus these two extra calculations will show the limits of longitude error that might be caused by a range of 20' in the possible error of the D. R. latitude.

This rather obvious procedure was probably used long ago by more than one intelligent navigator; but it was first published in 1837 by Thomas H. Sumner, an American merchant captain. He used the method in dramatic circumstances of great danger; and he brought his ship safely into port. According to his own account, he made three calculations of the longitude, using three assumed latitudes differing by 10', and he of course obtained three different longitudes. He then marked or plotted (p. 55) on his chart the point indicated by the first assumed latitude and its computed longitude. At this point the ship must have been located, if the first assumed latitude had been correct. The other two latitudes, with their computed longitudes, indicated two more points on the chart; and at one of these points the ship must have been, if either of these additional latitudes was correct.

Sumner found that the three points on the chart lay *in a straight line*; and it became at once evident that whatever latitude he might assume (within reason) he would always get a point on the same straight line, after computing the longitude. In other words, although he did not know his latitude accurately, and so could not compute his longitude accurately, yet he had found a straight line on the chart upon which his ship was surely situated.

Such a line can always be found in the way Sumner found it, or in some preferable modern way; and such a line we shall call a "Sumner line," though some writers on navigation prefer to call it a "line of position."

On the occasion of laying down his line, Sumner found that it passed directly through Small's Light, near the Irish coast; and as the line bore E.N.E. on his chart, he simply put the ship on that course, and in less than an hour he "made" Small's Light, actually bearing E.N.E. $\frac{1}{2}$ E., and, as he says, "close aboard." He had had no observations after passing longitude 21° W., until the morning of Dec. 17, when these historic events occurred. He was off a rocky lee shore, in

the midst of a winter gale, after crossing the Atlantic; only a seaman can understand the relief he must have felt when that light suddenly appeared off the bow.

We have given this account of Sumner's experience to impress on the young navigator that he *must positively* familiarize himself with the Sumner method of navigation. Should we be so fortunate as to have any experienced navigator among our readers, we ask him to try the Sumner method once more, in the manner explained below, even if he may have found it troublesome in the past on account of certain difficulties in its application. For the Sumner method is the best method of navigation on all oceans and at all times: even when a noon-sight is available for latitude, it is better to treat it as a Sumner observation, and work out the Sumner line.

The principal objection urged against it by certain practical navigators arises from the small scale of existing ocean track charts, on which a distance of 10' is represented by about $\frac{1}{8}$ inch. A line like Sumner's, 20' long, would have only a length of $\frac{1}{4}$ inch on the chart; and such a little line would not be long enough to show accurately the direction in which it pointed. When near a coast, as in Sumner's case, this difficulty disappears, because navigators always have (or always *should* have and *use*) the large scale charts that can be obtained for coastwise waters.

But it is inconvenient for navigators to begin using a method off the coast, on the last day of a voyage, different from the form employed for many days at sea. Therefore, some authorities recommend the construction of a special large scale chart, with its latitude and longitude lines, each time an observation is made throughout the voyage, so that the Sumner line can always be drawn on a sufficiently large scale. It is no wonder that navigators have not generally adopted this somewhat laborious proceeding; and in the method given below we shall utilize the Sumner idea without requiring any lines to be drawn on charts.

Another objection to Sumner navigation is that it requires too much calculation; three longitude calculations for one observation, as Sumner practiced it. This objection is also quite removed now by the use of suitable tables such as we give in the present volume.

But before proceeding to explain these tables, we must outline briefly the real principle on which rests the complete utilization of the Sumner method on the open sea. There the navigator wants to know the ship's position in both latitude and longitude; and will not be satisfied with a mere line, with the ship "somewhere on the line." Along the coast such a line might help him to find Small's Light; but he is not looking for coast lights at sea.

And the Sumner method takes care of this matter in the simplest possible way. We have seen (p. 88) that two different observations are always necessary by any method to get both latitude and longitude. But two such observations by the Sumner method give two different lines on the chart: and as the ship must be located on both lines, her actual position must be at their point of intersection. We shall show how the required latitude and longitude of the ship at the point of intersection can be found by a simple calculation, without the drawing of any lines on the chart.

Coming now to the modern method of calculating a Sumner line, we must first state a general fundamental principle that may be easily verified by geometrical considerations. The true bearing (p. 44) of a Sumner line on a chart is always 90° greater than the true bearing or azimuth (p. 44) of the sun (or star) at the moment of observation. Or, in other words, the Sumner line bears at right angles to the sun at the time of observation.

We shall show how the bearing or azimuth of the sun can always be found from suitable "azimuth tables"; but the Sumner line is not completely known from its bearing alone. To locate it properly it is necessary to know in addition the latitude and longitude of *some point on the line*, which we

will call a "Sumner point." Then, knowing such a point of the line, and the bearing of the line, we may say we know the line completely, and, if necessary, could draw it on a chart.

Now to find the required Sumner point. We always have the D. R. position of the ship at the moment of observation; which we will call the "D. R. point." It is easy to find out if the D. R. point is also a Sumner point. It is merely necessary to calculate what the sun's altitude would be for a ship at the D. R. point, and then compare this calculated altitude with the one actually observed. If the D. R. point was really a Sumner point (which will rarely happen), the two altitudes will agree; if not, the amount of disagreement will show how far the D. R. point is distant from the nearest Sumner point.¹

The first step, then, in Sumner navigation, is the calculation of the altitude, supposing the ship to be at the D. R. point at the moment of observation. To do this for a sun observation, we first calculate the Greenwich apparent time (abbreviated G. A. T.) of the observation, just as was done in the case of a time-sight on p. 102. To this G. A. T. we then add the ship's D. R. longitude, if east, or subtract it, if west, to get T (p. 100), the ship's apparent time of the observation. We then use the formulas on p. 113, in which X and Z are "auxiliary angles" required in the calculations, but not otherwise of special interest. These formulas are called the "cosine-haversine" formulas.

There are several other sets of formulas with which the same problem can be solved. One set, called the "haversine" formulas, involves the use of haversines only; another, called the "sine-cosine" formulas, solves the problem with sines and cosines. But neither is preferable to the following cosine-haversine set.

¹ This method is often called the Marcq Saint Hilaire method; but it should probably be credited to Lord Kelvin, who published "Tables for Facilitating Sumner's Method at Sea" in 1876. These tables follow the method described above.

If observation was made before noon, ship's time,

$$\text{hav. } X = \cos \text{ lat.} + \cos \text{ dec.} + \text{hav. } (24^h - T), \quad (1)$$

If observation was made after noon, ship's time,

$$\text{hav. } X = \cos \text{ lat.} + \cos \text{ dec.} + \text{hav. } T, \quad (2)$$

$$\text{lat.} - \text{dec.} = \text{diff.}^1 \text{ of lat. and dec., if both are } + \text{ or both } -, \quad (3)$$

$$\text{lat.} - \text{dec.} = \text{sum}^1 \text{ of lat. and dec. if one is } + \text{ and one } -, \quad (4)$$

$$\text{No. hav. } Z = \text{No. hav. (lat.} - \text{dec.)} + \text{No. hav. } X, \quad (5)$$

$$\text{Alt.} = 90^\circ - Z. \quad (6)$$

Now we can compare the altitude computed by formula (6) with the observed altitude, fully corrected for index error, etc. The difference between the two altitudes in minutes will be the distance in miles of the nearest Sumner point from the D. R. point, for the minute and nautical mile here correspond, as they do in the case of differences of latitude (p. 15). The bearing of the Sumner point from the D. R. point will be the same as the sun's azimuth if the observed altitude is greater than the computed altitude: but if the observed altitude is less than the computed, the bearing of the Sumner point will be 180° greater than the sun's azimuth.

The bearing and distance of the Sumner point from the D. R. point once known, it is easy, by means of the traverse table (p. 10), to obtain the latitude and longitude of the Sumner point from the known latitude and longitude of the D. R. point; or, which is the same thing, from the ship's D. R. latitude and longitude.

Before giving examples of these calculations, it remains to show how the sun's bearing or azimuth can be taken from Table 11 (p. 284), called the azimuth table. The pair of arguments (p. 11) for entering this table are: first, in the left-hand column, the declination, which is here used without regard to its sign; and second, in the four topmost hori-

¹ In using formulas (3) and (4), pay no attention to + or - signs after the right formula is once chosen. The difference between latitude and declination is always taken by subtracting the smaller from the larger; and the sum by adding them, without regarding their + or - signs. Cf. also p. 89.

zontal lines, T (p. 100), the ship's apparent time at the moment of observation.

Having found this pair of arguments, we look in the column under T , and in the horizontal line opposite the declination. There we find an "index number." Next we look up the altitude, as computed by formula (6), page 113, in the right-hand column of the azimuth table, and follow along the horizontal line belonging to that altitude, until we reach a number equal (or nearly equal) to the index number. Then we go down the column containing this second appearance of the index number, and find the azimuth at the bottom of the page. The table gives approximate azimuths only, but the approximation is sufficient for our present purpose.

The azimuths at the bottom of the page appear in four horizontal lines, of which the upper two belong to forenoon observations, and the lower two to afternoon observations. All azimuths are counted from the north, through east, south, and west, from 0° to 360° , like compass courses in United States Navy practice (p. 41). It is important for the navigator to record, at the time of observation, the word "forenoon" or "afternoon," and also the sun's roughly approximate bearing, to aid in choosing which of the azimuths at the bottom of the tabular page is the right one. The record showing whether the observation was made in the forenoon or afternoon limits the choice to two of the lines of azimuths; and if there is any doubt remaining between these two, the following rules may clear it up.

When latitude is $+$ and declination $-$, azimuth is between 90° and 270° ;

When latitude is $+$ and declination $+$, if declination is greater than latitude, azimuth is *not* between 90° and 270° ;

When latitude is $-$ and declination $-$, if declination is greater than latitude, azimuth is between 90° and 270° ;

When latitude is $-$ and declination $+$, azimuth is *not* between 90° and 270° .

In other cases, and especially when latitude and declination are nearly equal, the foregoing rules are insufficient, and we must consult Table 12 (p. 290), the "auxiliary azimuth table." This table has latitude and declination for its pair of arguments, the former in the left-hand vertical column, the latter in the topmost horizontal line: and in using the table it is not necessary to pay attention to the + and - signs of latitude and declination. Start with the latitude, and follow its horizontal line to the right until you reach the column having the declination at its head. There you will find an "auxiliary angle," which must be compared with the altitude computed by formula (6), page 113. Then:

If the computed altitude is greater than the auxiliary angle, and if latitude is +, azimuth is between 90° and 270° ;

If the computed altitude is less than the auxiliary angle, and if latitude is -, azimuth is between 90° and 270° ;

If the computed altitude is less than the auxiliary angle, and if latitude is +, azimuth is *not* between 90° and 270° ;

If the computed altitude is greater than the auxiliary angle, and if latitude is -, azimuth is *not* between 90° and 270° .

It will rarely happen that any of the foregoing rules will be needed, if the navigator will make a careful observation of the sun's azimuth with the azimuth circle or pelorus (p. 44), as soon as possible after the sextant altitude has been observed. The ship's course should also be specially recorded when this observation is made. This proceeding is not merely a convenience to avoid consulting the foregoing rules in using the azimuth table: it is really essential to safe navigation, for a comparison of the observed azimuth with that derived from the table will make the compass error (p. 43) known. The variation is known from the chart; so that if we observe the compass error, we can allow for the variation, and get the deviation. This can then be compared with the deviation table (p. 48), to see if there has been any change in the compass since leaving port. It is

a great advantage of the Sumner method that the sun's azimuth comes out as a sort of by-product, so that the compass can be verified without any additional special calculations.

We shall now illustrate all the above considerations by means of examples; beginning with the observation already treated as a time-sight (p. 101). That observation we shall now work by the Sumner method. From page 101 we take the following:

Date of observation, Dec. 18, 1917, in the afternoon; D. R. latitude, $42^{\circ} 20' N.$; D. R. longitude, $35^{\circ} 16' W.$; altitude observed, $14^{\circ} 19'$; time by watch, $2^h 29^m 58^s$; C. - W., $2^h 27^m 8^s$; chronometer correction, $2^m 8^s$ slow of G. M. T.; index correction, $+ 4'$; height of eye, 24 ft.

From the preparatory part of the calculation (p. 102), we also copy the following additional numbers:

Declination, line (6), page 102 $-23^{\circ} 24'$ (1)
 Greenwich apparent time (G. A. T.) of observation,
 line (8), page 102 $5^h 2^m 35^s$ (2)

We have next to calculate, by the formulas on page 113, the altitude corresponding to the D. R. point, for which the latitude and longitude are given above. The longitude is $35^{\circ} 16' W.$, or, at 15° to the hour (Table 9, p. 249):

D. R. longitude is $2^h 21^m 4^s W.$ (3)
 Subtracting (3) from (2), according to page 112,
 gives ship's apparent time of observation, $T.. 2 41 31$ (4)

We are now prepared to apply formulas (1) to (6), page 113. We choose formula (2) for an afternoon observation¹; and write:

¹ For a forenoon observation we should choose formula (1), and should therefore need to know $24^h - T$ instead of T . This would make necessary another line in the form of calculation, and it would follow line (4). This new line might be numbered (4'); and in it would be written $24^h - T$, obtained by subtracting T (line 4) from 24^h .

| | |
|---|-------------|
| Cos lat., $42^{\circ} 20'$ N. by D. R. (see Table 4, p. 238) | 9.86879 (5) |
| Cos dec., $23^{\circ} 24'$, line (1) (see Table 4, p. 219) | 9.96273 (6) |
| Hav. T , $2^{\text{A}} 41^{\text{M}} 31^{\text{S}}$, line (4) (see Table 10, p. 260) | 9.07596 (7) |
| Adding (5) to (7) gives hav. X (dropping 20, p. 25) | 8.90748 (8) |

Now we choose formula (4), because latitude and declination are $+$ and $-$;

| | |
|---|-----------------------|
| The latitude is, by D. R. | $42^{\circ} 20'$ (9) |
| Adding (1) and (9) according to formula (4) gives (lat. $-$ dec.) | $65^{\circ} 44'$ (10) |
| Now we have, Table 10, page 266, No. hav. of (10) | 0.29451 (11) |
| No. hav. X , ¹ line (8) | 0.08082 (12) |
| Adding (11) and (12), according to formula (5), page 113, gives No. hav. Z | 0.37533 (13) |
| And Z , corresponding to (13) is found from Table 10, page 268 | $75^{\circ} 34'$ (14) |
| Then, by formula (6) computed altitude $= 90^{\circ} - Z$ (14), or | $14^{\circ} 26'$ (15) |

This computed altitude (15) must now be compared with the observed altitude, fully corrected. We find :

| | |
|---|-----------------------|
| Obs'd alt., fully corrected, line (17), page 102, is | $14^{\circ} 30'$ (16) |
| Difference between (15) and (16), in minutes, is the distance of Sumner point from D. R. point in miles (p. 113). It is | 4 miles (17) |

Next we must find the sun's azimuth from Table 11, page 286. The top argument for entering the table is T , line (4), and it must be found in the "afternoon" lines. The argument for the left-hand column is the declination, line (1). Under T , and opposite declination, we find the tabular index number 5872.² Then we find the computed altitude, line (15), in the right-hand column of Table 11, page 286, and

¹ This No. hav. X comes from Table 10, page 258, without looking up the angle X at all. We simply find hav. X in the table, and take the No. hav. X out of the adjoining heavy type column. No interpolations are needed, the nearest tabular numbers being sufficiently accurate.

² The index numbers and the azimuth need not be very accurate: it is sufficient to use the nearest tabular arguments, so that interpolation is not essential.

follow its horizontal line till we again come upon the index number 5872. It lies about halfway between 5703 and 5973. Going down the two columns containing these index numbers, we find in the afternoon azimuth lines two values of the azimuth, 217° and 323° . The choice between these two numbers would be very easy, if the observer's record contained even a rough estimate of the sun's bearing at the time of observation. We have purposely not made this available, so as to show how to consult the directions on page 114, and there we find that when the latitude is + and the declination -, the azimuth is between 90° and 270° . So we finally choose 217° for the sun's azimuth.

Since the observed altitude (16) is greater than the computed altitude (15), the bearing of the Sumner point from the D. R. point, according to page 113, is the same as the sun's azimuth, or 217° . And as we now know the bearing and distance of the Sumner point from the D. R. point, we can find its latitude and longitude by a simple application of the traverse table (p. 154).

We have merely to consider the bearing and distance to be a course angle and distance, and imagine a ship to have sailed from the one point to the other. In the present case, the distance is 4 miles (line 17), the course 217° : and Table 1 (p. 164) gives the corresponding latitude $3'.2$, departure 2.4. The longitude difference is obtained from the departure by Table 2 (p. 174) and is, for latitude 42° , about $3'.2$. Dropping odd fractions, the latitude difference and longitude difference both come out $3'$. The Sumner point is therefore $3'$ distant from the D. R. point in both latitude and longitude. And since the bearing 217° indicates on the compass card that the Sumner point is south and west of the D. R. point, it follows that:

| | |
|--|--------------------------------|
| Lat. of Sumner point = D. R. lat. - $3'$ = | |
| $42^\circ 20' \text{ N. (line 9) - } 3' \dots\dots\dots$ | $42^\circ 17' \text{ N. (18)}$ |
| Long. of Sumner point = D. R. long. + $3'$ $\dots\dots\dots$ | $35 19 \text{ W. (19)}$ |
| Azimuth of Sumner line (p. 111) $\dots\dots\dots$ | $307^\circ \quad (20)$ |

It is important for the reader to understand that the foregoing calculation is given in extended detail so as to make it easy for the beginner to follow. In condensed form, we should have the following arrangement of the calculation, corresponding to the condensed time-sight form (p. 104). Part of the work here repeated from page 104 has no attached reference numbers in parentheses: the new part of the work has references to the detailed calculation just given.

SUMNER LINE, CONDENSED FORM. SUN

| | | | |
|--|--|--|--|
| Obs'd alt.: $14^{\circ} 19'$ | | Decl. 4^h : $23^{\circ} 23'.7$ S. | |
| Index: + 4 | | H. D.: 0.1 | |
| Table 6: + 12 | | Decl. $4^h 59^m$: $23^{\circ} 24'$ S. | |
| Table 7: - 5 | | Eq. time, 4^h : + $3^m 22^s.3$ | |
| Corr'd alt.: $14^{\circ} 30'$ | | H. D.: 1.2 | |
| | | Eq. time, $4^h 59^m$: + 3 21.1 | |
| Watch time: $2^h 29^m 58^s$ | | | |
| C. - W.: 2 27 8 | | | |
| Chr. time: 4 57 6 | | | |
| Chr. corr'n: + 2 8 | | | |
| G. M. T. 18th: 4 59 14 | | | |
| Eq. of time: + 3 21 | | | |
| G. app. time: 5 2 35 | | | |
| D. R. long.: 2 21 4 W. (3) | | | |
| Ship's app. time, T : 2 41 31 (4) | | hav. T (or $24^h - T$) ¹ : 9.07596 | |
| D. R. lat.: $42^{\circ} 20'$ N. (9) | | cos lat.: 9.86879 | |
| Dec.: 23 24 S. (1) | | cos dec.: <u>9.96273</u> | |
| | | sum = hav. X : 8.90748 | |
| | | No. hav. X : 0.08082 (12) | |
| | | No. hav. (lat. | |
| Lat. - Dec.: 65 44 (10) | | - dec.): <u>0.29451</u> (11) | |
| Z: 75 34 (14) | | No. hav. Z 0.37533 (13) | |
| Comp'd alt.: 14 26 (15) | | | |
| Obs'd alt.: 14 30 (16) | | | |
| Diff.: 4 (17) | | | |
| Index No.: 5872 | | | |
| Azimuth: 217° | | | |
| Lat. diff.: $3'.2$ | | Dep.: 2.4 | |
| | | Long. diff.: $3'.2$ | |
| D. R. lat.: $42^{\circ} 20'$ N. (9) | | D. R. long.: $35^{\circ} 16'$ W. (3) | |
| Sumner pt. lat.: 42 17 N. (18) | | Sumner pt. long.: 35 19 W. (19) | |
| Azimuth of Sumner line: 307° (20) | | | |

¹ See footnote, p. 116.

When the object observed is a star (cf. p. 104) or planet, the choice between formulas (1) and (2), page 113, is not quite the same as in the case of a solar observation. We must use formula (1) if the star was on the east side of the sky when observed, which might be called a "forenoon" observation of the star; and we must use (2) if the star was on the west side of the sky, giving an "afternoon" star observation. The use of the remaining formulas (3) to (6) is the same as for the sun; but T is now no longer the ship's apparent time. Instead, it is the star's hour-angle (p. 104); to find it for use in formulas (1) and (2), and in Table 11, we must first calculate (p. 85) the Greenwich sidereal time corresponding to the G. M. T. of the observation, as taken from the chronometer, duly corrected for error and rate; and then use the following formulas:

(7) Greenwich hour-angle = Greenwich sidereal time - right ascension of star,

(8) $\left\{ \begin{array}{l} T = \text{Greenwich hour-angle} + \text{D. R. longitude, if east,} \\ T = \text{Greenwich hour-angle} - \text{D. R. longitude, if west.} \end{array} \right.$

As an application of the Sumner method to a star observation, let us take the observation of Sirius, Dec. 17, 1917, off Cape Agulhas, already treated as a time-sight (p. 105).

From the preliminary calculations there given, we have:

| | | |
|---|---|-----|
| Greenwich hour-angle, line (11), page 105 | 2 ^h 6 ^m 34 ^s | (1) |
| D. R. longitude (p. 105) is 20° 41' E., or by | | |
| Table 9 (p. 249) | 1 22 44 E. | (2) |
| By formula (8) above, we add (1) and (2), | | |
| giving T | 3 29 18 | (3) |

The star bore west¹ (p. 105) so we choose formula (2) (p. 113), and write:

| | | |
|--|----------------------|-----|
| cos lat. (p. 106, line 19), 35° 20' S. by D. R. | | |
| (see Table 4, p. 231) | 9.91158 | (4) |
| cos dec. (p. 106, line 12), - 16° 36' (Tab. 4, p. 212) | 9.98151 | (5) |
| hav. T , 3 ^h 29 ^m 18 ^s (line 3, above) (see Table 10, p. 263) | 9.28872 | (6) |
| Adding (4) to (6) gives, by formula (2), page 113, hav. X , | 9.18181 ² | (7) |

¹ See p. 116, footnote.

² Sum diminished by 20 (see footnote, p. 102).

Next we choose formula (3), page 113, since latitude and declination are both $-$. We have:

$$\text{By formula (3), lat. - dec.} = 35^{\circ} 20' - 16^{\circ} 36' = 18^{\circ} 44' \quad (8)$$

We now use formula (5), page 113. We have:

$$\text{No. hav. } 18^{\circ} 44' (8) \text{ (see Table 10, p. 254)} \dots\dots\dots 0.02649 \quad (9)$$

$$\text{No. hav. } X^1 (7) \text{ (see Table 10, p. 261)} \dots\dots\dots 0.15194 \quad (10)$$

$$\text{Adding (9) and (10) gives No. hav. } Z \dots\dots\dots 0.17843 \quad (11)$$

And Z , corresponding to (11) is found from

$$\text{Table 10, page 262} \dots\dots\dots 49^{\circ} 59' \quad (12)$$

Then, by formula (6), page 113,

$$\text{computed alt.} = 90^{\circ} - Z (12), \text{ or} \dots\dots\dots 40^{\circ} 1' \quad (13)$$

This computed altitude (13) must be compared with the observed altitude, fully corrected.

$$\text{This was (p. 106, line 18)} \dots\dots\dots 40^{\circ} 2' \quad (14)$$

$$\begin{aligned} \text{Difference between (13) and (14), in minutes, or dis-} \\ \text{tance of Sumner point from D. R. point in miles} \\ \text{(p. 113)} \dots\dots\dots 1 \text{ mile} \quad (15) \end{aligned}$$

Next we find the star's azimuth from Table 11, page 287.

The top argument for entering the table is T , line (3), and it must be found in the "afternoon" lines, since the star bore W . The argument for the left-hand column is the declination, line (5). Under T (p. 287), and opposite declination, we find (approximately) the tabular index number 7550. Then we find the computed altitude, 40° (13), in the right-hand column of the table (p. 289), and follow along its horizontal line until we again reach the index number 7550. The nearest to 7550 is 7544; and under this number, at the foot of the column, we find the two "afternoon" azimuths 260° and 280° .

These two numbers are so nearly equal that there is uncertainty in choosing between them. Had the observer taken the star's bearing by compass at the time of observation (p. 115), the uncertainty would be removed. But in the absence of this information, we must have recourse to Table 12 (p. 290), the auxiliary azimuth table. Entering this table with the pair of arguments of the present

¹ No. hav. here obtained from hav. without finding the angle X (p. 117, footnote).

problem: viz. latitude 35° , declination 17° , we find the auxiliary angle 31° . The computed altitude (13) being 40° , is greater than the auxiliary angle, and the latitude is —. Therefore, by the instructions (p. 115), the azimuth is *not* between 90° and 270° . We therefore choose 280° as our final azimuth, since 260° , the other possible value, is in the prohibited area between 90° and 270° .

The computed altitude (13) being less than the observed altitude, this observation places the Sumner point 1 mile (15) from the D. R. point, and bearing from it 280° , the same as the sun's azimuth (p. 113). The traverse table (p. 156) gives, for distance 1 and course 280° , latitude 0.2, departure 1.0. The longitude difference, by Table 2 (p. 172), is $1'.2$, for the departure 1.0. Therefore, since azimuth 280° indicates on the compass card that the Sumner point is W. and N. of the D. R. point, we have:

$$\text{lat. of Sumner point} = -35^\circ 20' (4) + 0'.2 = -35^\circ 20' \quad (16)$$

$$\text{long. of Sumner point} = 20^\circ 41' \text{ E. } (2) - 1'.2 = 20^\circ 40' \text{ E. } (17)$$

The bearing of the Sumner line will be 90° greater than the star's azimuth (p. 111); so we have:

$$\begin{aligned} \text{Bearing of Sumner line} &= 280^\circ + 90^\circ = 370^\circ; \text{ or,} \\ &\text{dropping } 360^\circ = 10^\circ \end{aligned} \quad (18)$$

The foregoing calculation of the Sumner point from a star observation can of course also be put in condensed form. In doing so, we have repeated certain numbers from page 107 without references in parentheses. But numbers taken from the extended calculation just given have their reference numbers attached.

This condensed form, like the others previously given, is the form of calculation which would be used in actual navigation. It is most important, in the interest of numerical accuracy, to make all calculations upon forms; and no numbers should be written on the forms without having an adjoining statement as to the meaning of the numbers.

SUMNER LINE, CONDENSED FORM. STAR

| | | |
|----------------------|---|--------------------|
| Watch time: | 16 ^h 29 ^m 48 ^s | |
| C. - W.: | - 1 23 50 | |
| Chr. time: | 15 5 58 | |
| Chr. corr'n: | - 2 28 | Obs'd alt.: 40° 3' |
| G. M. T.: | 15 3 30 | Index: + 5 |
| R. A. mean sun: | 17 42 10 | Table 6: - 1 |
| Corr'n, past noon: | 2 28 | Table 7: - 5 |
| Greenw'h sid. time: | 8 48 8 | Corr'd alt.: 40 2 |
| R. A. of Sirius: | 6 41 34 | |
| Greenw'h hour-angle: | 2 6 34 | |
| D. R. long.: | 1 22 44 E. (2) | |
| T: | 3 29 18 (3) | |

| | | | | | |
|------------------------------------|--|-----------|-----------------|--------------|------|
| T or $(24^h - T)$ ¹ : | 3 ^h 29 ^m 18 ^s (3) | hav.: | 9.28872 | (6) | |
| Dec.: | - 16° 36' | cos: | 9.98151 | (5) | |
| D. R. lat.: | - 35 20 | cos: | 9.91158 | (4) | |
| Sum of 3 = hav. X : | | | 9.18181 | (7) | |
| No. hav. X : | | | 0.15194 | (10) | |
| Lat. - Dec.: | 18° 44' (8); | No. hav.: | 0.02649 | (9) | |
| Sum of 2 = No. hav. Z : | | | 0.17843 | (11) | |
| Z : | | | 49° 59' | (12) | |
| Computed alt. = 90° - Z : | | | 40 1 | (13) | |
| Obs'd alt., corr'd: | | | 40 2 | (14) | |
| Diff.: | | | 1 | (15) | |
| Index No.: | 7550 | | | | |
| Azimuth: | 280° | | | | |
| Lat. diff.: | 0'.2 | Dep.: | 1.0 | Long. diff.: | 1'.2 |
| Sumner pt. lat.: | - 35° 20' (16); | long.: | 20° 40' E. (17) | | |
| Bearing of Sumner line: | 10° (18) | | | | |

We have now, in the foregoing examples, illustrated the manner of determining a Sumner line completely by ascertaining the latitude and longitude of one point on the line (the Sumner point), and the bearing of the line itself at that point. It may be desired to draw the line on the chart, which will always interest the navigator if he is near the coast and has a large-scale chart. To draw it, we merely locate the Sumner point on the chart by its latitude and longi-

¹ See footnote, p. 116.

tude, and then draw the line through the point so that it will make with the meridian an angle equal to the bearing which has been computed for the line. The Sumner line should be extended in *both* directions from the Sumner point, for any convenient distance, in such a way that the point will be near the middle of the line.

We can now gain a better understanding as to Sumner navigation by comparing the results obtained in one of the foregoing examples with the corresponding calculation of the same example as a time-sight. Thus from the same observation (pp. 104, 119)

AS A TIME-SIGHT

From D. R. latitude $42^{\circ} 20' N.$;
D. R. longitude $35^{\circ} 16' W.$, we
found the ship's longitude to be
 $35^{\circ} 24' W.$

AS A SUMNER OBSERVATION

From D. R. latitude $42^{\circ} 20' N.$;
D. R. longitude $35^{\circ} 16' W.$, we
found the Sumner point to be
in latitude $42^{\circ} 17'$; longitude 35°
 $19' W.$; and azimuth of Sumner
line, 307° .

Starting with the same observed altitude, and the same D. R. position of the ship, we get quite different results by the two methods of calculation. The time-sight gives us nothing but a longitude; and it will be the correct ship's longitude only if the D. R. latitude was also correct (p. 101). Therefore the time-sight calculation leaves us with *both* latitude and longitude still affected by possible errors in the D. R. latitude.

On the other hand, the Sumner calculation gives us both a latitude and a longitude, but neither belongs to the ship's position. They both belong to the position of the Sumner point, but they are free from the effects of any D. R. errors. They fix the Sumner point only, but they fix it *correctly*. Furthermore, our knowledge that the ship is somewhere on the Sumner line is also a fact, free from error. So what we learn from the Sumner method is sure; what we get by the older methods is all really D. R. information in some

degree. The Sumner method is independent of D. R., an advantage of which the value cannot be estimated too highly.

Furthermore, it can be shown mathematically (cf. p. 111) that a single observation can never really do more than determine a line on which the ship must be. Even a noon-sight does no more than this; for in determining the ship's latitude, it really only makes known a horizontal line (the ship's latitude parallel) on the chart. In other words, for a noon-sight the Sumner line is horizontal, or has a bearing of 90° . And it will always come out 90° , if a noon-sight is worked as a Sumner observation.

But the principal purpose of our present comparison of the two methods of calculation is to warn the navigator against falling into the error of imagining the ship to be at the Sumner point. The observation does no more than tell us where the Sumner point is, and that the ship is somewhere on the line; so far as the observation is concerned, all points on the line are equally likely to be the ship's true position. Therefore it is misleading to call the Sumner point the ship's "most probable position." Were it so, a second observation, made later in the day, would give another "most probable position" of the ship. We should then be naturally led to take as the ship's final location a point midway between the two "most probables," ascribing their divergence to possible errors of observation. But the ship's real position we already know (p. 111) to be at the *intersection* of the two Sumner lines resulting from the two observations. And this intersecting point may be many miles from both "most probables," and from the above-mentioned midpoint between them.

Less than two observations cannot fix the ship's position completely; when two have been made, a correct application of the Sumner method requires that the intersection point of two Sumner lines be determined by calculation. But before explaining the method of doing this, we must describe an excellent alternative way of making Sumner

calculations such as we have given in the above examples. The results are the same results as before, but they are obtained with less work, and quite without logarithms, by means of special tables such as our Table 13 (p. 292),¹ which we shall call Kelvin's Sumner Line Table.

This table has a pair of arguments (p. 11), a and b , a appearing at the heads of the tabular columns, and b in the left-hand column of each page. Corresponding to these two arguments, the table gives two angles, K and Q ; so that whenever a and b are given we can find the corresponding K and Q ; or, if a and K should be given, we can find the corresponding b and Q .

In the Sumner problem we obtain, by preparatory calculation (cf. pp. 119, 123), the following data :

Declination of sun (or star); D. R. latitude; D. R. longitude; T , the ship's apparent time of the observation for the sun, or the hour-angle for a star;

and we wish to get the computed altitude and the azimuth.

The principle on which Table 13 depends is that the D. R. latitude and longitude being always somewhat uncertain, we can, if we choose, change them by reasonable amounts before beginning our calculations. The Sumner point will then be determined by its distance and bearing from the *changed* D. R. point, instead of the original D. R. point. By this device the tabular calculation is much facilitated. The use of the table is easy after a little practice, the work being divided into a series of separate operations. In describing these operations we have used small subscript numbers, to distinguish the several arguments, etc.; as, for instance, in Operation 1 we use a_1 , b_1 , K_1 .

¹ These tables were first published by Lord Kelvin in 1876. More extended ones were recently issued by Lieutenant de Aquino, of the Brazilian Navy; and these were reprinted by the Hydrographic Office, United States Navy, in 1917. Aquino also improved Kelvin's method of using his table.

OPERATION 1, requiring no interpolation. Enter Table 13 with:

Arg. a_1 = declination, taken without regard to + or - sign, and correct to the nearest whole degree only;

Arg. b_1 = T , if T is between 0^h and 6^h ;

= $12^h - T$, if T is between 6^h and 12^h ;

= $T - 12^h$, if T is between 12^h and 18^h ;

= $24^h - T$, if T is between 18^h and 24^h ;

and before use b_1 must be turned into degrees with Table 9 (p. 249). It need be correct to the nearest degree only. This proceeding will make b_1 always less than 90° .

Then take from the table the tabular angle K_1 , also correct to the nearest degree only.

OPERATION 2, requiring simple interpolation. Enter the table a second time with:

Arg. a_2 = the K_1 , obtained in Operation 1.

Then, under this a_2 , run down the K -column until you find the declination (taken without regard to + or - sign); so that, in other words, K_2 = declination.

Take from the table the angle Q_2 , which stands next to the declination K_2 , and also the b_2 , which is in the left-hand argument column, in the same horizontal line with the declination K_2 in the K -column. It will rarely be possible to find the declination (which must this time be exact to the nearest minute) in the K -column; so that a simple interpolation will be necessary in getting Q_2 and b_2 . An example of this interpolation will be found on page 129; and, as we shall see, it is practically the only numerical calculation required in the whole problem. The Kelvin method is very much shorter than it looks.

The angle Q_2 is used in choosing the longitude of the "changed D. R. point"; the latitude of that point will be found in Operation 3. To utilize Q_2 for a sun observation, calculate the Greenwich apparent time (G. A. T.) of the

observation, as on page 102, line (8), and turn it into degrees with Table 9 (page 249). Then:

- (1) W. long. of changed D. R. point = G. A. T. - Q_2 , if, in Operation 1, T was less than 6^h ;
- (2) W. long. of changed D. R. point = G. A. T. - $(180^\circ - Q_2)$ if, in Operation 1, T was between 6^h and 12^h ;
- (3) W. long. of changed D. R. point = G. A. T. - $(180^\circ + Q_2)$ if, in Operation 1, T was between 12^h and 18^h ;
- (4) W. long. of changed D. R. point = G. A. T. - $(360^\circ - Q_2)$ if, in Operation 1, T was between 18^h and 24^h .

When the subtractions in these formulas cannot be made, the G. A. T. may be increased by 360° ; and when the west longitude comes out greater than 180° , subtract it from 360° , and call it east longitude.

In the case of a star, we must use, in the above formulas, the Greenwich hour-angle, instead of the G. A. T. See page 105, line (11), for the method of obtaining it.

OPERATION 3, requiring no interpolation. Enter the table a third time with:

Arg. $a_3 = K_1$, again as obtained in Operation 1.

- (5) Arg. $b_3 = 90^\circ - (b_2 + \text{changed D. R. lat.})$, if latitude and declination are of opposite signs, one + and one -;
- (6) Arg. $b_3 = (b_2 + \text{changed D. R. lat.}) - 90^\circ$, if T was between 90° and 270° ;
- (7) Arg. $b_3 = 90^\circ - (b_2 - \text{changed D. R. lat.})$, if latitude is less than b_2 ;
- (8) Arg. $b_3 = 90^\circ + (b_2 - \text{changed D. R. lat.})$, if latitude is greater than b_2 .

In choosing among formulas (5) to (8), give them precedence in order; do not use (7) or (8) if the conditions stated for (5) or (6) are satisfied. And at this point, use your privilege of choosing any reasonable changed D. R. latitude for the ship; and choose one that differs as little as possible from the original D. R. latitude, and that yet makes b_3 a whole number of degrees. In this way, all further

interpolation is avoided. Having once chosen among the formulas, the latitude is used without regard to + or - signs.

To complete Operation 3, having entered the table with the pair of arguments a_3 and b_3 , take out the tabular K_3 and Q_3 .

K_3 is now the computed altitude, to be used (p. 113) in locating the Sumner point from the changed D. R. point; and Q_3 is the sun's true azimuth, which will always come from the table less than 90° . If the ship is in the northern hemisphere, this azimuth must be counted from the north point of the horizon if, in Operation 3, we used formulas (6) or (7); or from the south point of the horizon, if we used formulas (5) or (8). With the ship in the southern hemisphere, interchange the north and south points of the horizon in these directions. And in both hemispheres, the azimuth will of course be counted toward the east or west, according as the observation was a "forenoon" or "afternoon" one (cf. p. 120).

We shall now use Table 13 for the example given on page 119 in condensed form. We have (p. 127):

OPERATION 1.

$a_1 = \text{dec.} = 23^\circ$, p. 119, line (1), to the nearest degree;

$b_1 = T = 2^h 41^m 31^s$, p. 119, line (4) = 40° , to the nearest degree; and, with a_1 and b_1 as arguments, Table 13 gives (p. 298): $K_1 = 36^\circ$, to the nearest degree.

OPERATION 2.

$$a_2 = K_1 = 36^\circ.$$

$$K_2 = 23^\circ 24', \text{ p. 119, line (1)}$$

and, with a_2 and K_2 , we must find Q_2 and b_2 . Running down the column headed $a = 36^\circ$ (p. 302), we find:

$$\text{When } K_2 = 23^\circ 5', Q_2 = 39^\circ 43', b_2 = 29^\circ,$$

$$\text{When } K_2 = 23^\circ 51', Q_2 = 40^\circ 0', b_2 = 30^\circ.$$

We wish to interpolate for $K_2 = 23^\circ 24'$, which is $19'$ down from $23^\circ 5'$ toward $23^\circ 51'$. The whole distance from

$23^{\circ} 5'$ to $23^{\circ} 51'$ is $46'$. Therefore we must interpolate down $\frac{1}{8}$ of the whole interval from $Q_2 = 39^{\circ} 43'$ to $Q_2 = 40^{\circ} 0'$. The difference between these two Q_2 's is $17'$; therefore the final Q_2 , belonging to $K_2 = 23^{\circ} 24'$, is $39^{\circ} 43' + \frac{1}{8} \times 17' = 39^{\circ} 43' + 7' = 39^{\circ} 50'$. Similarly, the difference between the two b_2 's being $60'$, the final value of b_2 , for $K_2 = 23^{\circ} 24'$, is $29^{\circ} + \frac{1}{8} \times 60' = 29^{\circ} 25'$. These two little interpolations are *practically all the calculation* required in the whole problem.

To find the longitude of the changed D. R. point from the above $Q_2 = 39^{\circ} 50'$, we take from page 102, line (8),

| | |
|---|------------------|
| Greenwich apparent time of observation, | $5^h 2^m 35^s$ |
| which, by Table 9 (p. 249) is, | $75^{\circ} 39'$ |

We now use formula (1), page 128, because T , in Operation 1, was less than 6^h . We get :

$$\begin{aligned} \text{W. long. of ch'd D. R. pt.} &= \text{G. A. T.} - Q_2 = 75^{\circ} 39' - 39^{\circ} 50' \\ &= 35^{\circ} 49' \text{ W.} \end{aligned}$$

OPERATION 3.

$$a_3 = K_1 = 36^{\circ}.$$

The D. R. latitude is $+42^{\circ} 20'$ (p. 119, line (9)); and as the declination is $-$, we choose formula (5), page 128. This, *without* changing the D. R. latitude, would give $b_3 = 90^{\circ} - (b_2 + \text{D. R. lat.}) = 90^{\circ} - (29^{\circ} 25' + 42^{\circ} 20') = 90^{\circ} - 71^{\circ} 45'$; but by choosing a *changed* D. R. latitude of $42^{\circ} 35'$, we shall make b_3 a whole number of degrees. So we have :

$$b_3 = 90^{\circ} - (b_2 + \text{changed D. R. latitude}) = 90^{\circ} - (29^{\circ} 25' + 42^{\circ} 35') = 90^{\circ} - 72^{\circ} = 18^{\circ}.$$

Now we enter the table with the arguments $a_3 = 36^{\circ}$, and $b_3 = 18^{\circ}$, and obtain, without interpolation (p. 302) :

$$\begin{aligned} K_3 &= \text{computed altitude} = 14^{\circ} 29', \\ Q_3 &= \text{sun's true azimuth} = 37^{\circ} 22'. \end{aligned}$$

This azimuth must be counted from the south point of the horizon, since we used formula (5) in Operation 3; and

as the observation was an afternoon one, the correct azimuth will be S. $37^{\circ} 22'$ W. (cf. p. 19). Counted in the United States Navy way, from the north toward the east, and so around to 360° , the azimuth will be $217^{\circ} 22'$.

On page 119, we found: Computed altitude, $14^{\circ} 26'$; azimuth, 217° .

This computed altitude differs by $3'$ from the value just found by Table 13. The difference is due to our having changed the D. R. point.

From the changed D. R. point, in latitude $42^{\circ} 35'$ N.; longitude $35^{\circ} 49'$ W., we now calculate (see Condensed Form, next page) the position of the Sumner point to be: latitude $42^{\circ} 34'$ N.; longitude $35^{\circ} 50'$ W. The former position, as obtained on page 119, was: latitude $42^{\circ} 17'$ N.; longitude $35^{\circ} 19'$ W.

These two Sumner point positions should lie on the same Sumner line if the method of Table 13 gives correct results; and they will satisfy this test, if the bearing of a line joining them agrees with the azimuth of the Sumner line, which is $217^{\circ} + 90^{\circ} = 307^{\circ}$. From the two Sumner point positions we have: latitude difference = $17'$; longitude difference = $31'$; departure (Table 2, p. 174) = 23.0. The traverse table (p. 164) gives, for latitude 17, departure 23.0, the distance 28, course 307° . The agreement is perfect, and shows that the same Sumner line passes through both points, though they are 28 miles apart. This test also shows that the calculation may indicate *any* point on the Sumner line as *the* Sumner point, if the D. R. position of the ship is uncertain: and so we again call attention to the error of taking the calculated Sumner point as the ship's most probable position (cf. p. 125).

We now, as usual, repeat the above calculation by Table 13, in condensed form, and including the final determination of the position of the Sumner point from the changed D. R. point.

SUMNER LINE BY TABLE 13, CONDENSED FORM. SUN

[The following is taken from page 119.]

| | | | |
|---|--|--------------|-------------------------------------|
| Decl., 4 ^h : | - 23° 23' 7 | Eq. of time: | + 3 ^m 22 ^s .3 |
| H. D.: | 0.1 | H. D.: | 1.2 |
| Decl., 4 ^h 59 ^m : | - 23 24 | Eq. time: | + 3 21.1 |
| Watch time: | 2 ^h 29 ^m 58 ^s | Obs'd alt.: | 14° 19' |
| C. - W.: | 2 27 8 | Index: | + 4 |
| Chr. time: | 4 57 6 | Table 6: | + 12 |
| Chr. corr'n: | + 2 8 | Table 7: | - 5 |
| G. M. T.: | 4 59 14 | Corr'd alt.: | 14 30 |
| Eq. of time: | + 3 21 | D. R. lat.: | 42° 20' N. |
| G. app. time: | 5 2 35 | D. R. long.: | 35° 16' W. |
| D. R. long.: | 2 21 4 W. (3) | | |
| Ship's app. time, T: | 2 41 31 (4) | | |

[The following is calculated with Table 13.]

| | | | |
|---|---|------------------------------------|--|
| OPERATION 1 | | OPERATION 2 | |
| $a_1 = \text{dec.} = 23^\circ$ | | $a_2 = K_1 = 36^\circ$ | |
| $b_1 = T = 2^h 41^m 31^s(4)$ | | $K_2 = \text{dec.} = 23^\circ 24'$ | |
| | | Table 13, $Q_2 = 39^\circ 50'$ | |
| Table 13, $K_1 = 36^\circ$ | | Table 13, $b_2 = 29^\circ 25'$ | |
| | Greenwich app. time = 5 ^h 2 ^m 35 ^s | $= 75^\circ 39'$ | |
| By page 128, form. (1), W. long. of changed D. R. pt. = | G. A. T. - Q_2 | | |
| | $= 35^\circ 49' \text{ W.}$ | | |
| Lat. of changed D. R. pt. = | $42^\circ 35' \text{ N.}$ | | |

| | |
|---|------------------------------|
| OPERATION 3 | |
| $a_3 = K_1 = 36^\circ$ | |
| $b_3 = 90^\circ - (b_2 + \text{changed D. R. lat.}) = 18^\circ$ | |
| Table 13, $K_3 = \text{comp'd alt.}$ | $= 14^\circ 29'$ |
| Table 13, $Q_3 = \text{azimuth of sun}$ | $= 37^\circ 22'$ |
| or, by U. S. Navy | $= 217^\circ 22'$ |
| Azimuth of Sumner line | $= 217^\circ 22' + 90^\circ$ |
| | $= 307^\circ 22'$ |
| Dist. of Sumner pt. from changed | |
| D. R. pt. = corr'd obs'd alt. - comp'd alt. | $= 1'$ or 1 mile |
| Bearing of Sumner pt. from changed D. R. pt. = | 217° , |
| since comp'd alt. is less than obs'd alt. | |
| Dist. 1, on course 217° , gives lat. diff., 0'.8; dep., 0.6; long. diff., 0'.8 | |
| Lat. of Sumner pt. = lat. of ch'd D. R. pt. - lat. diff. = | $42^\circ 34' \text{ N.}$ |
| Long. of Sumner pt. = long. of ch'd D. R. pt. + long. diff. = | $35^\circ 50' \text{ W.}$ |

A practised navigator can make the above complete calculation in a few minutes, as there are no logs used; and any one can easily obtain the necessary practice at sea by simply forming the habit of working his sights both as time-sights and as Sumners. To illustrate the subject further, we now give, in condensed form, the Star Example of p. 123, worked by Table 13.

SUMNER LINE BY TABLE 13, CONDENSED FORM. STAR

[The following is taken from page 123.]

| | | | |
|----------------------|---|--------------------|---------|
| Watch time: | 16 ^h 29 ^m 48 ^s | Obs'd alt.: | 40° 3' |
| C. - W.: | - 1 23 50 | Index: | + 5 |
| Chr. time: | 15 5 58 | Table 6: | - 1 |
| Chr. corr'n: | - 2 28 | Table 7: | - 5 |
| G. M. T.: | 15 3 30 | Corr'd obs'd alt.: | 40 2 |
| R. A. mean sun: | 17 42 10 | | |
| Corr'n, past noon: | 2 28 | Dec. of Sirius: | - 16 36 |
| Greenwich sid. time: | 8 48 8 | D. R. lat.: | - 35 20 |
| R. A. of Sirius: | 6 41 34 | | |
| Green. hour-angle: | 2 6 34 | | |
| D. R. long.: | 1 22 44 E. | | |
| T': | 3 29 18 | | |

[The following is calculated with Table 13.]

| OPERATION 1 | | OPERATION 2 | |
|--------------------------------|---|------------------------------------|--|
| $a_1 = \text{dec.} = 17^\circ$ | | $a_2 = K_1 = 49^\circ$ | |
| $b_1 = T' = 3^h 29^m 18^s$ | | $K_2 = \text{dec.} = 16^\circ 36'$ | |
| Table 13, $K_1 = 49^\circ$ | | Table 13, $Q_2 = 51^\circ 57'$ | |
| | | Table 13, $b_2 = 25^\circ 49'$ | |
| | By page 128, form. (1), | | |
| | W. long. of changed D. R. pt. = Green. hour-angle - Q_2^1 | | |
| | | = 339° 41' | |
| | | = 20° 19' E. | |
| | Lat. of changed D. R. pt. = - 35° 49' | | |

OPERATION 3

| | | |
|---|--|--|
| | $a_3 = K_1 = 49^\circ$ | |
| By form. (8), page 128, $b_3 = 90^\circ + (b_2 - \text{changed D. R. lat.}) = 80^\circ$ | | |
| Table 13, $K_3 = \text{comp'd alt.} = 40^\circ 15'$ | | |
| Table 13, $Q_3 = \text{az. of Sirius} = \text{N. } 81^\circ 25' \text{ W.}$ | | |
| | or, by U. S. Navy = 278° 35' | |
| | Az. of Sumner line = 368° 35', or 8° 35' | |

Dist. of Sumner pt. from changed
 D. R. pt. = corr'd obs'd alt. - comp'd alt. = - 13' or 13 miles
 Bearing of Sumner pt. from changed D. R. pt. = 99°,
 since comp'd alt. is greater than obs'd alt.
 Dist. 13, on course 99°, gives lat. diff., 2'.0; dep., 12.8; long. diff., 15'.9
 Lat. of Sumner pt. = lat. of ch'd D. R. pt. + lat. diff. = - 35° 51'
 Long. of Sumner pt. = long. of ch'd D. R. pt. + long. diff. = 20° 35' E.

To complete this part of our subject, it remains to show how the position of the ship can be found at the intersection of two Sumner lines (pp. 111, 125) resulting from two different observations. Figure 18 explains the nature of the problem; and it is almost exactly the same figure and

¹ Q_2 being larger than the Greenwich hour-angle, the latter was increased by 360°, to make the subtraction possible (p. 128).

problem treated in Chapter V, when we discussed fixing a ship's position by means of "bearings from the bow" (p. 54).

The two Sumner lines in Fig. 18 are SL and $S'L$, passing through the two Sumner points S and S' , whose latitudes and longitudes are known by calculation from the observed altitudes. The bearings or azimuths of the two Sumner lines from the north are the two angles NSL and $N'S'L$, which are also known from the previous calculations. It is now required to find the latitude and longitude of the intersection point L , where the ship is situated.

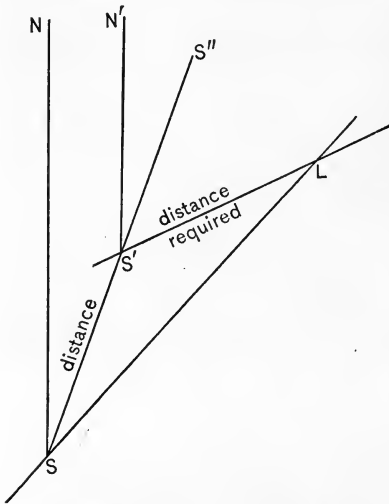


FIG. 18.—Intersection of Sumner Lines.

The similarity of this problem to the former one in Chapter V becomes plain, if we imagine a second ship sailing from one Sumner point to the other, as from S to S' , and taking bearings from her bow upon *our* ship, located at L . These bearings will be the two angles $S'SL$ and $S''S'L$. If the second of these angles should happen to be just twice as big as the first, the distance $S'L$ between the two ships at the time of the second bearing would be equal (p. 54) to the distance SS' run by the imagined ship between the two observations.

This would enable us to fix the position of the imagined ship at S' , if L were a lighthouse ashore. But if L is our ship, and S' a Sumner point of known position, the same observations of bow bearings would fix the position of our ship at L . Nor is it necessary (or possible) to measure

such imaginary bearings, or read the patent log to get the distance run by an imagined ship.

For the distance and bearing of the second Sumner point from the first can be obtained from their known latitudes and longitudes with the traverse table. Thus the line SS' (marked "distance") and the bearing (or course) angle NSS' become known. Furthermore, the "bow bearing" at S is the angle $S'SL$, and it is equal to the difference $NSL - NSS'$. We have just seen that NSS' is obtained from the traverse table; and NSL is the calculated azimuth of the Sumner line through S . In a similar way we get the other "bow bearing" $S''S'L$. If this were twice the first one, the "required distance" $S'L$ in the figure would be equal to the known distance SS' between the two Sumner points. If not, it can be easily shown mathematically that:

- (1) Required distance = known distance \times a factor,
- (2) log factor = $\sin S'SL - \sin (S''S'L - S'SL)$.

By these simple formulas the required distance $S'L$ might be found: and as we also know the latitude and longitude of the Sumner point S' , and the azimuth or bearing of $S'L$, the traverse table will make known the latitude and longitude of the ship at L . It is to be noted also that as we are at liberty to call either of the Sumner points S' , it is desirable to call that one S' which has the larger "bow bearing," so that there will be no difficulty about subtracting $S'SL$ from $S''S'L$.

The factor of formula (2) above can practically always be found in our Table 14, the Sumner Intersection Table, without using logarithms. The pair of arguments of the table are the smaller "bow bearing" and the larger "bow bearing"; the tabular number is the factor of formula (1) above, and will always give the distance of the intersection point from that one of the two Sumner points for which the bow bearing was the larger.

And it should not be forgotten that the Sumner line really

extends equally in both directions (p. 124) from the Sumner point, whereas, in Fig. 18, we have extended it mainly in the direction of the intersection point L . Now the calculated azimuth of any Sumner line may be changed 180° at will, because the bearings of the two ends of the line from the Sumner point differ by 180° , and we may take the bearing of the line to be the bearing of either end from the Sumner point in the middle of the line. Figure 18 shows, however, that for the purpose of the present problem we must choose the bearing of that end of the line which is nearest the point of intersection L ; nor does the choice ever offer difficulty, because the known D. R. position of the ship at L , when compared with the known positions of the two Sumner points, will always indicate whether L bears east or west of either Sumner point, and also whether it bears north or south. And the bearing of L once chosen, we can always find either of the two bow bearings by this formula :

- (3) Bow bearing = bearing of Sumner line *minus* bearing of the second Sumner point S' from the first point S .

In using formula (3) it is allowable to increase the bearings of the Sumner lines by 360° , when necessary to make the subtractions possible, and if the formula brings out bow bearings larger than 180° , subtract them from 360° , and proceed as before.

It is also always desirable to draw a rough sketch for every intersection problem occurring on shipboard so as to guard against accidental large errors like 90° or 180° in obtaining the two bow bearings; and also to make sure that the latitude and longitude of the intersection point L are correctly computed with the traverse table.

The foregoing assumes that the ship did not move from the point L between the two sextant observations from which the two Sumner lines were calculated. This will rarely be the case, because it is very desirable that the two observations, if they are both sun observations, be separated by

three or four hours, if possible. The condition of an unmoving ship will occur only if she is a sailing vessel becalmed, or a steamer at anchor; or if the two observations are made at nearly the same time upon two different heavenly bodies, such as two stars.

High accuracy in the resulting "fix" (p. 53) of the ship will then be attained, if the azimuths of the two stars differ by about 90° at the time of observation. The same favorable condition will be secured if one of the observations is made upon a star near upper transit (pp. 89, 96), in the twilight just before sunrise or after sunset; and the other observation, at nearly the same time, upon the sun, when it is about 12° or 15° above the horizon.

But if the ship has traveled a considerable distance between the two observations, it is necessary to allow for such travel before calculating the intersection point. Suppose she has gone a distance D , upon a course C , by D. R., between the two observations. Then simply find from Tables 1 and 2 the difference of latitude and longitude corresponding to distance D and course C ; and apply them as corrections to the latitude and longitude of the Sumner point belonging to the first observation. Everything else, including the bearing of the first Sumner line, remaining unchanged, the calculation then proceeds by Table 14, just as if the ship had not moved. The computed intersection point is then the ship's position at the time of the second sextant observation.

We shall now work some intersection examples.

Suppose we have two Sumner lines, as shown in the rough sketch, Fig. 19, taken on board a ship becalmed. The two sextant observations give:

| FOR ONE SUMNER POINT, S | FOR THE OTHER POINT, S' |
|---------------------------------------|--------------------------------------|
| lat. ¹ : $42^\circ 34' N.$ | $42^\circ 50' N.$ |
| long.: $35^\circ 50' W.$ | $35^\circ 36' W.$ |
| bearing of Sumner line: 307° | 93° (changed to 273°) |

¹ As found on page 132.

The rough sketch, Fig. 19, having been made, and the two "bow bearings" marked with little circular arcs as shown, we call that one of the two Sumner points S' , which has the larger bow bearing; and, for the point S' , we change

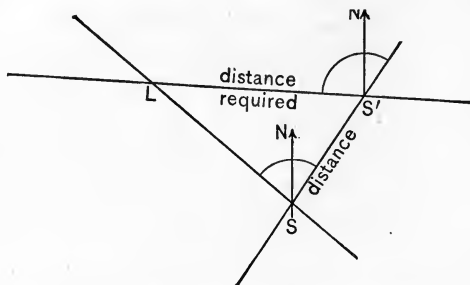


FIG. 19.—Rough Sketch of Sumner Intersection.

the bearing of the Sumner line from 93° to $180^\circ + 93^\circ = 273^\circ$, so as to count the bearing for that end of the line which is toward the intersection point L (p. 136). The other bearing, 307° , for the point S , is already correctly counted.

We now have, from the two Sumner point latitudes and longitudes: latitude difference = $16'$; longitude difference = $14'$; departure (Table 2, p. 174, for middle latitude 43°) = 10.2 ; and, for latitude difference = 16 , departure = 10.2 , we find (Table 1, p. 162), distance = 19 , course = 32° . The distance between the two Sumner points is therefore 19 miles, and the bearing of S' from S is 32° .

Now we apply formula (3), page 136, and find:

$$\text{Smaller bow bearing at } S = 307^\circ - 32^\circ = 275^\circ.$$

$$\text{Larger bow bearing at } S' = 273^\circ - 32^\circ = 241^\circ.$$

Being larger than 180° , these must be subtracted from 360° (p. 136), giving:

$$\text{Smaller bow bearing} = 85^\circ; \quad \text{Larger bow bearing} = 119^\circ.$$

Next we refer to Table 14, and find with the smaller bearing 85° , and the larger 119° the factor 1.78 (p. 322).

According to formula (1), page 135, we then have:

$$\begin{aligned} \text{Required distance } LS' &= \text{distance } SS' \times \text{factor} \\ &= 19 \times 1.78 = 33.8 \text{ miles.} \end{aligned}$$

Therefore the position of the ship at L is distant 33.8 miles from S' , and she bears 273° . With this distance and bearing or course angle, the traverse table (p. 154) gives: latitude = 1.8, departure = 33.8. For the departure 33.8, Table 2 gives, for the middle latitude 43° (p. 174), difference longitude = $46'.2$. The bearing 273° showing that the intersection point L is N. and W. of S' , we have:

$$\begin{aligned} \text{Latitude of ship at } L &= 42^\circ 50' \text{ N.} + 1'.8 = 42^\circ 51'.8 \text{ N.} \\ \text{Longitude of ship at } L &= 35^\circ 36' \text{ W.} + 46'.2 = 36^\circ 22' \text{ W.} \end{aligned}$$

As a second example take the following two Sumner lines, as shown in the rough sketch, Fig. 20. The two sextant observations give:

FOR ONE SUMNER POINT, S

$$\begin{aligned} \text{lat. : } &14^\circ 26' \text{ N.} \\ \text{long. : } &77^\circ 8' \text{ W.} \\ \text{bearing of line : } &53^\circ \end{aligned}$$

FOR THE OTHER POINT, S'

$$\begin{aligned} &15^\circ 30' \text{ N.} \\ &76^\circ 22'.5 \text{ W.} \\ &135^\circ \end{aligned}$$

And suppose the ship, in the interval between the two sextant observations, has traveled a distance $D = 31$ miles, on course $C = 205^\circ$. We must begin (p. 137) by shifting the first Sumner point S a distance D , on the course C . For this course and distance, we have (Table 1, p. 160): lat., $28'.1$; dep., 13.1 ; diff. long., $13'.5$ (Table 2, p. 168).

Therefore, the latitude and longitude of the first Sumner point must be corrected (p. 137) as follows:

$$\begin{aligned} \text{For the point } S, \text{ lat.} &= 14^\circ 26' \text{ N.} - 28'.1 = 13^\circ 58' \text{ N.} \\ \text{long.} &= 77^\circ 8' \text{ W.} + 13'.5 = 77^\circ 21'.5 \text{ W.} \end{aligned}$$

Bearing (unchanged) = 53° .

We now have, for the two Sumner points: lat. diff., $92'$;

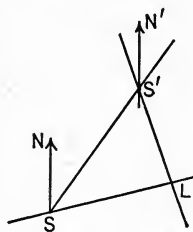


FIG. 20.—Rough Sketch of Sumner Intersection.

long. diff., 59'; dep., 57.0 (p. 169); dist., 108 miles (p. 162); bearing of S' from S , 32° .

Now we have, by formula (3), page 136 :

Smaller bow bearing at $S = 53^\circ - 32^\circ = 21^\circ$.

Larger bow bearing at $S' = 135^\circ - 32^\circ = 103^\circ$.

Table 14 (p. 319) gives the factor 0.36; so that the ship at L is distant from S' $108 \times .36 = 38.9$ miles, and bears 135° . For this distance and bearing we have (Table 1, p. 166), latitude = $27'.6$; departure = 27.6 ; and longitude difference (Table 2, p. 168) = $28'.6$. Finally, then, at the time of the second sextant observation, the ship at L was in latitude $15^\circ 30' \text{ N.} - 27'.6 = 15^\circ 2'.4 \text{ N.}$; and in longitude $76^\circ 22'.5 \text{ W.} - 28'.6 = 75^\circ 54' \text{ W.}$

CHAPTER X

A NAVIGATOR'S DAY AT SEA

THE present chapter contains a number of examples by means of which the reader can gain facility in the use of the methods set forth in the preceding pages.

The steam yacht *Nav* is bound from New York to Colon, and the captain plans to take his departure from the Sandy Hook Lightship, on Dec. 18, 1917, as early as possible in the morning.

The first bit of navigation, to be accomplished before the yacht leaves her anchorage in the "Horseshoe," is to ascertain by D. R. methods the proper course to steer from Sandy Hook. A glance at the track chart of the north Atlantic shows that she must go by way of Crooked Island Passage, and the Windward Passage between Cuba and Haiti. It is also apparent from the chart that the first land to be sighted among the islands is Watlings Island, and that the proper course should pass to the eastward of it.

The position of Sandy Hook Lightship¹ is lat. $40^{\circ} 28' N.$; long. $73^{\circ} 50' W.$ Hinchinbroke Rock, at the southern end of Watlings Island, is in lat. $23^{\circ} 57' N.$; long. $74^{\circ} 28' W.$ But the course should be shaped for a point about 12 miles east of Watlings Island, to be perfectly safe. The position of such a point is (approximately) lat. $23^{\circ} 57' N.$; long. $74^{\circ} 15' W.$ ²

¹ There is an excellent list of latitudes and longitudes in Bowditch's "Navigator."

² The difference between this longitude and that of Hinchinbroke Rock is 13'; but 13' here corresponds to about 12 miles, on account of Table 2.

ABSTRACT OF LOG. Steam Yacht *Nav*, Dec. 18, 1917

| | PATENT LOG | COMPASS COURSE | TRUE COURSE |
|---|---------------|-------------------|----------------|
| 7:02 A.M. Took departure from Sandy Hook Lightship..... | 26.2 | S. | 188° |
| 7:21 Sunrise, observed azimuth | 31.0 | S. | 188° |
| 8:00 | 41.0 | S. | 188° |
| 9:00 | 57.2 | S. | 188° |
| 9:36 Bow bearing, Barnegat.... | 67.0 | S. | 188° |
| 9:42 Altitude and azimuth..... | 69.1 | S. | 188° |
| 9:57 Beam bearing, Barnegat... (fix, lat. 39° 45' N.; long. 73° 59' W.) | 72.5 | S. | 188° |
| 10:00 | 73.4 | S. | 188° |
| 10:07 Changed course..... | 75.3 | S.½E. | 182° |
| 11:00 | 88.7 | S.½E. | 182° |
| 11:42 Ex-mer. obs'n lat. 39° 19'; D. R. long. 73° 58'..... | 98.5 | S.½E. | 182° |
| 12:00 | 102.6 | S.½E. | 182° |
| 1:00 P.M. | 117.7 | S.½E. | 182° |
| 2:00 | 133.0 | S.½E. | 182° |
| 3:00 | 149.0 | S.½E. | 182° |
| 4:00 | 163.8 | S.½E. | 182° |
| 4:12 Alt. and az., fix, lat. 38° 11'; long. 73° 54'..... | 166.9 | S.½E. | 182° |
| 5:00 | 182.0 | S.½E. | 182° |
| 6:00 | 197.2 | S.¾E. | 182½° |

By the method of page 20, the course from Sandy Hook Lightship should be 181°, and the distance is 990 miles. These numbers, and all subsequent numbers in the present chapter, should be verified by the reader.

The distance being quite large, it is well to check it by the logarithmic method, page 33. The result by this method is: course 181° 14', distance 991.7 miles.

The chart also shows that this course will carry the yacht very near Barnegat Light, on the coast of New Jersey. The position of this light is lat. 39° 46' N.; long. 74° 6' W. The captain decides that it will be well to plan passing this light

at about 5 miles' distance. The position of a point 5 miles east of Barnegat Light is lat. $39^{\circ} 46' N.$, long. $73^{\circ} 59' W.$ The course and distance to this point from Sandy Hook Ship are 189° and 42.5 miles. This course is so nearly the same as the course to Watlings Island that the captain decides to steer the 189° course.

All this work must be complete before reaching Sandy Hook, for the course from the lightship must be ready for the quartermaster before the lightship is passed. And there is still more preliminary work. For the courses calculated above are true courses (p. 43) and the quartermaster must have the compass course, so that he may be able to steer the yacht. The method of calculating the compass course from the true course is given on page 48; and in applying it the captain must have his deviation tables at hand. We shall assume that the tables printed on pages 48 and 49 were the ones furnished by the compass adjuster for the present voyage.

An examination of the Atlantic track chart shows that in the vicinity of Sandy Hook, the variation, V , is $10^{\circ} W.$, or -10° . By formula (3) (p. 49), we then have, since the true course T is 189° :

$$\text{Magnetic course} = M = T - V = 189^{\circ} - (-10^{\circ}) = 199^{\circ}.$$

The second deviation table (p. 49) shows that when the magnetic course (or magnetic bearing of ship's head) is 199° , the deviation, D , is $+18^{\circ}$. Then, with $V = -10^{\circ}$, $D = 18^{\circ}$, formula (1), page 45, gives:

$$\text{Compass error} = E = V + D = -10^{\circ} + 18^{\circ} = +8^{\circ}.$$

And from formula (2), page 45:

$$\text{Compass course } C = T - E = 189^{\circ} - 8^{\circ} = 181^{\circ};$$

and so the yacht must be steered on a 181° compass course for Barnegat. But the quartermaster is to steer by "points" so that the course nearest the 181° course is due south. The captain decides to have the yacht steered due south by

compass, and is prepared to give the quartermaster his orders as soon as Sandy Hook Lightship shall be reached.

The foregoing preliminary work having been completed the previous day, the anchor is tripped at the Horseshoe about an hour before daylight on Dec. 18, the weather being fine, sea smooth, and wind light from the northwest. The lightship is reached and passed at 7:02 A.M., ship's time, civil reckoning, the ship then taking her departure. At that moment, the patent log is read, and found to register 26.2 miles. The quartermaster gets his orders to steer south; and *all* the above facts are duly recorded in the log-book. And at every hour thereafter, 8, 9, 10, etc., a similar record must be made in the log-book.

The next event is sunrise, which occurs at 7:21, very soon after leaving the lightship. The sun's compass bearing can then be very conveniently observed, and will furnish an excellent check on the compass adjuster. This observation was made at 7:21 A.M., ship's time, civil reckoning, corresponding to 19^h 21^m, Dec. 17, ship's apparent time, astronomic reckoning; and the sun's bearing or azimuth was 113° by compass. This was entered in the log-book, and at the same time the patent log was read, and found to be 31.0 miles.

To check the deviation table, the procedure was then as follows:

By patent log the yacht had proceeded from the lightship a distance of $31.0 - 26.2 = 4.8$ miles, on a compass course of 180°, or true course of 188°; by D. R., she had therefore reached the position lat. 40° 23' N.; long. 73° 51' W. The sun's declination, from the almanac, is - 23° 23', and the (approximate¹) *T* (p. 100) is 19^h 21^m. The sun's true azimuth is found from Table 11 to be 121°; and in using the table for this purpose take the altitude of the sun, for the

¹ If there is any chance of this *T* being much in error, the captain's watch, by which the observation is timed, must be compared with the chronometer. See p. 94.

moment of sunrise, to be 0° . The observed compass azimuth having been 113° , formula (2), page 45, gave $E = T - C = 121^\circ - 113^\circ = +8^\circ$. Then from formula (1), page 45, $D = E - V = +8^\circ - (-10^\circ) = +18^\circ$. As expected, this deviation agrees with the deviation table, which would not be likely to go wrong so soon after the beginning of a voyage.

At 8 A.M. the patent log read 41.0; and at 9 A.M., 57.2. The course was still S. by compass, or 188° , true course.

At 9:24 Barnegat Light was sighted by the lookout, and the mate was ordered to take bow-and-beam bearings (p. 55) upon it.

At 9:36, the light bore 225° by compass, or 45° from the bow; patent log, 67.0.

At $9^h 42^m 28^s$ by his watch the captain took the altitude of the sun's lower limb with the sextant, and found it to be $18^\circ 51'$. Index correction was $+3'$, and height of eye, 15 feet. C. - W. was $4^h 51^m 50^s$; and the chr. correction by the rate card was 4^s , slow. Patent log, 69.1. At 9:45 by the watch, the sun's azimuth was again observed with pelorus, and found to be 137° , compass bearing. It was intended to work a Sumner line from the altitude by Kelvin's table; and the pelorus observation was made because the sun's true azimuth always comes out as a by-product, when Kelvin's table is used, and so it is just as well to have another check on the deviation table. This is the peculiar advantage of Kelvin's table. Without any additional calculations, the compass is always checked up on the very course the ship is steering. This is just what the good navigator wants.

The observations could not be worked up at once, because the captain wished to see the result of the mate's bow-and-beam bearings. At 9:57 by the watch, Barnegat bore abeam, on the starboard hand, or 270° by compass, the yacht being still on the 180° compass course. Patent log now 72.5.

Between the bow-and-beam bearings the run by log was $72.5 - 67 = 5.5$ miles. Therefore the yacht is now 5.5 miles from Barnegat Light, and the compass bearing of the light is 270° . The compass error being $+ 8^\circ$, the true bearing of the light is 278° ; and the bearing of the yacht from the light is the former bearing reversed, or $278^\circ - 180^\circ = 98^\circ$, true. From this comes an accurate and complete position of the yacht. Barnegat Light is in lat. $39^\circ 46' N.$; long. $74^\circ 6' W.$ The yacht, 5.5 miles away on the bearing 98° , must, by traverse table, be in lat. $39^\circ 45' N.$; long. $73^\circ 59' W.$

At 10 A.M., the log was 73.4, course 188° , true.

Now the captain prepared to shape a new course to be followed from the Barnegat bow-and-beam bearing "fix" in the above lat. $39^\circ 45' N.$; long. $73^\circ 59' W.$, at 9:57.

Allowing ten minutes to work up the new course, the captain plans to change course at 10:07. At that time the ship, on her course of 188° , will be (at 15-knot speed) 2.5 S. and practically 0' W. of the Barnegat position. So the course will be changed when the yacht is in lat. $39^\circ 42' N.$; long. $73^\circ 59' W.$, at 10:07. The course and distance from there to the point 12 miles east of Hinchinbroke Rock are: distance, 945 miles; course, 181° , true, or 173° by compass.

Therefore, by the table on page 52, the quartermaster gets the new course S. $\frac{1}{2}$ E. by compass, at 10:07. This corresponds to 174° by compass, or 182° true course; and at 10:07, when the course was changed, the patent log read 75.3.

Now the Sumner line, from the observation at $9^h 42^m 28^s$ by the watch, was worked by Kelvin's table; and the result was:

Sumner point is in lat. $39^\circ 50' N.$; long. $73^\circ 56' W.$; bearing of Sumner line 237° .

It is necessary, as a check, to ascertain whether this Sumner line passes through the position obtained for the ship by the Barnegat bearings. Before doing this, the Sumner point must be shifted by the method of page 137, to allow for

the motion of the yacht between 9:42, when the sextant observation was made, and 9:57, when Barnegat bore abeam. The difference is 15 minutes, and in that time the ship moved south 3.4 miles by the patent log and an insignificant distance west.

Therefore the corrected Sumner data are :

Sumner point is in lat. $39^{\circ} 46'.6$ N. ; long. $73^{\circ} 56'$ W. ; bearing of Sumner line 237° .

If everything fits, this Sumner line must pass through the Barnegat "fix" of the yacht in lat. $39^{\circ} 45'$ N. ; long. $73^{\circ} 59'$ W., because the yacht must have been somewhere on the line.

The traverse table shows that the bearing of a line passing the Sumner point and the yacht's position is 235° , differing only 2° from the Sumner line bearing ; so this check is satisfactory. But a better way to check this matter is to determine the yacht's position from the intersection of two lines, one of which is the Sumner line, and the other the beam bearing of Barnegat Light. This can be done by the method of page 133. The data of the problem are :

Sumner point : lat. $39^{\circ} 46'.6$ N.
long. $73^{\circ} 56'$ W.

Line bears 237°

Barnegat Light : lat. $39^{\circ} 46'$ N.
long. $74^{\circ} 6'$ W.

Line bears 98°

We shall call Barnegat Light S' ; and then formula (3), page 136, gives, for the two bow bearings :

$$\text{At Sumner point, } S, 237^{\circ} - 266^{\circ} = 29^{\circ}.$$

$$\text{At Barnegat, } S', 98^{\circ} - 266^{\circ} = 168^{\circ}.$$

For these two bearings, Table 14 gives the factor 0.74, and the yacht is placed 6 miles from Barnegat, on the 98° bearing. The bow-and-beam observations gave 5.5 miles, so the check by the Sumner line is excellent.

It remains for the captain to utilize the azimuth observa-

tion made at 9:45. The bearing of the Sumner line was 237° , and therefore the sun's true azimuth was 147° . The observed azimuth, by pelorus (p. 145), was 137° . The compass error was therefore $+10^\circ$. The variation being -10° , the deviation by formula (1), page 45, is $D = 10^\circ - (-10^\circ) = +20^\circ$.

On page 143 we found that the deviation table made this deviation $+18^\circ$; so that the table appears to require a correction of $+2^\circ$. The captain decides not to correct the table for the present, unless later azimuth observations shall confirm it, especially as the sunrise observation showed the adjuster's results to be correct. Azimuth observations made when the sun is high in the sky are not quite as reliable as sunrise ones. Moreover, the observation was made at 9:45, whereas the altitude observation, for which the true azimuth was calculated with Kelvin's table, was made at 9:42, so that the true azimuth must have been in error by the sun's azimuth change in three minutes. This could have been avoided by giving the mate orders to observe the azimuth at about the same moment when the captain took the altitude. Or, the sun's azimuth change in three minutes might be taken from the azimuth table, and the computed true azimuth duly corrected.

At 11 the log read 88.7, and the course was $S.\frac{1}{2}E.$ by compass, or 182° , true.

At about 11:30, the weather showing signs of becoming thick, no preparations were made for a noon-sight by the method of page 86; and rather than take the risk of losing his noon observation altogether, the captain took an ex-meridian altitude at $11^h 42^m 0^s$ by his watch; log was 98.5; the sextant reading $26^\circ 55'$; index $+3'$; height of eye 15 ft.; C. - W. was now $4^h 51^m 42^s$; and chronometer slow 4^s .

The observation was worked by Kelvin's table, and gave the Sumner point in lat. $39^\circ 20' N.$; long. $73^\circ 40' W.$; bearing of Sumner line 86° . Figure 21 is a rough sketch of this Sumner line. It is very nearly horizontal; had the observation been

made at noon precisely, it would have been perfectly horizontal.

It would now have been possible to move up the Sumner line observed at 9:42, and obtain an intersection to fix the position of the yacht. But this did not seem necessary to the captain, because of the beam bearing obtained at Barnegat at 9:57, which gave a good fix.

And the present Sumner line being so nearly horizontal, it is not necessary to know the longitude very accurately to obtain an exact latitude. The longitude by D. R. is

sufficient, and it is $73^{\circ} 58' W$. The difference between this longitude and that of the Sumner point ($73^{\circ} 40'$) is $18'$; and the ship at *L* (fig. 21) bears $180^{\circ} + 86^{\circ} = 266^{\circ}$ from the Sumner point. Table 2 gives the dep. 14.0 for long. diff. $18'$, in lat. 39° . And for course 266° , dep. 14.0, we find in Table 1, lat. diff. $1'.0$, so the yacht's latitude is $1'$ less than that of the Sumner point, and is therefore $39^{\circ} 19'$. This happens to be in exact accord with the D. R. latitude, which was also $39^{\circ} 19'$. This was perfectly satisfactory, and the captain decided to carry this Sumner line forward for an intersection, in case he should obtain an observation in the afternoon.

At 12, the patent log read 102.6, course $S.\frac{1}{2}E.$, 182° true; D. R. lat. $39^{\circ} 15'$; long. $73^{\circ} 58'$; distance to Watlings Island 918 miles.

Had the yacht been on a course other than almost due south, it would have been necessary to set the watch and the

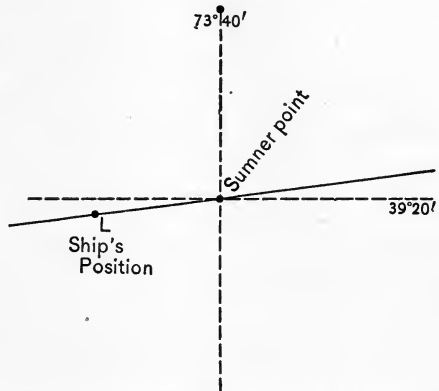


FIG. 21. — Sumner Line from ex-Meridian Observation.

cabin clock to ship's apparent time. In fact, some navigators set their watches to ship's apparent time before every observation (p. 94):

at 1, log read 117.7, misty,
 at 2, log read 133.0, misty,
 at 3, log read 149.0 misty,
 at 4, log read 163.8, clearing.

At $4^h 12^m 18^s$ by the watch, the weather having cleared, the altitude of the sun was found to be $4^\circ 38'$; index $+ 4'$; eye 15 ft.; C. - W. $4^h 51^m 50^s$; chronometer slow 4^s ; log 166.9. Sun's azimuth, observed by the mate at the same time, came out 224° by compass.

This observation was worked for a Sumner line by the Kelvin table, and gave:

Position of Sumner point lat. $38^\circ 6' N.$; long. $73^\circ 49' W.$; bearing of line 145° ; azimuth of sun 235° .

The Sumner line obtained at $11^h 42^m 0^s$ was brought up to the time of the present observation by D. R. (p. 137), giving:

position of 11:42 Sumner point, after moving it, lat. $38^\circ 12' N.$; long. $73^\circ 43' W.$; bearing of the line 86° . Both lines were then sketched, as shown in Fig. 22. The point S is the (moved) Sumner point from the 11:42 observation, S'

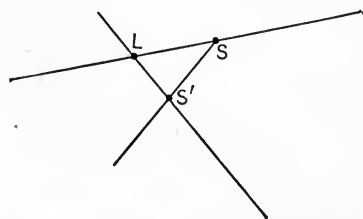


FIG. 22. — Rough Sketch of Sumner Line Intersection.

that from the 4:12 observation. The intersection point L is the position of the ship at 4:12, and it came out (p. 134): lat. $38^\circ 11' N.$; long. $73^\circ 43' W.$ The position brought up by D. R. from 11:42 was: lat. $38^\circ 11'$; long. $74^\circ 1'$; so that there has been an easterly set of the current, amounting to 7' of longitude in $4\frac{1}{2}$ hours. The sun's true azimuth at 4:12 was 235° , from the Kelvin table; and the pelorus observation gave 224° . The compass error was therefore

+ 11°. The variation being $- 10^\circ$, the deviation must be $D = 11^\circ - (- 10^\circ) = + 21^\circ$. The deviation table made this deviation + 18°, so that table seems to require a correction of + 3°. The pelorus observation of 9 : 45 gave a correction of + 2° for the deviation table; and as this is now apparently confirmed, the captain decides to examine the chart again, before finally shaping course for the night, to see if the yacht has not perhaps moved into a region where the variation is different from the Sandy Hook variation so far used.

At 5 the log read 182.0, course was still 182° true.

The captain now prepared to shape the course for the night, and to change his course, if necessary, at 6 : 00. His first step was to obtain the D. R. position at 6 : 00, starting from the observed position at 4 : 12. This gave position at 6 : 00, by D. R. : lat. $37^\circ 41'$; long. $73^\circ 55'$. The easterly current¹ of about 2' per hour set the yacht farther east about 3' between 4 : 12 and 6 : 00. Therefore he took the D. R. position at 6 : 00 to be lat. $37^\circ 41'$; long. $73^\circ 52'$. The position of the point of destination, 12 miles east of Watlings Island, is still : lat. $23^\circ 57'$; long. $74^\circ 15'$. The true course and distance to that point from the yacht's 6 : 00 position is therefore, by traverse table : course $181\frac{1}{2}^\circ$; dist. 824 miles.

A further examination of the track chart shows that the variation, which was $- 10^\circ$ at Sandy Hook, is now $- 8^\circ$. The compass error, from the last pelorus observation, was + 11°. Consequently, by the pelorus observation, the compass course for the night should be $181\frac{1}{2}^\circ - 11^\circ = 170\frac{1}{2}^\circ$, or S. $\frac{3}{4}$ E. (see the Table on p. 52). Furthermore, the variation being now $- 8^\circ$ and the error + 11° makes the deviation $D = E - V = + 11^\circ - (- 8^\circ) = + 19^\circ$. The compass adjuster's deviation of + 18° is therefore vindicated, and the compass course S. $\frac{3}{4}$ E. can be set for the night.

At 6 the log read 197.2, course S. $\frac{3}{4}$ E., or $182\frac{1}{2}^\circ$ true.

¹ Doubtless the Gulf Stream.

In conclusion, the captain of the *Nav* hopes he has been able to make his imagined proceedings clear enough to help the young navigator in planning his own first day's work at sea. May it be the first of many happy and successful days. And let him not forget, when attempting to verify the various calculations and problems of the *Nav*, that every observation in this book has been prepared by calculation, and none is the result of actual sextant observing. Should inconsistencies or errors be found by any young navigator, it is hoped that he will make them known so that they may be corrected, in case the *Nav* shall be required to make another voyage in a second edition.

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PUBLISHERS' NOTE

Table 3, Number Logarithms, has been reprinted from "The Macmillan Logarithmic and Trigonometric Tables," New York, 1917.

Table 1. Traverse Table

| Dist. | 1° (179°, 181°, 359°) | | 2° (178°, 182°, 358°) | | ½ Pt. 3° (177°, 183°, 357°) | | 4° (176°, 184°, 356°) | | 5° (175°, 185°, 355°) | | ½ Pt. 6° (174°, 186°, 354°) | | 7° (173°, 187°, 353°) | |
|-------|--------------------------|------|--------------------------|------|--------------------------------|------|--------------------------|------|--------------------------|------|--------------------------------|------|--------------------------|------|
| | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. |
| 1 | 1.0 | 0.0 | 1.0 | 0.0 | 1.0 | 0.1 | 1.0 | 0.1 | 1.0 | 0.1 | 1.0 | 0.1 | 1.0 | 0.1 |
| 2 | 2.0 | 0.0 | 2.0 | 0.1 | 2.0 | 0.1 | 2.0 | 0.1 | 2.0 | 0.2 | 2.0 | 0.2 | 2.0 | 0.2 |
| 3 | 3.0 | 0.1 | 3.0 | 0.1 | 3.0 | 0.2 | 3.0 | 0.2 | 3.0 | 0.3 | 3.0 | 0.3 | 3.0 | 0.4 |
| 4 | 4.0 | 0.1 | 4.0 | 0.1 | 4.0 | 0.2 | 4.0 | 0.3 | 4.0 | 0.3 | 4.0 | 0.4 | 4.0 | 0.5 |
| 5 | 5.0 | 0.1 | 5.0 | 0.2 | 5.0 | 0.3 | 5.0 | 0.3 | 5.0 | 0.4 | 5.0 | 0.5 | 5.0 | 0.6 |
| 6 | 6.0 | 0.1 | 6.0 | 0.2 | 6.0 | 0.3 | 6.0 | 0.4 | 6.0 | 0.5 | 6.0 | 0.6 | 6.0 | 0.7 |
| 7 | 7.0 | 0.1 | 7.0 | 0.2 | 7.0 | 0.4 | 7.0 | 0.5 | 7.0 | 0.6 | 7.0 | 0.7 | 6.9 | 0.9 |
| 8 | 8.0 | 0.1 | 8.0 | 0.3 | 8.0 | 0.4 | 8.0 | 0.6 | 8.0 | 0.7 | 8.0 | 0.8 | 7.9 | 1.0 |
| 9 | 9.0 | 0.2 | 9.0 | 0.3 | 9.0 | 0.5 | 9.0 | 0.6 | 9.0 | 0.8 | 9.0 | 0.9 | 8.9 | 1.1 |
| 10 | 10.0 | 0.2 | 10.0 | 0.3 | 10.0 | 0.5 | 10.0 | 0.7 | 10.0 | 0.9 | 9.9 | 1.0 | 9.9 | 1.2 |
| 11 | 11.0 | 0.2 | 11.0 | 0.4 | 11.0 | 0.6 | 11.0 | 0.8 | 11.0 | 1.0 | 10.9 | 1.1 | 10.9 | 1.3 |
| 12 | 12.0 | 0.2 | 12.0 | 0.4 | 12.0 | 0.6 | 12.0 | 0.8 | 12.0 | 1.0 | 11.9 | 1.3 | 11.9 | 1.5 |
| 13 | 13.0 | 0.2 | 13.0 | 0.5 | 13.0 | 0.7 | 13.0 | 0.9 | 13.0 | 1.1 | 12.9 | 1.4 | 12.9 | 1.6 |
| 14 | 14.0 | 0.2 | 14.0 | 0.5 | 14.0 | 0.7 | 14.0 | 1.0 | 13.9 | 1.2 | 13.9 | 1.5 | 13.9 | 1.7 |
| 15 | 15.0 | 0.3 | 15.0 | 0.5 | 15.0 | 0.8 | 15.0 | 1.0 | 14.9 | 1.3 | 14.9 | 1.6 | 14.9 | 1.8 |
| 16 | 16.0 | 0.3 | 16.0 | 0.6 | 16.0 | 0.8 | 16.0 | 1.1 | 15.9 | 1.4 | 15.9 | 1.7 | 15.9 | 1.9 |
| 17 | 17.0 | 0.3 | 17.0 | 0.6 | 17.0 | 0.9 | 17.0 | 1.2 | 16.9 | 1.5 | 16.9 | 1.8 | 16.9 | 2.1 |
| 18 | 18.0 | 0.3 | 18.0 | 0.6 | 18.0 | 0.9 | 18.0 | 1.3 | 17.9 | 1.6 | 17.9 | 1.9 | 17.9 | 2.2 |
| 19 | 19.0 | 0.3 | 19.0 | 0.7 | 19.0 | 1.0 | 19.0 | 1.3 | 18.9 | 1.7 | 18.9 | 2.0 | 18.9 | 2.3 |
| 20 | 20.0 | 0.3 | 20.0 | 0.7 | 20.0 | 1.0 | 20.0 | 1.4 | 19.9 | 1.7 | 19.9 | 2.1 | 19.9 | 2.4 |
| 21 | 21.0 | 0.4 | 21.0 | 0.7 | 21.0 | 1.1 | 20.9 | 1.5 | 20.9 | 1.8 | 20.9 | 2.2 | 20.8 | 2.6 |
| 22 | 22.0 | 0.4 | 22.0 | 0.8 | 22.0 | 1.2 | 21.9 | 1.5 | 21.9 | 1.9 | 21.9 | 2.3 | 21.8 | 2.7 |
| 23 | 23.0 | 0.4 | 23.0 | 0.8 | 23.0 | 1.2 | 22.9 | 1.6 | 22.9 | 2.0 | 22.9 | 2.4 | 22.8 | 2.8 |
| 24 | 24.0 | 0.4 | 24.0 | 0.8 | 24.0 | 1.3 | 23.9 | 1.7 | 23.9 | 2.1 | 23.9 | 2.5 | 23.8 | 2.9 |
| 25 | 25.0 | 0.4 | 25.0 | 0.9 | 25.0 | 1.3 | 24.9 | 1.7 | 24.9 | 2.2 | 24.9 | 2.6 | 24.8 | 3.0 |
| 26 | 26.0 | 0.5 | 26.0 | 0.9 | 26.0 | 1.4 | 25.9 | 1.8 | 25.9 | 2.3 | 25.9 | 2.7 | 25.8 | 3.2 |
| 27 | 27.0 | 0.5 | 27.0 | 0.9 | 27.0 | 1.4 | 26.9 | 1.9 | 26.9 | 2.4 | 26.9 | 2.8 | 26.8 | 3.3 |
| 28 | 28.0 | 0.5 | 28.0 | 1.0 | 28.0 | 1.5 | 27.9 | 2.0 | 27.9 | 2.4 | 27.8 | 2.9 | 27.8 | 3.4 |
| 29 | 29.0 | 0.5 | 29.0 | 1.0 | 29.0 | 1.5 | 28.9 | 2.0 | 28.9 | 2.5 | 28.8 | 3.0 | 28.8 | 3.5 |
| 30 | 30.0 | 0.5 | 30.0 | 1.0 | 30.0 | 1.6 | 29.9 | 2.1 | 29.9 | 2.6 | 29.8 | 3.1 | 29.8 | 3.7 |
| 31 | 31.0 | 0.5 | 31.0 | 1.1 | 31.0 | 1.6 | 30.9 | 2.2 | 30.9 | 2.7 | 30.8 | 3.2 | 30.8 | 3.8 |
| 32 | 32.0 | 0.6 | 32.0 | 1.1 | 32.0 | 1.7 | 31.9 | 2.2 | 31.9 | 2.8 | 31.8 | 3.3 | 31.8 | 3.9 |
| 33 | 33.0 | 0.6 | 33.0 | 1.2 | 33.0 | 1.7 | 32.9 | 2.3 | 32.9 | 2.9 | 32.8 | 3.4 | 32.8 | 4.0 |
| 34 | 34.0 | 0.6 | 34.0 | 1.2 | 34.0 | 1.8 | 33.9 | 2.4 | 33.9 | 3.0 | 33.8 | 3.6 | 33.7 | 4.1 |
| 35 | 35.0 | 0.6 | 35.0 | 1.2 | 35.0 | 1.8 | 34.9 | 2.4 | 34.9 | 3.1 | 34.8 | 3.7 | 34.7 | 4.3 |
| 36 | 36.0 | 0.6 | 36.0 | 1.3 | 36.0 | 1.9 | 35.9 | 2.5 | 35.9 | 3.1 | 35.8 | 3.8 | 35.7 | 4.4 |
| 37 | 37.0 | 0.6 | 37.0 | 1.3 | 36.9 | 1.9 | 36.9 | 2.6 | 36.9 | 3.2 | 36.8 | 3.9 | 36.7 | 4.5 |
| 38 | 38.0 | 0.7 | 38.0 | 1.3 | 37.9 | 2.0 | 37.9 | 2.7 | 37.9 | 3.3 | 37.8 | 4.0 | 37.7 | 4.6 |
| 39 | 39.0 | 0.7 | 39.0 | 1.4 | 38.9 | 2.0 | 38.9 | 2.7 | 38.9 | 3.4 | 38.8 | 4.1 | 38.7 | 4.8 |
| 40 | 40.0 | 0.7 | 40.0 | 1.4 | 39.9 | 2.1 | 39.9 | 2.8 | 39.8 | 3.5 | 39.8 | 4.2 | 39.7 | 4.9 |
| 41 | 41.0 | 0.7 | 41.0 | 1.4 | 40.9 | 2.1 | 40.9 | 2.9 | 40.8 | 3.6 | 40.8 | 4.3 | 40.7 | 5.0 |
| 42 | 42.0 | 0.7 | 42.0 | 1.5 | 41.9 | 2.2 | 41.9 | 2.9 | 41.8 | 3.7 | 41.8 | 4.4 | 41.7 | 5.1 |
| 43 | 43.0 | 0.8 | 43.0 | 1.5 | 42.9 | 2.3 | 42.9 | 3.0 | 42.8 | 3.7 | 42.8 | 4.5 | 42.7 | 5.2 |
| 44 | 44.0 | 0.8 | 44.0 | 1.5 | 43.9 | 2.3 | 43.9 | 3.1 | 43.8 | 3.8 | 43.8 | 4.6 | 43.7 | 5.4 |
| 45 | 45.0 | 0.8 | 45.0 | 1.6 | 44.9 | 2.4 | 44.9 | 3.1 | 44.8 | 3.9 | 44.8 | 4.7 | 44.7 | 5.5 |
| 46 | 46.0 | 0.8 | 46.0 | 1.6 | 45.9 | 2.4 | 45.9 | 3.2 | 45.8 | 4.0 | 45.7 | 4.8 | 45.7 | 5.6 |
| 47 | 47.0 | 0.8 | 47.0 | 1.6 | 46.9 | 2.5 | 46.9 | 3.3 | 46.8 | 4.1 | 46.7 | 4.9 | 46.6 | 5.7 |
| 48 | 48.0 | 0.8 | 48.0 | 1.7 | 47.9 | 2.5 | 47.9 | 3.3 | 47.8 | 4.2 | 47.7 | 5.0 | 47.6 | 5.8 |
| 49 | 49.0 | 0.9 | 49.0 | 1.7 | 48.9 | 2.6 | 48.9 | 3.4 | 48.8 | 4.3 | 48.7 | 5.1 | 48.6 | 6.0 |
| 50 | 50.0 | 0.9 | 50.0 | 1.7 | 49.9 | 2.6 | 49.9 | 3.5 | 49.8 | 4.4 | 49.7 | 5.2 | 49.6 | 6.1 |
| 100 | 100.0 | 1.7 | 99.9 | 3.5 | 99.9 | 5.2 | 99.8 | 7.0 | 99.6 | 8.7 | 99.5 | 10.5 | 99.3 | 12.2 |
| 200 | 200.0 | 3.5 | 199.9 | 7.0 | 199.7 | 10.5 | 199.5 | 14.0 | 199.2 | 17.4 | 198.9 | 20.9 | 198.5 | 24.4 |
| 300 | 300.0 | 5.2 | 299.8 | 10.5 | 299.6 | 15.7 | 299.3 | 20.9 | 298.9 | 26.1 | 298.4 | 31.4 | 297.8 | 36.6 |
| 400 | 399.9 | 7.0 | 399.8 | 13.9 | 399.4 | 20.9 | 399.0 | 27.9 | 398.5 | 34.9 | 397.8 | 41.8 | 397.0 | 48.7 |
| 500 | 499.9 | 8.8 | 499.7 | 17.4 | 499.3 | 26.2 | 498.8 | 34.8 | 498.1 | 43.6 | 497.3 | 52.3 | 496.3 | 61.0 |
| | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. |
| | (91°, 269°, 271°) | | (92°, 268°, 272°) | | (93°, 267°, 273°) | | (94°, 266°, 274°) | | (95°, 265°, 275°) | | (96°, 264°, 276°) | | (97°, 263°, 277°) | |
| | 89° | | 88° | | 7½ Pt. 87° | | 86° | | 85° | | 7½ Pt. 84° | | 83° | |

Table 1. Traverse Table

| Dist. | 1° (179°, 181°, 359°) | | 2° (178°, 182°, 358°) | | ½ Pt. 3° (177°, 183°, 357°) | | 4° (176°, 184°, 356°) | | 5° (175°, 185°, 355°) | | ½ Pt. 6° (174°, 186°, 354°) | | 7° (173°, 187°, 353°) | |
|-------|--------------------------|------|--------------------------|------|--------------------------------|------|--------------------------|------|--------------------------|------|--------------------------------|------|--------------------------|-------|
| | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. |
| 51 | 51.0 | 0.9 | 51.0 | 1.8 | 50.9 | 2.7 | 50.9 | 3.6 | 50.8 | 4.4 | 50.7 | 5.3 | 50.6 | 6.2 |
| 52 | 52.0 | 0.9 | 52.0 | 1.8 | 51.9 | 2.7 | 51.9 | 3.6 | 51.8 | 4.5 | 51.7 | 5.4 | 51.6 | 6.3 |
| 53 | 53.0 | 0.9 | 53.0 | 1.8 | 52.9 | 2.8 | 52.9 | 3.7 | 52.8 | 4.6 | 52.7 | 5.5 | 52.6 | 6.5 |
| 54 | 54.0 | 0.9 | 54.0 | 1.9 | 53.9 | 2.8 | 53.9 | 3.8 | 53.8 | 4.7 | 53.7 | 5.6 | 53.6 | 6.6 |
| 55 | 55.0 | 1.0 | 55.0 | 1.9 | 54.9 | 2.9 | 54.9 | 3.8 | 54.8 | 4.8 | 54.7 | 5.7 | 54.6 | 6.7 |
| 56 | 56.0 | 1.0 | 56.0 | 2.0 | 55.9 | 2.9 | 55.9 | 3.9 | 55.8 | 4.9 | 55.7 | 5.9 | 55.6 | 6.8 |
| 57 | 57.0 | 1.0 | 57.0 | 2.0 | 56.9 | 3.0 | 56.9 | 4.0 | 56.8 | 5.0 | 56.7 | 6.0 | 56.6 | 6.9 |
| 58 | 58.0 | 1.0 | 58.0 | 2.0 | 57.9 | 3.0 | 57.9 | 4.0 | 57.8 | 5.1 | 57.7 | 6.1 | 57.6 | 7.1 |
| 59 | 59.0 | 1.0 | 59.0 | 2.1 | 58.9 | 3.1 | 58.9 | 4.1 | 58.8 | 5.1 | 58.7 | 6.2 | 58.6 | 7.2 |
| 60 | 60.0 | 1.0 | 60.0 | 2.1 | 59.9 | 3.1 | 59.9 | 4.2 | 59.8 | 5.2 | 59.7 | 6.3 | 59.6 | 7.3 |
| 61 | 61.0 | 1.1 | 61.0 | 2.1 | 60.9 | 3.2 | 60.9 | 4.3 | 60.8 | 5.3 | 60.7 | 6.4 | 60.5 | 7.4 |
| 62 | 62.0 | 1.1 | 62.0 | 2.2 | 61.9 | 3.2 | 61.8 | 4.3 | 61.8 | 5.4 | 61.7 | 6.5 | 61.5 | 7.6 |
| 63 | 63.0 | 1.1 | 63.0 | 2.2 | 62.9 | 3.3 | 62.8 | 4.4 | 62.8 | 5.5 | 62.7 | 6.6 | 62.5 | 7.7 |
| 64 | 64.0 | 1.1 | 64.0 | 2.2 | 63.9 | 3.3 | 63.8 | 4.5 | 63.8 | 5.6 | 63.6 | 6.7 | 63.5 | 7.8 |
| 65 | 65.0 | 1.1 | 65.0 | 2.3 | 64.9 | 3.4 | 64.8 | 4.5 | 64.8 | 5.7 | 64.6 | 6.8 | 64.5 | 7.9 |
| 66 | 66.0 | 1.2 | 66.0 | 2.3 | 65.9 | 3.5 | 65.8 | 4.6 | 65.7 | 5.8 | 65.6 | 6.9 | 65.5 | 8.0 |
| 67 | 67.0 | 1.2 | 67.0 | 2.3 | 66.9 | 3.5 | 66.8 | 4.7 | 66.7 | 5.8 | 66.6 | 7.0 | 66.5 | 8.2 |
| 68 | 68.0 | 1.2 | 68.0 | 2.4 | 67.9 | 3.6 | 67.8 | 4.7 | 67.7 | 5.9 | 67.6 | 7.1 | 67.5 | 8.3 |
| 69 | 69.0 | 1.2 | 69.0 | 2.4 | 68.9 | 3.6 | 68.8 | 4.8 | 68.7 | 6.0 | 68.6 | 7.2 | 68.5 | 8.4 |
| 70 | 70.0 | 1.2 | 70.0 | 2.4 | 69.9 | 3.7 | 69.8 | 4.9 | 69.7 | 6.1 | 69.6 | 7.3 | 69.5 | 8.5 |
| 71 | 71.0 | 1.2 | 71.0 | 2.5 | 70.9 | 3.7 | 70.8 | 5.0 | 70.7 | 6.2 | 70.6 | 7.4 | 70.5 | 8.7 |
| 72 | 72.0 | 1.3 | 72.0 | 2.5 | 71.9 | 3.8 | 71.8 | 5.0 | 71.7 | 6.3 | 71.6 | 7.5 | 71.5 | 8.8 |
| 73 | 73.0 | 1.3 | 73.0 | 2.5 | 72.9 | 3.8 | 72.8 | 5.1 | 72.7 | 6.4 | 72.6 | 7.6 | 72.5 | 8.9 |
| 74 | 74.0 | 1.3 | 74.0 | 2.6 | 73.9 | 3.9 | 73.8 | 5.2 | 73.7 | 6.4 | 73.6 | 7.7 | 73.4 | 9.0 |
| 75 | 75.0 | 1.3 | 75.0 | 2.6 | 74.9 | 3.9 | 74.8 | 5.2 | 74.7 | 6.5 | 74.6 | 7.8 | 74.4 | 9.1 |
| 76 | 76.0 | 1.3 | 76.0 | 2.7 | 75.9 | 4.0 | 75.8 | 5.3 | 75.7 | 6.6 | 75.6 | 7.9 | 75.4 | 9.3 |
| 77 | 77.0 | 1.3 | 77.0 | 2.7 | 76.9 | 4.0 | 76.8 | 5.4 | 76.7 | 6.7 | 76.6 | 8.0 | 76.4 | 9.4 |
| 78 | 78.0 | 1.4 | 78.0 | 2.7 | 77.9 | 4.1 | 77.8 | 5.4 | 77.7 | 6.8 | 77.6 | 8.2 | 77.4 | 9.5 |
| 79 | 79.0 | 1.4 | 79.0 | 2.8 | 78.9 | 4.1 | 78.8 | 5.5 | 78.7 | 6.9 | 78.6 | 8.3 | 78.4 | 9.6 |
| 80 | 80.0 | 1.4 | 80.0 | 2.8 | 79.9 | 4.2 | 79.8 | 5.6 | 79.7 | 7.0 | 79.6 | 8.4 | 79.4 | 9.7 |
| 81 | 81.0 | 1.4 | 81.0 | 2.8 | 80.9 | 4.2 | 80.8 | 5.7 | 80.7 | 7.1 | 80.6 | 8.5 | 80.4 | 9.9 |
| 82 | 82.0 | 1.4 | 82.0 | 2.9 | 81.9 | 4.3 | 81.8 | 5.7 | 81.7 | 7.1 | 81.6 | 8.6 | 81.4 | 10.0 |
| 83 | 83.0 | 1.4 | 82.9 | 2.9 | 82.9 | 4.3 | 82.8 | 5.8 | 82.7 | 7.2 | 82.5 | 8.7 | 82.4 | 10.1 |
| 84 | 84.0 | 1.5 | 83.9 | 2.9 | 83.9 | 4.4 | 83.8 | 5.9 | 83.7 | 7.3 | 83.5 | 8.8 | 83.4 | 10.2 |
| 85 | 85.0 | 1.5 | 84.9 | 3.0 | 84.9 | 4.4 | 84.8 | 5.9 | 84.7 | 7.4 | 84.5 | 8.9 | 84.4 | 10.4 |
| 86 | 86.0 | 1.5 | 85.9 | 3.0 | 85.9 | 4.5 | 85.8 | 6.0 | 85.7 | 7.5 | 85.5 | 9.0 | 85.4 | 10.5 |
| 87 | 87.0 | 1.5 | 86.9 | 3.0 | 86.9 | 4.6 | 86.8 | 6.1 | 86.7 | 7.6 | 86.5 | 9.1 | 86.4 | 10.6 |
| 88 | 88.0 | 1.5 | 87.9 | 3.1 | 87.9 | 4.6 | 87.8 | 6.1 | 87.7 | 7.7 | 87.5 | 9.2 | 87.3 | 10.7 |
| 89 | 89.0 | 1.6 | 88.9 | 3.1 | 88.9 | 4.7 | 88.8 | 6.2 | 88.7 | 7.8 | 88.5 | 9.3 | 88.3 | 10.8 |
| 90 | 90.0 | 1.6 | 89.9 | 3.1 | 89.9 | 4.7 | 89.8 | 6.3 | 89.7 | 7.8 | 89.5 | 9.4 | 89.3 | 11.0 |
| 91 | 91.0 | 1.6 | 90.9 | 3.2 | 90.9 | 4.8 | 90.8 | 6.3 | 90.7 | 7.9 | 90.5 | 9.5 | 90.3 | 11.1 |
| 92 | 92.0 | 1.6 | 91.9 | 3.2 | 91.9 | 4.8 | 91.8 | 6.4 | 91.6 | 8.0 | 91.5 | 9.6 | 91.3 | 11.2 |
| 93 | 93.0 | 1.6 | 92.9 | 3.2 | 92.9 | 4.9 | 92.8 | 6.5 | 92.6 | 8.1 | 92.5 | 9.7 | 92.3 | 11.3 |
| 94 | 94.0 | 1.6 | 93.9 | 3.3 | 93.9 | 4.9 | 93.8 | 6.6 | 93.6 | 8.2 | 93.5 | 9.8 | 93.3 | 11.5 |
| 95 | 95.0 | 1.7 | 94.9 | 3.3 | 94.9 | 5.0 | 94.8 | 6.6 | 94.6 | 8.3 | 94.5 | 9.9 | 94.3 | 11.6 |
| 96 | 96.0 | 1.7 | 95.9 | 3.4 | 95.9 | 5.0 | 95.8 | 6.7 | 95.6 | 8.4 | 95.5 | 10.0 | 95.3 | 11.7 |
| 97 | 97.0 | 1.7 | 96.9 | 3.4 | 96.9 | 5.1 | 96.8 | 6.8 | 96.6 | 8.5 | 96.5 | 10.1 | 96.3 | 11.8 |
| 98 | 98.0 | 1.7 | 97.9 | 3.4 | 97.9 | 5.1 | 97.8 | 6.8 | 97.6 | 8.5 | 97.5 | 10.2 | 97.3 | 11.9 |
| 99 | 99.0 | 1.7 | 98.9 | 3.5 | 98.9 | 5.2 | 98.8 | 6.9 | 98.6 | 8.6 | 98.5 | 10.3 | 98.3 | 12.1 |
| 100 | 100.0 | 1.7 | 99.9 | 3.5 | 99.9 | 5.2 | 99.8 | 7.0 | 99.6 | 8.7 | 99.5 | 10.5 | 99.3 | 12.2 |
| 600 | 599.9 | 10.5 | 599.6 | 20.9 | 599.2 | 31.4 | 598.6 | 41.9 | 597.7 | 52.3 | 596.7 | 62.7 | 595.5 | 73.1 |
| 700 | 699.8 | 12.2 | 699.5 | 24.4 | 699.0 | 36.6 | 698.2 | 48.8 | 697.2 | 61.0 | 696.1 | 73.2 | 694.9 | 85.3 |
| 800 | 799.8 | 14.0 | 799.5 | 27.9 | 798.9 | 41.9 | 798.0 | 55.8 | 796.9 | 69.7 | 795.6 | 83.6 | 794.1 | 97.5 |
| 900 | 899.7 | 15.7 | 899.3 | 31.4 | 898.6 | 47.1 | 897.6 | 62.8 | 896.4 | 78.4 | 895.0 | 94.1 | 893.3 | 109.6 |
| | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. |
| | (91°, 269°, 271°) | | (92°, 268°, 272°) | | (93°, 267°, 273°) | | (94°, 266°, 274°) | | (95°, 265°, 275°) | | (96°, 264°, 276°) | | (97°, 263°, 277°) | |
| | 89° | | 88° | | 7½ Pt. 87° | | 86° | | 85° | | 7½ Pt. 84° | | 83° | |

Table 1. Traverse Table

| Dist. | ¼ Pt. 8° (172°, 188°, 352°) | | 9° (171°, 189°, 351°) | | 10° (170°, 190°, 350°) | | 1 Pt. 11° (169°, 191°, 349°) | | 12° (168°, 192°, 348°) | | 13° (167°, 193°, 347°) | | 1½ Pt. 14° (166°, 194°, 346°) | |
|-------|--------------------------------|------|--------------------------|------|---------------------------|------|---------------------------------|------|---------------------------|-------|---------------------------|-------|----------------------------------|-------|
| | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. |
| 1 | 1.0 | 0.1 | 1.0 | 0.2 | 1.0 | 0.2 | 1.0 | 0.2 | 1.0 | 0.2 | 1.0 | 0.2 | 1.0 | 0.2 |
| 2 | 2.0 | 0.3 | 2.0 | 0.3 | 2.0 | 0.3 | 2.0 | 0.4 | 2.0 | 0.4 | 1.9 | 0.4 | 1.9 | 0.5 |
| 3 | 3.0 | 0.4 | 3.0 | 0.5 | 3.0 | 0.5 | 2.9 | 0.6 | 2.9 | 0.6 | 2.9 | 0.7 | 2.9 | 0.7 |
| 4 | 4.0 | 0.6 | 4.0 | 0.6 | 3.9 | 0.7 | 3.9 | 0.8 | 3.9 | 0.8 | 3.9 | 0.9 | 3.9 | 1.0 |
| 5 | 5.0 | 0.7 | 4.9 | 0.8 | 4.9 | 0.9 | 4.9 | 1.0 | 4.9 | 1.0 | 4.9 | 1.1 | 4.9 | 1.2 |
| 6 | 5.9 | 0.8 | 5.9 | 0.9 | 5.9 | 1.0 | 5.9 | 1.1 | 5.9 | 1.2 | 5.8 | 1.3 | 5.8 | 1.5 |
| 7 | 6.9 | 1.0 | 6.9 | 1.1 | 6.9 | 1.2 | 6.9 | 1.3 | 6.8 | 1.5 | 6.8 | 1.6 | 6.8 | 1.7 |
| 8 | 7.9 | 1.1 | 7.9 | 1.3 | 7.9 | 1.4 | 7.9 | 1.5 | 7.8 | 1.7 | 7.8 | 1.8 | 7.8 | 1.9 |
| 9 | 8.9 | 1.3 | 8.9 | 1.4 | 8.9 | 1.6 | 8.8 | 1.7 | 8.8 | 1.9 | 8.8 | 2.0 | 8.7 | 2.2 |
| 10 | 9.9 | 1.4 | 9.9 | 1.6 | 9.8 | 1.7 | 9.8 | 1.9 | 9.8 | 2.1 | 9.7 | 2.2 | 9.7 | 2.4 |
| 11 | 10.9 | 1.5 | 10.9 | 1.7 | 10.8 | 1.9 | 10.8 | 2.1 | 10.8 | 2.3 | 10.7 | 2.5 | 10.7 | 2.7 |
| 12 | 11.9 | 1.7 | 11.9 | 1.9 | 11.8 | 2.1 | 11.8 | 2.3 | 11.7 | 2.5 | 11.7 | 2.7 | 11.6 | 2.9 |
| 13 | 12.9 | 1.8 | 12.8 | 2.0 | 12.8 | 2.3 | 12.8 | 2.5 | 12.7 | 2.7 | 12.7 | 2.9 | 12.6 | 3.1 |
| 14 | 13.9 | 1.9 | 13.8 | 2.2 | 13.8 | 2.4 | 13.7 | 2.7 | 13.7 | 2.9 | 13.6 | 3.1 | 13.6 | 3.4 |
| 15 | 14.9 | 2.1 | 14.8 | 2.3 | 14.8 | 2.6 | 14.7 | 2.9 | 14.7 | 3.1 | 14.6 | 3.4 | 14.6 | 3.6 |
| 16 | 15.8 | 2.2 | 15.8 | 2.5 | 15.8 | 2.8 | 15.7 | 3.1 | 15.7 | 3.3 | 15.6 | 3.6 | 15.5 | 3.9 |
| 17 | 16.8 | 2.4 | 16.8 | 2.7 | 16.7 | 3.0 | 16.7 | 3.2 | 16.6 | 3.5 | 16.6 | 3.8 | 16.5 | 4.1 |
| 18 | 17.8 | 2.5 | 17.8 | 2.9 | 17.7 | 3.1 | 17.7 | 3.4 | 17.6 | 3.7 | 17.5 | 4.0 | 17.5 | 4.4 |
| 19 | 18.8 | 2.6 | 18.8 | 3.0 | 18.7 | 3.3 | 18.7 | 3.6 | 18.6 | 4.0 | 18.5 | 4.3 | 18.4 | 4.6 |
| 20 | 19.8 | 2.8 | 19.8 | 3.1 | 19.7 | 3.5 | 19.6 | 3.8 | 19.6 | 4.2 | 19.5 | 4.5 | 19.4 | 4.8 |
| 21 | 20.8 | 2.9 | 20.7 | 3.3 | 20.7 | 3.6 | 20.6 | 4.0 | 20.5 | 4.4 | 20.5 | 4.7 | 20.4 | 5.1 |
| 22 | 21.8 | 3.1 | 21.7 | 3.4 | 21.7 | 3.8 | 21.6 | 4.2 | 21.5 | 4.6 | 21.4 | 4.9 | 21.3 | 5.3 |
| 23 | 22.8 | 3.2 | 22.7 | 3.6 | 22.7 | 4.0 | 22.6 | 4.4 | 22.5 | 4.8 | 22.4 | 5.2 | 22.3 | 5.6 |
| 24 | 23.8 | 3.3 | 23.7 | 3.8 | 23.6 | 4.2 | 23.6 | 4.6 | 23.5 | 5.0 | 23.4 | 5.4 | 23.3 | 5.8 |
| 25 | 24.8 | 3.5 | 24.7 | 3.9 | 24.6 | 4.3 | 24.5 | 4.8 | 24.5 | 5.2 | 24.4 | 5.6 | 24.3 | 6.0 |
| 26 | 25.7 | 3.6 | 25.7 | 4.1 | 25.6 | 4.5 | 25.5 | 5.0 | 25.4 | 5.4 | 25.3 | 5.8 | 25.2 | 6.3 |
| 27 | 26.7 | 3.8 | 26.7 | 4.2 | 26.6 | 4.7 | 26.5 | 5.2 | 26.4 | 5.6 | 26.3 | 6.1 | 26.2 | 6.5 |
| 28 | 27.7 | 3.9 | 27.7 | 4.4 | 27.6 | 4.9 | 27.5 | 5.3 | 27.4 | 5.8 | 27.3 | 6.3 | 27.2 | 6.8 |
| 29 | 28.7 | 4.0 | 28.6 | 4.5 | 28.6 | 5.0 | 28.5 | 5.5 | 28.4 | 6.0 | 28.3 | 6.5 | 28.1 | 7.0 |
| 30 | 29.7 | 4.2 | 29.6 | 4.7 | 29.5 | 5.2 | 29.4 | 5.7 | 29.3 | 6.2 | 29.2 | 6.7 | 29.1 | 7.3 |
| 31 | 30.7 | 4.3 | 30.6 | 4.8 | 30.5 | 5.4 | 30.4 | 5.9 | 30.3 | 6.4 | 30.2 | 7.0 | 30.1 | 7.5 |
| 32 | 31.7 | 4.5 | 31.6 | 5.0 | 31.5 | 5.6 | 31.4 | 6.1 | 31.3 | 6.7 | 31.2 | 7.2 | 31.0 | 7.7 |
| 33 | 32.7 | 4.6 | 32.6 | 5.2 | 32.5 | 5.7 | 32.4 | 6.3 | 32.3 | 6.9 | 32.2 | 7.4 | 32.0 | 8.0 |
| 34 | 33.7 | 4.7 | 33.6 | 5.3 | 33.5 | 5.9 | 33.4 | 6.5 | 33.3 | 7.1 | 33.1 | 7.6 | 33.0 | 8.2 |
| 35 | 34.7 | 4.9 | 34.6 | 5.5 | 34.5 | 6.1 | 34.4 | 6.7 | 34.2 | 7.3 | 34.1 | 7.9 | 34.0 | 8.5 |
| 36 | 35.6 | 5.0 | 35.6 | 5.6 | 35.5 | 6.3 | 35.3 | 6.9 | 35.2 | 7.5 | 35.1 | 8.1 | 34.9 | 8.7 |
| 37 | 36.6 | 5.1 | 36.5 | 5.8 | 36.4 | 6.4 | 36.3 | 7.1 | 36.2 | 7.7 | 36.1 | 8.3 | 35.9 | 9.0 |
| 38 | 37.6 | 5.3 | 37.5 | 5.9 | 37.4 | 6.6 | 37.3 | 7.3 | 37.2 | 7.9 | 37.0 | 8.5 | 36.9 | 9.2 |
| 39 | 38.6 | 5.4 | 38.5 | 6.1 | 38.4 | 6.8 | 38.3 | 7.4 | 38.1 | 8.1 | 38.0 | 8.8 | 37.8 | 9.4 |
| 40 | 39.6 | 5.6 | 39.5 | 6.3 | 39.4 | 6.9 | 39.3 | 7.6 | 39.1 | 8.3 | 39.0 | 9.0 | 38.8 | 9.7 |
| 41 | 40.6 | 5.7 | 40.5 | 6.4 | 40.4 | 7.1 | 40.2 | 7.8 | 40.1 | 8.5 | 39.9 | 9.2 | 39.8 | 9.9 |
| 42 | 41.6 | 5.8 | 41.5 | 6.6 | 41.4 | 7.3 | 41.2 | 8.0 | 41.1 | 8.7 | 40.9 | 9.4 | 40.8 | 10.2 |
| 43 | 42.6 | 6.0 | 42.5 | 6.7 | 42.3 | 7.5 | 42.2 | 8.2 | 42.1 | 8.9 | 41.9 | 9.7 | 41.7 | 10.4 |
| 44 | 43.6 | 6.1 | 43.5 | 6.9 | 43.3 | 7.6 | 43.2 | 8.4 | 43.0 | 9.1 | 42.9 | 9.9 | 42.7 | 10.6 |
| 45 | 44.6 | 6.3 | 44.4 | 7.0 | 44.3 | 7.8 | 44.2 | 8.6 | 44.0 | 9.4 | 43.8 | 10.1 | 43.7 | 10.9 |
| 46 | 45.6 | 6.4 | 45.4 | 7.2 | 45.3 | 8.0 | 45.2 | 8.8 | 45.0 | 9.6 | 44.8 | 10.3 | 44.6 | 11.1 |
| 47 | 46.5 | 6.5 | 46.4 | 7.4 | 46.3 | 8.2 | 46.1 | 9.0 | 46.0 | 9.8 | 45.8 | 10.6 | 45.6 | 11.4 |
| 48 | 47.5 | 6.7 | 47.4 | 7.5 | 47.3 | 8.3 | 47.1 | 9.2 | 47.0 | 10.0 | 46.8 | 10.8 | 46.6 | 11.6 |
| 49 | 48.5 | 6.8 | 48.4 | 7.7 | 48.3 | 8.5 | 48.1 | 9.3 | 47.9 | 10.2 | 47.7 | 11.0 | 47.5 | 11.9 |
| 50 | 49.5 | 7.0 | 49.4 | 7.8 | 49.2 | 8.7 | 49.1 | 9.5 | 48.9 | 10.4 | 48.7 | 11.2 | 48.5 | 12.1 |
| 100 | 99.0 | 13.9 | 98.8 | 15.6 | 98.5 | 17.4 | 98.2 | 19.1 | 97.8 | 20.8 | 97.4 | 22.5 | 97.0 | 24.2 |
| 200 | 198.1 | 27.8 | 197.5 | 31.3 | 197.0 | 34.7 | 196.3 | 38.2 | 195.6 | 41.6 | 194.9 | 45.0 | 194.1 | 48.4 |
| 300 | 297.1 | 41.8 | 296.3 | 46.9 | 295.4 | 52.1 | 294.5 | 57.2 | 293.4 | 62.4 | 292.3 | 67.5 | 291.1 | 72.6 |
| 400 | 396.1 | 55.7 | 395.1 | 62.6 | 393.9 | 69.5 | 392.6 | 76.3 | 391.3 | 83.1 | 389.8 | 90.0 | 388.1 | 96.7 |
| 500 | 495.1 | 69.6 | 493.8 | 78.2 | 492.4 | 86.8 | 490.8 | 95.4 | 489.1 | 104.0 | 487.2 | 112.4 | 485.1 | 121.0 |
| | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. |
| | (98°, 262°, 278°) | | (99°, 261°, 279°) | | (100°, 260°, 280°) | | (101°, 259°, 281°) | | (102°, 258°, 282°) | | (103°, 257°, 283°) | | (104°, 256°, 284°) | |
| | 7½ Pt. 82° | | 81° | | 80° | | 7 Pt. 79° | | 78° | | 77° | | 6¾ Pt. 76° | |

The 1-Pt. or 11° Courses are : N. by E., N. by W., S. by E., S. by W.

Table 1. Traverse Table

| Dist. | ¼ Pt. 8° (172°, 188°, 352°) | | 9° (171°, 189°, 351°) | | 10° (170°, 190°, 350°) | | 1 Pt. 11° (169°, 191°, 349°) | | 12° (168°, 192°, 348°) | | 13° (167°, 193°, 347°) | | 1½ Pt. 14° (166°, 194°, 346°) | |
|-------|--------------------------------|-------|--------------------------|-------|---------------------------|-------|---------------------------------|-------|---------------------------|-------|---------------------------|-------|----------------------------------|-------|
| | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. |
| 51 | 50.5 | 7.1 | 50.4 | 8.0 | 50.2 | 8.9 | 50.1 | 9.7 | 49.9 | 10.6 | 49.7 | 11.5 | 49.5 | 12.3 |
| 52 | 51.5 | 7.2 | 51.4 | 8.1 | 51.2 | 9.0 | 51.0 | 9.9 | 50.9 | 10.8 | 50.7 | 11.7 | 50.5 | 12.6 |
| 53 | 52.5 | 7.4 | 52.3 | 8.3 | 52.2 | 9.2 | 52.0 | 10.1 | 51.8 | 11.0 | 51.6 | 11.9 | 51.4 | 12.8 |
| 54 | 53.5 | 7.5 | 53.3 | 8.4 | 53.2 | 9.4 | 53.0 | 10.3 | 52.8 | 11.2 | 52.6 | 12.1 | 52.4 | 13.0 |
| 55 | 54.5 | 7.7 | 54.3 | 8.6 | 54.2 | 9.6 | 54.0 | 10.5 | 53.8 | 11.4 | 53.6 | 12.4 | 53.4 | 13.3 |
| 56 | 55.5 | 7.8 | 55.3 | 8.8 | 55.1 | 9.7 | 55.0 | 10.7 | 54.8 | 11.6 | 54.6 | 12.6 | 54.3 | 13.5 |
| 57 | 56.4 | 7.9 | 56.3 | 8.9 | 56.1 | 9.9 | 56.0 | 10.9 | 55.8 | 11.9 | 55.5 | 12.8 | 55.3 | 13.8 |
| 58 | 57.4 | 8.1 | 57.3 | 9.1 | 57.1 | 10.1 | 56.9 | 11.1 | 56.7 | 12.1 | 56.5 | 13.0 | 56.3 | 14.0 |
| 59 | 58.4 | 8.2 | 58.3 | 9.2 | 58.1 | 10.2 | 57.9 | 11.3 | 57.7 | 12.3 | 57.5 | 13.3 | 57.2 | 14.3 |
| 60 | 59.4 | 8.4 | 59.3 | 9.4 | 59.1 | 10.4 | 58.9 | 11.4 | 58.7 | 12.5 | 58.5 | 13.5 | 58.2 | 14.5 |
| 61 | 60.4 | 8.5 | 60.2 | 9.5 | 60.1 | 10.6 | 59.9 | 11.6 | 59.7 | 12.7 | 59.4 | 13.7 | 59.2 | 14.8 |
| 62 | 61.4 | 8.6 | 61.2 | 9.7 | 61.1 | 10.8 | 60.9 | 11.8 | 60.6 | 12.9 | 60.4 | 13.9 | 60.2 | 15.0 |
| 63 | 62.4 | 8.8 | 62.2 | 9.9 | 62.0 | 10.9 | 61.8 | 12.0 | 61.6 | 13.1 | 61.4 | 14.2 | 61.1 | 15.2 |
| 64 | 63.4 | 8.9 | 63.2 | 10.0 | 63.0 | 11.1 | 62.8 | 12.2 | 62.6 | 13.3 | 62.4 | 14.4 | 62.1 | 15.5 |
| 65 | 64.4 | 9.0 | 64.2 | 10.2 | 64.0 | 11.3 | 63.8 | 12.4 | 63.6 | 13.5 | 63.3 | 14.6 | 63.1 | 15.7 |
| 66 | 65.4 | 9.2 | 65.2 | 10.3 | 65.0 | 11.5 | 64.8 | 12.6 | 64.6 | 13.7 | 64.3 | 14.8 | 64.0 | 16.0 |
| 67 | 66.3 | 9.3 | 66.2 | 10.5 | 66.0 | 11.6 | 65.8 | 12.8 | 65.5 | 13.9 | 65.3 | 15.1 | 65.0 | 16.2 |
| 68 | 67.3 | 9.5 | 67.2 | 10.6 | 67.0 | 11.8 | 66.8 | 13.0 | 66.5 | 14.1 | 66.3 | 15.3 | 66.0 | 16.5 |
| 69 | 68.3 | 9.6 | 68.2 | 10.8 | 68.0 | 12.0 | 67.7 | 13.2 | 67.5 | 14.3 | 67.2 | 15.5 | 67.0 | 16.7 |
| 70 | 69.3 | 9.7 | 69.1 | 11.0 | 68.9 | 12.2 | 68.7 | 13.4 | 68.5 | 14.6 | 68.2 | 15.7 | 67.9 | 16.9 |
| 71 | 70.3 | 9.9 | 70.1 | 11.1 | 69.9 | 12.3 | 69.7 | 13.5 | 69.4 | 14.8 | 69.2 | 16.0 | 68.9 | 17.2 |
| 72 | 71.3 | 10.0 | 71.1 | 11.3 | 70.9 | 12.5 | 70.7 | 13.7 | 70.4 | 15.0 | 70.2 | 16.2 | 69.9 | 17.4 |
| 73 | 72.3 | 10.2 | 72.1 | 11.4 | 71.9 | 12.7 | 71.7 | 13.9 | 71.4 | 15.2 | 71.1 | 16.4 | 70.8 | 17.7 |
| 74 | 73.3 | 10.3 | 73.1 | 11.6 | 72.9 | 12.8 | 72.6 | 14.1 | 72.4 | 15.4 | 72.1 | 16.6 | 71.8 | 17.9 |
| 75 | 74.3 | 10.4 | 74.1 | 11.7 | 73.9 | 13.0 | 73.6 | 14.3 | 73.4 | 15.6 | 73.1 | 16.9 | 72.8 | 18.1 |
| 76 | 75.3 | 10.6 | 75.1 | 11.9 | 74.8 | 13.2 | 74.6 | 14.5 | 74.3 | 15.8 | 74.1 | 17.1 | 73.7 | 18.4 |
| 77 | 76.3 | 10.7 | 76.1 | 12.0 | 75.8 | 13.4 | 75.6 | 14.7 | 75.3 | 16.0 | 75.0 | 17.3 | 74.7 | 18.6 |
| 78 | 77.2 | 10.9 | 77.0 | 12.2 | 76.8 | 13.5 | 76.6 | 14.9 | 76.3 | 16.2 | 76.0 | 17.5 | 75.7 | 18.9 |
| 79 | 78.2 | 11.0 | 78.0 | 12.4 | 77.8 | 13.7 | 77.5 | 15.1 | 77.3 | 16.4 | 77.0 | 17.8 | 76.7 | 19.1 |
| 80 | 79.2 | 11.1 | 79.0 | 12.5 | 78.8 | 13.9 | 78.5 | 15.3 | 78.3 | 16.6 | 77.9 | 18.0 | 77.6 | 19.4 |
| 81 | 80.2 | 11.3 | 80.0 | 12.7 | 79.8 | 14.1 | 79.5 | 15.5 | 79.2 | 16.8 | 78.9 | 18.2 | 78.6 | 19.6 |
| 82 | 81.2 | 11.4 | 81.0 | 12.8 | 80.8 | 14.2 | 80.5 | 15.6 | 80.2 | 17.0 | 79.9 | 18.4 | 79.6 | 19.8 |
| 83 | 82.2 | 11.6 | 82.0 | 13.0 | 81.7 | 14.4 | 81.5 | 15.8 | 81.2 | 17.3 | 80.9 | 18.7 | 80.5 | 20.1 |
| 84 | 83.2 | 11.7 | 83.0 | 13.1 | 82.7 | 14.6 | 82.5 | 16.0 | 82.2 | 17.5 | 81.8 | 18.9 | 81.5 | 20.3 |
| 85 | 84.2 | 11.8 | 84.0 | 13.3 | 83.7 | 14.8 | 83.4 | 16.2 | 83.1 | 17.7 | 82.8 | 19.1 | 82.5 | 20.6 |
| 86 | 85.2 | 12.0 | 84.9 | 13.5 | 84.7 | 14.9 | 84.4 | 16.4 | 84.1 | 17.9 | 83.8 | 19.3 | 83.4 | 20.8 |
| 87 | 86.2 | 12.1 | 85.9 | 13.6 | 85.7 | 15.1 | 85.4 | 16.6 | 85.1 | 18.1 | 84.8 | 19.6 | 84.4 | 21.0 |
| 88 | 87.1 | 12.2 | 86.9 | 13.8 | 86.7 | 15.3 | 86.4 | 16.8 | 86.1 | 18.3 | 85.7 | 19.8 | 85.4 | 21.3 |
| 89 | 88.1 | 12.4 | 87.9 | 13.9 | 87.6 | 15.5 | 87.4 | 17.0 | 87.1 | 18.5 | 86.7 | 20.0 | 86.4 | 21.5 |
| 90 | 89.1 | 12.5 | 88.9 | 14.1 | 88.6 | 15.6 | 88.3 | 17.2 | 88.0 | 18.7 | 87.7 | 20.2 | 87.3 | 21.8 |
| 91 | 90.1 | 12.7 | 89.9 | 14.2 | 89.6 | 15.8 | 89.3 | 17.4 | 89.0 | 18.9 | 88.7 | 20.5 | 88.3 | 22.0 |
| 92 | 91.1 | 12.8 | 90.9 | 14.4 | 90.6 | 16.0 | 90.3 | 17.6 | 90.0 | 19.1 | 89.6 | 20.7 | 89.3 | 22.3 |
| 93 | 92.1 | 12.9 | 91.9 | 14.5 | 91.6 | 16.1 | 91.3 | 17.7 | 91.0 | 19.3 | 90.6 | 20.9 | 90.2 | 22.5 |
| 94 | 93.1 | 13.1 | 92.8 | 14.7 | 92.6 | 16.3 | 92.3 | 17.9 | 91.9 | 19.5 | 91.6 | 21.1 | 91.2 | 22.7 |
| 95 | 94.1 | 13.2 | 93.8 | 14.9 | 93.6 | 16.5 | 93.3 | 18.1 | 92.9 | 19.8 | 92.6 | 21.4 | 92.2 | 23.0 |
| 96 | 95.1 | 13.4 | 94.8 | 15.0 | 94.5 | 16.7 | 94.2 | 18.3 | 93.9 | 20.0 | 93.5 | 21.6 | 93.1 | 23.2 |
| 97 | 96.1 | 13.5 | 95.8 | 15.2 | 95.5 | 16.8 | 95.2 | 18.5 | 94.9 | 20.2 | 94.5 | 21.8 | 94.1 | 23.5 |
| 98 | 97.0 | 13.6 | 96.8 | 15.3 | 96.5 | 17.0 | 96.2 | 18.7 | 95.9 | 20.4 | 95.5 | 22.0 | 95.1 | 23.7 |
| 99 | 98.0 | 13.8 | 97.8 | 15.5 | 97.5 | 17.2 | 97.2 | 18.9 | 96.8 | 20.6 | 96.5 | 22.3 | 96.1 | 24.0 |
| 100 | 99.0 | 13.9 | 98.8 | 15.6 | 98.5 | 17.4 | 98.2 | 19.1 | 97.8 | 20.8 | 97.4 | 22.5 | 97.0 | 24.2 |
| 600 | 594.2 | 83.5 | 592.6 | 93.8 | 590.9 | 104.2 | 589.0 | 114.5 | 586.9 | 124.7 | 584.6 | 135.0 | 582.2 | 145.1 |
| 700 | 693.3 | 97.4 | 691.3 | 109.4 | 689.5 | 121.5 | 687.1 | 133.6 | 684.7 | 145.5 | 682.1 | 157.5 | 679.2 | 169.3 |
| 800 | 792.3 | 111.4 | 790.2 | 125.1 | 787.9 | 139.0 | 785.2 | 152.6 | 782.5 | 166.3 | 779.4 | 180.0 | 776.2 | 193.6 |
| 900 | 891.3 | 125.2 | 888.8 | 140.8 | 886.3 | 156.3 | 883.3 | 171.7 | 880.2 | 187.1 | 876.8 | 202.4 | 873.2 | 217.7 |
| | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. |
| | (98°, 262°, 278°) | | (99°, 261°, 279°) | | (100°, 260°, 280°) | | (101°, 259°, 281°) | | (102°, 258°, 282°) | | (103°, 257°, 283°) | | (104°, 256°, 284°) | |
| | 7½ Pt. 82° | | 81° | | 80° | | 7 Pt. 79° | | 78° | | 77° | | 6¾ Pt. 76° | |

The 7-Pt. or 79° Courses are: E. by N., W. by N., E. by S., W. by S.

Table 1. Traverse Table

| Dist. | 15° (165°, 195°, 345°) | | 16° (164°, 196°, 344°) | | 1½ Pt. 17° (163°, 197°, 343°) | | 18° (162°, 198°, 342°) | | 19° (161°, 199°, 341°) | | 1¼ Pt. 20° (160°, 200°, 340°) | |
|-------|---------------------------|-------|---------------------------|-------|----------------------------------|-------|---------------------------|-------|---------------------------|-------|----------------------------------|-------|
| | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. |
| 1 | 1.0 | 0.3 | 1.0 | 0.3 | 1.0 | 0.3 | 1.0 | 0.3 | 0.9 | 0.3 | 0.9 | 0.3 |
| 2 | 1.9 | 0.5 | 1.9 | 0.6 | 1.9 | 0.6 | 1.9 | 0.6 | 1.9 | 0.7 | 1.9 | 0.7 |
| 3 | 2.9 | 0.8 | 2.9 | 0.8 | 2.9 | 0.9 | 2.9 | 0.9 | 2.8 | 1.0 | 2.8 | 1.0 |
| 4 | 3.9 | 1.0 | 3.8 | 1.1 | 3.8 | 1.2 | 3.8 | 1.2 | 3.8 | 1.3 | 3.8 | 1.4 |
| 5 | 4.8 | 1.3 | 4.8 | 1.4 | 4.8 | 1.5 | 4.8 | 1.5 | 4.7 | 1.6 | 4.7 | 1.7 |
| 6 | 5.8 | 1.6 | 5.8 | 1.7 | 5.7 | 1.8 | 5.7 | 1.9 | 5.7 | 2.0 | 5.6 | 2.1 |
| 7 | 6.8 | 1.8 | 6.7 | 1.9 | 6.7 | 2.0 | 6.7 | 2.2 | 6.6 | 2.3 | 6.6 | 2.4 |
| 8 | 7.7 | 2.1 | 7.7 | 2.2 | 7.7 | 2.3 | 7.6 | 2.5 | 7.6 | 2.6 | 7.5 | 2.7 |
| 9 | 8.7 | 2.3 | 8.7 | 2.5 | 8.6 | 2.6 | 8.6 | 2.8 | 8.5 | 2.9 | 8.5 | 3.1 |
| 10 | 9.7 | 2.6 | 9.6 | 2.8 | 9.6 | 2.9 | 9.5 | 3.1 | 9.5 | 3.3 | 9.4 | 3.4 |
| 11 | 10.6 | 2.8 | 10.6 | 3.0 | 10.5 | 3.2 | 10.5 | 3.4 | 10.4 | 3.6 | 10.3 | 3.8 |
| 12 | 11.6 | 3.1 | 11.5 | 3.3 | 11.5 | 3.5 | 11.4 | 3.7 | 11.3 | 3.9 | 11.3 | 4.1 |
| 13 | 12.6 | 3.4 | 12.5 | 3.6 | 12.4 | 3.8 | 12.4 | 4.0 | 12.3 | 4.2 | 12.2 | 4.4 |
| 14 | 13.5 | 3.6 | 13.5 | 3.9 | 13.4 | 4.1 | 13.3 | 4.3 | 13.2 | 4.6 | 13.2 | 4.8 |
| 15 | 14.5 | 3.9 | 14.4 | 4.1 | 14.3 | 4.4 | 14.3 | 4.6 | 14.2 | 4.9 | 14.1 | 5.1 |
| 16 | 15.5 | 4.1 | 15.4 | 4.4 | 15.3 | 4.7 | 15.2 | 4.9 | 15.1 | 5.2 | 15.0 | 5.5 |
| 17 | 16.4 | 4.4 | 16.3 | 4.7 | 16.3 | 5.0 | 16.2 | 5.3 | 16.1 | 5.5 | 16.0 | 5.8 |
| 18 | 17.4 | 4.7 | 17.3 | 5.0 | 17.2 | 5.3 | 17.1 | 5.6 | 17.0 | 5.9 | 16.9 | 6.2 |
| 19 | 18.4 | 4.9 | 18.3 | 5.2 | 18.2 | 5.6 | 18.1 | 5.9 | 18.0 | 6.2 | 17.9 | 6.5 |
| 20 | 19.3 | 5.2 | 19.2 | 5.5 | 19.1 | 5.8 | 19.0 | 6.2 | 18.9 | 6.5 | 18.8 | 6.8 |
| 21 | 20.3 | 5.4 | 20.2 | 5.8 | 20.1 | 6.1 | 20.0 | 6.5 | 19.9 | 6.8 | 19.7 | 7.2 |
| 22 | 21.3 | 5.7 | 21.1 | 6.1 | 21.0 | 6.4 | 20.9 | 6.8 | 20.8 | 7.2 | 20.7 | 7.5 |
| 23 | 22.2 | 6.0 | 22.1 | 6.3 | 22.0 | 6.7 | 21.9 | 7.1 | 21.7 | 7.5 | 21.6 | 7.9 |
| 24 | 23.2 | 6.2 | 23.1 | 6.6 | 23.0 | 7.0 | 22.8 | 7.4 | 22.7 | 7.8 | 22.6 | 8.2 |
| 25 | 24.1 | 6.5 | 24.0 | 6.9 | 23.9 | 7.3 | 23.8 | 7.7 | 23.6 | 8.1 | 23.5 | 8.6 |
| 26 | 25.1 | 6.7 | 25.0 | 7.2 | 24.9 | 7.6 | 24.7 | 8.0 | 24.6 | 8.5 | 24.4 | 8.9 |
| 27 | 26.1 | 7.0 | 26.0 | 7.4 | 25.8 | 7.9 | 25.7 | 8.3 | 25.5 | 8.8 | 25.4 | 9.2 |
| 28 | 27.0 | 7.2 | 26.9 | 7.7 | 26.8 | 8.2 | 26.6 | 8.7 | 26.5 | 9.1 | 26.3 | 9.6 |
| 29 | 28.0 | 7.5 | 27.9 | 8.0 | 27.7 | 8.5 | 27.6 | 9.0 | 27.4 | 9.4 | 27.3 | 9.9 |
| 30 | 29.0 | 7.8 | 28.8 | 8.3 | 28.7 | 8.8 | 28.5 | 9.3 | 28.4 | 9.8 | 28.2 | 10.3 |
| 31 | 29.9 | 8.0 | 29.8 | 8.5 | 29.6 | 9.1 | 29.5 | 9.6 | 29.3 | 10.1 | 29.1 | 10.6 |
| 32 | 30.9 | 8.3 | 30.8 | 8.8 | 30.6 | 9.4 | 30.4 | 9.9 | 30.3 | 10.4 | 30.1 | 10.9 |
| 33 | 31.9 | 8.5 | 31.7 | 9.1 | 31.6 | 9.6 | 31.4 | 10.2 | 31.2 | 10.7 | 31.0 | 11.3 |
| 34 | 32.8 | 8.8 | 32.7 | 9.4 | 32.5 | 9.9 | 32.3 | 10.5 | 32.1 | 11.1 | 31.9 | 11.6 |
| 35 | 33.8 | 9.1 | 33.6 | 9.6 | 33.5 | 10.2 | 33.3 | 10.8 | 33.1 | 11.4 | 32.9 | 12.0 |
| 36 | 34.8 | 9.3 | 34.6 | 9.9 | 34.4 | 10.5 | 34.2 | 11.1 | 34.0 | 11.7 | 33.8 | 12.3 |
| 37 | 35.7 | 9.6 | 35.6 | 10.2 | 35.4 | 10.8 | 35.2 | 11.4 | 35.0 | 12.0 | 34.8 | 12.7 |
| 38 | 36.7 | 9.8 | 36.5 | 10.5 | 36.3 | 11.1 | 36.1 | 11.7 | 35.9 | 12.4 | 35.7 | 13.0 |
| 39 | 37.7 | 10.1 | 37.5 | 10.7 | 37.3 | 11.4 | 37.1 | 12.1 | 36.9 | 12.7 | 36.6 | 13.3 |
| 40 | 38.6 | 10.4 | 38.5 | 11.0 | 38.3 | 11.7 | 38.0 | 12.4 | 37.8 | 13.0 | 37.6 | 13.7 |
| 41 | 39.6 | 10.6 | 39.4 | 11.3 | 39.2 | 12.0 | 39.0 | 12.7 | 38.8 | 13.3 | 38.5 | 14.0 |
| 42 | 40.6 | 10.9 | 40.4 | 11.6 | 40.2 | 12.3 | 39.9 | 13.0 | 39.7 | 13.7 | 39.5 | 14.4 |
| 43 | 41.5 | 11.1 | 41.3 | 11.9 | 41.1 | 12.6 | 40.9 | 13.3 | 40.7 | 14.0 | 40.4 | 14.7 |
| 44 | 42.5 | 11.4 | 42.3 | 12.1 | 42.1 | 12.9 | 41.8 | 13.6 | 41.6 | 14.3 | 41.3 | 15.0 |
| 45 | 43.5 | 11.6 | 43.3 | 12.4 | 43.0 | 13.2 | 42.8 | 13.9 | 42.5 | 14.7 | 42.3 | 15.4 |
| 46 | 44.4 | 11.9 | 44.2 | 12.7 | 44.0 | 13.4 | 43.7 | 14.2 | 43.5 | 15.0 | 43.2 | 15.7 |
| 47 | 45.4 | 12.2 | 45.2 | 13.0 | 44.9 | 13.7 | 44.7 | 14.5 | 44.4 | 15.3 | 44.2 | 16.1 |
| 48 | 46.4 | 12.4 | 46.1 | 13.2 | 45.9 | 14.0 | 45.7 | 14.8 | 45.4 | 15.6 | 45.1 | 16.4 |
| 49 | 47.3 | 12.7 | 47.1 | 13.5 | 46.9 | 14.3 | 46.6 | 15.1 | 46.3 | 16.0 | 46.0 | 16.8 |
| 50 | 48.3 | 12.9 | 48.1 | 13.8 | 47.8 | 14.6 | 47.6 | 15.5 | 47.3 | 16.3 | 47.0 | 17.1 |
| 100 | 96.6 | 25.9 | 96.1 | 27.6 | 95.6 | 29.2 | 95.1 | 30.9 | 94.6 | 32.6 | 94.0 | 34.2 |
| 200 | 193.2 | 51.8 | 192.3 | 55.1 | 191.3 | 58.5 | 190.2 | 61.8 | 189.1 | 65.1 | 187.9 | 68.4 |
| 300 | 289.8 | 77.6 | 288.4 | 82.7 | 286.9 | 87.7 | 285.3 | 92.7 | 283.7 | 97.7 | 281.9 | 102.6 |
| 400 | 386.3 | 103.5 | 384.5 | 110.2 | 382.5 | 117.0 | 380.4 | 123.6 | 378.2 | 130.2 | 375.9 | 136.8 |
| 500 | 483.0 | 129.4 | 480.6 | 137.8 | 478.1 | 146.2 | 475.5 | 154.5 | 472.8 | 162.8 | 469.9 | 171.0 |
| | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. |
| | (105°, 255°, 285°) | | (106°, 254°, 286°) | | (107°, 253°, 287°) | | (108°, 252°, 288°) | | (109°, 251°, 289°) | | (110°, 250°, 290°) | |
| | 75° | | 74° | | 6½ Pt. 73° | | 72° | | 71° | | 6¼ Pt. 70° | |

Table 1. Traverse Table

| Dist. | 15° (165°, 195°, 345°) | | 16° (164°, 196°, 344°) | | 1½ Pt. 17° (163°, 197°, 343°) | | 18° (162°, 198°, 342°) | | 19° (161°, 199°, 341°) | | 1½ Pt. 20° (160°, 200°, 340°) | |
|-------|---------------------------|-------|---------------------------|-------|----------------------------------|-------|---------------------------|-------|---------------------------|-------|----------------------------------|-------|
| | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. |
| 51 | 49.3 | 13.2 | 49.0 | 14.1 | 48.8 | 14.9 | 48.5 | 15.8 | 48.2 | 16.6 | 47.9 | 17.4 |
| 52 | 50.2 | 13.5 | 50.0 | 14.3 | 49.7 | 15.2 | 49.5 | 16.1 | 49.2 | 16.9 | 48.9 | 17.8 |
| 53 | 51.2 | 13.7 | 50.9 | 14.6 | 50.7 | 15.5 | 50.4 | 16.4 | 50.1 | 17.3 | 49.8 | 18.1 |
| 54 | 52.2 | 14.0 | 51.9 | 14.9 | 51.6 | 15.8 | 51.4 | 16.7 | 51.1 | 17.6 | 50.7 | 18.5 |
| 55 | 53.1 | 14.2 | 52.9 | 15.2 | 52.6 | 16.1 | 52.3 | 17.0 | 52.0 | 17.9 | 51.7 | 18.8 |
| 56 | 54.1 | 14.5 | 53.8 | 15.4 | 53.6 | 16.4 | 53.3 | 17.3 | 52.9 | 18.2 | 52.6 | 19.2 |
| 57 | 55.1 | 14.8 | 54.8 | 15.7 | 54.5 | 16.7 | 54.2 | 17.6 | 53.9 | 18.6 | 53.6 | 19.5 |
| 58 | 56.0 | 15.0 | 55.8 | 16.0 | 55.5 | 17.0 | 55.2 | 17.9 | 54.8 | 18.9 | 54.5 | 19.8 |
| 59 | 57.0 | 15.3 | 56.7 | 16.3 | 56.4 | 17.2 | 56.1 | 18.2 | 55.8 | 19.2 | 55.4 | 20.2 |
| 60 | 58.0 | 15.5 | 57.7 | 16.5 | 57.4 | 17.5 | 57.1 | 18.5 | 56.7 | 19.5 | 56.4 | 20.5 |
| 61 | 58.9 | 15.8 | 58.6 | 16.8 | 58.3 | 17.8 | 58.0 | 18.9 | 57.7 | 19.9 | 57.3 | 20.9 |
| 62 | 59.9 | 16.0 | 59.6 | 17.1 | 59.3 | 18.1 | 59.0 | 19.2 | 58.6 | 20.2 | 58.3 | 21.2 |
| 63 | 60.9 | 16.3 | 60.6 | 17.4 | 60.2 | 18.4 | 59.9 | 19.5 | 59.6 | 20.5 | 59.2 | 21.5 |
| 64 | 61.8 | 16.6 | 61.5 | 17.6 | 61.2 | 18.7 | 60.9 | 19.8 | 60.5 | 20.8 | 60.1 | 21.9 |
| 65 | 62.8 | 16.8 | 62.5 | 17.9 | 62.2 | 19.0 | 61.8 | 20.1 | 61.5 | 21.2 | 61.1 | 22.2 |
| 66 | 63.8 | 17.1 | 63.4 | 18.2 | 63.1 | 19.3 | 62.8 | 20.4 | 62.4 | 21.5 | 62.0 | 22.6 |
| 67 | 64.7 | 17.3 | 64.4 | 18.5 | 64.1 | 19.6 | 63.7 | 20.7 | 63.3 | 21.8 | 63.0 | 22.9 |
| 68 | 65.7 | 17.6 | 65.4 | 18.7 | 65.0 | 19.9 | 64.7 | 21.0 | 64.3 | 22.1 | 63.9 | 23.3 |
| 69 | 66.6 | 17.9 | 66.3 | 19.0 | 66.0 | 20.2 | 65.6 | 21.3 | 65.2 | 22.5 | 64.8 | 23.6 |
| 70 | 67.6 | 18.1 | 67.3 | 19.3 | 66.9 | 20.5 | 66.6 | 21.6 | 66.2 | 22.8 | 65.8 | 23.9 |
| 71 | 68.6 | 18.4 | 68.2 | 19.6 | 67.9 | 20.8 | 67.5 | 21.9 | 67.1 | 23.1 | 66.7 | 24.3 |
| 72 | 69.5 | 18.6 | 69.2 | 19.8 | 68.9 | 21.1 | 68.5 | 22.2 | 68.1 | 23.4 | 67.7 | 24.6 |
| 73 | 70.5 | 18.9 | 70.2 | 20.1 | 69.8 | 21.3 | 69.4 | 22.6 | 69.0 | 23.8 | 68.6 | 25.0 |
| 74 | 71.5 | 19.2 | 71.1 | 20.4 | 70.8 | 21.6 | 70.4 | 22.9 | 70.0 | 24.1 | 69.5 | 25.3 |
| 75 | 72.4 | 19.4 | 72.1 | 20.7 | 71.7 | 21.9 | 71.3 | 23.2 | 70.9 | 24.4 | 70.5 | 25.7 |
| 76 | 73.4 | 19.7 | 73.1 | 20.9 | 72.7 | 22.2 | 72.3 | 23.5 | 71.9 | 24.7 | 71.4 | 26.0 |
| 77 | 74.4 | 19.9 | 74.0 | 21.2 | 73.6 | 22.5 | 73.2 | 23.8 | 72.8 | 25.1 | 72.4 | 26.3 |
| 78 | 75.3 | 20.2 | 75.0 | 21.5 | 74.6 | 22.8 | 74.2 | 24.1 | 73.8 | 25.4 | 73.3 | 26.7 |
| 79 | 76.3 | 20.4 | 75.9 | 21.8 | 75.5 | 23.1 | 75.1 | 24.4 | 74.7 | 25.7 | 74.2 | 27.0 |
| 80 | 77.3 | 20.7 | 76.9 | 22.1 | 76.5 | 23.4 | 76.1 | 24.7 | 75.6 | 26.0 | 75.2 | 27.4 |
| 81 | 78.2 | 21.0 | 77.9 | 22.3 | 77.5 | 23.7 | 77.0 | 25.0 | 76.6 | 26.4 | 76.1 | 27.7 |
| 82 | 79.2 | 21.2 | 78.8 | 22.6 | 78.4 | 24.0 | 78.0 | 25.3 | 77.5 | 26.7 | 77.1 | 28.0 |
| 83 | 80.2 | 21.5 | 79.8 | 22.9 | 79.4 | 24.3 | 78.9 | 25.6 | 78.5 | 27.0 | 78.0 | 28.4 |
| 84 | 81.1 | 21.7 | 80.7 | 23.2 | 80.3 | 24.6 | 79.9 | 26.0 | 79.4 | 27.3 | 78.9 | 28.7 |
| 85 | 82.1 | 22.0 | 81.7 | 23.4 | 81.3 | 24.9 | 80.8 | 26.3 | 80.4 | 27.7 | 79.9 | 29.1 |
| 86 | 83.1 | 22.3 | 82.7 | 23.7 | 82.2 | 25.1 | 81.8 | 26.6 | 81.3 | 28.0 | 80.8 | 29.4 |
| 87 | 84.0 | 22.5 | 83.6 | 24.0 | 83.2 | 25.4 | 82.7 | 26.9 | 82.3 | 28.3 | 81.8 | 29.8 |
| 88 | 85.0 | 22.8 | 84.6 | 24.3 | 84.2 | 25.7 | 83.7 | 27.2 | 83.2 | 28.7 | 82.7 | 30.1 |
| 89 | 86.0 | 23.0 | 85.6 | 24.5 | 85.1 | 26.0 | 84.6 | 27.5 | 84.2 | 29.0 | 83.6 | 30.4 |
| 90 | 86.9 | 23.3 | 86.5 | 24.8 | 86.1 | 26.3 | 85.6 | 27.8 | 85.1 | 29.3 | 84.6 | 30.8 |
| 91 | 87.9 | 23.6 | 87.5 | 25.1 | 87.0 | 26.6 | 86.5 | 28.1 | 86.0 | 29.6 | 85.5 | 31.1 |
| 92 | 88.9 | 23.8 | 88.4 | 25.4 | 88.0 | 26.9 | 87.5 | 28.4 | 87.0 | 30.0 | 86.5 | 31.5 |
| 93 | 89.8 | 24.1 | 89.4 | 25.6 | 88.9 | 27.2 | 88.4 | 28.7 | 87.9 | 30.3 | 87.4 | 31.8 |
| 94 | 90.8 | 24.3 | 90.4 | 25.9 | 89.9 | 27.5 | 89.4 | 29.0 | 88.9 | 30.6 | 88.3 | 32.1 |
| 95 | 91.8 | 24.6 | 91.3 | 26.2 | 90.8 | 27.8 | 90.4 | 29.4 | 89.8 | 30.9 | 89.3 | 32.5 |
| 96 | 92.7 | 24.8 | 92.3 | 26.5 | 91.8 | 28.1 | 91.3 | 29.7 | 90.8 | 31.3 | 90.2 | 32.8 |
| 97 | 93.7 | 25.1 | 93.2 | 26.7 | 92.8 | 28.4 | 92.3 | 30.0 | 91.7 | 31.6 | 91.2 | 33.2 |
| 98 | 94.7 | 25.4 | 94.2 | 27.0 | 93.7 | 28.7 | 93.2 | 30.3 | 92.7 | 31.9 | 92.1 | 33.5 |
| 99 | 95.6 | 25.6 | 95.2 | 27.3 | 94.7 | 28.9 | 94.2 | 30.6 | 93.6 | 32.2 | 93.0 | 33.9 |
| 100 | 96.6 | 25.9 | 96.1 | 27.6 | 95.6 | 29.2 | 95.1 | 30.9 | 94.6 | 32.6 | 94.0 | 34.2 |
| 700 | 579.5 | 155.3 | 576.8 | 165.4 | 573.8 | 175.4 | 570.6 | 185.4 | 567.3 | 195.3 | 563.8 | 205.2 |
| 600 | 676.1 | 181.1 | 672.8 | 193.0 | 669.4 | 204.6 | 665.8 | 216.3 | 661.9 | 227.9 | 657.9 | 239.4 |
| 800 | 772.7 | 207.0 | 769.0 | 220.5 | 765.0 | 233.9 | 760.8 | 247.3 | 756.5 | 260.4 | 751.8 | 273.6 |
| 900 | 869.2 | 232.9 | 865.0 | 248.0 | 860.6 | 263.1 | 855.9 | 278.1 | 850.9 | 292.9 | 845.7 | 307.8 |
| | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. |
| | (105°, 255°, 285°) | | (106°, 254°, 286°) | | (107°, 253°, 287°) | | (108°, 252°, 288°) | | (109°, 251°, 289°) | | (110°, 250°, 290°) | |
| | 75° | | 74° | | 6½ Pt. 73° | | 72° | | 71° | | 70° | |

Table 1. Traverse Table

| Dist. | 21° (159°, 201°, 339°) | | 22° (158°, 202°, 338°) | | 2 Pt. 23° (157°, 203°, 337°) | | 24° (156°, 204°, 336°) | | 2½ Pt. 25° (155°, 205°, 335°) | | 26° (154°, 206°, 334°) | |
|-------|---------------------------|-------|---------------------------|-------|---------------------------------|-------|---------------------------|-------|----------------------------------|-------|---------------------------|-------|
| | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. |
| 1 | 0.9 | 0.4 | 0.9 | 0.4 | 0.9 | 0.4 | 0.9 | 0.4 | 0.9 | 0.4 | 0.9 | 0.4 |
| 2 | 1.9 | 0.7 | 1.9 | 0.7 | 1.8 | 0.8 | 1.8 | 0.8 | 1.8 | 0.8 | 1.8 | 0.9 |
| 3 | 2.8 | 1.1 | 2.8 | 1.1 | 2.8 | 1.2 | 2.7 | 1.2 | 2.7 | 1.3 | 2.7 | 1.3 |
| 4 | 3.7 | 1.4 | 3.7 | 1.5 | 3.7 | 1.6 | 3.7 | 1.6 | 3.6 | 1.7 | 3.6 | 1.8 |
| 5 | 4.7 | 1.8 | 4.6 | 1.9 | 4.6 | 2.0 | 4.6 | 2.0 | 4.5 | 2.1 | 4.5 | 2.2 |
| 6 | 5.6 | 2.2 | 5.6 | 2.2 | 5.5 | 2.3 | 5.5 | 2.4 | 5.4 | 2.5 | 5.4 | 2.6 |
| 7 | 6.5 | 2.5 | 6.5 | 2.6 | 6.4 | 2.7 | 6.4 | 2.8 | 6.3 | 3.0 | 6.3 | 3.1 |
| 8 | 7.5 | 2.9 | 7.4 | 3.0 | 7.4 | 3.1 | 7.3 | 3.3 | 7.3 | 3.4 | 7.2 | 3.5 |
| 9 | 8.4 | 3.2 | 8.3 | 3.4 | 8.3 | 3.5 | 8.2 | 3.7 | 8.2 | 3.8 | 8.1 | 3.9 |
| 10 | 9.3 | 3.6 | 9.3 | 3.7 | 9.2 | 3.9 | 9.1 | 4.1 | 9.1 | 4.2 | 9.0 | 4.4 |
| 11 | 10.3 | 3.9 | 10.2 | 4.1 | 10.1 | 4.3 | 10.0 | 4.5 | 10.0 | 4.6 | 9.9 | 4.8 |
| 12 | 11.2 | 4.3 | 11.1 | 4.5 | 11.0 | 4.7 | 11.0 | 4.9 | 10.9 | 5.1 | 10.8 | 5.3 |
| 13 | 12.1 | 4.7 | 12.1 | 4.9 | 12.0 | 5.1 | 11.9 | 5.3 | 11.8 | 5.5 | 11.7 | 5.7 |
| 14 | 13.1 | 5.0 | 13.0 | 5.2 | 12.9 | 5.5 | 12.8 | 5.7 | 12.7 | 5.9 | 12.6 | 6.1 |
| 15 | 14.0 | 5.4 | 13.9 | 5.6 | 13.8 | 5.9 | 13.7 | 6.1 | 13.6 | 6.3 | 13.5 | 6.6 |
| 16 | 14.9 | 5.7 | 14.8 | 6.0 | 14.7 | 6.3 | 14.6 | 6.5 | 14.5 | 6.8 | 14.4 | 7.0 |
| 17 | 15.9 | 6.1 | 15.8 | 6.4 | 15.6 | 6.6 | 15.5 | 6.9 | 15.4 | 7.2 | 15.3 | 7.5 |
| 18 | 16.8 | 6.5 | 16.7 | 6.7 | 16.6 | 7.0 | 16.4 | 7.3 | 16.3 | 7.6 | 16.2 | 7.9 |
| 19 | 17.7 | 6.8 | 17.6 | 7.1 | 17.5 | 7.4 | 17.4 | 7.7 | 17.2 | 8.0 | 17.1 | 8.3 |
| 20 | 18.7 | 7.2 | 18.5 | 7.5 | 18.4 | 7.8 | 18.3 | 8.1 | 18.1 | 8.5 | 18.0 | 8.8 |
| 21 | 19.6 | 7.5 | 19.5 | 7.9 | 19.3 | 8.2 | 19.2 | 8.5 | 19.0 | 8.9 | 18.9 | 9.2 |
| 22 | 20.5 | 7.9 | 20.4 | 8.2 | 20.3 | 8.6 | 20.1 | 8.9 | 19.9 | 9.3 | 19.8 | 9.6 |
| 23 | 21.5 | 8.2 | 21.3 | 8.6 | 21.2 | 9.0 | 21.0 | 9.4 | 20.8 | 9.7 | 20.7 | 10.1 |
| 24 | 22.4 | 8.6 | 22.3 | 9.0 | 22.1 | 9.4 | 21.9 | 9.8 | 21.8 | 10.1 | 21.6 | 10.5 |
| 25 | 23.3 | 9.0 | 23.2 | 9.4 | 23.0 | 9.8 | 22.8 | 10.2 | 22.7 | 10.6 | 22.5 | 11.0 |
| 26 | 24.3 | 9.3 | 24.1 | 9.7 | 23.9 | 10.2 | 23.8 | 10.6 | 23.6 | 11.0 | 23.4 | 11.4 |
| 27 | 25.2 | 9.7 | 25.0 | 10.1 | 24.9 | 10.5 | 24.7 | 11.0 | 24.5 | 11.4 | 24.3 | 11.8 |
| 28 | 26.1 | 10.0 | 26.0 | 10.5 | 25.8 | 10.9 | 25.6 | 11.4 | 25.4 | 11.8 | 25.2 | 12.3 |
| 29 | 27.1 | 10.4 | 26.9 | 10.9 | 26.7 | 11.3 | 26.5 | 11.8 | 26.3 | 12.3 | 26.1 | 12.7 |
| 30 | 28.0 | 10.8 | 27.8 | 11.2 | 27.6 | 11.7 | 27.4 | 12.2 | 27.2 | 12.7 | 27.0 | 13.2 |
| 31 | 28.9 | 11.1 | 28.7 | 11.6 | 28.5 | 12.1 | 28.3 | 12.6 | 28.1 | 13.1 | 27.9 | 13.6 |
| 32 | 29.9 | 11.5 | 29.7 | 12.0 | 29.5 | 12.5 | 29.2 | 13.0 | 29.0 | 13.5 | 28.8 | 14.0 |
| 33 | 30.8 | 11.8 | 30.6 | 12.4 | 30.4 | 12.9 | 30.1 | 13.4 | 29.9 | 13.9 | 29.7 | 14.5 |
| 34 | 31.7 | 12.2 | 31.5 | 12.7 | 31.3 | 13.3 | 31.1 | 13.8 | 30.8 | 14.4 | 30.6 | 14.9 |
| 35 | 32.7 | 12.5 | 32.5 | 13.1 | 32.2 | 13.7 | 32.0 | 14.2 | 31.7 | 14.8 | 31.5 | 15.3 |
| 36 | 33.6 | 12.9 | 33.4 | 13.5 | 33.1 | 14.1 | 32.9 | 14.6 | 32.6 | 15.2 | 32.4 | 15.8 |
| 37 | 34.5 | 13.3 | 34.3 | 13.9 | 34.1 | 14.5 | 33.8 | 15.0 | 33.5 | 15.6 | 33.3 | 16.2 |
| 38 | 35.5 | 13.6 | 35.2 | 14.2 | 35.0 | 14.8 | 34.7 | 15.5 | 34.4 | 16.1 | 34.2 | 16.7 |
| 39 | 36.4 | 14.0 | 36.2 | 14.6 | 35.9 | 15.2 | 35.6 | 15.9 | 35.3 | 16.5 | 35.1 | 17.1 |
| 40 | 37.3 | 14.3 | 37.1 | 15.0 | 36.8 | 15.6 | 36.5 | 16.3 | 36.3 | 16.9 | 36.0 | 17.5 |
| 41 | 38.3 | 14.7 | 38.0 | 15.4 | 37.7 | 16.0 | 37.5 | 16.7 | 37.2 | 17.3 | 36.9 | 18.0 |
| 42 | 39.2 | 15.1 | 38.9 | 15.7 | 38.7 | 16.4 | 38.4 | 17.1 | 38.1 | 17.7 | 37.7 | 18.4 |
| 43 | 40.1 | 15.4 | 39.9 | 16.1 | 39.6 | 16.8 | 39.3 | 17.5 | 39.0 | 18.2 | 38.6 | 18.8 |
| 44 | 41.1 | 15.8 | 40.8 | 16.5 | 40.5 | 17.2 | 40.2 | 17.9 | 39.9 | 18.6 | 39.5 | 19.3 |
| 45 | 42.0 | 16.1 | 41.7 | 16.9 | 41.4 | 17.6 | 41.1 | 18.3 | 40.8 | 19.0 | 40.4 | 19.7 |
| 46 | 42.9 | 16.5 | 42.7 | 17.2 | 42.3 | 18.0 | 42.0 | 18.7 | 41.7 | 19.4 | 41.3 | 20.2 |
| 47 | 43.9 | 16.8 | 43.6 | 17.6 | 43.3 | 18.4 | 42.9 | 19.1 | 42.6 | 19.9 | 42.2 | 20.6 |
| 48 | 44.8 | 17.2 | 44.5 | 18.0 | 44.2 | 18.8 | 43.9 | 19.5 | 43.5 | 20.3 | 43.1 | 21.0 |
| 49 | 45.7 | 17.6 | 45.4 | 18.4 | 45.1 | 19.1 | 44.8 | 19.9 | 44.4 | 20.7 | 44.0 | 21.5 |
| 50 | 46.7 | 17.9 | 46.4 | 18.7 | 46.0 | 19.5 | 45.7 | 20.3 | 45.3 | 21.1 | 44.9 | 21.9 |
| 100 | 93.4 | 35.8 | 92.7 | 37.5 | 92.1 | 39.1 | 91.4 | 40.7 | 90.6 | 42.3 | 89.9 | 43.8 |
| 200 | 186.7 | 71.7 | 185.4 | 74.9 | 184.1 | 78.1 | 182.7 | 81.3 | 181.3 | 84.5 | 179.8 | 87.7 |
| 300 | 280.1 | 107.5 | 278.2 | 112.4 | 276.2 | 117.2 | 274.1 | 122.0 | 271.9 | 126.8 | 269.6 | 131.5 |
| 400 | 373.4 | 143.4 | 370.9 | 149.8 | 368.2 | 156.3 | 365.4 | 162.7 | 362.5 | 169.0 | 359.5 | 175.4 |
| 500 | 466.8 | 179.2 | 463.6 | 187.3 | 460.2 | 195.4 | 456.8 | 203.4 | 453.1 | 211.3 | 449.4 | 219.2 |
| | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. |
| | (111°, 249°, 291°) | | (112°, 248°, 292°) | | (113°, 247°, 293°) | | (114°, 246°, 294°) | | (115°, 245°, 295°) | | (116°, 244°, 296°) | |
| | 69° | | 6 Pt. 68° | | 67° | | 66° | | 5½ Pt. 65° | | 64° | |

The 2-Pt. or 23° Courses are: N.N.E., N.N.W., S.S.E., S.S.W.

Table 1. Traverse Table

| Dist. | 21° (159°, 201°, 339°) | | 22° (158°, 202°, 338°) | | 2 Pt. 23° (157°, 203°, 337°) | | 24° (156°, 204°, 336°) | | 2½ Pt. 25° (155°, 205°, 335°) | | 26° (154°, 206°, 334°) | |
|-------|---------------------------|-------|---------------------------|-------|---------------------------------|-------|---------------------------|-------|----------------------------------|-------|---------------------------|-------|
| | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. |
| | (111°, 249°, 291°) | | (112°, 248°, 292°) | | (113°, 247°, 293°) | | (114°, 246°, 294°) | | (115°, 245°, 295°) | | (116°, 244°, 296°) | |
| 51 | 47.6 | 18.3 | 47.3 | 19.1 | 46.9 | 19.9 | 46.6 | 20.7 | 46.2 | 21.6 | 45.8 | 22.4 |
| 52 | 48.5 | 18.6 | 48.2 | 19.5 | 47.9 | 20.3 | 47.5 | 21.2 | 47.1 | 22.0 | 46.7 | 22.8 |
| 53 | 49.5 | 19.0 | 49.1 | 19.9 | 48.8 | 20.7 | 48.4 | 21.6 | 48.0 | 22.4 | 47.6 | 23.2 |
| 54 | 50.4 | 19.4 | 50.1 | 20.2 | 49.7 | 21.1 | 49.3 | 22.0 | 48.9 | 22.8 | 48.5 | 23.7 |
| 55 | 51.3 | 19.7 | 51.0 | 20.6 | 50.6 | 21.5 | 50.2 | 22.4 | 49.8 | 23.2 | 49.4 | 24.1 |
| 56 | 52.3 | 20.1 | 51.9 | 21.0 | 51.5 | 21.9 | 51.2 | 22.8 | 50.8 | 23.7 | 50.3 | 24.5 |
| 57 | 53.2 | 20.4 | 52.8 | 21.4 | 52.5 | 22.3 | 52.1 | 23.2 | 51.7 | 24.1 | 51.2 | 25.0 |
| 58 | 54.1 | 20.8 | 53.8 | 21.7 | 53.4 | 22.7 | 53.0 | 23.6 | 52.6 | 24.5 | 52.1 | 25.4 |
| 59 | 55.1 | 21.1 | 54.7 | 22.1 | 54.3 | 23.1 | 53.9 | 24.0 | 53.5 | 24.9 | 53.0 | 25.9 |
| 60 | 56.0 | 21.5 | 55.6 | 22.5 | 55.2 | 23.4 | 54.8 | 24.4 | 54.4 | 25.4 | 53.9 | 26.3 |
| 61 | 56.9 | 21.9 | 56.6 | 22.9 | 56.2 | 23.8 | 55.7 | 24.8 | 55.3 | 25.8 | 54.8 | 26.7 |
| 62 | 57.9 | 22.2 | 57.5 | 23.2 | 57.1 | 24.2 | 56.6 | 25.2 | 56.2 | 26.2 | 55.7 | 27.2 |
| 63 | 58.8 | 22.6 | 58.4 | 23.6 | 58.0 | 24.6 | 57.6 | 25.6 | 57.1 | 26.6 | 56.6 | 27.6 |
| 64 | 59.7 | 22.9 | 59.3 | 24.0 | 58.9 | 25.0 | 58.5 | 26.0 | 58.0 | 27.0 | 57.5 | 28.1 |
| 65 | 60.7 | 23.3 | 60.3 | 24.3 | 59.8 | 25.4 | 59.4 | 26.4 | 58.9 | 27.5 | 58.4 | 28.5 |
| 66 | 61.6 | 23.7 | 61.2 | 24.7 | 60.8 | 25.8 | 60.3 | 26.8 | 59.8 | 27.9 | 59.3 | 28.9 |
| 67 | 62.5 | 24.0 | 62.1 | 25.1 | 61.7 | 26.2 | 61.2 | 27.3 | 60.7 | 28.3 | 60.2 | 29.4 |
| 68 | 63.5 | 24.4 | 63.0 | 25.5 | 62.6 | 26.6 | 62.1 | 27.7 | 61.6 | 28.7 | 61.1 | 29.8 |
| 69 | 64.4 | 24.7 | 64.0 | 25.8 | 63.5 | 27.0 | 63.0 | 28.1 | 62.5 | 29.2 | 62.0 | 30.2 |
| 70 | 65.4 | 25.1 | 64.9 | 26.2 | 64.4 | 27.4 | 63.9 | 28.5 | 63.4 | 29.6 | 62.9 | 30.7 |
| 71 | 66.3 | 25.4 | 65.8 | 26.6 | 65.4 | 27.7 | 64.9 | 28.9 | 64.3 | 30.0 | 63.8 | 31.1 |
| 72 | 67.2 | 25.8 | 66.8 | 27.0 | 66.3 | 28.1 | 65.8 | 29.3 | 65.3 | 30.4 | 64.7 | 31.6 |
| 73 | 68.2 | 26.2 | 67.7 | 27.3 | 67.2 | 28.5 | 66.7 | 29.7 | 66.2 | 30.9 | 65.6 | 32.0 |
| 74 | 69.1 | 26.5 | 68.6 | 27.7 | 68.1 | 28.9 | 67.6 | 30.1 | 67.1 | 31.3 | 66.5 | 32.4 |
| 75 | 70.0 | 26.9 | 69.5 | 28.1 | 69.0 | 29.3 | 68.5 | 30.5 | 68.0 | 31.7 | 67.4 | 32.9 |
| 76 | 71.0 | 27.2 | 70.5 | 28.5 | 70.0 | 29.7 | 69.4 | 30.9 | 68.9 | 32.1 | 68.3 | 33.3 |
| 77 | 71.9 | 27.6 | 71.4 | 28.8 | 70.9 | 30.1 | 70.3 | 31.3 | 69.8 | 32.5 | 69.2 | 33.8 |
| 78 | 72.8 | 28.0 | 72.3 | 29.2 | 71.8 | 30.5 | 71.3 | 31.7 | 70.7 | 33.0 | 70.1 | 34.2 |
| 79 | 73.0 | 28.3 | 73.2 | 29.6 | 72.7 | 30.9 | 72.2 | 32.1 | 71.6 | 33.4 | 71.0 | 34.6 |
| 80 | 74.7 | 28.7 | 74.2 | 30.0 | 73.6 | 31.3 | 73.1 | 32.5 | 72.5 | 33.8 | 71.9 | 35.1 |
| 81 | 75.6 | 29.0 | 75.1 | 30.3 | 74.6 | 31.6 | 74.0 | 32.9 | 73.4 | 34.2 | 72.8 | 35.5 |
| 82 | 76.6 | 29.4 | 76.0 | 30.7 | 75.5 | 32.0 | 74.9 | 33.4 | 74.3 | 34.7 | 73.7 | 35.9 |
| 83 | 77.5 | 29.7 | 77.0 | 31.1 | 76.4 | 32.4 | 75.8 | 33.8 | 75.2 | 35.1 | 74.6 | 36.4 |
| 84 | 78.4 | 30.1 | 77.9 | 31.5 | 77.3 | 32.8 | 76.7 | 34.2 | 76.1 | 35.5 | 75.5 | 36.8 |
| 85 | 79.4 | 30.5 | 78.8 | 31.8 | 78.2 | 33.2 | 77.7 | 34.6 | 77.0 | 35.9 | 76.4 | 37.3 |
| 86 | 80.3 | 30.8 | 79.7 | 32.2 | 79.2 | 33.6 | 78.6 | 35.0 | 77.9 | 36.3 | 77.3 | 37.7 |
| 87 | 81.2 | 31.2 | 80.7 | 32.6 | 80.1 | 34.0 | 79.5 | 35.4 | 78.8 | 36.8 | 78.2 | 38.1 |
| 88 | 82.2 | 31.5 | 81.6 | 33.0 | 81.0 | 34.4 | 80.4 | 35.8 | 79.8 | 37.2 | 79.1 | 38.6 |
| 89 | 83.1 | 31.9 | 82.5 | 33.3 | 81.9 | 34.8 | 81.3 | 36.2 | 80.7 | 37.6 | 80.0 | 39.0 |
| 90 | 84.0 | 32.3 | 83.4 | 33.7 | 82.8 | 35.2 | 82.2 | 36.6 | 81.6 | 38.0 | 80.9 | 39.5 |
| 91 | 85.0 | 32.6 | 84.4 | 34.1 | 83.8 | 35.6 | 83.1 | 37.0 | 82.5 | 38.5 | 81.8 | 39.9 |
| 92 | 85.9 | 33.0 | 85.3 | 34.5 | 84.7 | 35.9 | 84.0 | 37.4 | 83.4 | 38.9 | 82.7 | 40.3 |
| 93 | 86.8 | 33.3 | 86.2 | 34.8 | 85.6 | 36.3 | 85.0 | 37.8 | 84.3 | 39.3 | 83.6 | 40.8 |
| 94 | 87.8 | 33.7 | 87.2 | 35.2 | 86.5 | 36.7 | 85.9 | 38.2 | 85.2 | 39.7 | 84.5 | 41.2 |
| 95 | 88.7 | 34.0 | 88.1 | 35.6 | 87.4 | 37.1 | 86.8 | 38.6 | 86.1 | 40.1 | 85.4 | 41.6 |
| 96 | 89.6 | 34.4 | 89.0 | 36.0 | 88.4 | 37.5 | 87.7 | 39.0 | 87.0 | 40.6 | 86.3 | 42.1 |
| 97 | 90.6 | 34.8 | 89.9 | 36.3 | 89.3 | 37.9 | 88.6 | 39.5 | 87.9 | 41.0 | 87.2 | 42.5 |
| 98 | 91.5 | 35.1 | 90.9 | 36.7 | 90.2 | 38.3 | 89.5 | 39.9 | 88.8 | 41.4 | 88.1 | 43.0 |
| 99 | 92.4 | 35.5 | 91.8 | 37.1 | 91.1 | 38.7 | 90.4 | 40.3 | 89.7 | 41.8 | 89.0 | 43.4 |
| 100 | 93.4 | 35.8 | 92.7 | 37.5 | 92.1 | 39.1 | 91.4 | 40.7 | 90.6 | 42.3 | 89.9 | 43.8 |
| 600 | 560.1 | 215.0 | 556.3 | 224.8 | 552.3 | 234.4 | 548.1 | 244.0 | 543.8 | 253.6 | 539.3 | 263.0 |
| 700 | 653.6 | 250.8 | 649.1 | 262.2 | 644.3 | 273.5 | 639.5 | 284.7 | 634.5 | 295.8 | 629.2 | 306.8 |
| 800 | 746.9 | 286.7 | 741.8 | 299.7 | 736.4 | 312.6 | 730.8 | 324.4 | 725.1 | 338.1 | 719.1 | 350.6 |
| 900 | 840.3 | 322.5 | 834.5 | 337.1 | 828.3 | 351.7 | 822.1 | 366.0 | 815.6 | 380.3 | 808.9 | 394.5 |
| | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. |
| | (111°, 249°, 291°) | | (112°, 248°, 292°) | | (113°, 247°, 293°) | | (114°, 246°, 294°) | | (115°, 245°, 295°) | | (116°, 244°, 296°) | |
| | 69° | | 6 Pt. 68° | | 67° | | 66° | | 5½ Pt. 65° | | 64° | |

The 6-Pt. or 68° Courses are: E.N.E., W.N.W., E.S.E., W.S.W.

Table 1. Traverse Table

| Distr. | 27° (153°, 207°, 333°) | | 2½ Pt. 28° (152°, 208°, 332°) | | 29° (151°, 209°, 331°) | | 30° (150°, 210°, 330°) | | 2¾ Pt. 31° (149°, 211°, 329°) | | 32° (148°, 212°, 328°) | |
|--------|---------------------------|-------|----------------------------------|-------|---------------------------|-------|---------------------------|-------|----------------------------------|-------|---------------------------|-------|
| | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. |
| 1 | 0.9 | 0.5 | 0.9 | 0.5 | 0.9 | 0.5 | 0.9 | 0.5 | 0.9 | 0.5 | 0.8 | 0.5 |
| 2 | 1.8 | 0.9 | 1.8 | 0.9 | 1.7 | 1.0 | 1.7 | 1.0 | 1.7 | 1.0 | 1.7 | 1.1 |
| 3 | 2.7 | 1.4 | 2.6 | 1.4 | 2.6 | 1.5 | 2.6 | 1.5 | 2.6 | 1.5 | 2.5 | 1.6 |
| 4 | 3.6 | 1.8 | 3.5 | 1.9 | 3.5 | 1.9 | 3.5 | 2.0 | 3.4 | 2.1 | 3.4 | 2.1 |
| 5 | 4.5 | 2.3 | 4.4 | 2.3 | 4.4 | 2.4 | 4.3 | 2.5 | 4.3 | 2.6 | 4.2 | 2.6 |
| 6 | 5.3 | 2.7 | 5.3 | 2.8 | 5.2 | 2.9 | 5.2 | 3.0 | 5.1 | 3.1 | 5.1 | 3.2 |
| 7 | 6.2 | 3.2 | 6.2 | 3.3 | 6.1 | 3.4 | 6.1 | 3.5 | 6.0 | 3.6 | 5.9 | 3.7 |
| 8 | 7.1 | 3.6 | 7.1 | 3.8 | 7.0 | 3.9 | 6.9 | 4.0 | 6.9 | 4.1 | 6.8 | 4.2 |
| 9 | 8.0 | 4.1 | 7.9 | 4.2 | 7.9 | 4.4 | 7.8 | 4.5 | 7.7 | 4.6 | 7.6 | 4.8 |
| 10 | 8.9 | 4.5 | 8.8 | 4.7 | 8.7 | 4.8 | 8.7 | 5.0 | 8.6 | 5.2 | 8.5 | 5.3 |
| 11 | 9.8 | 5.0 | 9.7 | 5.2 | 9.6 | 5.3 | 9.5 | 5.5 | 9.4 | 5.7 | 9.3 | 5.8 |
| 12 | 10.7 | 5.4 | 10.6 | 5.6 | 10.5 | 5.8 | 10.4 | 6.0 | 10.3 | 6.2 | 10.2 | 6.4 |
| 13 | 11.6 | 5.9 | 11.5 | 6.1 | 11.4 | 6.3 | 11.3 | 6.5 | 11.1 | 6.7 | 11.0 | 6.9 |
| 14 | 12.5 | 6.4 | 12.4 | 6.6 | 12.2 | 6.8 | 12.1 | 7.0 | 12.0 | 7.2 | 11.9 | 7.4 |
| 15 | 13.4 | 6.8 | 13.2 | 7.0 | 13.1 | 7.3 | 13.0 | 7.5 | 12.9 | 7.7 | 12.7 | 7.9 |
| 16 | 14.3 | 7.3 | 14.1 | 7.5 | 14.0 | 7.8 | 13.9 | 8.0 | 13.7 | 8.2 | 13.6 | 8.5 |
| 17 | 15.1 | 7.7 | 15.0 | 8.0 | 14.9 | 8.2 | 14.7 | 8.5 | 14.6 | 8.8 | 14.4 | 9.0 |
| 18 | 16.0 | 8.2 | 15.9 | 8.5 | 15.7 | 8.7 | 15.6 | 9.0 | 15.4 | 9.3 | 15.3 | 9.5 |
| 19 | 16.9 | 8.6 | 16.8 | 8.9 | 16.6 | 9.2 | 16.5 | 9.5 | 16.3 | 9.8 | 16.1 | 10.1 |
| 20 | 17.8 | 9.1 | 17.7 | 9.4 | 17.5 | 9.7 | 17.3 | 10.0 | 17.1 | 10.3 | 17.0 | 10.6 |
| 21 | 18.7 | 9.5 | 18.5 | 9.9 | 18.4 | 10.2 | 18.2 | 10.5 | 18.0 | 10.8 | 17.8 | 11.1 |
| 22 | 19.6 | 10.0 | 19.4 | 10.3 | 19.2 | 10.7 | 19.1 | 11.0 | 18.9 | 11.3 | 18.7 | 11.7 |
| 23 | 20.5 | 10.4 | 20.3 | 10.8 | 20.1 | 11.2 | 19.9 | 11.5 | 19.7 | 11.8 | 19.5 | 12.2 |
| 24 | 21.4 | 10.9 | 21.2 | 11.3 | 21.0 | 11.6 | 20.8 | 12.0 | 20.6 | 12.4 | 20.4 | 12.7 |
| 25 | 22.3 | 11.3 | 22.1 | 11.7 | 21.9 | 12.1 | 21.7 | 12.5 | 21.4 | 12.9 | 21.2 | 13.2 |
| 26 | 23.2 | 11.8 | 23.0 | 12.2 | 22.7 | 12.6 | 22.5 | 13.0 | 22.3 | 13.4 | 22.0 | 13.8 |
| 27 | 24.1 | 12.3 | 23.8 | 12.7 | 23.6 | 13.1 | 23.4 | 13.5 | 23.1 | 13.9 | 22.9 | 14.3 |
| 28 | 24.9 | 12.7 | 24.7 | 13.1 | 24.5 | 13.6 | 24.2 | 14.0 | 24.0 | 14.4 | 23.7 | 14.8 |
| 29 | 25.8 | 13.2 | 25.6 | 13.6 | 25.4 | 14.1 | 25.1 | 14.5 | 24.9 | 14.9 | 24.6 | 15.4 |
| 30 | 26.7 | 13.6 | 26.5 | 14.1 | 26.2 | 14.5 | 26.0 | 15.0 | 25.7 | 15.5 | 25.4 | 15.9 |
| 31 | 27.6 | 14.1 | 27.4 | 14.6 | 27.1 | 15.0 | 26.8 | 15.5 | 26.6 | 16.0 | 26.3 | 16.4 |
| 32 | 28.5 | 14.5 | 28.3 | 15.0 | 28.0 | 15.5 | 27.7 | 16.0 | 27.4 | 16.5 | 27.1 | 17.0 |
| 33 | 29.4 | 15.0 | 29.1 | 15.5 | 28.9 | 16.0 | 28.6 | 16.5 | 28.3 | 17.0 | 28.0 | 17.5 |
| 34 | 30.3 | 15.4 | 30.0 | 16.0 | 29.7 | 16.5 | 29.4 | 17.0 | 29.1 | 17.5 | 28.8 | 18.0 |
| 35 | 31.2 | 15.9 | 30.9 | 16.4 | 30.6 | 17.0 | 30.3 | 17.5 | 30.0 | 18.0 | 29.7 | 18.5 |
| 36 | 32.1 | 16.3 | 31.8 | 16.9 | 31.5 | 17.5 | 31.2 | 18.0 | 30.9 | 18.5 | 30.5 | 19.1 |
| 37 | 33.0 | 16.8 | 32.7 | 17.4 | 32.4 | 17.9 | 32.0 | 18.5 | 31.7 | 19.1 | 31.4 | 19.6 |
| 38 | 33.9 | 17.3 | 33.6 | 17.8 | 33.2 | 18.4 | 32.9 | 19.0 | 32.6 | 19.6 | 32.2 | 20.1 |
| 39 | 34.7 | 17.7 | 34.4 | 18.3 | 34.1 | 18.9 | 33.8 | 19.5 | 33.4 | 20.1 | 33.1 | 20.7 |
| 40 | 35.6 | 18.2 | 35.3 | 18.8 | 35.0 | 19.4 | 34.6 | 20.0 | 34.3 | 20.6 | 33.9 | 21.2 |
| 41 | 36.5 | 18.6 | 36.2 | 19.2 | 35.9 | 19.9 | 35.5 | 20.5 | 35.1 | 21.1 | 34.8 | 21.7 |
| 42 | 37.4 | 19.1 | 37.1 | 19.7 | 36.7 | 20.4 | 36.4 | 21.0 | 36.0 | 21.6 | 35.6 | 22.3 |
| 43 | 38.3 | 19.5 | 38.0 | 20.2 | 37.6 | 20.8 | 37.2 | 21.5 | 36.9 | 22.1 | 36.5 | 22.8 |
| 44 | 39.2 | 20.0 | 38.8 | 20.7 | 38.5 | 21.3 | 38.1 | 22.0 | 37.7 | 22.7 | 37.3 | 23.3 |
| 45 | 40.1 | 20.4 | 39.7 | 21.1 | 39.4 | 21.8 | 39.0 | 22.5 | 38.6 | 23.2 | 38.2 | 23.8 |
| 46 | 41.0 | 20.9 | 40.6 | 21.6 | 40.2 | 22.3 | 39.8 | 23.0 | 39.4 | 23.7 | 39.0 | 24.4 |
| 47 | 41.9 | 21.3 | 41.5 | 22.1 | 41.1 | 22.8 | 40.7 | 23.5 | 40.3 | 24.2 | 39.9 | 24.9 |
| 48 | 42.8 | 21.8 | 42.4 | 22.5 | 42.0 | 23.3 | 41.6 | 24.0 | 41.1 | 24.7 | 40.7 | 25.4 |
| 49 | 43.7 | 22.2 | 43.3 | 23.0 | 42.9 | 23.8 | 42.4 | 24.5 | 42.0 | 25.2 | 41.6 | 26.0 |
| 50 | 44.6 | 22.7 | 44.1 | 23.5 | 43.7 | 24.2 | 43.3 | 25.0 | 42.9 | 25.8 | 42.4 | 26.5 |
| 100 | 89.1 | 45.4 | 88.3 | 46.9 | 87.5 | 48.5 | 86.6 | 50.0 | 85.7 | 51.5 | 84.8 | 53.0 |
| 200 | 178.2 | 90.8 | 176.6 | 93.9 | 174.9 | 97.0 | 173.2 | 100.0 | 171.4 | 103.0 | 169.6 | 106.0 |
| 300 | 267.3 | 136.2 | 264.9 | 140.8 | 262.4 | 145.4 | 259.8 | 150.0 | 257.1 | 154.5 | 254.4 | 159.0 |
| 400 | 356.4 | 181.6 | 353.1 | 187.8 | 349.8 | 193.9 | 346.4 | 200.0 | 342.9 | 206.0 | 339.2 | 211.9 |
| 500 | 445.5 | 227.0 | 441.5 | 234.7 | 437.3 | 242.4 | 433.0 | 250.0 | 428.6 | 257.5 | 424.0 | 265.0 |
| | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. |
| | (117°, 243°, 297°) | | (118°, 242°, 298°) | | (119°, 241°, 299°) | | (120°, 240°, 300°) | | (121°, 239°, 301°) | | (122°, 238°, 302°) | |
| | 63° | | 5½ Pt. 62° | | 61° | | 60° | | 5¼ Pt. 59° | | 58° | |

Table 1. Traverse Table

| Dist. | 27° (153°, 207°, 333°) | | 2½ Pt. 28° (152°, 208°, 332°) | | 29° (151°, 209°, 331°) | | 30° (150°, 210°, 330°) | | 2¾ Pt. 31° (149°, 211°, 329°) | | 32° (148°, 212°, 328°) | |
|-------|---------------------------|-------|----------------------------------|-------|---------------------------|-------|---------------------------|-------|----------------------------------|-------|---------------------------|-------|
| | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. |
| 51 | 45.4 | 23.2 | 45.0 | 23.9 | 44.6 | 24.7 | 44.2 | 25.5 | 43.7 | 26.3 | 43.3 | 27.0 |
| 52 | 46.3 | 23.6 | 45.9 | 24.4 | 45.5 | 25.2 | 45.0 | 26.0 | 44.6 | 26.8 | 44.1 | 27.6 |
| 53 | 47.2 | 24.1 | 46.8 | 24.9 | 46.4 | 25.7 | 45.9 | 26.5 | 45.4 | 27.3 | 44.9 | 28.1 |
| 54 | 48.1 | 24.5 | 47.7 | 25.4 | 47.2 | 26.2 | 46.8 | 27.0 | 46.3 | 27.8 | 45.8 | 28.6 |
| 55 | 49.0 | 25.0 | 48.6 | 25.8 | 48.1 | 26.7 | 47.6 | 27.5 | 47.1 | 28.3 | 46.6 | 29.1 |
| 56 | 49.9 | 25.4 | 49.4 | 26.3 | 49.0 | 27.1 | 48.5 | 28.0 | 48.0 | 28.8 | 47.5 | 29.7 |
| 57 | 50.8 | 25.9 | 50.3 | 26.8 | 49.9 | 27.6 | 49.4 | 28.5 | 48.9 | 29.4 | 48.3 | 30.2 |
| 58 | 51.7 | 26.3 | 51.2 | 27.2 | 50.7 | 28.1 | 50.2 | 29.0 | 49.7 | 29.9 | 49.2 | 30.7 |
| 59 | 52.6 | 26.8 | 52.1 | 27.7 | 51.6 | 28.6 | 51.1 | 29.5 | 50.6 | 30.4 | 50.0 | 31.3 |
| 60 | 53.5 | 27.2 | 53.0 | 28.2 | 52.5 | 29.1 | 52.0 | 30.0 | 51.4 | 30.9 | 50.9 | 31.8 |
| 61 | 54.4 | 27.7 | 53.9 | 28.6 | 53.4 | 29.6 | 52.8 | 30.5 | 52.3 | 31.4 | 51.7 | 32.3 |
| 62 | 55.2 | 28.1 | 54.7 | 29.1 | 54.2 | 30.1 | 53.7 | 31.0 | 53.1 | 31.9 | 52.6 | 32.9 |
| 63 | 56.1 | 28.6 | 55.6 | 29.6 | 55.1 | 30.5 | 54.6 | 31.5 | 54.0 | 32.4 | 53.4 | 33.4 |
| 64 | 57.0 | 29.1 | 56.5 | 30.0 | 56.0 | 31.0 | 55.4 | 32.0 | 54.9 | 33.0 | 54.3 | 33.9 |
| 65 | 57.9 | 29.5 | 57.4 | 30.5 | 56.9 | 31.5 | 56.3 | 32.5 | 55.7 | 33.5 | 55.1 | 34.4 |
| 66 | 58.8 | 30.0 | 58.3 | 31.0 | 57.7 | 32.0 | 57.2 | 33.0 | 56.6 | 34.0 | 56.0 | 35.0 |
| 67 | 59.7 | 30.4 | 59.2 | 31.5 | 58.6 | 32.5 | 58.0 | 33.5 | 57.4 | 34.5 | 56.8 | 35.5 |
| 68 | 60.6 | 30.9 | 60.0 | 31.9 | 59.5 | 33.0 | 58.9 | 34.0 | 58.3 | 35.0 | 57.7 | 36.0 |
| 69 | 61.5 | 31.3 | 60.9 | 32.4 | 60.3 | 33.5 | 59.8 | 34.5 | 59.1 | 35.5 | 58.5 | 36.6 |
| 70 | 62.4 | 31.8 | 61.8 | 32.9 | 61.2 | 33.9 | 60.6 | 35.0 | 60.0 | 36.1 | 59.4 | 37.1 |
| 71 | 63.3 | 32.2 | 62.7 | 33.3 | 62.1 | 34.4 | 61.5 | 35.5 | 60.9 | 36.6 | 60.2 | 37.6 |
| 72 | 64.2 | 32.7 | 63.6 | 33.8 | 63.0 | 34.9 | 62.4 | 36.0 | 61.7 | 37.1 | 61.1 | 38.2 |
| 73 | 65.0 | 33.1 | 64.5 | 34.3 | 63.8 | 35.4 | 63.2 | 36.5 | 62.6 | 37.6 | 61.9 | 38.7 |
| 74 | 65.9 | 33.6 | 65.3 | 34.7 | 64.7 | 35.9 | 64.1 | 37.0 | 63.4 | 38.1 | 62.8 | 39.2 |
| 75 | 66.8 | 34.0 | 66.2 | 35.2 | 65.6 | 36.4 | 65.0 | 37.5 | 64.3 | 38.6 | 63.6 | 39.7 |
| 76 | 67.7 | 34.5 | 67.1 | 35.7 | 66.5 | 36.8 | 65.8 | 38.0 | 65.1 | 39.1 | 64.5 | 40.3 |
| 77 | 68.6 | 35.0 | 68.0 | 36.1 | 67.3 | 37.3 | 66.7 | 38.5 | 66.0 | 39.7 | 65.3 | 40.8 |
| 78 | 69.5 | 35.4 | 68.9 | 36.6 | 68.2 | 37.8 | 67.5 | 39.0 | 66.9 | 40.2 | 66.1 | 41.3 |
| 79 | 70.4 | 35.9 | 69.8 | 37.1 | 69.1 | 38.3 | 68.4 | 39.5 | 67.7 | 40.7 | 67.0 | 41.9 |
| 80 | 71.3 | 36.3 | 70.6 | 37.6 | 70.0 | 38.8 | 69.3 | 40.0 | 68.6 | 41.2 | 67.8 | 42.4 |
| 81 | 72.2 | 36.8 | 71.5 | 38.0 | 70.8 | 39.3 | 70.1 | 40.5 | 69.4 | 41.7 | 68.7 | 42.9 |
| 82 | 73.1 | 37.2 | 72.4 | 38.5 | 71.7 | 39.8 | 71.0 | 41.0 | 70.3 | 42.2 | 69.5 | 43.5 |
| 83 | 74.0 | 37.7 | 73.3 | 39.0 | 72.6 | 40.2 | 71.9 | 41.5 | 71.1 | 42.7 | 70.4 | 44.0 |
| 84 | 74.8 | 38.1 | 74.2 | 39.4 | 73.5 | 40.7 | 72.7 | 42.0 | 72.0 | 43.3 | 71.2 | 44.5 |
| 85 | 75.7 | 38.6 | 75.1 | 39.9 | 74.3 | 41.2 | 73.6 | 42.5 | 72.9 | 43.8 | 72.1 | 45.0 |
| 86 | 76.6 | 39.0 | 75.9 | 40.4 | 75.2 | 41.7 | 74.5 | 43.0 | 73.7 | 44.3 | 72.9 | 45.6 |
| 87 | 77.5 | 39.5 | 76.8 | 40.8 | 76.1 | 42.2 | 75.3 | 43.5 | 74.6 | 44.8 | 73.8 | 46.1 |
| 88 | 78.4 | 40.0 | 77.7 | 41.3 | 77.0 | 42.7 | 76.2 | 44.0 | 75.4 | 45.3 | 74.6 | 46.6 |
| 89 | 79.3 | 40.4 | 78.6 | 41.8 | 77.8 | 43.1 | 77.1 | 44.5 | 76.3 | 45.8 | 75.5 | 47.2 |
| 90 | 80.2 | 40.9 | 79.5 | 42.3 | 78.7 | 43.6 | 77.9 | 45.0 | 77.1 | 46.4 | 76.3 | 47.7 |
| 91 | 81.1 | 41.3 | 80.3 | 42.7 | 79.6 | 44.1 | 78.8 | 45.5 | 78.0 | 46.9 | 77.2 | 48.2 |
| 92 | 82.0 | 41.8 | 81.2 | 43.2 | 80.5 | 44.6 | 79.7 | 46.0 | 78.9 | 47.4 | 78.0 | 48.8 |
| 93 | 82.9 | 42.2 | 82.1 | 43.7 | 81.3 | 45.1 | 80.5 | 46.5 | 79.7 | 47.9 | 78.9 | 49.3 |
| 94 | 83.8 | 42.7 | 83.0 | 44.1 | 82.2 | 45.6 | 81.4 | 47.0 | 80.6 | 48.4 | 79.7 | 49.8 |
| 95 | 84.6 | 43.1 | 83.9 | 44.6 | 83.1 | 46.1 | 82.3 | 47.5 | 81.4 | 48.9 | 80.6 | 50.3 |
| 96 | 85.5 | 43.6 | 84.8 | 45.1 | 84.0 | 46.5 | 83.1 | 48.0 | 82.3 | 49.4 | 81.4 | 50.9 |
| 97 | 86.4 | 44.0 | 85.6 | 45.5 | 84.8 | 47.0 | 84.0 | 48.5 | 83.1 | 50.0 | 82.3 | 51.4 |
| 98 | 87.3 | 44.5 | 86.5 | 46.0 | 85.7 | 47.5 | 84.9 | 49.0 | 84.0 | 50.5 | 83.1 | 51.9 |
| 99 | 88.2 | 44.9 | 87.4 | 46.5 | 86.6 | 48.0 | 85.7 | 49.5 | 84.9 | 51.0 | 84.0 | 52.5 |
| 100 | 89.1 | 45.4 | 88.3 | 46.9 | 87.5 | 48.5 | 86.6 | 50.0 | 85.7 | 51.5 | 84.8 | 53.0 |
| 600 | 534.6 | 272.4 | 529.8 | 281.7 | 524.8 | 290.9 | 519.6 | 300.0 | 514.3 | 309.0 | 508.8 | 318.0 |
| 700 | 623.7 | 317.8 | 618.0 | 328.6 | 612.2 | 339.4 | 606.1 | 350.0 | 600.1 | 360.4 | 593.6 | 371.0 |
| 800 | 712.9 | 363.2 | 706.3 | 375.6 | 699.7 | 387.9 | 692.8 | 400.0 | 685.8 | 412.0 | 678.4 | 423.9 |
| 900 | 801.9 | 408.5 | 794.5 | 422.5 | 787.0 | 436.3 | 779.3 | 450.0 | 771.4 | 463.4 | 763.2 | 476.8 |
| | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. |
| | (117°, 243°, 297°) | | (118°, 242°, 298°) | | (119°, 241°, 299°) | | (120°, 240°, 300°) | | (121°, 239°, 301°) | | (122°, 238°, 302°) | |
| | 63° | | 5½ Pt. 62° | | 61° | | 60° | | 5¼ Pt. 59° | | 58° | |

Table 1. Traverse Table

| Dist. | 33° (147°, 213°, 327°) | | 3 Pt. 34° (146°, 214°, 326°) | | 35° (145°, 215°, 325°) | | 36° (144°, 216°, 324°) | | 3½ Pt. 37° (143°, 217°, 323°) | | 38° (142°, 218°, 322°) | |
|-------|---------------------------|-------|---------------------------------|-------|---------------------------|-------|---------------------------|-------|----------------------------------|-------|---------------------------|-------|
| | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. |
| | 1 | 0.8 | 0.5 | 0.8 | 0.6 | 0.8 | 0.6 | 0.8 | 0.6 | 0.8 | 0.6 | 0.8 |
| 2 | 1.7 | 1.1 | 1.7 | 1.1 | 1.6 | 1.1 | 1.6 | 1.2 | 1.6 | 1.2 | 1.6 | 1.2 |
| 3 | 2.5 | 1.6 | 2.5 | 1.7 | 2.5 | 1.7 | 2.4 | 1.8 | 2.4 | 1.8 | 2.4 | 1.8 |
| 4 | 3.4 | 2.2 | 3.3 | 2.2 | 3.3 | 2.3 | 3.2 | 2.4 | 3.2 | 2.4 | 3.2 | 2.5 |
| 5 | 4.2 | 2.7 | 4.1 | 2.8 | 4.1 | 2.9 | 4.0 | 2.9 | 4.0 | 3.0 | 3.9 | 3.1 |
| 6 | 5.0 | 3.3 | 5.0 | 3.4 | 4.9 | 3.4 | 4.9 | 3.5 | 4.8 | 3.6 | 4.7 | 3.7 |
| 7 | 5.9 | 3.8 | 5.8 | 3.9 | 5.7 | 4.0 | 5.7 | 4.1 | 5.6 | 4.2 | 5.5 | 4.3 |
| 8 | 6.7 | 4.4 | 6.6 | 4.5 | 6.6 | 4.6 | 6.5 | 4.7 | 6.4 | 4.8 | 6.3 | 4.9 |
| 9 | 7.5 | 4.9 | 7.5 | 5.0 | 7.4 | 5.2 | 7.3 | 5.3 | 7.2 | 5.4 | 7.1 | 5.5 |
| 10 | 8.4 | 5.4 | 8.3 | 5.6 | 8.2 | 5.7 | 8.1 | 5.9 | 8.0 | 6.0 | 7.9 | 6.2 |
| 11 | 9.2 | 6.0 | 9.1 | 6.2 | 9.0 | 6.3 | 8.9 | 6.5 | 8.8 | 6.6 | 8.7 | 6.8 |
| 12 | 10.1 | 6.5 | 9.9 | 6.7 | 9.8 | 6.9 | 9.7 | 7.1 | 9.6 | 7.2 | 9.5 | 7.4 |
| 13 | 10.9 | 7.1 | 10.8 | 7.3 | 10.6 | 7.5 | 10.5 | 7.6 | 10.4 | 7.8 | 10.2 | 8.0 |
| 14 | 11.7 | 7.6 | 11.6 | 7.8 | 11.5 | 8.0 | 11.3 | 8.2 | 11.2 | 8.4 | 11.0 | 8.6 |
| 15 | 12.6 | 8.2 | 12.4 | 8.4 | 12.3 | 8.6 | 12.1 | 8.8 | 12.0 | 9.0 | 11.8 | 9.2 |
| 16 | 13.4 | 8.7 | 13.3 | 8.9 | 13.1 | 9.2 | 12.9 | 9.4 | 12.8 | 9.6 | 12.6 | 9.9 |
| 17 | 14.3 | 9.3 | 14.1 | 9.5 | 13.9 | 9.8 | 13.8 | 10.0 | 13.6 | 10.2 | 13.4 | 10.5 |
| 18 | 15.1 | 9.8 | 14.9 | 10.1 | 14.7 | 10.3 | 14.6 | 10.6 | 14.4 | 10.8 | 14.2 | 11.1 |
| 19 | 15.9 | 10.3 | 15.8 | 10.6 | 15.6 | 10.9 | 15.4 | 11.2 | 15.2 | 11.4 | 15.0 | 11.7 |
| 20 | 16.8 | 10.9 | 16.6 | 11.2 | 16.4 | 11.5 | 16.2 | 11.8 | 16.0 | 12.0 | 15.8 | 12.3 |
| 21 | 17.6 | 11.4 | 17.4 | 11.7 | 17.2 | 12.0 | 17.0 | 12.3 | 16.8 | 12.6 | 16.5 | 12.9 |
| 22 | 18.5 | 12.0 | 18.2 | 12.3 | 18.0 | 12.6 | 17.8 | 12.9 | 17.6 | 13.2 | 17.3 | 13.5 |
| 23 | 19.3 | 12.5 | 19.1 | 12.9 | 18.8 | 13.2 | 18.6 | 13.5 | 18.4 | 13.8 | 18.1 | 14.2 |
| 24 | 20.1 | 13.1 | 19.9 | 13.4 | 19.7 | 13.8 | 19.4 | 14.1 | 19.2 | 14.4 | 18.9 | 14.8 |
| 25 | 21.0 | 13.6 | 20.7 | 14.0 | 20.5 | 14.3 | 20.2 | 14.7 | 20.0 | 15.0 | 19.7 | 15.4 |
| 26 | 21.8 | 14.2 | 21.6 | 14.5 | 21.3 | 14.9 | 21.0 | 15.3 | 20.8 | 15.6 | 20.5 | 16.0 |
| 27 | 22.6 | 14.7 | 22.4 | 15.1 | 22.1 | 15.5 | 21.8 | 15.9 | 21.6 | 16.2 | 21.3 | 16.6 |
| 28 | 23.5 | 15.2 | 23.2 | 15.7 | 22.9 | 16.1 | 22.7 | 16.5 | 22.4 | 16.9 | 22.1 | 17.2 |
| 29 | 24.3 | 15.8 | 24.0 | 16.2 | 23.8 | 16.6 | 23.5 | 17.0 | 23.2 | 17.5 | 22.9 | 17.9 |
| 30 | 25.2 | 16.3 | 24.9 | 16.8 | 24.6 | 17.2 | 24.3 | 17.6 | 24.0 | 18.1 | 23.6 | 18.5 |
| 31 | 26.0 | 16.9 | 25.7 | 17.3 | 25.4 | 17.8 | 25.1 | 18.2 | 24.8 | 18.7 | 24.4 | 19.1 |
| 32 | 26.8 | 17.4 | 26.5 | 17.9 | 26.2 | 18.4 | 25.9 | 18.8 | 25.6 | 19.3 | 25.2 | 19.7 |
| 33 | 27.7 | 18.0 | 27.4 | 18.5 | 27.0 | 18.9 | 26.7 | 19.4 | 26.4 | 19.9 | 26.0 | 20.3 |
| 34 | 28.5 | 18.5 | 28.2 | 19.0 | 27.9 | 19.5 | 27.5 | 20.0 | 27.2 | 20.5 | 26.8 | 20.9 |
| 35 | 29.4 | 19.1 | 29.0 | 19.6 | 28.7 | 20.1 | 28.3 | 20.6 | 28.0 | 21.1 | 27.6 | 21.5 |
| 36 | 30.2 | 19.6 | 29.8 | 20.1 | 29.5 | 20.6 | 29.1 | 21.2 | 28.8 | 21.7 | 28.4 | 22.2 |
| 37 | 31.0 | 20.2 | 30.7 | 20.7 | 30.3 | 21.2 | 29.9 | 21.7 | 29.5 | 22.3 | 29.2 | 22.8 |
| 38 | 31.9 | 20.7 | 31.5 | 21.2 | 31.1 | 21.8 | 30.7 | 22.3 | 30.3 | 22.9 | 29.9 | 23.4 |
| 39 | 32.7 | 21.2 | 32.3 | 21.8 | 31.9 | 22.4 | 31.6 | 22.9 | 31.1 | 23.5 | 30.7 | 24.0 |
| 40 | 33.5 | 21.8 | 33.2 | 22.4 | 32.8 | 22.9 | 32.4 | 23.5 | 31.9 | 24.1 | 31.5 | 24.6 |
| 41 | 34.4 | 22.3 | 34.0 | 22.9 | 33.6 | 23.5 | 33.2 | 24.1 | 32.7 | 24.7 | 32.3 | 25.2 |
| 42 | 35.2 | 22.9 | 34.8 | 23.5 | 34.4 | 24.1 | 34.0 | 24.7 | 33.5 | 25.3 | 33.1 | 25.9 |
| 43 | 36.1 | 23.4 | 35.6 | 24.0 | 35.2 | 24.7 | 34.8 | 25.3 | 34.3 | 25.9 | 33.9 | 26.5 |
| 44 | 36.9 | 24.0 | 36.5 | 24.6 | 36.0 | 25.2 | 35.6 | 25.9 | 35.1 | 26.5 | 34.7 | 27.1 |
| 45 | 37.7 | 24.5 | 37.3 | 25.2 | 36.9 | 25.8 | 36.4 | 26.5 | 35.9 | 27.1 | 35.5 | 27.7 |
| 46 | 38.6 | 25.1 | 38.1 | 25.7 | 37.7 | 26.4 | 37.2 | 27.0 | 36.7 | 27.7 | 36.2 | 28.3 |
| 47 | 39.4 | 25.6 | 39.0 | 26.3 | 38.5 | 27.0 | 38.0 | 27.6 | 37.5 | 28.3 | 37.0 | 28.9 |
| 48 | 40.3 | 26.1 | 39.8 | 26.8 | 39.3 | 27.5 | 38.8 | 28.2 | 38.3 | 28.9 | 37.8 | 29.6 |
| 49 | 41.1 | 26.7 | 40.6 | 27.4 | 40.1 | 28.1 | 39.6 | 28.8 | 39.1 | 29.5 | 38.6 | 30.2 |
| 50 | 41.9 | 27.2 | 41.5 | 28.0 | 41.0 | 28.7 | 40.5 | 29.4 | 39.9 | 30.1 | 39.4 | 30.8 |
| 100 | 83.9 | 54.5 | 82.9 | 55.9 | 81.9 | 57.4 | 80.9 | 58.8 | 79.9 | 60.2 | 78.8 | 61.6 |
| 200 | 167.7 | 108.9 | 165.8 | 111.8 | 163.8 | 114.7 | 161.8 | 117.6 | 159.7 | 120.4 | 157.6 | 123.1 |
| 300 | 251.6 | 163.4 | 248.7 | 167.8 | 245.7 | 172.1 | 242.7 | 176.3 | 239.6 | 180.5 | 236.4 | 184.7 |
| 400 | 335.5 | 217.8 | 331.6 | 223.7 | 327.7 | 229.4 | 323.6 | 235.1 | 319.4 | 240.7 | 315.2 | 246.3 |
| 500 | 419.3 | 272.3 | 414.5 | 279.6 | 409.6 | 286.8 | 404.5 | 293.9 | 399.3 | 300.9 | 394.0 | 307.8 |
| | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. |
| | (123°, 237°, 303°) | | (124°, 236°, 304°) | | (125°, 235°, 305°) | | (126°, 234°, 306°) | | (127°, 233°, 307°) | | (128°, 232°, 308°) | |
| | 57° | | 5 Pt. 56° | | 55° | | 54° | | 4½ Pt. 53° | | 52° | |

The 3-Pt. or 34° Courses are: N.E. by N., N.W. by N., S.E. by S., S.W. by S.

Table 1. Traverse Table

| DISTR. | 33° (147°, 213°, 327°) | | 3 Pt. 34° (146°, 214°, 326°) | | 35° (145°, 215°, 325°) | | 36° (144°, 216°, 324°) | | 3½ Pt. 37° (143°, 217°, 323°) | | 38° (142°, 218°, 322°) | |
|--------|---------------------------|-------|---------------------------------|-------|---------------------------|-------|---------------------------|-------|----------------------------------|-------|---------------------------|-------|
| | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. |
| | (123°, 237°, 303°) | | (124°, 236°, 304°) | | (125°, 235°, 305°) | | (126°, 234°, 306°) | | (127°, 233°, 307°) | | (128°, 232°, 308°) | |
| 51 | 42.8 | 27.8 | 42.3 | 28.5 | 41.8 | 29.3 | 41.3 | 30.0 | 40.7 | 30.7 | 40.2 | 31.4 |
| 52 | 43.6 | 28.3 | 43.1 | 29.1 | 42.6 | 29.8 | 42.1 | 30.6 | 41.5 | 31.3 | 41.0 | 32.0 |
| 53 | 44.4 | 28.9 | 43.9 | 29.6 | 43.4 | 30.4 | 42.9 | 31.2 | 42.3 | 31.9 | 41.8 | 32.6 |
| 54 | 45.3 | 29.4 | 44.8 | 30.2 | 44.2 | 31.0 | 43.7 | 31.7 | 43.1 | 32.5 | 42.6 | 33.2 |
| 55 | 46.1 | 30.0 | 45.6 | 30.8 | 45.1 | 31.5 | 44.5 | 32.3 | 43.9 | 33.1 | 43.3 | 33.9 |
| 56 | 47.0 | 30.5 | 46.4 | 31.3 | 45.9 | 32.1 | 45.3 | 32.9 | 44.7 | 33.7 | 44.1 | 34.5 |
| 57 | 47.8 | 31.0 | 47.3 | 31.9 | 46.7 | 32.7 | 46.1 | 33.5 | 45.5 | 34.3 | 44.9 | 35.1 |
| 58 | 48.6 | 31.6 | 48.1 | 32.4 | 47.5 | 33.3 | 46.9 | 34.1 | 46.3 | 34.9 | 45.7 | 35.7 |
| 59 | 49.5 | 32.1 | 48.9 | 33.0 | 48.3 | 33.8 | 47.7 | 34.7 | 47.1 | 35.5 | 46.5 | 36.3 |
| 60 | 50.3 | 32.7 | 49.7 | 33.6 | 49.1 | 34.4 | 48.5 | 35.3 | 47.9 | 36.1 | 47.3 | 36.9 |
| 61 | 51.2 | 33.2 | 50.6 | 34.1 | 50.0 | 35.0 | 49.4 | 35.9 | 48.7 | 36.7 | 48.1 | 37.6 |
| 62 | 52.0 | 33.8 | 51.4 | 34.7 | 50.8 | 35.6 | 50.2 | 36.4 | 49.5 | 37.3 | 48.9 | 38.2 |
| 63 | 52.8 | 34.3 | 52.2 | 35.2 | 51.6 | 36.1 | 51.0 | 37.0 | 50.3 | 37.9 | 49.6 | 38.8 |
| 64 | 53.7 | 34.9 | 53.1 | 35.8 | 52.4 | 36.7 | 51.8 | 37.6 | 51.1 | 38.5 | 50.4 | 39.4 |
| 65 | 54.5 | 35.4 | 53.9 | 36.3 | 53.2 | 37.3 | 52.6 | 38.2 | 51.9 | 39.1 | 51.2 | 40.0 |
| 66 | 55.4 | 35.9 | 54.7 | 36.9 | 54.1 | 37.9 | 53.4 | 38.8 | 52.7 | 39.7 | 52.0 | 40.6 |
| 67 | 56.2 | 36.5 | 55.5 | 37.5 | 54.9 | 38.4 | 54.2 | 39.4 | 53.5 | 40.3 | 52.8 | 41.2 |
| 68 | 57.0 | 37.0 | 56.4 | 38.0 | 55.7 | 39.0 | 55.0 | 40.0 | 54.3 | 40.9 | 53.6 | 41.9 |
| 69 | 57.9 | 37.6 | 57.2 | 38.6 | 56.5 | 39.6 | 55.8 | 40.6 | 55.1 | 41.5 | 54.4 | 42.5 |
| 70 | 58.7 | 38.1 | 58.0 | 39.1 | 57.3 | 40.2 | 56.6 | 41.1 | 55.9 | 42.1 | 55.2 | 43.1 |
| 71 | 59.5 | 38.7 | 58.9 | 39.7 | 58.2 | 40.7 | 57.4 | 41.7 | 56.7 | 42.7 | 55.9 | 43.7 |
| 72 | 60.4 | 39.2 | 59.7 | 40.3 | 59.0 | 41.3 | 58.2 | 42.3 | 57.5 | 43.3 | 56.7 | 44.3 |
| 73 | 61.2 | 39.8 | 60.5 | 40.8 | 59.8 | 41.9 | 59.1 | 42.9 | 58.3 | 43.9 | 57.5 | 44.9 |
| 74 | 62.1 | 40.3 | 61.3 | 41.4 | 60.6 | 42.4 | 59.9 | 43.5 | 59.1 | 44.5 | 58.3 | 45.6 |
| 75 | 62.9 | 40.8 | 62.2 | 41.9 | 61.4 | 43.0 | 60.7 | 44.1 | 59.9 | 45.1 | 59.1 | 46.2 |
| 76 | 63.7 | 41.4 | 63.0 | 42.5 | 62.3 | 43.6 | 61.5 | 44.7 | 60.7 | 45.7 | 59.9 | 46.8 |
| 77 | 64.6 | 41.9 | 63.8 | 43.1 | 63.1 | 44.2 | 62.3 | 45.3 | 61.5 | 46.3 | 60.7 | 47.4 |
| 78 | 65.4 | 42.5 | 64.7 | 43.6 | 63.9 | 44.7 | 63.1 | 45.8 | 62.3 | 46.9 | 61.5 | 48.0 |
| 79 | 66.3 | 43.0 | 65.5 | 44.2 | 64.7 | 45.3 | 63.9 | 46.4 | 63.1 | 47.5 | 62.3 | 48.6 |
| 80 | 67.1 | 43.6 | 66.3 | 44.7 | 65.5 | 45.9 | 64.7 | 47.0 | 63.9 | 48.1 | 63.0 | 49.3 |
| 81 | 67.9 | 44.1 | 67.2 | 45.3 | 66.4 | 46.5 | 65.5 | 47.6 | 64.7 | 48.7 | 63.8 | 49.9 |
| 82 | 68.8 | 44.7 | 68.0 | 45.9 | 67.2 | 47.0 | 66.3 | 48.2 | 65.5 | 49.3 | 64.6 | 50.5 |
| 83 | 69.6 | 45.2 | 68.8 | 46.4 | 68.0 | 47.6 | 67.1 | 48.8 | 66.3 | 50.0 | 65.4 | 51.1 |
| 84 | 70.4 | 45.7 | 69.6 | 47.0 | 68.8 | 48.2 | 68.0 | 49.4 | 67.1 | 50.6 | 66.2 | 51.7 |
| 85 | 71.3 | 46.3 | 70.5 | 47.5 | 69.6 | 48.8 | 68.8 | 50.0 | 67.9 | 51.2 | 67.0 | 52.3 |
| 86 | 72.1 | 46.8 | 71.3 | 48.1 | 70.4 | 49.3 | 69.6 | 50.5 | 68.7 | 51.8 | 67.8 | 52.9 |
| 87 | 73.0 | 47.4 | 72.1 | 48.6 | 71.3 | 49.9 | 70.4 | 51.1 | 69.5 | 52.4 | 68.6 | 53.6 |
| 88 | 73.8 | 47.9 | 73.0 | 49.2 | 72.1 | 50.5 | 71.2 | 51.7 | 70.3 | 53.0 | 69.3 | 54.2 |
| 89 | 74.6 | 48.5 | 73.8 | 49.8 | 72.9 | 51.0 | 72.0 | 52.3 | 71.1 | 53.6 | 70.1 | 54.8 |
| 90 | 75.5 | 49.0 | 74.6 | 50.3 | 73.7 | 51.6 | 72.8 | 52.9 | 71.9 | 54.2 | 70.9 | 55.4 |
| 91 | 76.3 | 49.6 | 75.4 | 50.9 | 74.5 | 52.2 | 73.6 | 53.5 | 72.7 | 54.8 | 71.7 | 56.0 |
| 92 | 77.2 | 50.1 | 76.3 | 51.4 | 75.4 | 52.8 | 74.4 | 54.1 | 73.5 | 55.4 | 72.5 | 56.6 |
| 93 | 78.0 | 50.7 | 77.1 | 52.0 | 76.2 | 53.3 | 75.2 | 54.7 | 74.3 | 56.0 | 73.3 | 57.3 |
| 94 | 78.8 | 51.2 | 77.9 | 52.6 | 77.0 | 53.9 | 76.0 | 55.3 | 75.1 | 56.6 | 74.1 | 57.9 |
| 95 | 79.7 | 51.7 | 78.8 | 53.1 | 77.8 | 54.5 | 76.9 | 55.8 | 75.9 | 57.2 | 74.9 | 58.5 |
| 96 | 80.5 | 52.3 | 79.6 | 53.7 | 78.6 | 55.1 | 77.7 | 56.4 | 76.7 | 57.8 | 75.6 | 59.1 |
| 97 | 81.4 | 52.8 | 80.4 | 54.2 | 79.5 | 55.6 | 78.5 | 57.0 | 77.5 | 58.4 | 76.4 | 59.7 |
| 98 | 82.2 | 53.4 | 81.2 | 54.8 | 80.3 | 56.2 | 79.3 | 57.6 | 78.3 | 59.0 | 77.2 | 60.3 |
| 99 | 83.0 | 53.9 | 82.1 | 55.4 | 81.1 | 56.8 | 80.1 | 58.2 | 79.1 | 59.6 | 78.0 | 61.0 |
| 100 | 83.9 | 54.5 | 82.9 | 55.9 | 81.9 | 57.4 | 80.9 | 58.8 | 79.9 | 60.2 | 78.8 | 61.6 |
| 600 | 503.2 | 326.8 | 497.4 | 335.5 | 491.5 | 344.1 | 485.4 | 352.7 | 479.2 | 361.1 | 472.8 | 369.4 |
| 700 | 587.0 | 381.3 | 580.3 | 391.4 | 573.5 | 401.5 | 566.2 | 411.4 | 559.0 | 421.3 | 551.6 | 430.8 |
| 800 | 671.0 | 435.7 | 663.3 | 447.4 | 655.4 | 458.8 | 647.3 | 470.2 | 638.9 | 481.5 | 630.4 | 492.5 |
| 900 | 754.8 | 490.1 | 746.1 | 503.2 | 737.2 | 516.2 | 728.1 | 528.9 | 718.6 | 541.7 | 709.1 | 554.0 |
| | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. |
| | (123°, 237°, 303°) | | (124°, 236°, 304°) | | (125°, 235°, 305°) | | (126°, 234°, 306°) | | (127°, 233°, 307°) | | (128°, 232°, 308°) | |
| | 57° | | 5 Pt. 56° | | 55° | | 54° | | 4½ Pt. 53° | | 52° | |

The 5-Pt. or 56° Courses are : N.E. by E., S.E. by E., N.W. by W., S.W. by W.

Table 1. Traverse Table

| Dist. | 3½ Pt. 39° (141°, 219°, 321°) | | 40° (140°, 220°, 320°) | | 41° (139°, 221°, 319°) | | 3¾ Pt. 42° (138°, 222°, 318°) | | 43° (137°, 223°, 317°) | | 44° (136°, 224°, 316°) | | 4 Pt. 45° (135°, 225°, 315°) | |
|-------|----------------------------------|-------|---------------------------|-------|---------------------------|-------|----------------------------------|-------|---------------------------|-------|---------------------------|-------|---------------------------------|-------|
| | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. |
| 1 | 0.8 | 0.6 | 0.8 | 0.6 | 0.8 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 |
| 2 | 1.6 | 1.3 | 1.5 | 1.3 | 1.5 | 1.3 | 1.5 | 1.3 | 1.5 | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 |
| 3 | 2.3 | 1.9 | 2.3 | 1.9 | 2.3 | 2.0 | 2.2 | 2.0 | 2.2 | 2.0 | 2.2 | 2.1 | 2.1 | 2.1 |
| 4 | 3.1 | 2.5 | 3.1 | 2.6 | 3.0 | 2.6 | 3.0 | 2.7 | 2.9 | 2.7 | 2.9 | 2.8 | 2.8 | 2.8 |
| 5 | 3.9 | 3.1 | 3.8 | 3.2 | 3.8 | 3.3 | 3.7 | 3.3 | 3.7 | 3.4 | 3.6 | 3.5 | 3.5 | 3.5 |
| 6 | 4.7 | 3.8 | 4.6 | 3.9 | 4.5 | 3.9 | 4.5 | 4.0 | 4.4 | 4.1 | 4.3 | 4.2 | 4.2 | 4.2 |
| 7 | 5.4 | 4.4 | 5.4 | 4.5 | 5.3 | 4.6 | 5.2 | 4.7 | 5.1 | 4.8 | 5.0 | 4.9 | 4.9 | 4.9 |
| 8 | 6.2 | 5.0 | 6.1 | 5.1 | 6.0 | 5.2 | 5.9 | 5.4 | 5.9 | 5.5 | 5.8 | 5.6 | 5.7 | 5.7 |
| 9 | 7.0 | 5.7 | 6.9 | 5.8 | 6.8 | 5.9 | 6.7 | 6.0 | 6.6 | 6.1 | 6.5 | 6.3 | 6.4 | 6.4 |
| 10 | 7.8 | 6.3 | 7.7 | 6.4 | 7.5 | 6.6 | 7.4 | 6.7 | 7.3 | 6.8 | 7.2 | 6.9 | 7.1 | 7.1 |
| 11 | 8.5 | 6.9 | 8.4 | 7.1 | 8.3 | 7.2 | 8.2 | 7.4 | 8.0 | 7.5 | 7.9 | 7.6 | 7.8 | 7.8 |
| 12 | 9.3 | 7.6 | 9.2 | 7.7 | 9.1 | 7.9 | 8.9 | 8.0 | 8.8 | 8.2 | 8.6 | 8.3 | 8.5 | 8.5 |
| 13 | 10.1 | 8.2 | 10.0 | 8.4 | 9.8 | 8.5 | 9.7 | 8.7 | 9.5 | 8.9 | 9.4 | 9.0 | 9.2 | 9.2 |
| 14 | 10.9 | 8.8 | 10.7 | 9.0 | 10.6 | 9.2 | 10.4 | 9.4 | 10.2 | 9.5 | 10.1 | 9.7 | 9.9 | 9.9 |
| 15 | 11.7 | 9.4 | 11.5 | 9.6 | 11.3 | 9.8 | 11.1 | 10.0 | 11.0 | 10.2 | 10.8 | 10.4 | 10.6 | 10.6 |
| 16 | 12.4 | 10.1 | 12.3 | 10.3 | 12.1 | 10.5 | 11.9 | 10.7 | 11.7 | 10.9 | 11.5 | 11.1 | 11.3 | 11.3 |
| 17 | 13.2 | 10.7 | 13.0 | 10.9 | 12.8 | 11.2 | 12.6 | 11.4 | 12.4 | 11.6 | 12.2 | 11.8 | 12.0 | 12.0 |
| 18 | 14.0 | 11.3 | 13.8 | 11.6 | 13.6 | 11.8 | 13.4 | 12.0 | 13.2 | 12.3 | 12.9 | 12.5 | 12.7 | 12.7 |
| 19 | 14.8 | 12.0 | 14.6 | 12.2 | 14.3 | 12.5 | 14.1 | 12.7 | 13.9 | 13.0 | 13.7 | 13.2 | 13.4 | 13.4 |
| 20 | 15.5 | 12.6 | 15.3 | 12.9 | 15.1 | 13.1 | 14.9 | 13.4 | 14.6 | 13.6 | 14.4 | 13.9 | 14.1 | 14.1 |
| 21 | 16.3 | 13.2 | 16.1 | 13.5 | 15.8 | 13.8 | 15.6 | 14.1 | 15.4 | 14.3 | 15.1 | 14.6 | 14.8 | 14.8 |
| 22 | 17.1 | 13.8 | 16.9 | 14.1 | 16.6 | 14.4 | 16.3 | 14.7 | 16.1 | 15.0 | 15.8 | 15.3 | 15.6 | 15.6 |
| 23 | 17.9 | 14.5 | 17.6 | 14.8 | 17.4 | 15.1 | 17.1 | 15.4 | 16.8 | 15.7 | 16.5 | 16.0 | 16.3 | 16.3 |
| 24 | 18.7 | 15.1 | 18.4 | 15.4 | 18.1 | 15.7 | 17.8 | 16.1 | 17.6 | 16.4 | 17.3 | 16.7 | 17.0 | 17.0 |
| 25 | 19.4 | 15.7 | 19.2 | 16.1 | 18.9 | 16.4 | 18.6 | 16.7 | 18.3 | 17.0 | 18.0 | 17.4 | 17.7 | 17.7 |
| 26 | 20.2 | 16.4 | 19.9 | 16.7 | 19.6 | 17.1 | 19.3 | 17.4 | 19.0 | 17.7 | 18.7 | 18.1 | 18.4 | 18.4 |
| 27 | 21.0 | 17.0 | 20.7 | 17.4 | 20.4 | 17.7 | 20.1 | 18.1 | 19.7 | 18.4 | 19.4 | 18.8 | 19.1 | 19.1 |
| 28 | 21.8 | 17.6 | 21.4 | 18.0 | 21.1 | 18.4 | 20.8 | 18.7 | 20.5 | 19.1 | 20.1 | 19.5 | 19.8 | 19.8 |
| 29 | 22.5 | 18.3 | 22.2 | 18.6 | 21.9 | 19.0 | 21.6 | 19.4 | 21.2 | 19.8 | 20.9 | 20.1 | 20.5 | 20.5 |
| 30 | 23.3 | 18.9 | 23.0 | 19.3 | 22.6 | 19.7 | 22.3 | 20.1 | 21.9 | 20.5 | 21.6 | 20.8 | 21.2 | 21.2 |
| 31 | 24.1 | 19.5 | 23.7 | 19.9 | 23.4 | 20.3 | 23.0 | 20.7 | 22.7 | 21.1 | 22.3 | 21.5 | 21.9 | 21.9 |
| 32 | 24.9 | 20.1 | 24.5 | 20.6 | 24.2 | 21.0 | 23.8 | 21.4 | 23.4 | 21.8 | 23.0 | 22.2 | 22.6 | 22.6 |
| 33 | 25.6 | 20.8 | 25.3 | 21.2 | 24.9 | 21.6 | 24.5 | 22.1 | 24.1 | 22.5 | 23.7 | 22.9 | 23.3 | 23.3 |
| 34 | 26.4 | 21.4 | 26.0 | 21.9 | 25.7 | 22.3 | 25.3 | 22.8 | 24.9 | 23.2 | 24.5 | 23.6 | 24.0 | 24.0 |
| 35 | 27.2 | 22.0 | 26.8 | 22.5 | 26.4 | 23.0 | 26.0 | 23.4 | 25.6 | 23.9 | 25.2 | 24.3 | 24.7 | 24.7 |
| 36 | 28.0 | 22.7 | 27.6 | 23.1 | 27.2 | 23.6 | 26.8 | 24.1 | 26.3 | 24.6 | 25.9 | 25.0 | 25.5 | 25.5 |
| 37 | 28.8 | 23.3 | 28.3 | 23.8 | 27.9 | 24.3 | 27.5 | 24.8 | 27.1 | 25.2 | 26.6 | 25.7 | 26.2 | 26.2 |
| 38 | 29.5 | 23.9 | 29.1 | 24.4 | 28.7 | 24.9 | 28.2 | 25.4 | 27.8 | 25.9 | 27.3 | 26.4 | 26.9 | 26.9 |
| 39 | 30.3 | 24.5 | 29.9 | 25.1 | 29.4 | 25.6 | 29.0 | 26.1 | 28.5 | 26.6 | 28.1 | 27.1 | 27.6 | 27.6 |
| 40 | 31.1 | 25.2 | 30.6 | 25.7 | 30.2 | 26.2 | 29.7 | 26.8 | 29.3 | 27.3 | 28.8 | 27.8 | 28.3 | 28.3 |
| 41 | 31.9 | 25.8 | 31.4 | 26.4 | 30.9 | 26.9 | 30.5 | 27.4 | 30.0 | 28.0 | 29.5 | 28.5 | 29.0 | 29.0 |
| 42 | 32.6 | 26.4 | 32.2 | 27.0 | 31.7 | 27.6 | 31.2 | 28.1 | 30.7 | 28.6 | 30.2 | 29.2 | 29.7 | 29.7 |
| 43 | 33.4 | 27.1 | 32.9 | 27.6 | 32.5 | 28.2 | 32.0 | 28.8 | 31.4 | 29.3 | 30.9 | 29.9 | 30.4 | 30.4 |
| 44 | 34.2 | 27.7 | 33.7 | 28.3 | 33.2 | 28.9 | 32.7 | 29.4 | 32.2 | 30.0 | 31.7 | 30.6 | 31.1 | 31.1 |
| 45 | 35.0 | 28.3 | 34.5 | 28.9 | 34.0 | 29.5 | 33.4 | 30.1 | 32.9 | 30.7 | 32.4 | 31.3 | 31.8 | 31.8 |
| 46 | 35.7 | 28.9 | 35.2 | 29.6 | 34.7 | 30.2 | 34.2 | 30.8 | 33.6 | 31.4 | 33.1 | 32.0 | 32.5 | 32.5 |
| 47 | 36.5 | 29.6 | 36.0 | 30.2 | 35.5 | 30.8 | 34.9 | 31.4 | 34.4 | 32.1 | 33.8 | 32.6 | 33.2 | 33.2 |
| 48 | 37.3 | 30.2 | 36.8 | 30.9 | 36.2 | 31.5 | 35.7 | 32.1 | 35.1 | 32.7 | 34.5 | 33.3 | 33.9 | 33.9 |
| 49 | 38.1 | 30.8 | 37.5 | 31.5 | 37.0 | 32.1 | 36.4 | 32.8 | 35.8 | 33.4 | 35.2 | 34.0 | 34.6 | 34.6 |
| 50 | 38.9 | 31.5 | 38.3 | 32.1 | 37.7 | 32.8 | 37.2 | 33.5 | 36.6 | 34.1 | 36.0 | 34.7 | 35.4 | 35.4 |
| 100 | 77.7 | 62.9 | 76.6 | 64.3 | 75.5 | 65.6 | 74.3 | 66.9 | 73.1 | 68.2 | 71.9 | 69.5 | 70.7 | 70.7 |
| 200 | 155.4 | 125.9 | 153.2 | 128.6 | 150.9 | 131.2 | 148.6 | 133.8 | 146.3 | 136.4 | 143.9 | 138.9 | 141.4 | 141.4 |
| 300 | 233.1 | 188.8 | 229.8 | 192.8 | 226.4 | 196.8 | 222.9 | 200.7 | 219.4 | 204.6 | 215.8 | 208.4 | 212.1 | 212.1 |
| 400 | 310.9 | 251.7 | 306.4 | 257.1 | 301.9 | 262.4 | 297.3 | 267.7 | 292.6 | 272.8 | 287.7 | 277.9 | 282.8 | 282.8 |
| 500 | 388.6 | 314.7 | 383.0 | 321.4 | 377.3 | 328.0 | 371.6 | 334.6 | 365.7 | 341.0 | 359.7 | 347.3 | 353.5 | 353.5 |
| | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. |
| | (129°, 231°, 309°) | | (130°, 230°, 310°) | | (131°, 229°, 311°) | | (132°, 228°, 312°) | | (133°, 227°, 313°) | | (134°, 226°, 314°) | | (135°, 225°, 315°) | |
| | 4½ Pt. 51° | | 50° | | 49° | | 4½ Pt. 48° | | 47° | | 46° | | 4 Pt. 45° | |

The 4-Pt. or 45° Courses are : N.E., N.W., S.E., S.W.

Table 1. Traverse Table

| Dist. | 3½ Pt. 39° (141°, 219°, 321°) | | 40° (140°, 220°, 320°) | | 41° (139°, 221°, 319°) | | 3¾ Pt. 42° (138°, 222°, 318°) | | 43° (137°, 223°, 317°) | | 44° (136°, 224°, 316°) | | 4 Pt. 45° (135°, 225°, 315°) | |
|-------|----------------------------------|-------|---------------------------|-------|---------------------------|-------|----------------------------------|-------|---------------------------|-------|---------------------------|-------|---------------------------------|-------|
| | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. | Lat. | Dep. |
| | (129°, 231°, 309°) | | (130°, 230°, 310°) | | (131°, 229°, 311°) | | (132°, 228°, 312°) | | (133°, 227°, 313°) | | (134°, 226°, 314°) | | (135°, 225°, 315°) | |
| 51 | 39.6 | 32.1 | 39.1 | 32.8 | 38.5 | 33.5 | 37.9 | 34.1 | 37.3 | 34.8 | 36.7 | 35.4 | 36.1 | 36.1 |
| 52 | 40.4 | 32.7 | 39.8 | 33.4 | 39.2 | 34.1 | 38.6 | 34.8 | 38.0 | 35.5 | 37.4 | 36.1 | 36.8 | 36.8 |
| 53 | 41.2 | 33.4 | 40.6 | 34.1 | 40.0 | 34.8 | 39.4 | 35.5 | 38.8 | 36.1 | 38.1 | 36.8 | 37.5 | 37.5 |
| 54 | 42.0 | 34.0 | 41.4 | 34.7 | 40.8 | 35.4 | 40.1 | 36.1 | 39.5 | 36.8 | 38.8 | 37.5 | 38.2 | 38.2 |
| 55 | 42.7 | 34.6 | 42.1 | 35.4 | 41.5 | 36.1 | 40.9 | 36.8 | 40.2 | 37.5 | 39.6 | 38.2 | 38.9 | 38.9 |
| 56 | 43.5 | 35.2 | 42.9 | 36.0 | 42.3 | 36.7 | 41.6 | 37.5 | 41.0 | 38.2 | 40.3 | 38.9 | 39.6 | 39.6 |
| 57 | 44.3 | 35.9 | 43.7 | 36.6 | 43.0 | 37.4 | 42.4 | 38.1 | 41.7 | 38.9 | 41.0 | 39.6 | 40.3 | 40.3 |
| 58 | 45.1 | 36.5 | 44.4 | 37.3 | 43.8 | 38.1 | 43.1 | 38.8 | 42.4 | 39.6 | 41.7 | 40.3 | 41.0 | 41.0 |
| 59 | 45.9 | 37.1 | 45.2 | 37.9 | 44.5 | 38.7 | 43.8 | 39.5 | 43.1 | 40.2 | 42.4 | 41.0 | 41.7 | 41.7 |
| 60 | 46.6 | 37.8 | 46.0 | 38.6 | 45.3 | 39.4 | 44.6 | 40.1 | 43.9 | 40.9 | 43.2 | 41.7 | 42.4 | 42.4 |
| 61 | 47.4 | 38.4 | 46.7 | 39.2 | 46.0 | 40.0 | 45.3 | 40.8 | 44.6 | 41.6 | 43.9 | 42.4 | 43.1 | 43.1 |
| 62 | 48.2 | 39.0 | 47.5 | 39.9 | 46.8 | 40.7 | 46.1 | 41.5 | 45.3 | 42.3 | 44.6 | 43.1 | 43.8 | 43.8 |
| 63 | 49.0 | 39.6 | 48.3 | 40.5 | 47.5 | 41.3 | 46.8 | 42.2 | 46.1 | 43.0 | 45.3 | 43.8 | 44.5 | 44.5 |
| 64 | 49.7 | 40.3 | 49.0 | 41.1 | 48.3 | 42.0 | 47.6 | 42.8 | 46.8 | 43.6 | 46.0 | 44.5 | 45.3 | 45.3 |
| 65 | 50.5 | 40.9 | 49.8 | 41.8 | 49.1 | 42.6 | 48.3 | 43.5 | 47.5 | 44.3 | 46.8 | 45.2 | 46.0 | 46.0 |
| 66 | 51.3 | 41.5 | 50.6 | 42.4 | 49.8 | 43.3 | 49.0 | 44.2 | 48.3 | 45.0 | 47.5 | 45.8 | 46.7 | 46.7 |
| 67 | 52.1 | 42.2 | 51.3 | 43.1 | 50.6 | 44.0 | 49.8 | 44.8 | 49.0 | 45.7 | 48.2 | 46.5 | 47.4 | 47.4 |
| 68 | 52.8 | 42.8 | 52.1 | 43.7 | 51.3 | 44.6 | 50.5 | 45.5 | 49.7 | 46.4 | 48.9 | 47.2 | 48.1 | 48.1 |
| 69 | 53.6 | 43.4 | 52.9 | 44.4 | 52.1 | 45.3 | 51.3 | 46.2 | 50.5 | 47.1 | 49.6 | 47.9 | 48.8 | 48.8 |
| 70 | 54.4 | 44.1 | 53.6 | 45.0 | 52.8 | 45.9 | 52.0 | 46.8 | 51.2 | 47.7 | 50.4 | 48.6 | 49.5 | 49.5 |
| 71 | 55.2 | 44.7 | 54.4 | 45.6 | 53.6 | 46.6 | 52.8 | 47.5 | 51.9 | 48.4 | 51.1 | 49.3 | 50.2 | 50.2 |
| 72 | 56.0 | 45.3 | 55.2 | 46.3 | 54.3 | 47.2 | 53.5 | 48.2 | 52.7 | 49.1 | 51.8 | 50.0 | 50.9 | 50.9 |
| 73 | 56.7 | 45.9 | 55.9 | 46.9 | 55.1 | 47.9 | 54.2 | 48.8 | 53.4 | 49.8 | 52.5 | 50.7 | 51.6 | 51.6 |
| 74 | 57.5 | 46.6 | 56.7 | 47.6 | 55.8 | 48.5 | 55.0 | 49.5 | 54.1 | 50.5 | 53.2 | 51.4 | 52.3 | 52.3 |
| 75 | 58.3 | 47.2 | 57.5 | 48.2 | 56.6 | 49.2 | 55.7 | 50.2 | 54.9 | 51.1 | 54.0 | 52.1 | 53.0 | 53.0 |
| 76 | 59.1 | 47.8 | 58.2 | 48.9 | 57.4 | 49.9 | 56.5 | 50.9 | 55.6 | 51.8 | 54.7 | 52.8 | 53.7 | 53.7 |
| 77 | 59.8 | 48.5 | 59.0 | 49.5 | 58.1 | 50.5 | 57.2 | 51.5 | 56.3 | 52.5 | 55.4 | 53.5 | 54.4 | 54.4 |
| 78 | 60.6 | 49.1 | 59.8 | 50.1 | 58.9 | 51.2 | 58.0 | 52.2 | 57.0 | 53.2 | 56.1 | 54.2 | 55.2 | 55.2 |
| 79 | 61.4 | 49.7 | 60.5 | 50.8 | 59.6 | 51.8 | 58.7 | 52.9 | 57.8 | 53.9 | 56.8 | 54.9 | 55.9 | 55.9 |
| 80 | 62.2 | 50.3 | 61.3 | 51.4 | 60.4 | 52.5 | 59.5 | 53.5 | 58.5 | 54.6 | 57.5 | 55.6 | 56.6 | 56.6 |
| 81 | 62.9 | 51.0 | 62.0 | 52.1 | 61.1 | 53.1 | 60.2 | 54.2 | 59.2 | 55.2 | 58.3 | 56.3 | 57.3 | 57.3 |
| 82 | 63.7 | 51.6 | 62.8 | 52.7 | 61.9 | 53.8 | 60.9 | 54.9 | 60.0 | 55.9 | 59.0 | 57.0 | 58.0 | 58.0 |
| 83 | 64.5 | 52.2 | 63.6 | 53.4 | 62.6 | 54.5 | 61.7 | 55.5 | 60.7 | 56.6 | 59.7 | 57.7 | 58.7 | 58.7 |
| 84 | 65.3 | 52.9 | 64.3 | 54.0 | 63.4 | 55.1 | 62.4 | 56.2 | 61.4 | 57.3 | 60.4 | 58.4 | 59.4 | 59.4 |
| 85 | 66.1 | 53.5 | 65.1 | 54.6 | 64.2 | 55.8 | 63.2 | 56.9 | 62.2 | 58.0 | 61.1 | 59.0 | 60.1 | 60.1 |
| 86 | 66.8 | 54.1 | 65.9 | 55.3 | 64.9 | 56.4 | 63.9 | 57.5 | 62.9 | 58.7 | 61.9 | 59.7 | 60.8 | 60.8 |
| 87 | 67.6 | 54.8 | 66.6 | 55.9 | 65.7 | 57.1 | 64.7 | 58.2 | 63.6 | 59.3 | 62.6 | 60.4 | 61.5 | 61.5 |
| 88 | 68.4 | 55.4 | 67.4 | 56.6 | 66.4 | 57.7 | 65.4 | 58.9 | 64.4 | 60.0 | 63.3 | 61.1 | 62.2 | 62.2 |
| 89 | 69.2 | 56.0 | 68.2 | 57.2 | 67.2 | 58.4 | 66.1 | 59.6 | 65.1 | 60.7 | 64.0 | 61.8 | 62.9 | 62.9 |
| 90 | 69.9 | 56.6 | 68.9 | 57.9 | 67.9 | 59.0 | 66.9 | 60.2 | 65.8 | 61.4 | 64.7 | 62.5 | 63.6 | 63.6 |
| 91 | 70.7 | 57.3 | 69.7 | 58.5 | 68.7 | 59.7 | 67.6 | 60.9 | 66.6 | 62.1 | 65.5 | 63.2 | 64.3 | 64.3 |
| 92 | 71.5 | 57.9 | 70.5 | 59.1 | 69.4 | 60.4 | 68.4 | 61.6 | 67.3 | 62.7 | 66.2 | 63.9 | 65.1 | 65.1 |
| 93 | 72.3 | 58.5 | 71.2 | 59.8 | 70.2 | 61.0 | 69.1 | 62.2 | 68.0 | 63.4 | 66.9 | 64.6 | 65.8 | 65.8 |
| 94 | 73.1 | 59.2 | 72.0 | 60.4 | 70.9 | 61.7 | 69.9 | 62.9 | 68.7 | 64.1 | 67.6 | 65.3 | 66.5 | 66.5 |
| 95 | 73.8 | 59.8 | 72.8 | 61.1 | 71.7 | 62.3 | 70.6 | 63.6 | 69.5 | 64.8 | 68.3 | 66.0 | 67.2 | 67.2 |
| 96 | 74.6 | 60.4 | 73.5 | 61.7 | 72.5 | 63.0 | 71.3 | 64.2 | 70.2 | 65.5 | 69.1 | 66.7 | 67.9 | 67.9 |
| 97 | 75.4 | 61.0 | 74.3 | 62.4 | 73.2 | 63.6 | 72.1 | 64.9 | 70.9 | 66.2 | 69.8 | 67.4 | 68.6 | 68.6 |
| 98 | 76.2 | 61.7 | 75.1 | 63.0 | 74.0 | 64.3 | 72.8 | 65.6 | 71.7 | 66.8 | 70.5 | 68.1 | 69.3 | 69.3 |
| 99 | 76.9 | 62.3 | 75.8 | 63.6 | 74.7 | 64.9 | 73.6 | 66.2 | 72.4 | 67.5 | 71.2 | 68.8 | 70.0 | 70.0 |
| 100 | 77.7 | 62.9 | 76.6 | 64.3 | 75.5 | 65.6 | 74.3 | 66.9 | 73.1 | 68.2 | 71.9 | 69.5 | 70.7 | 70.7 |
| 600 | 466.3 | 377.6 | 459.6 | 385.7 | 452.8 | 393.6 | 445.9 | 401.5 | 438.8 | 409.2 | 431.6 | 416.8 | 424.3 | 424.3 |
| 700 | 543.9 | 440.6 | 536.3 | 450.0 | 528.3 | 459.2 | 520.2 | 468.4 | 511.9 | 477.4 | 503.5 | 486.3 | 495.0 | 495.0 |
| 800 | 621.8 | 503.5 | 613.0 | 514.2 | 603.9 | 524.8 | 594.6 | 535.3 | 585.1 | 545.6 | 575.4 | 555.8 | 565.7 | 565.7 |
| 900 | 699.3 | 566.3 | 689.5 | 578.5 | 679.2 | 590.3 | 668.8 | 602.2 | 658.2 | 613.8 | 647.3 | 625.2 | 636.3 | 636.3 |

The 4-Pt. or 45° Courses are: N.E., N.W., S.E., S.W.

TO CHANGE LONG. DIFF. INTO DEP., SUBTRACT TABULAR NUMBER FROM LONG. DIFF.

| LONG. DIFF. OR DEP. | MIDDLE LATITUDE | | | | | | | | | | | | | | |
|---------------------|-----------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| | 1° | 2° | 3° | 4° | 5° | 6° | 7° | 8° | 9° | 10° | 11° | 12° | 13° | 14° | 15° |
| 1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 |
| 3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| 4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| 5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.2 |
| 6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.2 | 0.2 | 0.2 |
| 7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.2 | 0.2 | 0.2 | 0.2 |
| 8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.2 | 0.2 | 0.2 | 0.3 |
| 9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.1 | 0.2 | 0.2 | 0.2 | 0.3 | 0.3 |
| 10 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.1 | 0.2 | 0.2 | 0.2 | 0.3 | 0.3 | 0.3 |
| 11 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.1 | 0.2 | 0.2 | 0.2 | 0.3 | 0.3 | 0.4 |
| 12 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.1 | 0.2 | 0.2 | 0.3 | 0.3 | 0.4 | 0.4 |
| 13 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.1 | 0.2 | 0.2 | 0.3 | 0.3 | 0.4 | 0.4 |
| 14 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.1 | 0.2 | 0.2 | 0.3 | 0.3 | 0.4 | 0.4 | 0.5 |
| 15 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.1 | 0.2 | 0.2 | 0.3 | 0.3 | 0.4 | 0.4 | 0.5 |
| 16 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.2 | 0.2 | 0.2 | 0.3 | 0.3 | 0.4 | 0.5 | 0.5 |
| 17 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.2 | 0.2 | 0.3 | 0.3 | 0.4 | 0.4 | 0.5 | 0.6 |
| 18 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.2 | 0.2 | 0.3 | 0.3 | 0.4 | 0.5 | 0.5 | 0.6 |
| 19 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.2 | 0.2 | 0.3 | 0.3 | 0.4 | 0.5 | 0.6 | 0.6 |
| 20 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.2 | 0.2 | 0.3 | 0.4 | 0.4 | 0.5 | 0.6 | 0.7 |
| 21 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.2 | 0.2 | 0.3 | 0.3 | 0.4 | 0.5 | 0.5 | 0.6 | 0.7 |
| 22 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.2 | 0.2 | 0.3 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.7 |
| 23 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.2 | 0.2 | 0.3 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 |
| 24 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.2 | 0.2 | 0.3 | 0.4 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 |
| 25 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.2 | 0.2 | 0.3 | 0.4 | 0.5 | 0.5 | 0.6 | 0.7 | 0.9 |
| 26 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.2 | 0.3 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 |
| 27 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.2 | 0.3 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 |
| 28 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.2 | 0.3 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 1.0 |
| 29 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.2 | 0.3 | 0.4 | 0.4 | 0.5 | 0.6 | 0.7 | 0.9 | 1.0 |
| 30 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 | 1.0 |
| 31 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 | 1.1 |
| 32 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 1.0 | 1.1 |
| 33 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 1.0 | 1.1 |
| 34 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.3 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.9 | 1.0 | 1.2 |
| 35 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.3 | 0.3 | 0.4 | 0.5 | 0.6 | 0.8 | 0.9 | 1.0 | 1.2 |
| 36 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.3 | 0.4 | 0.4 | 0.5 | 0.7 | 0.8 | 0.9 | 1.1 | 1.2 |
| 37 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 | 1.1 | 1.3 |
| 38 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 1.0 | 1.1 | 1.3 |
| 39 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.9 | 1.0 | 1.2 | 1.3 |
| 40 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.9 | 1.0 | 1.2 | 1.4 |
| 41 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.8 | 0.9 | 1.1 | 1.2 | 1.4 |
| 42 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.8 | 0.9 | 1.1 | 1.2 | 1.4 |
| 43 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.2 | 0.3 | 0.4 | 0.5 | 0.7 | 0.8 | 0.9 | 1.1 | 1.3 | 1.5 |
| 44 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.2 | 0.3 | 0.4 | 0.5 | 0.7 | 0.8 | 1.0 | 1.1 | 1.3 | 1.5 |
| 45 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.2 | 0.3 | 0.4 | 0.6 | 0.7 | 0.8 | 1.0 | 1.2 | 1.3 | 1.5 |
| 46 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.3 | 0.3 | 0.4 | 0.6 | 0.7 | 0.8 | 1.0 | 1.2 | 1.4 | 1.6 |
| 47 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.9 | 1.0 | 1.2 | 1.4 | 1.6 |
| 48 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.9 | 1.0 | 1.2 | 1.4 | 1.6 |
| 49 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.9 | 1.1 | 1.3 | 1.5 | 1.7 |
| 50 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.8 | 0.9 | 1.1 | 1.3 | 1.5 | 1.7 |
| 100 | 0.0 | 0.1 | 0.1 | 0.2 | 0.4 | 0.5 | 0.7 | 1.0 | 1.2 | 1.5 | 1.8 | 2.2 | 2.6 | 3.0 | 3.4 |
| 200 | 0.0 | 0.1 | 0.3 | 0.5 | 0.8 | 1.1 | 1.5 | 1.9 | 2.5 | 3.0 | 3.7 | 4.4 | 5.1 | 5.9 | 6.8 |
| 300 | 0.0 | 0.2 | 0.4 | 0.7 | 1.1 | 1.6 | 2.2 | 2.9 | 3.7 | 4.6 | 5.5 | 6.6 | 7.7 | 8.9 | 10.2 |
| 400 | 0.1 | 0.2 | 0.6 | 1.0 | 1.5 | 2.2 | 3.0 | 3.9 | 4.9 | 6.1 | 7.4 | 8.7 | 10.2 | 11.9 | 13.7 |
| 500 | 0.1 | 0.3 | 0.7 | 1.2 | 1.9 | 2.7 | 3.7 | 4.9 | 6.2 | 7.6 | 9.2 | 10.9 | 12.8 | 14.9 | 17.0 |
| | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.01 | 1.01 | 1.01 | 1.01 | 1.02 | 1.02 | 1.02 | 1.03 | 1.03 | 1.04 |

FACTOR

TO CHANGE DEP. INTO LONG. DIFF., MULTIPLY TABULAR NUMBER BY FACTOR AT FOOT OF COLUMN, AND ADD PRODUCT TO DEP.

TO CHANGE LONG. DIFF. INTO DEP. **SUBTRACT** TABULAR NUMBER FROM LONG. DIFF.

| LONG. DIFF. OR DEP. | MIDDLE LATITUDE | | | | | | | | | | | | | | |
|---------------------|-----------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| | 1° | 2° | 3° | 4° | 5° | 6° | 7° | 8° | 9° | 10° | 11° | 12° | 13° | 14° | 15° |
| 51 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.8 | 0.9 | 1.1 | 1.3 | 1.5 | 1.7 |
| 52 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.8 | 1.0 | 1.1 | 1.3 | 1.5 | 1.8 |
| 53 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.7 | 0.8 | 1.0 | 1.2 | 1.4 | 1.6 | 1.8 |
| 54 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.7 | 0.8 | 1.0 | 1.2 | 1.4 | 1.6 | 1.8 |
| 55 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.7 | 0.8 | 1.0 | 1.2 | 1.4 | 1.6 | 1.9 |
| 56 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.7 | 0.9 | 1.0 | 1.2 | 1.4 | 1.7 | 1.9 |
| 57 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.3 | 0.4 | 0.6 | 0.7 | 0.9 | 1.0 | 1.2 | 1.5 | 1.7 | 1.9 |
| 58 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.3 | 0.4 | 0.6 | 0.7 | 0.9 | 1.1 | 1.3 | 1.5 | 1.7 | 2.0 |
| 59 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.3 | 0.4 | 0.6 | 0.7 | 0.9 | 1.1 | 1.3 | 1.5 | 1.8 | 2.0 |
| 60 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.3 | 0.4 | 0.6 | 0.7 | 0.9 | 1.1 | 1.3 | 1.5 | 1.8 | 2.0 |
| 61 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.3 | 0.5 | 0.6 | 0.8 | 0.9 | 1.1 | 1.3 | 1.6 | 1.8 | 2.1 |
| 62 | 0.0 | 0.0 | 0.1 | 0.2 | 0.2 | 0.3 | 0.5 | 0.6 | 0.8 | 0.9 | 1.1 | 1.4 | 1.6 | 1.8 | 2.1 |
| 63 | 0.0 | 0.0 | 0.1 | 0.2 | 0.2 | 0.3 | 0.5 | 0.6 | 0.8 | 1.0 | 1.2 | 1.4 | 1.6 | 1.9 | 2.1 |
| 64 | 0.0 | 0.0 | 0.1 | 0.2 | 0.2 | 0.4 | 0.5 | 0.6 | 0.8 | 1.0 | 1.2 | 1.4 | 1.6 | 1.9 | 2.2 |
| 65 | 0.0 | 0.0 | 0.1 | 0.2 | 0.2 | 0.4 | 0.5 | 0.6 | 0.8 | 1.0 | 1.2 | 1.4 | 1.7 | 1.9 | 2.2 |
| 66 | 0.0 | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.8 | 1.0 | 1.2 | 1.4 | 1.7 | 2.0 | 2.2 |
| 67 | 0.0 | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.7 | 0.8 | 1.0 | 1.2 | 1.5 | 1.7 | 2.0 | 2.3 |
| 68 | 0.0 | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.7 | 0.8 | 1.0 | 1.2 | 1.5 | 1.7 | 2.0 | 2.3 |
| 69 | 0.0 | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.7 | 0.8 | 1.0 | 1.3 | 1.5 | 1.8 | 2.0 | 2.4 |
| 70 | 0.0 | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.7 | 0.9 | 1.1 | 1.3 | 1.5 | 1.8 | 2.1 | 2.4 |
| 71 | 0.0 | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.7 | 0.9 | 1.1 | 1.3 | 1.6 | 1.8 | 2.1 | 2.4 |
| 72 | 0.0 | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.7 | 0.9 | 1.1 | 1.3 | 1.6 | 1.8 | 2.1 | 2.5 |
| 73 | 0.0 | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.7 | 0.9 | 1.1 | 1.3 | 1.6 | 1.9 | 2.2 | 2.5 |
| 74 | 0.0 | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.6 | 0.7 | 0.9 | 1.1 | 1.4 | 1.6 | 1.9 | 2.2 | 2.5 |
| 75 | 0.0 | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.6 | 0.7 | 0.9 | 1.1 | 1.4 | 1.6 | 1.9 | 2.2 | 2.6 |
| 76 | 0.0 | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.6 | 0.7 | 0.9 | 1.2 | 1.4 | 1.7 | 1.9 | 2.3 | 2.6 |
| 77 | 0.0 | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.6 | 0.7 | 0.9 | 1.2 | 1.4 | 1.7 | 2.0 | 2.3 | 2.6 |
| 78 | 0.0 | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.6 | 0.8 | 1.0 | 1.2 | 1.4 | 1.7 | 2.0 | 2.3 | 2.7 |
| 79 | 0.0 | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.6 | 0.8 | 1.0 | 1.2 | 1.5 | 1.7 | 2.0 | 2.3 | 2.7 |
| 80 | 0.0 | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.6 | 0.8 | 1.0 | 1.2 | 1.5 | 1.7 | 2.1 | 2.4 | 2.7 |
| 81 | 0.0 | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.6 | 0.8 | 1.0 | 1.2 | 1.5 | 1.8 | 2.1 | 2.4 | 2.8 |
| 82 | 0.0 | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.6 | 0.8 | 1.0 | 1.2 | 1.5 | 1.8 | 2.1 | 2.4 | 2.8 |
| 83 | 0.0 | 0.1 | 0.1 | 0.2 | 0.3 | 0.5 | 0.6 | 0.8 | 1.0 | 1.3 | 1.5 | 1.8 | 2.1 | 2.5 | 2.8 |
| 84 | 0.0 | 0.1 | 0.1 | 0.2 | 0.3 | 0.5 | 0.6 | 0.8 | 1.0 | 1.3 | 1.5 | 1.8 | 2.2 | 2.5 | 2.9 |
| 85 | 0.0 | 0.1 | 0.1 | 0.2 | 0.3 | 0.5 | 0.6 | 0.8 | 1.0 | 1.3 | 1.6 | 1.9 | 2.2 | 2.5 | 2.9 |
| 86 | 0.0 | 0.1 | 0.1 | 0.2 | 0.3 | 0.5 | 0.6 | 0.8 | 1.1 | 1.3 | 1.6 | 1.9 | 2.2 | 2.6 | 2.9 |
| 87 | 0.0 | 0.1 | 0.1 | 0.2 | 0.3 | 0.5 | 0.6 | 0.8 | 1.1 | 1.3 | 1.6 | 1.9 | 2.2 | 2.6 | 3.0 |
| 88 | 0.0 | 0.1 | 0.1 | 0.2 | 0.3 | 0.5 | 0.7 | 0.9 | 1.1 | 1.3 | 1.6 | 1.9 | 2.3 | 2.6 | 3.0 |
| 89 | 0.0 | 0.1 | 0.1 | 0.2 | 0.3 | 0.5 | 0.7 | 0.9 | 1.1 | 1.4 | 1.6 | 1.9 | 2.3 | 2.6 | 3.0 |
| 90 | 0.0 | 0.1 | 0.1 | 0.2 | 0.3 | 0.5 | 0.7 | 0.9 | 1.1 | 1.4 | 1.7 | 2.0 | 2.3 | 2.7 | 3.1 |
| 91 | 0.0 | 0.1 | 0.1 | 0.2 | 0.3 | 0.5 | 0.7 | 0.9 | 1.1 | 1.4 | 1.7 | 2.0 | 2.3 | 2.7 | 3.1 |
| 92 | 0.0 | 0.1 | 0.1 | 0.2 | 0.4 | 0.5 | 0.7 | 0.9 | 1.1 | 1.4 | 1.7 | 2.0 | 2.4 | 2.7 | 3.1 |
| 93 | 0.0 | 0.1 | 0.1 | 0.2 | 0.4 | 0.5 | 0.7 | 0.9 | 1.1 | 1.4 | 1.7 | 2.0 | 2.4 | 2.8 | 3.2 |
| 94 | 0.0 | 0.1 | 0.1 | 0.2 | 0.4 | 0.5 | 0.7 | 0.9 | 1.2 | 1.4 | 1.7 | 2.1 | 2.4 | 2.8 | 3.2 |
| 95 | 0.0 | 0.1 | 0.1 | 0.2 | 0.4 | 0.5 | 0.7 | 0.9 | 1.2 | 1.4 | 1.7 | 2.1 | 2.4 | 2.8 | 3.2 |
| 96 | 0.0 | 0.1 | 0.1 | 0.2 | 0.4 | 0.5 | 0.7 | 0.9 | 1.2 | 1.5 | 1.8 | 2.1 | 2.5 | 2.9 | 3.3 |
| 97 | 0.0 | 0.1 | 0.1 | 0.2 | 0.4 | 0.5 | 0.7 | 0.9 | 1.2 | 1.5 | 1.8 | 2.1 | 2.5 | 2.9 | 3.3 |
| 98 | 0.0 | 0.1 | 0.1 | 0.2 | 0.4 | 0.5 | 0.7 | 1.0 | 1.2 | 1.5 | 1.8 | 2.1 | 2.5 | 2.9 | 3.3 |
| 99 | 0.0 | 0.1 | 0.1 | 0.2 | 0.4 | 0.5 | 0.7 | 1.0 | 1.2 | 1.5 | 1.8 | 2.2 | 2.5 | 2.9 | 3.4 |
| 100 | 0.0 | 0.1 | 0.1 | 0.2 | 0.4 | 0.5 | 0.7 | 1.0 | 1.2 | 1.5 | 1.8 | 2.2 | 2.6 | 3.0 | 3.4 |
| 600 | 0.1 | 0.4 | 0.8 | 1.4 | 2.3 | 3.3 | 4.5 | 5.8 | 7.4 | 9.1 | 10.0 | 13.1 | 15.4 | 17.8 | 20.5 |
| 700 | 0.2 | 0.5 | 1.0 | 1.8 | 2.8 | 3.9 | 5.1 | 6.7 | 8.7 | 10.5 | 12.9 | 15.3 | 17.9 | 20.8 | 23.9 |
| 800 | 0.2 | 0.5 | 1.1 | 2.0 | 3.1 | 4.4 | 5.9 | 7.7 | 9.8 | 12.1 | 14.8 | 17.5 | 20.6 | 23.8 | 27.3 |
| 900 | 0.3 | 0.7 | 1.4 | 2.4 | 3.6 | 5.0 | 6.7 | 8.7 | 11.2 | 13.7 | 16.7 | 19.8 | 23.2 | 26.8 | 30.8 |
| | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.01 | 1.01 | 1.01 | 1.01 | 1.02 | 1.02 | 1.02 | 1.03 | 1.03 | 1.04 |

FACTOR

TO CHANGE DEP. INTO LONG. DIFF. MULTIPLY TABULAR NUMBER BY FACTOR AT FOOT OF COLUMN AND **ADD** PRODUCT TO DEP.

TO CHANGE LONG. DIFF. INTO DEP., SUBTRACT TABULAR NUMBER FROM LONG. DIFF.

| LONG. DIFF. OR DEP. | MIDDLE LATITUDE | | | | | | | | | | | | |
|------------------------------|-----------------|------|------|------|------|------|------|------|------|------|------|------|------|
| | 16° | 17° | 18° | 19° | 20° | 21° | 22° | 23° | 24° | 25° | 26° | 27° | 28° |
| 1 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| 2 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| 3 | 0.1 | 0.1 | 0.1 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.3 | 0.3 | 0.3 | 0.3 | 0.4 |
| 4 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.3 | 0.3 | 0.3 | 0.3 | 0.4 | 0.4 | 0.4 | 0.5 |
| 5 | 0.2 | 0.2 | 0.2 | 0.3 | 0.3 | 0.3 | 0.4 | 0.4 | 0.4 | 0.5 | 0.5 | 0.5 | 0.6 |
| 6 | 0.2 | 0.3 | 0.3 | 0.3 | 0.4 | 0.4 | 0.4 | 0.5 | 0.5 | 0.6 | 0.6 | 0.7 | 0.7 |
| 7 | 0.3 | 0.3 | 0.3 | 0.4 | 0.4 | 0.5 | 0.5 | 0.6 | 0.6 | 0.7 | 0.7 | 0.8 | 0.8 |
| 8 | 0.3 | 0.3 | 0.4 | 0.4 | 0.5 | 0.5 | 0.6 | 0.6 | 0.7 | 0.7 | 0.8 | 0.9 | 0.9 |
| 9 | 0.3 | 0.4 | 0.4 | 0.5 | 0.5 | 0.6 | 0.7 | 0.7 | 0.8 | 0.8 | 0.9 | 1.0 | 1.1 |
| 10 | 0.4 | 0.4 | 0.5 | 0.5 | 0.6 | 0.7 | 0.7 | 0.8 | 0.9 | 0.9 | 1.0 | 1.1 | 1.2 |
| 11 | 0.4 | 0.5 | 0.5 | 0.6 | 0.7 | 0.7 | 0.8 | 0.9 | 1.0 | 1.0 | 1.1 | 1.2 | 1.3 |
| 12 | 0.5 | 0.5 | 0.6 | 0.7 | 0.7 | 0.8 | 0.9 | 1.0 | 1.0 | 1.1 | 1.2 | 1.3 | 1.4 |
| 13 | 0.5 | 0.6 | 0.6 | 0.7 | 0.8 | 0.9 | 0.9 | 1.0 | 1.1 | 1.2 | 1.3 | 1.4 | 1.5 |
| 14 | 0.5 | 0.6 | 0.7 | 0.8 | 0.8 | 0.9 | 1.0 | 1.1 | 1.2 | 1.3 | 1.4 | 1.5 | 1.6 |
| 15 | 0.6 | 0.7 | 0.7 | 0.8 | 0.9 | 1.0 | 1.1 | 1.2 | 1.3 | 1.4 | 1.5 | 1.6 | 1.8 |
| 16 | 0.6 | 0.7 | 0.8 | 0.9 | 1.0 | 1.1 | 1.2 | 1.3 | 1.4 | 1.5 | 1.6 | 1.7 | 1.9 |
| 17 | 0.7 | 0.7 | 0.8 | 0.9 | 1.0 | 1.1 | 1.2 | 1.4 | 1.5 | 1.6 | 1.7 | 1.9 | 2.0 |
| 18 | 0.7 | 0.8 | 0.9 | 1.0 | 1.1 | 1.2 | 1.3 | 1.4 | 1.6 | 1.7 | 1.8 | 2.0 | 2.1 |
| 19 | 0.7 | 0.8 | 0.9 | 1.0 | 1.1 | 1.3 | 1.4 | 1.5 | 1.6 | 1.8 | 1.9 | 2.1 | 2.2 |
| 20 | 0.8 | 0.9 | 1.0 | 1.1 | 1.2 | 1.3 | 1.5 | 1.6 | 1.7 | 1.9 | 2.0 | 2.2 | 2.3 |
| 21 | 0.8 | 0.9 | 1.0 | 1.1 | 1.3 | 1.4 | 1.5 | 1.7 | 1.8 | 2.0 | 2.1 | 2.3 | 2.5 |
| 22 | 0.9 | 1.0 | 1.1 | 1.2 | 1.3 | 1.5 | 1.6 | 1.7 | 1.9 | 2.1 | 2.2 | 2.4 | 2.6 |
| 23 | 0.9 | 1.0 | 1.1 | 1.3 | 1.4 | 1.5 | 1.7 | 1.8 | 2.0 | 2.2 | 2.3 | 2.5 | 2.7 |
| 24 | 0.9 | 1.0 | 1.2 | 1.3 | 1.4 | 1.6 | 1.7 | 1.9 | 2.1 | 2.2 | 2.4 | 2.6 | 2.8 |
| 25 | 1.0 | 1.1 | 1.2 | 1.4 | 1.5 | 1.7 | 1.8 | 2.0 | 2.2 | 2.3 | 2.5 | 2.7 | 2.9 |
| 26 | 1.0 | 1.1 | 1.3 | 1.4 | 1.6 | 1.7 | 1.9 | 2.1 | 2.2 | 2.4 | 2.6 | 2.8 | 3.0 |
| 27 | 1.0 | 1.2 | 1.3 | 1.5 | 1.6 | 1.8 | 2.0 | 2.1 | 2.3 | 2.5 | 2.7 | 2.9 | 3.2 |
| 28 | 1.1 | 1.2 | 1.4 | 1.5 | 1.7 | 1.9 | 2.0 | 2.2 | 2.4 | 2.6 | 2.8 | 3.1 | 3.3 |
| 29 | 1.1 | 1.3 | 1.4 | 1.6 | 1.7 | 1.9 | 2.1 | 2.3 | 2.5 | 2.7 | 2.9 | 3.2 | 3.4 |
| 30 | 1.2 | 1.3 | 1.5 | 1.6 | 1.8 | 2.0 | 2.2 | 2.4 | 2.6 | 2.8 | 3.0 | 3.3 | 3.5 |
| 31 | 1.2 | 1.4 | 1.5 | 1.7 | 1.9 | 2.1 | 2.3 | 2.5 | 2.7 | 2.9 | 3.1 | 3.4 | 3.6 |
| 32 | 1.2 | 1.4 | 1.6 | 1.7 | 1.9 | 2.1 | 2.3 | 2.5 | 2.8 | 3.0 | 3.2 | 3.5 | 3.7 |
| 33 | 1.3 | 1.4 | 1.6 | 1.8 | 2.0 | 2.2 | 2.4 | 2.6 | 2.9 | 3.1 | 3.3 | 3.6 | 3.9 |
| 34 | 1.3 | 1.5 | 1.7 | 1.9 | 2.1 | 2.3 | 2.5 | 2.7 | 2.9 | 3.2 | 3.4 | 3.7 | 4.0 |
| 35 | 1.4 | 1.5 | 1.7 | 1.9 | 2.1 | 2.3 | 2.5 | 2.8 | 3.0 | 3.3 | 3.5 | 3.8 | 4.1 |
| 36 | 1.4 | 1.6 | 1.8 | 2.0 | 2.2 | 2.4 | 2.6 | 2.9 | 3.1 | 3.4 | 3.6 | 3.9 | 4.2 |
| 37 | 1.4 | 1.6 | 1.8 | 2.0 | 2.2 | 2.5 | 2.7 | 2.9 | 3.2 | 3.5 | 3.7 | 4.0 | 4.3 |
| 38 | 1.5 | 1.7 | 1.9 | 2.1 | 2.3 | 2.5 | 2.8 | 3.0 | 3.3 | 3.6 | 3.8 | 4.1 | 4.4 |
| 39 | 1.5 | 1.7 | 1.9 | 2.1 | 2.4 | 2.6 | 2.8 | 3.1 | 3.4 | 3.7 | 3.9 | 4.3 | 4.6 |
| 40 | 1.5 | 1.7 | 2.0 | 2.2 | 2.4 | 2.7 | 2.9 | 3.2 | 3.5 | 3.7 | 4.0 | 4.4 | 4.7 |
| 41 | 1.6 | 1.8 | 2.0 | 2.2 | 2.5 | 2.7 | 3.0 | 3.3 | 3.5 | 3.8 | 4.1 | 4.5 | 4.8 |
| 42 | 1.6 | 1.8 | 2.1 | 2.3 | 2.5 | 2.8 | 3.1 | 3.3 | 3.6 | 3.9 | 4.3 | 4.6 | 4.9 |
| 43 | 1.7 | 1.9 | 2.1 | 2.3 | 2.6 | 2.9 | 3.1 | 3.4 | 3.7 | 4.0 | 4.4 | 4.7 | 5.0 |
| 44 | 1.7 | 1.9 | 2.2 | 2.4 | 2.7 | 2.9 | 3.2 | 3.5 | 3.8 | 4.1 | 4.5 | 4.8 | 5.2 |
| 45 | 1.7 | 2.0 | 2.2 | 2.5 | 2.7 | 3.0 | 3.3 | 3.6 | 3.9 | 4.2 | 4.6 | 4.9 | 5.3 |
| 46 | 1.8 | 2.0 | 2.3 | 2.5 | 2.8 | 3.1 | 3.3 | 3.7 | 4.0 | 4.3 | 4.7 | 5.0 | 5.4 |
| 47 | 1.8 | 2.1 | 2.3 | 2.6 | 2.8 | 3.1 | 3.4 | 3.7 | 4.1 | 4.4 | 4.8 | 5.1 | 5.5 |
| 48 | 1.9 | 2.1 | 2.3 | 2.6 | 2.9 | 3.2 | 3.5 | 3.8 | 4.1 | 4.5 | 4.9 | 5.2 | 5.6 |
| 49 | 1.9 | 2.1 | 2.4 | 2.7 | 3.0 | 3.3 | 3.6 | 3.9 | 4.2 | 4.6 | 5.0 | 5.3 | 5.7 |
| 50 | 1.9 | 2.2 | 2.4 | 2.7 | 3.0 | 3.3 | 3.6 | 4.0 | 4.3 | 4.7 | 5.1 | 5.4 | 5.9 |
| 100 | 3.9 | 4.4 | 4.9 | 5.4 | 6.0 | 6.6 | 7.3 | 7.9 | 8.6 | 9.4 | 10.1 | 10.9 | 11.7 |
| 200 | 7.7 | 8.7 | 9.8 | 10.9 | 12.1 | 13.3 | 14.6 | 15.9 | 17.3 | 18.7 | 20.2 | 21.8 | 23.4 |
| 300 | 11.6 | 13.1 | 14.7 | 16.3 | 18.1 | 19.9 | 21.8 | 23.8 | 25.9 | 28.1 | 30.4 | 32.7 | 35.1 |
| 400 | 15.5 | 17.5 | 19.6 | 21.8 | 24.1 | 26.6 | 29.1 | 31.8 | 34.6 | 37.5 | 40.5 | 43.6 | 46.9 |
| 500 | 19.4 | 21.9 | 24.5 | 27.2 | 30.1 | 33.2 | 36.4 | 39.8 | 43.2 | 46.9 | 50.6 | 54.5 | 58.5 |
| | 1.04 | 1.05 | 1.05 | 1.06 | 1.06 | 1.07 | 1.08 | 1.09 | 1.09 | 1.10 | 1.11 | 1.12 | 1.13 |

FACTOR

TO CHANGE DEP. INTO LONG. DIFF., MULTIPLY TABULAR NUMBER BY FACTOR AT FOOT OF COLUMN AND ADD PRODUCT TO DEP.

TO CHANGE LONG. DIFF. INTO DEP. **SUBTRACT** TABULAR NUMBER FROM LONG. DIFF.

| LONG. DIFF. OR DEP. | MIDDLE LATITUDE | | | | | | | | | | | | |
|---------------------|-----------------|------|------|------|------|------|------|------|------|------|------|------|-------|
| | 16° | 17° | 18° | 19° | 20° | 21° | 22° | 23° | 24° | 25° | 26° | 27° | 28° |
| 51 | 2.0 | 2.2 | 2.5 | 2.8 | 3.1 | 3.4 | 3.7 | 4.1 | 4.4 | 4.8 | 5.2 | 5.6 | 6.0 |
| 52 | 2.0 | 2.3 | 2.5 | 2.8 | 3.1 | 3.5 | 3.8 | 4.1 | 4.5 | 4.9 | 5.3 | 5.7 | 6.1 |
| 53 | 2.1 | 2.3 | 2.6 | 2.9 | 3.2 | 3.5 | 3.9 | 4.2 | 4.6 | 5.0 | 5.4 | 5.8 | 6.2 |
| 54 | 2.1 | 2.4 | 2.6 | 2.9 | 3.3 | 3.6 | 3.9 | 4.3 | 4.7 | 5.1 | 5.5 | 5.9 | 6.3 |
| 55 | 2.1 | 2.4 | 2.7 | 3.0 | 3.3 | 3.7 | 4.0 | 4.4 | 4.8 | 5.2 | 5.6 | 6.0 | 6.4 |
| 56 | 2.2 | 2.4 | 2.7 | 3.1 | 3.4 | 3.7 | 4.1 | 4.5 | 4.8 | 5.2 | 5.7 | 6.1 | 6.6 |
| 57 | 2.2 | 2.5 | 2.8 | 3.1 | 3.4 | 3.8 | 4.2 | 4.5 | 4.9 | 5.3 | 5.8 | 6.2 | 6.7 |
| 58 | 2.2 | 2.5 | 2.8 | 3.2 | 3.5 | 3.9 | 4.2 | 4.6 | 5.0 | 5.4 | 5.9 | 6.3 | 6.8 |
| 59 | 2.3 | 2.6 | 2.9 | 3.2 | 3.6 | 3.9 | 4.3 | 4.7 | 5.1 | 5.5 | 6.0 | 6.4 | 6.9 |
| 60 | 2.3 | 2.6 | 2.9 | 3.3 | 3.6 | 4.0 | 4.4 | 4.8 | 5.2 | 5.6 | 6.1 | 6.5 | 7.0 |
| 61 | 2.4 | 2.7 | 3.0 | 3.3 | 3.7 | 4.1 | 4.4 | 4.8 | 5.3 | 5.7 | 6.2 | 6.6 | 7.1 |
| 62 | 2.4 | 2.7 | 3.0 | 3.4 | 3.7 | 4.1 | 4.5 | 4.9 | 5.4 | 5.8 | 6.3 | 6.8 | 7.3 |
| 63 | 2.4 | 2.8 | 3.1 | 3.4 | 3.8 | 4.2 | 4.6 | 5.0 | 5.4 | 5.9 | 6.4 | 6.9 | 7.4 |
| 64 | 2.5 | 2.8 | 3.1 | 3.5 | 3.9 | 4.3 | 4.7 | 5.1 | 5.5 | 6.0 | 6.5 | 7.0 | 7.5 |
| 65 | 2.5 | 2.8 | 3.2 | 3.5 | 3.9 | 4.3 | 4.7 | 5.2 | 5.6 | 6.1 | 6.6 | 7.1 | 7.6 |
| 66 | 2.6 | 2.9 | 3.2 | 3.6 | 4.0 | 4.4 | 4.8 | 5.2 | 5.7 | 6.2 | 6.7 | 7.2 | 7.7 |
| 67 | 2.6 | 2.9 | 3.3 | 3.7 | 4.0 | 4.5 | 4.9 | 5.3 | 5.8 | 6.3 | 6.8 | 7.3 | 7.8 |
| 68 | 2.6 | 3.0 | 3.3 | 3.7 | 4.1 | 4.5 | 5.0 | 5.4 | 5.9 | 6.4 | 6.9 | 7.4 | 8.0 |
| 69 | 2.7 | 3.0 | 3.4 | 3.8 | 4.2 | 4.6 | 5.0 | 5.5 | 6.0 | 6.5 | 7.0 | 7.5 | 8.1 |
| 70 | 2.7 | 3.1 | 3.4 | 3.8 | 4.2 | 4.6 | 5.1 | 5.6 | 6.1 | 6.6 | 7.1 | 7.6 | 8.2 |
| 71 | 2.8 | 3.1 | 3.5 | 3.9 | 4.3 | 4.7 | 5.2 | 5.6 | 6.1 | 6.7 | 7.2 | 7.7 | 8.3 |
| 72 | 2.8 | 3.1 | 3.5 | 3.9 | 4.3 | 4.8 | 5.2 | 5.7 | 6.2 | 6.7 | 7.3 | 7.8 | 8.4 |
| 73 | 2.8 | 3.2 | 3.6 | 4.0 | 4.4 | 4.8 | 5.3 | 5.8 | 6.3 | 6.8 | 7.4 | 8.0 | 8.5 |
| 74 | 2.9 | 3.2 | 3.6 | 4.0 | 4.5 | 4.9 | 5.4 | 5.9 | 6.4 | 6.9 | 7.5 | 8.1 | 8.7 |
| 75 | 2.9 | 3.3 | 3.7 | 4.1 | 4.5 | 5.0 | 5.5 | 6.0 | 6.5 | 7.0 | 7.6 | 8.2 | 8.8 |
| 76 | 2.9 | 3.3 | 3.7 | 4.1 | 4.6 | 5.0 | 5.5 | 6.0 | 6.6 | 7.1 | 7.7 | 8.3 | 8.9 |
| 77 | 3.0 | 3.4 | 3.8 | 4.2 | 4.6 | 5.1 | 5.6 | 6.1 | 6.7 | 7.2 | 7.8 | 8.4 | 9.0 |
| 78 | 3.0 | 3.4 | 3.8 | 4.2 | 4.7 | 5.2 | 5.7 | 6.2 | 6.7 | 7.3 | 7.9 | 8.5 | 9.1 |
| 79 | 3.1 | 3.5 | 3.9 | 4.3 | 4.8 | 5.2 | 5.8 | 6.3 | 6.8 | 7.4 | 8.0 | 8.6 | 9.2 |
| 80 | 3.1 | 3.5 | 3.9 | 4.4 | 4.8 | 5.3 | 5.8 | 6.4 | 6.9 | 7.5 | 8.1 | 8.7 | 9.4 |
| 81 | 3.1 | 3.5 | 4.0 | 4.4 | 4.9 | 5.4 | 5.9 | 6.4 | 7.0 | 7.6 | 8.2 | 8.8 | 9.5 |
| 82 | 3.2 | 3.6 | 4.0 | 4.5 | 4.9 | 5.4 | 6.0 | 6.5 | 7.1 | 7.7 | 8.3 | 8.9 | 9.6 |
| 83 | 3.2 | 3.6 | 4.1 | 4.5 | 5.0 | 5.5 | 6.0 | 6.6 | 7.2 | 7.8 | 8.4 | 9.0 | 9.7 |
| 84 | 3.3 | 3.7 | 4.1 | 4.6 | 5.1 | 5.6 | 6.1 | 6.7 | 7.3 | 7.9 | 8.5 | 9.2 | 9.8 |
| 85 | 3.3 | 3.7 | 4.2 | 4.6 | 5.1 | 5.6 | 6.2 | 6.8 | 7.3 | 8.0 | 8.6 | 9.3 | 9.9 |
| 86 | 3.3 | 3.8 | 4.2 | 4.7 | 5.2 | 5.7 | 6.3 | 6.8 | 7.4 | 8.1 | 8.7 | 9.4 | 10.1 |
| 87 | 3.4 | 3.8 | 4.3 | 4.7 | 5.2 | 5.8 | 6.3 | 6.9 | 7.5 | 8.2 | 8.8 | 9.5 | 10.2 |
| 88 | 3.4 | 3.8 | 4.3 | 4.8 | 5.3 | 5.8 | 6.4 | 7.0 | 7.6 | 8.2 | 8.9 | 9.6 | 10.3 |
| 89 | 3.4 | 3.9 | 4.4 | 4.8 | 5.4 | 5.9 | 6.5 | 7.1 | 7.7 | 8.3 | 9.0 | 9.7 | 10.4 |
| 90 | 3.5 | 3.9 | 4.4 | 4.9 | 5.4 | 6.0 | 6.6 | 7.2 | 7.8 | 8.4 | 9.1 | 9.8 | 10.5 |
| 91 | 3.5 | 4.0 | 4.5 | 5.0 | 5.5 | 6.0 | 6.6 | 7.2 | 7.9 | 8.5 | 9.2 | 9.9 | 10.7 |
| 92 | 3.6 | 4.0 | 4.5 | 5.0 | 5.5 | 6.1 | 6.7 | 7.3 | 8.0 | 8.6 | 9.3 | 10.0 | 10.8 |
| 93 | 3.6 | 4.1 | 4.6 | 5.1 | 5.6 | 6.2 | 6.8 | 7.4 | 8.0 | 8.7 | 9.4 | 10.1 | 10.9 |
| 94 | 3.6 | 4.1 | 4.6 | 5.1 | 5.7 | 6.2 | 6.8 | 7.5 | 8.1 | 8.8 | 9.5 | 10.2 | 11.0 |
| 95 | 3.7 | 4.2 | 4.6 | 5.2 | 5.7 | 6.3 | 6.9 | 7.6 | 8.2 | 8.9 | 9.6 | 10.4 | 11.1 |
| 96 | 3.7 | 4.2 | 4.7 | 5.2 | 5.8 | 6.4 | 7.0 | 7.6 | 8.3 | 9.0 | 9.7 | 10.5 | 11.2 |
| 97 | 3.8 | 4.2 | 4.7 | 5.3 | 5.8 | 6.4 | 7.1 | 7.7 | 8.4 | 9.1 | 9.8 | 10.6 | 11.4 |
| 98 | 3.8 | 4.3 | 4.8 | 5.3 | 5.9 | 6.5 | 7.1 | 7.8 | 8.5 | 9.2 | 9.9 | 10.7 | 11.5 |
| 99 | 3.8 | 4.3 | 4.8 | 5.4 | 6.0 | 6.6 | 7.2 | 7.9 | 8.6 | 9.3 | 10.0 | 10.8 | 11.6 |
| 100 | 3.9 | 4.4 | 4.9 | 5.4 | 6.0 | 6.6 | 7.3 | 7.9 | 8.6 | 9.4 | 10.1 | 10.9 | 11.7 |
| 600 | 23.2 | 26.2 | 29.4 | 32.7 | 36.2 | 39.9 | 43.7 | 47.7 | 51.9 | 56.2 | 60.7 | 65.4 | 70.2 |
| 700 | 27.2 | 30.6 | 34.2 | 38.1 | 42.1 | 46.4 | 50.9 | 55.7 | 60.5 | 65.5 | 70.8 | 76.3 | 82.0 |
| 800 | 31.0 | 35.0 | 39.2 | 43.5 | 48.2 | 53.1 | 58.2 | 63.6 | 69.2 | 74.9 | 80.9 | 87.1 | 93.7 |
| 900 | 35.0 | 39.4 | 44.1 | 49.1 | 54.3 | 59.7 | 65.5 | 71.7 | 77.9 | 84.4 | 91.1 | 98.1 | 105.5 |
| | 1.04 | 1.05 | 1.05 | 1.06 | 1.06 | 1.07 | 1.08 | 1.09 | 1.10 | 1.10 | 1.11 | 1.12 | 1.13 |

FACTOR

TO CHANGE DEP. INTO LONG. DIFF. MULTIPLY TABULAR NUMBER BY FACTOR AT FOOT OF COLUMN, AND ADD PRODUCT TO DEP.

TO CHANGE LONG. DIFF. INTO DEP., SUBTRACT TABULAR NUMBER FROM LONG. DIFF.

| LONG. DIFF. OR DEP. | MIDDLE LATITUDE | | | | | | | | | | | |
|------------------------------|-----------------|------|------|------|------|------|------|------|-------|-------|-------|-------|
| | 29° | 30° | 31° | 32° | 33° | 34° | 35° | 36° | 37° | 38° | 39° | 40° |
| 1 | 0.1 | 0.1 | 0.1 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| 2 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.5 |
| 3 | 0.4 | 0.4 | 0.4 | 0.5 | 0.5 | 0.5 | 0.5 | 0.6 | 0.6 | 0.6 | 0.7 | 0.7 |
| 4 | 0.5 | 0.5 | 0.6 | 0.6 | 0.6 | 0.7 | 0.7 | 0.8 | 0.8 | 0.8 | 0.9 | 0.9 |
| 5 | 0.6 | 0.7 | 0.7 | 0.8 | 0.8 | 0.9 | 0.9 | 1.0 | 1.0 | 1.1 | 1.1 | 1.2 |
| 6 | 0.8 | 0.8 | 0.9 | 0.9 | 1.0 | 1.0 | 1.1 | 1.1 | 1.2 | 1.3 | 1.3 | 1.4 |
| 7 | 0.9 | 0.9 | 1.0 | 1.1 | 1.1 | 1.2 | 1.3 | 1.3 | 1.4 | 1.5 | 1.6 | 1.6 |
| 8 | 1.0 | 1.1 | 1.1 | 1.2 | 1.3 | 1.4 | 1.4 | 1.5 | 1.6 | 1.7 | 1.8 | 1.9 |
| 9 | 1.1 | 1.2 | 1.3 | 1.4 | 1.5 | 1.5 | 1.6 | 1.7 | 1.8 | 1.9 | 2.0 | 2.1 |
| 10 | 1.3 | 1.3 | 1.4 | 1.5 | 1.6 | 1.7 | 1.8 | 1.9 | 2.0 | 2.1 | 2.2 | 2.3 |
| 11 | 1.4 | 1.5 | 1.6 | 1.7 | 1.8 | 1.9 | 2.0 | 2.1 | 2.2 | 2.3 | 2.5 | 2.6 |
| 12 | 1.5 | 1.6 | 1.7 | 1.8 | 1.9 | 2.1 | 2.2 | 2.3 | 2.4 | 2.5 | 2.7 | 2.8 |
| 13 | 1.6 | 1.7 | 1.9 | 2.0 | 2.1 | 2.2 | 2.4 | 2.5 | 2.6 | 2.8 | 2.9 | 3.0 |
| 14 | 1.8 | 1.9 | 2.0 | 2.1 | 2.3 | 2.4 | 2.5 | 2.7 | 2.8 | 3.0 | 3.1 | 3.3 |
| 15 | 1.9 | 2.0 | 2.1 | 2.3 | 2.4 | 2.6 | 2.7 | 2.9 | 3.0 | 3.2 | 3.3 | 3.5 |
| 16 | 2.0 | 2.1 | 2.3 | 2.4 | 2.6 | 2.7 | 2.9 | 3.1 | 3.2 | 3.4 | 3.6 | 3.7 |
| 17 | 2.1 | 2.3 | 2.4 | 2.6 | 2.7 | 2.9 | 3.1 | 3.2 | 3.4 | 3.6 | 3.8 | 4.0 |
| 18 | 2.3 | 2.4 | 2.6 | 2.7 | 2.9 | 3.1 | 3.3 | 3.4 | 3.6 | 3.8 | 4.0 | 4.2 |
| 19 | 2.4 | 2.5 | 2.7 | 2.9 | 3.1 | 3.2 | 3.4 | 3.6 | 3.8 | 4.0 | 4.2 | 4.4 |
| 20 | 2.5 | 2.7 | 2.9 | 3.0 | 3.2 | 3.4 | 3.6 | 3.8 | 4.0 | 4.2 | 4.5 | 4.7 |
| 21 | 2.6 | 2.8 | 3.0 | 3.2 | 3.4 | 3.6 | 3.8 | 4.0 | 4.2 | 4.5 | 4.7 | 4.9 |
| 22 | 2.8 | 2.9 | 3.1 | 3.3 | 3.5 | 3.8 | 4.0 | 4.2 | 4.4 | 4.7 | 4.9 | 5.1 |
| 23 | 2.9 | 3.1 | 3.3 | 3.5 | 3.7 | 3.9 | 4.2 | 4.4 | 4.6 | 4.9 | 5.1 | 5.4 |
| 24 | 3.0 | 3.2 | 3.4 | 3.6 | 3.9 | 4.1 | 4.3 | 4.6 | 4.8 | 5.1 | 5.3 | 5.6 |
| 25 | 3.1 | 3.3 | 3.6 | 3.8 | 4.0 | 4.3 | 4.5 | 4.8 | 5.0 | 5.3 | 5.6 | 5.8 |
| 26 | 3.3 | 3.5 | 3.7 | 4.0 | 4.2 | 4.4 | 4.7 | 5.0 | 5.2 | 5.5 | 5.8 | 6.1 |
| 27 | 3.4 | 3.6 | 3.9 | 4.1 | 4.4 | 4.6 | 4.9 | 5.2 | 5.4 | 5.7 | 6.0 | 6.3 |
| 28 | 3.5 | 3.8 | 4.0 | 4.3 | 4.5 | 4.8 | 5.1 | 5.3 | 5.6 | 5.9 | 6.2 | 6.6 |
| 29 | 3.6 | 3.9 | 4.1 | 4.4 | 4.7 | 5.0 | 5.2 | 5.5 | 5.8 | 6.1 | 6.5 | 6.8 |
| 30 | 3.8 | 4.0 | 4.3 | 4.6 | 4.8 | 5.1 | 5.4 | 5.7 | 6.0 | 6.4 | 6.7 | 7.0 |
| 31 | 3.9 | 4.2 | 4.4 | 4.7 | 5.0 | 5.3 | 5.6 | 5.9 | 6.2 | 6.6 | 6.9 | 7.3 |
| 32 | 4.0 | 4.3 | 4.6 | 4.9 | 5.2 | 5.5 | 5.8 | 6.1 | 6.4 | 6.8 | 7.1 | 7.5 |
| 33 | 4.1 | 4.4 | 4.7 | 5.0 | 5.3 | 5.6 | 6.0 | 6.3 | 6.6 | 7.0 | 7.4 | 7.7 |
| 34 | 4.3 | 4.6 | 4.9 | 5.2 | 5.5 | 5.8 | 6.1 | 6.5 | 6.8 | 7.2 | 7.6 | 8.0 |
| 35 | 4.4 | 4.7 | 5.0 | 5.3 | 5.6 | 6.0 | 6.3 | 6.7 | 7.0 | 7.4 | 7.8 | 8.2 |
| 36 | 4.5 | 4.8 | 5.1 | 5.5 | 5.8 | 6.2 | 6.5 | 6.9 | 7.2 | 7.6 | 8.0 | 8.4 |
| 37 | 4.6 | 5.0 | 5.3 | 5.6 | 6.0 | 6.3 | 6.7 | 7.1 | 7.5 | 7.8 | 8.2 | 8.7 |
| 38 | 4.8 | 5.1 | 5.4 | 5.8 | 6.1 | 6.5 | 6.9 | 7.3 | 7.7 | 8.1 | 8.5 | 8.9 |
| 39 | 4.9 | 5.2 | 5.6 | 5.9 | 6.3 | 6.7 | 7.1 | 7.4 | 7.9 | 8.3 | 8.7 | 9.1 |
| 40 | 5.0 | 5.4 | 5.7 | 6.1 | 6.5 | 6.8 | 7.2 | 7.6 | 8.1 | 8.5 | 8.9 | 9.4 |
| 41 | 5.1 | 5.5 | 5.9 | 6.2 | 6.6 | 7.0 | 7.4 | 7.8 | 8.3 | 8.7 | 9.1 | 9.6 |
| 42 | 5.3 | 5.6 | 6.0 | 6.4 | 6.8 | 7.2 | 7.6 | 8.0 | 8.5 | 8.9 | 9.4 | 9.8 |
| 43 | 5.4 | 5.8 | 6.1 | 6.5 | 6.9 | 7.4 | 7.8 | 8.2 | 8.7 | 9.1 | 9.6 | 10.1 |
| 44 | 5.5 | 5.9 | 6.3 | 6.7 | 7.1 | 7.5 | 8.0 | 8.4 | 8.9 | 9.3 | 9.8 | 10.3 |
| 45 | 5.6 | 6.0 | 6.4 | 6.8 | 7.3 | 7.7 | 8.1 | 8.6 | 9.1 | 9.5 | 10.0 | 10.5 |
| 46 | 5.8 | 6.2 | 6.6 | 7.0 | 7.4 | 7.9 | 8.3 | 8.8 | 9.3 | 9.8 | 10.3 | 10.8 |
| 47 | 5.9 | 6.3 | 6.7 | 7.1 | 7.6 | 8.0 | 8.5 | 9.0 | 9.5 | 10.0 | 10.5 | 11.0 |
| 48 | 6.0 | 6.4 | 6.9 | 7.3 | 7.7 | 8.2 | 8.7 | 9.2 | 9.7 | 10.2 | 10.7 | 11.2 |
| 49 | 6.1 | 6.6 | 7.0 | 7.4 | 7.9 | 8.4 | 8.9 | 9.4 | 9.9 | 10.4 | 10.9 | 11.5 |
| 50 | 6.3 | 6.7 | 7.1 | 7.6 | 8.1 | 8.5 | 9.0 | 9.5 | 10.1 | 10.6 | 11.1 | 11.7 |
| 100 | 12.5 | 13.4 | 14.3 | 15.2 | 16.1 | 17.1 | 18.1 | 19.1 | 20.1 | 21.2 | 22.3 | 23.4 |
| 200 | 25.1 | 26.8 | 28.6 | 30.4 | 32.3 | 34.2 | 36.2 | 38.2 | 40.3 | 42.4 | 44.6 | 46.8 |
| 300 | 37.6 | 40.2 | 42.9 | 45.6 | 48.4 | 51.3 | 54.3 | 57.3 | 60.4 | 63.6 | 66.9 | 70.2 |
| 400 | 50.2 | 53.6 | 57.1 | 60.8 | 64.5 | 68.4 | 72.3 | 76.4 | 80.6 | 84.8 | 89.1 | 93.6 |
| 500 | 62.7 | 67.0 | 71.4 | 76.0 | 80.7 | 85.5 | 90.4 | 95.5 | 100.7 | 106.0 | 111.4 | 117.0 |
| | 1.14 | 1.15 | 1.17 | 1.18 | 1.19 | 1.21 | 1.22 | 1.24 | 1.25 | 1.27 | 1.29 | 1.31 |

FACTOR

TO CHANGE DEP. INTO LONG. DIFF., MULTIPLY TABULAR NUMBER BY FACTOR AT FOOT OF COLUMN, AND ADD PRODUCT TO DEP.

TO CHANGE LONG. DIFF. INTO DEP. **SUBTRACT** TABULAR NUMBER FROM LONG. DIFF.

| LONG. DIFF. OR DEP. | MIDDLE LATITUDE | | | | | | | | | | | |
|---------------------|-----------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| | 29° | 30° | 31° | 32° | 33° | 34° | 35° | 36° | 37° | 38° | 39° | 40° |
| 51 | 6.4 | 6.8 | 7.3 | 7.7 | 8.2 | 8.7 | 9.2 | 9.7 | 10.3 | 10.8 | 11.4 | 11.9 |
| 52 | 6.5 | 7.0 | 7.4 | 7.9 | 8.4 | 8.9 | 9.4 | 9.9 | 10.5 | 11.0 | 11.6 | 12.2 |
| 53 | 6.6 | 7.1 | 7.6 | 8.1 | 8.6 | 9.1 | 9.6 | 10.1 | 10.7 | 11.2 | 11.8 | 12.4 |
| 54 | 6.8 | 7.2 | 7.7 | 8.2 | 8.7 | 9.2 | 9.8 | 10.3 | 10.9 | 11.4 | 12.0 | 12.6 |
| 55 | 6.9 | 7.4 | 7.9 | 8.4 | 8.9 | 9.4 | 9.9 | 10.5 | 11.1 | 11.7 | 12.3 | 12.9 |
| 56 | 7.0 | 7.5 | 8.0 | 8.5 | 9.0 | 9.6 | 10.1 | 10.7 | 11.3 | 11.9 | 12.5 | 13.1 |
| 57 | 7.1 | 7.6 | 8.1 | 8.7 | 9.2 | 9.7 | 10.3 | 10.9 | 11.5 | 12.1 | 12.7 | 13.3 |
| 58 | 7.3 | 7.8 | 8.3 | 8.8 | 9.4 | 9.9 | 10.5 | 11.1 | 11.7 | 12.3 | 12.9 | 13.6 |
| 59 | 7.4 | 7.9 | 8.4 | 9.0 | 9.5 | 10.1 | 10.7 | 11.3 | 11.9 | 12.5 | 13.1 | 13.8 |
| 60 | 7.5 | 8.0 | 8.6 | 9.1 | 9.7 | 10.3 | 10.9 | 11.5 | 12.1 | 12.7 | 13.4 | 14.0 |
| 61 | 7.6 | 8.2 | 8.7 | 9.3 | 9.8 | 10.4 | 11.0 | 11.6 | 12.3 | 12.9 | 13.6 | 14.3 |
| 62 | 7.8 | 8.3 | 8.9 | 9.4 | 10.0 | 10.6 | 11.2 | 11.8 | 12.5 | 13.1 | 13.8 | 14.5 |
| 63 | 7.9 | 8.4 | 9.0 | 9.6 | 10.2 | 10.8 | 11.4 | 12.0 | 12.7 | 13.4 | 14.0 | 14.7 |
| 64 | 8.0 | 8.6 | 9.1 | 9.7 | 10.3 | 10.9 | 11.6 | 12.2 | 12.9 | 13.6 | 14.3 | 15.0 |
| 65 | 8.1 | 8.7 | 9.3 | 9.9 | 10.5 | 11.1 | 11.8 | 12.4 | 13.1 | 13.8 | 14.5 | 15.2 |
| 66 | 8.3 | 8.8 | 9.4 | 10.0 | 10.6 | 11.3 | 11.9 | 12.6 | 13.3 | 14.0 | 14.7 | 15.4 |
| 67 | 8.4 | 9.0 | 9.6 | 10.2 | 10.8 | 11.5 | 12.1 | 12.8 | 13.5 | 14.2 | 14.9 | 15.7 |
| 68 | 8.5 | 9.1 | 9.7 | 10.3 | 11.0 | 11.6 | 12.3 | 13.0 | 13.7 | 14.4 | 15.2 | 15.9 |
| 69 | 8.7 | 9.2 | 9.9 | 10.5 | 11.1 | 11.8 | 12.5 | 13.2 | 13.9 | 14.6 | 15.4 | 16.1 |
| 70 | 8.8 | 9.4 | 10.0 | 10.6 | 11.3 | 12.0 | 12.7 | 13.4 | 14.1 | 14.8 | 15.6 | 16.4 |
| 71 | 8.9 | 9.5 | 10.1 | 10.8 | 11.5 | 12.1 | 12.8 | 13.6 | 14.3 | 15.1 | 15.8 | 16.6 |
| 72 | 9.0 | 9.6 | 10.3 | 10.9 | 11.6 | 12.3 | 13.0 | 13.8 | 14.5 | 15.3 | 16.0 | 16.8 |
| 73 | 9.2 | 9.8 | 10.4 | 11.1 | 11.8 | 12.5 | 13.2 | 13.9 | 14.7 | 15.5 | 16.3 | 17.1 |
| 74 | 9.3 | 9.9 | 10.6 | 11.2 | 11.9 | 12.7 | 13.4 | 14.1 | 14.9 | 15.7 | 16.5 | 17.3 |
| 75 | 9.4 | 10.0 | 10.7 | 11.4 | 12.1 | 12.8 | 13.6 | 14.3 | 15.1 | 15.9 | 16.7 | 17.5 |
| 76 | 9.5 | 10.2 | 10.9 | 11.5 | 12.3 | 13.0 | 13.7 | 14.5 | 15.3 | 16.1 | 16.9 | 17.8 |
| 77 | 9.7 | 10.3 | 11.0 | 11.7 | 12.4 | 13.2 | 13.9 | 14.7 | 15.5 | 16.3 | 17.2 | 18.0 |
| 78 | 9.8 | 10.5 | 11.1 | 11.9 | 12.6 | 13.3 | 14.1 | 14.9 | 15.7 | 16.5 | 17.4 | 18.2 |
| 79 | 9.9 | 10.6 | 11.3 | 12.0 | 12.7 | 13.5 | 14.3 | 15.1 | 15.9 | 16.7 | 17.6 | 18.5 |
| 80 | 10.0 | 10.7 | 11.4 | 12.2 | 12.9 | 13.7 | 14.5 | 15.3 | 16.1 | 17.0 | 17.8 | 18.7 |
| 81 | 10.2 | 10.9 | 11.6 | 12.3 | 13.1 | 13.8 | 14.6 | 15.5 | 16.3 | 17.2 | 18.1 | 19.0 |
| 82 | 10.3 | 11.0 | 11.7 | 12.5 | 13.2 | 14.0 | 14.8 | 15.7 | 16.5 | 17.4 | 18.3 | 19.2 |
| 83 | 10.4 | 11.1 | 11.9 | 12.6 | 13.4 | 14.2 | 15.0 | 15.9 | 16.7 | 17.6 | 18.5 | 19.4 |
| 84 | 10.5 | 11.3 | 12.0 | 12.8 | 13.6 | 14.4 | 15.2 | 16.0 | 16.9 | 17.8 | 18.7 | 19.7 |
| 85 | 10.7 | 11.4 | 12.1 | 12.9 | 13.7 | 14.5 | 15.4 | 16.2 | 17.1 | 18.0 | 18.9 | 19.9 |
| 86 | 10.8 | 11.5 | 12.3 | 13.1 | 13.9 | 14.7 | 15.6 | 16.4 | 17.3 | 18.2 | 19.2 | 20.1 |
| 87 | 10.9 | 11.7 | 12.4 | 13.2 | 14.0 | 14.9 | 15.7 | 16.6 | 17.5 | 18.4 | 19.4 | 20.4 |
| 88 | 11.0 | 11.8 | 12.6 | 13.4 | 14.2 | 15.0 | 15.9 | 16.8 | 17.7 | 18.7 | 19.6 | 20.6 |
| 89 | 11.2 | 11.9 | 12.7 | 13.5 | 14.4 | 15.2 | 16.1 | 17.0 | 17.9 | 18.9 | 19.8 | 20.8 |
| 90 | 11.3 | 12.1 | 12.9 | 13.7 | 14.5 | 15.4 | 16.3 | 17.2 | 18.1 | 19.1 | 20.1 | 21.1 |
| 91 | 11.4 | 12.2 | 13.0 | 13.8 | 14.7 | 15.6 | 16.5 | 17.4 | 18.3 | 19.3 | 20.3 | 21.3 |
| 92 | 11.5 | 12.3 | 13.1 | 14.0 | 14.8 | 15.7 | 16.6 | 17.6 | 18.5 | 19.5 | 20.5 | 21.5 |
| 93 | 11.7 | 12.5 | 13.3 | 14.1 | 15.0 | 15.9 | 16.8 | 17.8 | 18.7 | 19.7 | 20.7 | 21.8 |
| 94 | 11.8 | 12.6 | 13.4 | 14.3 | 15.2 | 16.1 | 17.0 | 18.0 | 18.9 | 19.9 | 20.9 | 22.0 |
| 95 | 11.9 | 12.7 | 13.6 | 14.4 | 15.3 | 16.2 | 17.2 | 18.1 | 19.1 | 20.1 | 21.2 | 22.2 |
| 96 | 12.0 | 12.9 | 13.7 | 14.6 | 15.5 | 16.4 | 17.4 | 18.3 | 19.3 | 20.4 | 21.4 | 22.5 |
| 97 | 12.2 | 13.0 | 13.9 | 14.7 | 15.6 | 16.6 | 17.5 | 18.5 | 19.5 | 20.6 | 21.6 | 22.7 |
| 98 | 12.3 | 13.1 | 14.0 | 14.9 | 15.8 | 16.8 | 17.7 | 18.7 | 19.7 | 20.8 | 21.8 | 22.9 |
| 99 | 12.4 | 13.3 | 14.1 | 15.0 | 16.0 | 16.9 | 17.9 | 18.9 | 19.9 | 21.0 | 22.1 | 23.2 |
| 100 | 12.5 | 13.4 | 14.3 | 15.2 | 16.1 | 17.1 | 18.1 | 19.1 | 20.1 | 21.2 | 22.3 | 23.4 |
| 600 | 75.2 | 80.4 | 85.7 | 91.2 | 96.8 | 102.6 | 108.5 | 114.6 | 120.8 | 127.2 | 133.7 | 140.4 |
| 700 | 87.8 | 93.9 | 99.9 | 106.4 | 113.0 | 119.7 | 126.5 | 133.8 | 141.0 | 148.4 | 156.1 | 163.7 |
| 800 | 100.3 | 107.2 | 114.2 | 121.6 | 129.0 | 136.7 | 144.6 | 152.7 | 161.1 | 169.6 | 178.2 | 187.0 |
| 900 | 113.0 | 120.7 | 128.6 | 136.8 | 145.2 | 153.9 | 162.8 | 171.9 | 181.4 | 190.9 | 200.7 | 210.5 |
| | 1.14 | 1.15 | 1.17 | 1.18 | 1.19 | 1.21 | 1.22 | 1.24 | 1.25 | 1.27 | 1.29 | 1.31 |

FACTOR

TO CHANGE DEP. INTO LONG. DIFF. MULTIPLY TABULAR NUMBER BY FACTOR AT FOOT OF COLUMN AND **ADD** PRODUCT TO DEP.

TO CHANGE LONG. DIFF. INTO DEP., SUBTRACT TABULAR NUMBER FROM LONG. DIFF.

| LONG. DIFF. OR DEP. | MIDDLE LATITUDE | | | | | | | | | | |
|------------------------------|-----------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| | 41° | 42° | 43° | 44° | 45° | 46° | 47° | 48° | 49° | 50° | 51° |
| 1 | 0.2 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.4 | 0.4 |
| 2 | 0.5 | 0.5 | 0.5 | 0.6 | 0.6 | 0.6 | 0.6 | 0.7 | 0.7 | 0.7 | 0.7 |
| 3 | 0.7 | 0.8 | 0.8 | 0.8 | 0.9 | 0.9 | 1.0 | 1.0 | 1.0 | 1.1 | 1.1 |
| 4 | 1.0 | 1.0 | 1.1 | 1.1 | 1.2 | 1.2 | 1.3 | 1.3 | 1.4 | 1.4 | 1.5 |
| 5 | 1.2 | 1.3 | 1.3 | 1.4 | 1.5 | 1.5 | 1.6 | 1.7 | 1.7 | 1.8 | 1.9 |
| 6 | 1.5 | 1.5 | 1.6 | 1.7 | 1.8 | 1.8 | 1.9 | 2.0 | 2.1 | 2.1 | 2.2 |
| 7 | 1.7 | 1.8 | 1.9 | 2.0 | 2.1 | 2.1 | 2.2 | 2.3 | 2.4 | 2.5 | 2.6 |
| 8 | 2.0 | 2.1 | 2.1 | 2.2 | 2.3 | 2.4 | 2.5 | 2.6 | 2.8 | 2.9 | 3.0 |
| 9 | 2.2 | 2.3 | 2.4 | 2.5 | 2.6 | 2.7 | 2.9 | 3.0 | 3.1 | 3.2 | 3.3 |
| 10 | 2.5 | 2.6 | 2.7 | 2.8 | 2.9 | 3.1 | 3.2 | 3.3 | 3.4 | 3.6 | 3.7 |
| 11 | 2.7 | 2.8 | 3.0 | 3.1 | 3.2 | 3.4 | 3.5 | 3.6 | 3.8 | 3.9 | 4.1 |
| 12 | 2.9 | 3.1 | 3.2 | 3.4 | 3.5 | 3.7 | 3.8 | 4.0 | 4.1 | 4.3 | 4.4 |
| 13 | 3.2 | 3.3 | 3.5 | 3.6 | 3.8 | 4.0 | 4.1 | 4.3 | 4.5 | 4.6 | 4.8 |
| 14 | 3.4 | 3.6 | 3.8 | 3.9 | 4.1 | 4.3 | 4.5 | 4.6 | 4.8 | 5.0 | 5.2 |
| 15 | 3.7 | 3.9 | 4.0 | 4.2 | 4.4 | 4.6 | 4.8 | 5.0 | 5.2 | 5.4 | 5.6 |
| 16 | 3.9 | 4.1 | 4.3 | 4.5 | 4.7 | 4.9 | 5.1 | 5.3 | 5.5 | 5.7 | 5.9 |
| 17 | 4.2 | 4.4 | 4.6 | 4.8 | 5.0 | 5.2 | 5.4 | 5.6 | 5.8 | 6.1 | 6.3 |
| 18 | 4.4 | 4.6 | 4.8 | 5.1 | 5.3 | 5.5 | 5.7 | 6.0 | 6.2 | 6.4 | 6.7 |
| 19 | 4.7 | 4.9 | 5.1 | 5.3 | 5.6 | 5.8 | 6.0 | 6.3 | 6.5 | 6.8 | 7.0 |
| 20 | 4.9 | 5.1 | 5.4 | 5.6 | 5.9 | 6.1 | 6.4 | 6.6 | 6.9 | 7.1 | 7.4 |
| 21 | 5.2 | 5.4 | 5.6 | 5.9 | 6.2 | 6.4 | 6.7 | 6.9 | 7.2 | 7.5 | 7.8 |
| 22 | 5.4 | 5.7 | 5.9 | 6.2 | 6.4 | 6.7 | 7.0 | 7.3 | 7.6 | 7.9 | 8.2 |
| 23 | 5.6 | 5.9 | 6.2 | 6.5 | 6.7 | 7.0 | 7.3 | 7.6 | 7.9 | 8.2 | 8.5 |
| 24 | 5.9 | 6.2 | 6.4 | 6.7 | 7.0 | 7.3 | 7.6 | 7.9 | 8.3 | 8.6 | 8.9 |
| 25 | 6.1 | 6.4 | 6.7 | 7.0 | 7.3 | 7.6 | 8.0 | 8.3 | 8.6 | 8.9 | 9.3 |
| 26 | 6.4 | 6.7 | 7.0 | 7.3 | 7.6 | 7.9 | 8.3 | 8.6 | 8.9 | 9.3 | 9.6 |
| 27 | 6.6 | 6.9 | 7.3 | 7.6 | 7.9 | 8.2 | 8.6 | 8.9 | 9.3 | 9.6 | 10.0 |
| 28 | 6.9 | 7.2 | 7.5 | 7.9 | 8.2 | 8.5 | 8.9 | 9.3 | 9.6 | 10.0 | 10.4 |
| 29 | 7.1 | 7.4 | 7.8 | 8.1 | 8.5 | 8.9 | 9.2 | 9.6 | 10.0 | 10.4 | 10.7 |
| 30 | 7.4 | 7.7 | 8.1 | 8.4 | 8.8 | 9.2 | 9.5 | 9.9 | 10.3 | 10.7 | 11.1 |
| 31 | 7.6 | 8.0 | 8.3 | 8.7 | 9.1 | 9.5 | 9.9 | 10.3 | 10.7 | 11.1 | 11.5 |
| 32 | 7.8 | 8.2 | 8.6 | 9.0 | 9.4 | 9.8 | 10.2 | 10.6 | 11.0 | 11.4 | 11.9 |
| 33 | 8.1 | 8.5 | 8.9 | 9.3 | 9.7 | 10.1 | 10.5 | 10.9 | 11.4 | 11.8 | 12.2 |
| 34 | 8.3 | 8.7 | 9.1 | 9.5 | 10.0 | 10.4 | 10.8 | 11.2 | 11.7 | 12.1 | 12.6 |
| 35 | 8.6 | 9.0 | 9.4 | 9.8 | 10.3 | 10.7 | 11.1 | 11.6 | 12.0 | 12.5 | 13.0 |
| 36 | 8.8 | 9.2 | 9.7 | 10.1 | 10.5 | 11.0 | 11.4 | 11.9 | 12.4 | 12.9 | 13.3 |
| 37 | 9.1 | 9.5 | 9.9 | 10.4 | 10.8 | 11.3 | 11.8 | 12.2 | 12.7 | 13.2 | 13.7 |
| 38 | 9.3 | 9.8 | 10.2 | 10.7 | 11.1 | 11.6 | 12.1 | 12.6 | 13.1 | 13.6 | 14.1 |
| 39 | 9.6 | 10.0 | 10.5 | 10.9 | 11.4 | 11.9 | 12.4 | 12.9 | 13.4 | 13.9 | 14.5 |
| 40 | 9.8 | 10.3 | 10.7 | 11.2 | 11.7 | 12.2 | 12.7 | 13.2 | 13.8 | 14.3 | 14.8 |
| 41 | 10.1 | 10.5 | 11.0 | 11.5 | 12.0 | 12.5 | 13.0 | 13.6 | 14.1 | 14.6 | 15.2 |
| 42 | 10.3 | 10.8 | 11.3 | 11.8 | 12.3 | 12.8 | 13.4 | 13.9 | 14.4 | 15.0 | 15.6 |
| 43 | 10.5 | 11.0 | 11.6 | 12.1 | 12.6 | 13.1 | 13.7 | 14.2 | 14.8 | 15.4 | 15.9 |
| 44 | 10.8 | 11.3 | 11.8 | 12.3 | 12.9 | 13.4 | 14.0 | 14.6 | 15.1 | 15.7 | 16.3 |
| 45 | 11.0 | 11.6 | 12.1 | 12.6 | 13.2 | 13.7 | 14.3 | 14.9 | 15.5 | 16.1 | 16.7 |
| 46 | 11.3 | 11.8 | 12.4 | 12.9 | 13.5 | 14.0 | 14.6 | 15.2 | 15.8 | 16.4 | 17.1 |
| 47 | 11.5 | 12.1 | 12.6 | 13.2 | 13.8 | 14.4 | 14.9 | 15.6 | 16.2 | 16.8 | 17.4 |
| 48 | 11.8 | 12.3 | 12.9 | 13.5 | 14.1 | 14.7 | 15.3 | 15.9 | 16.5 | 17.1 | 17.8 |
| 49 | 12.0 | 12.6 | 13.2 | 13.8 | 14.4 | 15.0 | 15.6 | 16.2 | 16.9 | 17.5 | 18.2 |
| 50 | 12.3 | 12.8 | 13.4 | 14.0 | 14.6 | 15.3 | 15.9 | 16.5 | 17.2 | 17.9 | 18.5 |
| 100 | 24.5 | 25.7 | 26.9 | 28.1 | 29.3 | 30.5 | 31.8 | 33.1 | 34.4 | 35.7 | 37.1 |
| 200 | 49.1 | 51.4 | 53.7 | 56.1 | 58.6 | 61.1 | 63.6 | 66.2 | 68.8 | 71.4 | 74.1 |
| 300 | 73.6 | 77.1 | 80.6 | 84.2 | 87.9 | 91.6 | 95.4 | 99.3 | 103.2 | 107.2 | 111.2 |
| 400 | 98.1 | 102.7 | 107.4 | 112.3 | 117.2 | 122.1 | 127.2 | 132.3 | 137.6 | 142.9 | 148.3 |
| 500 | 122.7 | 128.4 | 134.3 | 140.3 | 146.5 | 152.7 | 159.0 | 165.4 | 172.0 | 178.6 | 185.3 |
| | 1.33 | 1.35 | 1.37 | 1.39 | 1.41 | 1.44 | 1.47 | 1.50 | 1.52 | 1.56 | 1.59 |

FACTOR

TO CHANGE DEP. INTO LONG. DIFF., MULTIPLY TABULAR NUMBER BY FACTOR AT FOOT OF COLUMN, AND ADD PRODUCT TO DEP.

TO CHANGE LONG. DIFF. INTO DEP. **SUBTRACT** TABULAR NUMBER FROM LONG. DIFF.

| LONG. DIFF. OR DEP. | MIDDLE LATITUDE | | | | | | | | | | |
|---------------------|-----------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| | 41° | 42° | 43° | 44° | 45° | 46° | 47° | 48° | 49° | 50° | 51° |
| 51 | 12.5 | 13.1 | 13.7 | 14.3 | 14.9 | 15.6 | 16.2 | 16.9 | 17.5 | 18.2 | 18.9 |
| 52 | 12.8 | 13.4 | 14.0 | 14.6 | 15.2 | 15.9 | 16.5 | 17.2 | 17.9 | 18.6 | 19.3 |
| 53 | 13.0 | 13.6 | 14.2 | 14.9 | 15.5 | 16.2 | 16.9 | 17.5 | 18.2 | 18.9 | 19.6 |
| 54 | 13.2 | 13.9 | 14.5 | 15.2 | 15.8 | 16.5 | 17.2 | 17.9 | 18.6 | 19.3 | 20.0 |
| 55 | 13.5 | 14.1 | 14.8 | 15.4 | 16.1 | 16.8 | 17.5 | 18.2 | 18.9 | 19.6 | 20.4 |
| 56 | 13.7 | 14.4 | 15.0 | 15.7 | 16.4 | 17.1 | 17.8 | 18.5 | 19.3 | 20.0 | 20.8 |
| 57 | 14.0 | 14.6 | 15.3 | 16.0 | 16.7 | 17.4 | 18.1 | 18.9 | 19.6 | 20.4 | 21.1 |
| 58 | 14.2 | 14.9 | 15.6 | 16.3 | 17.0 | 17.7 | 18.4 | 19.2 | 19.9 | 20.7 | 21.5 |
| 59 | 14.5 | 15.2 | 15.9 | 16.6 | 17.3 | 18.0 | 18.8 | 19.5 | 20.3 | 21.1 | 21.9 |
| 60 | 14.7 | 15.4 | 16.1 | 16.8 | 17.6 | 18.3 | 19.1 | 19.9 | 20.6 | 21.4 | 22.2 |
| 61 | 15.0 | 15.7 | 16.4 | 17.1 | 17.9 | 18.6 | 19.4 | 20.2 | 21.0 | 21.8 | 22.6 |
| 62 | 15.2 | 15.9 | 16.7 | 17.4 | 18.2 | 18.9 | 19.7 | 20.5 | 21.3 | 22.1 | 23.0 |
| 63 | 15.5 | 16.2 | 16.9 | 17.7 | 18.5 | 19.2 | 20.0 | 20.8 | 21.7 | 22.5 | 23.4 |
| 64 | 15.7 | 16.4 | 17.2 | 18.0 | 18.7 | 19.5 | 20.4 | 21.2 | 22.0 | 22.9 | 23.7 |
| 65 | 15.9 | 16.7 | 17.5 | 18.2 | 19.0 | 19.8 | 20.7 | 21.5 | 22.4 | 23.2 | 24.1 |
| 66 | 16.2 | 17.0 | 17.7 | 18.5 | 19.3 | 20.2 | 21.0 | 21.8 | 22.7 | 23.6 | 24.5 |
| 67 | 16.4 | 17.2 | 18.0 | 18.8 | 19.6 | 20.5 | 21.3 | 22.2 | 23.0 | 23.9 | 24.8 |
| 68 | 16.7 | 17.5 | 18.3 | 19.1 | 19.9 | 20.8 | 21.6 | 22.5 | 23.4 | 24.3 | 25.2 |
| 69 | 16.9 | 17.7 | 18.5 | 19.4 | 20.2 | 21.1 | 21.9 | 22.8 | 23.7 | 24.6 | 25.6 |
| 70 | 17.2 | 18.0 | 18.8 | 19.6 | 20.5 | 21.4 | 22.3 | 23.2 | 24.1 | 25.0 | 25.9 |
| 71 | 17.4 | 18.2 | 19.1 | 19.9 | 20.8 | 21.7 | 22.6 | 23.5 | 24.4 | 25.4 | 26.3 |
| 72 | 17.7 | 18.5 | 19.3 | 20.2 | 21.1 | 22.0 | 22.9 | 23.8 | 24.8 | 25.7 | 26.7 |
| 73 | 17.9 | 18.8 | 19.6 | 20.5 | 21.4 | 22.3 | 23.2 | 24.2 | 25.1 | 26.1 | 27.1 |
| 74 | 18.2 | 19.0 | 19.9 | 20.8 | 21.7 | 22.6 | 23.5 | 24.5 | 25.5 | 26.4 | 27.4 |
| 75 | 18.4 | 19.3 | 20.1 | 21.0 | 22.0 | 22.9 | 23.9 | 24.8 | 25.8 | 26.8 | 27.8 |
| 76 | 18.6 | 19.5 | 20.4 | 21.3 | 22.3 | 23.2 | 24.2 | 25.1 | 26.1 | 27.1 | 28.2 |
| 77 | 18.9 | 19.8 | 20.7 | 21.6 | 22.6 | 23.5 | 24.5 | 25.5 | 26.5 | 27.5 | 28.5 |
| 78 | 19.1 | 20.0 | 21.0 | 21.9 | 22.8 | 23.8 | 24.8 | 25.8 | 26.8 | 27.9 | 28.9 |
| 79 | 19.4 | 20.3 | 21.2 | 22.2 | 23.1 | 24.1 | 25.1 | 26.1 | 27.2 | 28.2 | 29.3 |
| 80 | 19.6 | 20.5 | 21.5 | 22.5 | 23.4 | 24.4 | 25.4 | 26.5 | 27.5 | 28.6 | 29.7 |
| 81 | 19.9 | 20.8 | 21.8 | 22.7 | 23.7 | 24.7 | 25.8 | 26.8 | 27.9 | 28.9 | 30.0 |
| 82 | 20.1 | 21.1 | 22.0 | 23.0 | 24.0 | 25.0 | 26.1 | 27.1 | 28.2 | 29.3 | 30.4 |
| 83 | 20.4 | 21.3 | 22.3 | 23.3 | 24.3 | 25.3 | 26.4 | 27.5 | 28.5 | 29.6 | 30.8 |
| 84 | 20.6 | 21.6 | 22.6 | 23.6 | 24.6 | 25.6 | 26.7 | 27.8 | 28.9 | 29.0 | 31.1 |
| 85 | 20.8 | 21.8 | 22.8 | 23.9 | 24.9 | 26.0 | 27.0 | 28.1 | 29.2 | 30.4 | 31.5 |
| 86 | 21.1 | 22.1 | 23.1 | 24.1 | 25.2 | 26.3 | 27.3 | 28.5 | 29.6 | 30.7 | 31.9 |
| 87 | 21.3 | 22.3 | 23.4 | 24.4 | 25.5 | 26.6 | 27.7 | 28.8 | 29.9 | 31.1 | 32.2 |
| 88 | 21.6 | 22.6 | 23.6 | 24.7 | 25.8 | 26.9 | 28.0 | 29.1 | 30.3 | 31.4 | 32.6 |
| 89 | 21.8 | 22.9 | 23.9 | 25.0 | 26.1 | 27.2 | 28.3 | 29.4 | 30.6 | 31.8 | 33.0 |
| 90 | 22.1 | 23.1 | 24.2 | 25.3 | 26.4 | 27.5 | 28.6 | 29.8 | 31.0 | 32.1 | 33.4 |
| 91 | 22.3 | 23.4 | 24.4 | 25.5 | 26.7 | 27.8 | 28.9 | 30.1 | 31.3 | 32.5 | 33.7 |
| 92 | 22.6 | 23.6 | 24.7 | 25.8 | 26.9 | 28.1 | 29.3 | 30.4 | 31.6 | 32.9 | 34.1 |
| 93 | 22.8 | 23.9 | 25.0 | 26.1 | 27.2 | 28.4 | 29.6 | 30.8 | 32.0 | 33.2 | 34.5 |
| 94 | 23.1 | 24.1 | 25.3 | 26.4 | 27.5 | 28.7 | 29.9 | 31.1 | 32.3 | 33.6 | 34.8 |
| 95 | 23.3 | 24.4 | 25.5 | 26.7 | 27.8 | 29.0 | 30.2 | 31.4 | 32.7 | 33.9 | 35.2 |
| 96 | 23.5 | 24.7 | 25.8 | 26.9 | 28.1 | 29.3 | 30.5 | 31.8 | 33.0 | 34.3 | 35.6 |
| 97 | 23.8 | 24.9 | 26.1 | 27.2 | 28.4 | 29.6 | 30.8 | 32.1 | 33.4 | 34.6 | 36.0 |
| 98 | 24.0 | 25.2 | 26.3 | 27.5 | 28.7 | 29.9 | 31.2 | 32.4 | 33.7 | 35.0 | 36.3 |
| 99 | 24.3 | 25.4 | 26.6 | 27.8 | 29.0 | 30.2 | 31.5 | 32.8 | 34.1 | 35.4 | 36.7 |
| 100 | 24.5 | 25.7 | 26.9 | 28.1 | 29.3 | 30.5 | 31.8 | 33.1 | 34.4 | 35.7 | 37.1 |
| 600 | 147.2 | 154.1 | 161.2 | 168.4 | 175.7 | 183.2 | 190.8 | 198.5 | 206.4 | 214.3 | 222.4 |
| 700 | 171.7 | 179.8 | 188.1 | 196.5 | 205.0 | 213.7 | 222.6 | 231.6 | 240.8 | 250.0 | 259.4 |
| 800 | 196.1 | 205.4 | 214.9 | 224.6 | 234.3 | 244.2 | 254.4 | 264.7 | 275.2 | 285.8 | 296.5 |
| 900 | 220.8 | 231.2 | 241.8 | 252.7 | 263.7 | 274.8 | 286.2 | 297.8 | 309.7 | 321.5 | 333.7 |
| | 1.33 | 1.35 | 1.37 | 1.39 | 1.41 | 1.44 | 1.47 | 1.50 | 1.52 | 1.56 | 1.59 |

FACTOR

TO CHANGE DEP. INTO LONG. DIFF. MULTIPLY TABULAR NUMBER BY FACTOR AT FOOT OF COLUMN AND **ADD** PRODUCT TO DEP.

TO CHANGE LONG. DIFF. INTO DEP., **SUBTRACT** TABULAR NUMBER
FROM LONG. DIFF.

| LONG. DIFF. OR DEP. | MIDDLE LATITUDE | | | | | | | | |
|------------------------------|-----------------|-------|-------|-------|-------|-------|-------|-------|-------|
| | 52° | 53° | 54° | 55° | 56° | 57° | 58° | 59° | 60° |
| 1 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.5 | 0.5 | 0.5 | 0.5 |
| 2 | 0.8 | 0.8 | 0.8 | 0.9 | 0.9 | 0.9 | 0.9 | 1.0 | 1.0 |
| 3 | 1.2 | 1.2 | 1.2 | 1.3 | 1.3 | 1.4 | 1.4 | 1.5 | 1.5 |
| 4 | 1.5 | 1.6 | 1.6 | 1.7 | 1.8 | 1.8 | 1.9 | 1.9 | 2.0 |
| 5 | 1.9 | 2.0 | 2.1 | 2.1 | 2.2 | 2.3 | 2.4 | 2.4 | 2.5 |
| 6 | 2.3 | 2.4 | 2.5 | 2.6 | 2.6 | 2.7 | 2.8 | 2.9 | 3.0 |
| 7 | 2.7 | 2.8 | 2.9 | 3.0 | 3.1 | 3.2 | 3.3 | 3.4 | 3.5 |
| 8 | 3.1 | 3.2 | 3.3 | 3.4 | 3.5 | 3.6 | 3.8 | 3.9 | 4.0 |
| 9 | 3.5 | 3.6 | 3.7 | 3.8 | 4.0 | 4.1 | 4.2 | 4.4 | 4.5 |
| 10 | 3.8 | 4.0 | 4.1 | 4.3 | 4.4 | 4.6 | 4.7 | 4.8 | 5.0 |
| 11 | 4.2 | 4.4 | 4.5 | 4.7 | 4.8 | 5.0 | 5.2 | 5.3 | 5.5 |
| 12 | 4.6 | 4.8 | 4.9 | 5.1 | 5.3 | 5.5 | 5.6 | 5.8 | 6.0 |
| 13 | 5.0 | 5.2 | 5.4 | 5.5 | 5.7 | 5.9 | 6.1 | 6.3 | 6.5 |
| 14 | 5.4 | 5.6 | 5.8 | 6.0 | 6.2 | 6.4 | 6.6 | 6.8 | 7.0 |
| 15 | 5.8 | 6.0 | 6.2 | 6.4 | 6.6 | 6.8 | 7.1 | 7.3 | 7.5 |
| 16 | 6.1 | 6.4 | 6.6 | 6.8 | 7.1 | 7.3 | 7.5 | 7.8 | 8.0 |
| 17 | 6.5 | 6.8 | 7.0 | 7.2 | 7.5 | 7.7 | 8.0 | 8.2 | 8.5 |
| 18 | 6.9 | 7.2 | 7.4 | 7.7 | 7.9 | 8.2 | 8.5 | 8.7 | 9.0 |
| 19 | 7.3 | 7.6 | 7.8 | 8.1 | 8.4 | 8.7 | 8.9 | 9.2 | 9.5 |
| 20 | 7.7 | 8.0 | 8.2 | 8.5 | 8.8 | 9.1 | 9.4 | 9.7 | 10.0 |
| 21 | 8.1 | 8.4 | 8.7 | 9.0 | 9.3 | 9.6 | 9.9 | 10.2 | 10.5 |
| 22 | 8.5 | 8.8 | 9.1 | 9.4 | 9.7 | 10.0 | 10.3 | 10.7 | 11.0 |
| 23 | 8.8 | 9.2 | 9.5 | 9.8 | 10.1 | 10.5 | 10.8 | 11.2 | 11.5 |
| 24 | 9.2 | 9.6 | 9.9 | 10.2 | 10.6 | 10.9 | 11.3 | 11.6 | 12.0 |
| 25 | 9.6 | 10.0 | 10.3 | 10.7 | 11.0 | 11.4 | 11.8 | 12.1 | 12.5 |
| 26 | 10.0 | 10.4 | 10.7 | 11.1 | 11.5 | 11.8 | 12.2 | 12.6 | 13.0 |
| 27 | 10.4 | 10.8 | 11.1 | 11.5 | 11.9 | 12.3 | 12.7 | 13.1 | 13.5 |
| 28 | 10.8 | 11.1 | 11.5 | 11.9 | 12.3 | 12.8 | 13.2 | 13.6 | 14.0 |
| 29 | 11.1 | 11.5 | 12.0 | 12.4 | 12.8 | 13.2 | 13.6 | 14.1 | 14.5 |
| 30 | 11.5 | 11.9 | 12.4 | 12.8 | 13.2 | 13.7 | 14.1 | 14.5 | 15.0 |
| 31 | 11.9 | 12.3 | 12.8 | 13.2 | 13.7 | 14.1 | 14.6 | 15.0 | 15.5 |
| 32 | 12.3 | 12.7 | 13.2 | 13.6 | 14.1 | 14.6 | 15.0 | 15.5 | 16.0 |
| 33 | 12.7 | 13.1 | 13.6 | 14.1 | 14.5 | 15.0 | 15.5 | 16.0 | 16.5 |
| 34 | 13.1 | 13.5 | 14.0 | 14.5 | 15.0 | 15.5 | 16.0 | 16.5 | 17.0 |
| 35 | 13.5 | 13.9 | 14.4 | 14.9 | 15.4 | 15.9 | 16.5 | 17.0 | 17.5 |
| 36 | 13.8 | 14.3 | 14.8 | 15.4 | 15.9 | 16.4 | 16.9 | 17.5 | 18.0 |
| 37 | 14.2 | 14.7 | 15.3 | 15.8 | 16.3 | 16.8 | 17.4 | 17.9 | 18.5 |
| 38 | 14.6 | 15.1 | 15.7 | 16.2 | 16.8 | 17.3 | 17.9 | 18.4 | 19.0 |
| 39 | 15.0 | 15.5 | 16.1 | 16.6 | 17.2 | 17.8 | 18.3 | 18.9 | 19.5 |
| 40 | 15.4 | 15.9 | 16.5 | 17.1 | 17.6 | 18.2 | 18.8 | 19.4 | 20.0 |
| 41 | 15.8 | 16.3 | 16.9 | 17.5 | 18.1 | 18.7 | 19.3 | 19.9 | 20.5 |
| 42 | 16.1 | 16.7 | 17.3 | 17.9 | 18.5 | 19.1 | 19.7 | 20.4 | 21.0 |
| 43 | 16.5 | 17.1 | 17.7 | 18.3 | 19.0 | 19.6 | 20.2 | 20.9 | 21.5 |
| 44 | 16.9 | 17.5 | 18.1 | 18.8 | 19.4 | 20.0 | 20.7 | 21.3 | 22.0 |
| 45 | 17.3 | 17.9 | 18.5 | 19.2 | 19.8 | 20.5 | 21.2 | 21.8 | 22.5 |
| 46 | 17.7 | 18.3 | 19.0 | 19.6 | 20.3 | 20.9 | 21.6 | 22.3 | 23.0 |
| 47 | 18.1 | 18.7 | 19.4 | 20.0 | 20.7 | 21.4 | 22.1 | 22.8 | 23.5 |
| 48 | 18.4 | 19.1 | 19.8 | 20.5 | 21.2 | 21.9 | 22.6 | 23.3 | 24.0 |
| 49 | 18.8 | 19.5 | 20.2 | 20.9 | 21.6 | 22.3 | 23.0 | 23.8 | 24.5 |
| 50 | 19.2 | 19.9 | 20.6 | 21.3 | 22.0 | 22.8 | 23.5 | 24.2 | 25.0 |
| 100 | 38.4 | 39.8 | 41.2 | 42.6 | 44.1 | 45.5 | 47.0 | 48.5 | 50.0 |
| 200 | 76.9 | 79.6 | 82.4 | 85.3 | 88.2 | 91.1 | 94.0 | 97.0 | 100.0 |
| 300 | 115.3 | 119.5 | 123.7 | 127.9 | 132.2 | 136.6 | 141.0 | 145.5 | 150.0 |
| 400 | 153.7 | 159.3 | 164.9 | 170.6 | 176.3 | 182.2 | 188.1 | 194.0 | 200.0 |
| 500 | 192.2 | 199.1 | 206.1 | 213.2 | 220.4 | 227.7 | 235.0 | 242.5 | 250.0 |
| | 1.62 | 1.66 | 1.70 | 1.74 | 1.79 | 1.84 | 1.89 | 1.94 | 2.00 |

FACTOR

TO CHANGE DEP. INTO LONG. DIFF., MULTIPLY TABULAR NUMBER BY
FACTOR AT FOOT OF COLUMN AND **ADD** PRODUCT TO DEP.

TO CHANGE LONG. DIFF. INTO DEP. **SUBTRACT** TABULAR NUMBER
FROM LONG. DIFF.

| LONG. DIFF. OR DEP. | MIDDLE LATITUDE | | | | | | | | |
|------------------------------|-----------------|-------|-------|-------|-------|-------|-------|-------|-------|
| | 52° | 53° | 54° | 55° | 56° | 57° | 58° | 59° | 60° |
| 51 | 19.6 | 20.3 | 21.0 | 21.7 | 22.5 | 23.2 | 24.0 | 24.7 | 25.5 |
| 52 | 20.0 | 20.7 | 21.4 | 22.2 | 22.9 | 23.7 | 24.4 | 25.2 | 26.0 |
| 53 | 20.4 | 21.1 | 21.8 | 22.6 | 23.4 | 24.1 | 24.9 | 25.7 | 26.5 |
| 54 | 20.8 | 21.5 | 22.3 | 23.0 | 23.8 | 24.6 | 25.4 | 26.2 | 27.0 |
| 55 | 21.1 | 21.9 | 22.7 | 23.5 | 24.2 | 25.0 | 25.9 | 26.7 | 27.5 |
| 56 | 21.5 | 22.3 | 23.1 | 23.9 | 24.7 | 25.5 | 26.3 | 27.2 | 28.0 |
| 57 | 21.9 | 22.7 | 23.5 | 24.3 | 25.1 | 26.0 | 26.8 | 27.6 | 28.5 |
| 58 | 22.3 | 23.1 | 23.9 | 24.7 | 25.6 | 26.4 | 27.3 | 28.1 | 29.0 |
| 59 | 22.7 | 23.5 | 24.3 | 25.2 | 26.0 | 26.9 | 27.7 | 28.6 | 29.5 |
| 60 | 23.1 | 23.9 | 24.7 | 25.6 | 26.4 | 27.3 | 28.2 | 29.1 | 30.0 |
| 61 | 23.4 | 24.3 | 25.1 | 26.0 | 26.9 | 27.8 | 28.7 | 29.6 | 30.5 |
| 62 | 23.8 | 24.7 | 25.6 | 26.4 | 27.3 | 28.2 | 29.1 | 30.1 | 31.0 |
| 63 | 24.2 | 25.1 | 26.0 | 26.9 | 27.8 | 28.7 | 29.6 | 30.6 | 31.5 |
| 64 | 24.6 | 25.5 | 26.4 | 27.3 | 28.2 | 29.1 | 30.1 | 31.0 | 32.0 |
| 65 | 25.0 | 25.9 | 26.8 | 27.7 | 28.7 | 29.6 | 30.6 | 31.5 | 32.5 |
| 66 | 25.4 | 26.3 | 27.2 | 28.1 | 29.1 | 30.1 | 31.0 | 32.0 | 33.0 |
| 67 | 25.8 | 26.7 | 27.6 | 28.6 | 29.5 | 30.5 | 31.5 | 32.5 | 33.5 |
| 68 | 26.1 | 27.1 | 28.0 | 29.0 | 30.0 | 31.0 | 32.0 | 33.0 | 34.0 |
| 69 | 26.5 | 27.5 | 28.4 | 29.4 | 30.4 | 31.4 | 32.4 | 33.5 | 34.5 |
| 70 | 26.9 | 27.9 | 28.9 | 29.8 | 30.9 | 31.9 | 32.9 | 33.9 | 35.0 |
| 71 | 27.3 | 28.3 | 29.3 | 30.3 | 31.3 | 32.3 | 33.4 | 34.4 | 35.5 |
| 72 | 27.7 | 28.7 | 29.7 | 30.7 | 31.7 | 32.8 | 33.8 | 34.9 | 36.0 |
| 73 | 28.1 | 29.1 | 30.1 | 31.1 | 32.2 | 33.2 | 34.3 | 35.4 | 36.5 |
| 74 | 28.4 | 29.5 | 30.5 | 31.6 | 32.6 | 33.7 | 34.8 | 35.9 | 37.0 |
| 75 | 28.8 | 29.9 | 30.9 | 32.0 | 33.1 | 34.2 | 35.3 | 36.4 | 37.5 |
| 76 | 29.2 | 30.3 | 31.3 | 32.4 | 33.5 | 34.6 | 35.7 | 36.9 | 38.0 |
| 77 | 29.6 | 30.7 | 31.7 | 32.8 | 33.9 | 35.1 | 36.2 | 37.3 | 38.5 |
| 78 | 30.0 | 31.1 | 32.2 | 33.3 | 34.4 | 35.5 | 36.7 | 37.8 | 39.0 |
| 79 | 30.4 | 31.5 | 32.6 | 33.7 | 34.8 | 36.0 | 37.1 | 38.3 | 39.5 |
| 80 | 30.7 | 31.9 | 33.0 | 34.1 | 35.3 | 36.4 | 37.6 | 38.8 | 40.0 |
| 81 | 31.1 | 32.3 | 33.4 | 34.5 | 35.7 | 36.9 | 38.1 | 39.3 | 40.5 |
| 82 | 31.5 | 32.7 | 33.8 | 35.0 | 36.1 | 37.3 | 38.5 | 39.8 | 41.0 |
| 83 | 31.9 | 33.0 | 34.2 | 35.4 | 36.6 | 37.8 | 39.0 | 40.3 | 41.5 |
| 84 | 32.3 | 33.4 | 34.6 | 35.8 | 37.0 | 38.3 | 39.5 | 40.7 | 42.0 |
| 85 | 32.7 | 33.8 | 35.0 | 36.2 | 37.5 | 38.7 | 40.0 | 41.2 | 42.5 |
| 86 | 33.1 | 34.2 | 35.5 | 36.7 | 37.9 | 39.2 | 40.4 | 41.7 | 43.0 |
| 87 | 33.4 | 34.6 | 35.9 | 37.1 | 38.4 | 39.6 | 40.9 | 42.2 | 43.5 |
| 88 | 33.8 | 35.0 | 36.3 | 37.5 | 38.8 | 40.1 | 41.4 | 42.7 | 44.0 |
| 89 | 34.2 | 35.4 | 36.7 | 38.0 | 39.2 | 40.5 | 41.8 | 43.2 | 44.5 |
| 90 | 34.6 | 35.8 | 37.1 | 38.4 | 39.7 | 41.0 | 42.3 | 43.6 | 45.0 |
| 91 | 35.0 | 36.2 | 37.5 | 38.8 | 40.1 | 41.4 | 42.8 | 44.1 | 45.5 |
| 92 | 35.4 | 36.6 | 37.9 | 39.2 | 40.6 | 41.9 | 43.2 | 44.6 | 46.0 |
| 93 | 35.7 | 37.0 | 38.3 | 39.7 | 41.0 | 42.3 | 43.7 | 45.1 | 46.5 |
| 94 | 36.1 | 37.4 | 38.7 | 40.1 | 41.4 | 42.8 | 44.2 | 45.6 | 47.0 |
| 95 | 36.5 | 37.8 | 39.2 | 40.5 | 41.9 | 43.3 | 44.7 | 46.1 | 47.5 |
| 96 | 36.9 | 38.2 | 39.6 | 40.9 | 42.3 | 43.7 | 45.1 | 46.6 | 48.0 |
| 97 | 37.3 | 38.6 | 40.0 | 41.4 | 42.8 | 44.2 | 45.6 | 47.0 | 48.5 |
| 98 | 37.7 | 39.0 | 40.4 | 41.8 | 43.2 | 44.6 | 46.1 | 47.5 | 49.0 |
| 99 | 38.0 | 39.4 | 40.8 | 42.2 | 43.6 | 45.1 | 46.5 | 48.0 | 49.5 |
| 100 | 38.4 | 39.8 | 41.2 | 42.6 | 44.1 | 45.5 | 47.0 | 48.5 | 50.0 |
| 600 | 230.6 | 238.9 | 247.3 | 255.9 | 264.5 | 273.2 | 282.0 | 291.0 | 300.0 |
| 700 | 269.2 | 279.7 | 288.6 | 298.5 | 308.6 | 318.7 | 329.0 | 339.6 | 350.0 |
| 800 | 307.5 | 319.5 | 329.8 | 341.2 | 352.6 | 364.3 | 376.1 | 388.0 | 400.0 |
| 900 | 346.0 | 358.3 | 371.1 | 383.8 | 396.8 | 409.9 | 423.2 | 436.6 | 450.0 |
| | 1.63 | 1.66 | 1.70 | 1.74 | 1.79 | 1.84 | 1.89 | 1.94 | 2.00 |
| | FACTOR | | | | | | | | |

TO CHANGE DEP. INTO LONG. DIFF. MULTIPLY TABULAR NUMBER BY
FACTOR AT FOOT OF COLUMN AND **ADD** PRODUCT TO DEP.

Table 3. Number Logarithms

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Prop. Pts. | | | |
|------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|------------|-------------------|-----------|-----------|
| 100 | 00 000 | 043 | 087 | 130 | 173 | 217 | 260 | 303 | 346 | 389 | | | | |
| 01 | 432 | 475 | 518 | 561 | 604 | 647 | 689 | 732 | 775 | 817 | | 44 | 43 | 42 |
| 02 | 860 | 903 | 945 | 988 | *030 | *072 | *115 | *157 | *199 | *242 | 1 | 4.4 | 4.3 | 4.2 |
| 03 | 01 284 | 326 | 368 | 410 | 452 | 494 | 536 | 578 | 620 | 662 | 2 | 8.8 | 8.6 | 8.4 |
| 04 | 703 | 745 | 787 | 828 | 870 | 912 | 953 | 995 | *036 | *078 | 3 | 13.2 | 12.9 | 12.6 |
| 05 | 02 119 | 160 | 202 | 243 | 284 | 325 | 366 | 407 | 449 | 490 | 4 | 17.6 | 17.2 | 16.8 |
| 06 | 531 | 572 | 612 | 653 | 694 | 735 | 776 | 816 | 857 | 898 | 5 | 22.0 | 21.5 | 21.0 |
| 07 | 938 | 979 | *019 | *060 | *100 | *141 | *181 | *222 | *262 | *302 | 6 | 26.4 | 25.8 | 25.2 |
| 08 | 03 342 | 383 | 423 | 463 | 503 | 543 | 583 | 623 | 663 | 703 | 7 | 30.8 | 30.1 | 29.4 |
| 09 | 743 | 782 | 822 | 862 | 902 | 941 | 981 | *021 | *060 | *100 | 8 | 35.2 | 34.4 | 33.6 |
| | | | | | | | | | | | 9 | 39.6 | 38.7 | 37.8 |
| 110 | 04 139 | 179 | 218 | 258 | 297 | 336 | 376 | 415 | 454 | 493 | | | | |
| 11 | 532 | 571 | 610 | 650 | 689 | 727 | 766 | 805 | 844 | 883 | | 41 | 40 | 39 |
| 12 | 922 | 961 | 999 | *038 | *077 | *115 | *154 | *192 | *231 | *269 | 1 | 4.1 | 4.0 | 3.9 |
| 13 | 05 308 | 346 | 385 | 423 | 461 | 500 | 538 | 576 | 614 | 652 | 2 | 8.2 | 8.0 | 7.8 |
| 14 | 690 | 729 | 767 | 805 | 843 | 881 | 918 | 956 | 994 | *032 | 3 | 12.3 | 12.0 | 11.7 |
| 15 | 06 070 | 108 | 145 | 183 | 221 | 258 | 296 | 333 | 371 | 408 | 4 | 16.4 | 16.0 | 15.6 |
| 16 | 446 | 483 | 521 | 558 | 595 | 633 | 670 | 707 | 744 | 781 | 5 | 20.5 | 20.0 | 19.5 |
| 17 | 819 | 856 | 893 | 930 | 967 | *004 | *041 | *078 | *115 | *151 | 6 | 24.6 | 24.0 | 23.4 |
| 18 | 07 188 | 225 | 262 | 298 | 335 | 372 | 408 | 445 | 482 | 518 | 7 | 28.7 | 28.0 | 27.3 |
| 19 | 555 | 591 | 628 | 664 | 700 | 737 | 773 | 809 | 846 | 882 | 8 | 32.8 | 32.0 | 31.2 |
| | | | | | | | | | | | 9 | 36.9 | 36.0 | 35.1 |
| 120 | 918 | 954 | 990 | *027 | *063 | *099 | *135 | *171 | *207 | *243 | | | | |
| 21 | 08 279 | 314 | 350 | 386 | 422 | 458 | 493 | 529 | 565 | 600 | | 38 | 37 | 36 |
| 22 | 636 | 672 | 707 | 743 | 778 | 814 | 849 | 884 | 920 | 955 | 1 | 3.8 | 3.7 | 3.6 |
| 23 | 991 | *026 | *061 | *096 | *132 | *167 | *202 | *237 | *272 | *307 | 2 | 7.6 | 7.4 | 7.2 |
| 24 | 09 342 | 377 | 412 | 447 | 482 | 517 | 552 | 587 | 621 | 656 | 3 | 11.4 | 11.1 | 10.8 |
| 25 | 691 | 726 | 760 | 795 | 830 | 864 | 899 | 934 | 968 | *003 | 4 | 15.2 | 14.8 | 14.4 |
| 26 | 10 037 | 072 | 106 | 140 | 175 | 209 | 243 | 278 | 312 | 346 | 5 | 19.0 | 18.5 | 18.0 |
| 27 | 380 | 415 | 449 | 483 | 517 | 551 | 585 | 619 | 653 | 687 | 6 | 22.8 | 22.2 | 21.6 |
| 28 | 721 | 755 | 789 | 823 | 857 | 890 | 924 | 958 | 992 | *025 | 7 | 26.6 | 25.9 | 25.2 |
| 29 | 11 059 | 093 | 126 | 160 | 193 | 227 | 261 | 294 | 327 | 361 | 8 | 30.4 | 29.6 | 28.8 |
| | | | | | | | | | | | 9 | 34.2 | 33.3 | 32.4 |
| 130 | 394 | 428 | 461 | 494 | 528 | 561 | 594 | 628 | 661 | 694 | | | | |
| 31 | 727 | 760 | 793 | 826 | 860 | 893 | 926 | 959 | 992 | *024 | | 35 | 34 | 33 |
| 32 | 12 057 | 090 | 123 | 156 | 189 | 222 | 254 | 287 | 320 | 352 | 1 | 3.5 | 3.4 | 3.3 |
| 33 | 385 | 418 | 450 | 483 | 516 | 548 | 581 | 613 | 646 | 678 | 2 | 7.0 | 6.8 | 6.6 |
| 34 | 710 | 743 | 775 | 808 | 840 | 872 | 905 | 937 | 969 | *001 | 3 | 10.5 | 10.2 | 9.9 |
| 35 | 13 033 | 066 | 098 | 130 | 162 | 194 | 226 | 258 | 290 | 322 | 4 | 14.0 | 13.6 | 13.2 |
| 36 | 354 | 386 | 418 | 450 | 481 | 513 | 545 | 577 | 609 | 640 | 5 | 17.5 | 17.0 | 16.5 |
| 37 | 672 | 704 | 735 | 767 | 799 | 830 | 862 | 893 | 925 | 956 | 6 | 21.0 | 20.4 | 19.8 |
| 38 | 988 | *019 | *051 | *082 | *114 | *145 | *176 | *208 | *239 | *270 | 7 | 24.5 | 23.8 | 23.1 |
| 39 | 14 301 | 333 | 364 | 395 | 426 | 457 | 489 | 520 | 551 | 582 | 8 | 28.0 | 27.2 | 26.4 |
| | | | | | | | | | | | 9 | 31.5 | 30.6 | 29.7 |
| 140 | 613 | 644 | 675 | 706 | 737 | 768 | 799 | 829 | 860 | 891 | | | | |
| 41 | 922 | 953 | 983 | *014 | *045 | *076 | *106 | *137 | *168 | *198 | | 32 | 31 | 30 |
| 42 | 15 229 | 259 | 290 | 320 | 351 | 381 | 412 | 442 | 473 | 503 | 1 | 3.2 | 3.1 | 3.0 |
| 43 | 534 | 564 | 594 | 625 | 655 | 685 | 715 | 746 | 776 | 806 | 2 | 6.4 | 6.2 | 6.0 |
| 44 | 836 | 866 | 897 | 927 | 957 | 987 | *017 | *047 | *077 | *107 | 3 | 9.6 | 9.3 | 9.0 |
| 45 | 16 137 | 167 | 197 | 227 | 256 | 286 | 316 | 346 | 376 | 406 | 4 | 12.8 | 12.4 | 12.0 |
| 46 | 435 | 465 | 495 | 524 | 554 | 584 | 613 | 643 | 673 | 702 | 5 | 16.0 | 15.5 | 15.0 |
| 47 | 732 | 761 | 791 | 820 | 850 | 879 | 909 | 938 | 967 | 997 | 6 | 19.2 | 18.6 | 18.0 |
| 48 | 17 026 | 056 | 085 | 114 | 143 | 173 | 202 | 231 | 260 | 289 | 7 | 22.4 | 21.7 | 21.0 |
| 49 | 319 | 348 | 377 | 406 | 435 | 464 | 493 | 522 | 551 | 580 | 8 | 25.6 | 24.8 | 24.0 |
| | | | | | | | | | | | 9 | 28.8 | 27.9 | 27.0 |
| 150 | 609 | 638 | 667 | 696 | 725 | 754 | 782 | 811 | 840 | 869 | | | | |
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | | Prop. Pts. | | |

Table 3. Number Logarithms

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Prop. Pts. | | | |
|------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|------------|-------------------|-----------|-----------|
| 150 | 17 609 | 638 | 667 | 696 | 725 | 754 | 782 | 811 | 840 | 869 | | | | |
| 51 | 898 | 926 | 955 | 984 | *013 | *041 | *070 | *099 | *127 | *156 | | | | |
| 52 | 18 184 | 213 | 241 | 270 | 298 | 327 | 355 | 384 | 412 | 441 | | | | |
| 53 | 469 | 498 | 526 | 554 | 583 | 611 | 639 | 667 | 696 | 724 | | | | |
| 54 | 752 | 780 | 808 | 837 | 865 | 893 | 921 | 949 | 977 | *005 | | | | |
| 55 | 19 033 | 061 | 089 | 117 | 145 | 173 | 201 | 229 | 257 | 285 | | | | |
| 56 | 312 | 340 | 368 | 396 | 424 | 451 | 479 | 507 | 535 | 562 | | | | |
| 57 | 590 | 618 | 645 | 673 | 700 | 728 | 756 | 783 | 811 | 838 | | | | |
| 58 | 866 | 893 | 921 | 948 | 976 | *003 | *030 | *058 | *085 | *112 | | | | |
| 59 | 20 140 | 167 | 194 | 222 | 249 | 276 | 303 | 330 | 358 | 385 | | | | |
| 160 | 412 | 439 | 466 | 493 | 520 | 548 | 575 | 602 | 629 | 656 | | | | |
| 61 | 683 | 710 | 737 | 763 | 790 | 817 | 844 | 871 | 898 | 925 | | 29 | 28 | 27 |
| 62 | 952 | 978 | *005 | *032 | *059 | *085 | *112 | *139 | *165 | *192 | 1 | 2.9 | 2.8 | 2.7 |
| 63 | 21 219 | 245 | 272 | 299 | 325 | 352 | 378 | 405 | 431 | 458 | 2 | 5.8 | 5.6 | 5.4 |
| 64 | 484 | 511 | 537 | 564 | 590 | 617 | 643 | 669 | 696 | 722 | 3 | 8.7 | 8.4 | 8.1 |
| 65 | 748 | 775 | 801 | 827 | 854 | 880 | 906 | 932 | 958 | 985 | 4 | 11.6 | 11.2 | 10.8 |
| 66 | 22 011 | 037 | 063 | 089 | 115 | 141 | 167 | 194 | 220 | 246 | 5 | 14.5 | 14.0 | 13.5 |
| 67 | 272 | 298 | 324 | 350 | 376 | 401 | 427 | 453 | 479 | 505 | 6 | 17.4 | 16.8 | 16.2 |
| 68 | 531 | 557 | 583 | 608 | 634 | 660 | 686 | 712 | 737 | 763 | 7 | 20.3 | 19.6 | 18.9 |
| 69 | 789 | 814 | 840 | 866 | 891 | 917 | 943 | 968 | 994 | *019 | 8 | 23.2 | 22.4 | 21.6 |
| | | | | | | | | | | | 9 | 26.1 | 25.2 | 24.3 |
| 170 | 23 045 | 070 | 096 | 121 | 147 | 172 | 198 | 223 | 249 | 274 | | | | |
| 71 | 300 | 325 | 350 | 376 | 401 | 426 | 452 | 477 | 502 | 528 | | 26 | 25 | 24 |
| 72 | 553 | 578 | 603 | 629 | 654 | 679 | 704 | 729 | 754 | 779 | 1 | 2.6 | 2.5 | 2.4 |
| 73 | 805 | 830 | 855 | 880 | 905 | 930 | 955 | 980 | *005 | *030 | 2 | 5.2 | 5.0 | 4.8 |
| 74 | 24 055 | 080 | 105 | 130 | 155 | 180 | 204 | 229 | 254 | 279 | 3 | 7.8 | 7.5 | 7.2 |
| 75 | 304 | 329 | 353 | 378 | 403 | 428 | 452 | 477 | 502 | 527 | 4 | 10.4 | 10.0 | 9.6 |
| 76 | 551 | 576 | 601 | 625 | 650 | 674 | 699 | 724 | 748 | 773 | 5 | 13.0 | 12.5 | 12.0 |
| 77 | 797 | 822 | 846 | 871 | 895 | 920 | 944 | 969 | 993 | *018 | 6 | 15.6 | 15.0 | 14.4 |
| 78 | 25 042 | 066 | 091 | 115 | 139 | 164 | 188 | 212 | 237 | 261 | 7 | 18.2 | 17.5 | 16.8 |
| 79 | 285 | 310 | 334 | 358 | 382 | 406 | 431 | 455 | 479 | 503 | 8 | 20.8 | 20.0 | 19.2 |
| | | | | | | | | | | | 9 | 23.4 | 22.5 | 21.6 |
| 180 | 527 | 551 | 575 | 600 | 624 | 648 | 672 | 696 | 720 | 744 | | | | |
| 81 | 768 | 792 | 816 | 840 | 864 | 888 | 912 | 935 | 959 | 983 | | 23 | 22 | 21 |
| 82 | 26 007 | 031 | 055 | 079 | 102 | 126 | 150 | 174 | 198 | 221 | 1 | 2.3 | 2.2 | 2.1 |
| 83 | 245 | 269 | 293 | 316 | 340 | 364 | 387 | 411 | 435 | 458 | 2 | 4.6 | 4.4 | 4.2 |
| 84 | 482 | 505 | 529 | 553 | 576 | 600 | 623 | 647 | 670 | 694 | 3 | 6.9 | 6.6 | 6.3 |
| 85 | 717 | 741 | 764 | 788 | 811 | 834 | 858 | 881 | 905 | 928 | 4 | 9.2 | 8.8 | 8.4 |
| 86 | 951 | 975 | 998 | *021 | *045 | *068 | *091 | *114 | *138 | *161 | 5 | 11.5 | 11.0 | 10.5 |
| 87 | 27 184 | 207 | 231 | 254 | 277 | 300 | 323 | 346 | 370 | 393 | 6 | 13.8 | 13.2 | 12.6 |
| 88 | 416 | 439 | 462 | 485 | 508 | 531 | 554 | 577 | 600 | 623 | 7 | 16.1 | 15.4 | 14.7 |
| 89 | 646 | 669 | 692 | 715 | 738 | 761 | 784 | 807 | 830 | 852 | 8 | 18.4 | 17.6 | 16.8 |
| | | | | | | | | | | | 9 | 20.7 | 19.8 | 18.9 |
| 190 | 875 | 898 | 921 | 944 | 967 | 989 | *012 | *035 | *058 | *081 | | | | |
| 91 | 28 103 | 126 | 149 | 171 | 194 | 217 | 240 | 262 | 285 | 307 | | | | |
| 92 | 330 | 353 | 375 | 398 | 421 | 443 | 466 | 488 | 511 | 533 | | | | |
| 93 | 556 | 578 | 601 | 623 | 646 | 668 | 691 | 713 | 735 | 758 | | | | |
| 94 | 780 | 803 | 825 | 847 | 870 | 892 | 914 | 937 | 959 | 981 | | | | |
| 95 | 29 003 | 026 | 048 | 070 | 092 | 115 | 137 | 159 | 181 | 203 | | | | |
| 96 | 226 | 248 | 270 | 292 | 314 | 336 | 358 | 380 | 403 | 425 | | | | |
| 97 | 447 | 469 | 491 | 513 | 535 | 557 | 579 | 601 | 623 | 645 | | | | |
| 98 | 667 | 688 | 710 | 732 | 754 | 776 | 798 | 820 | 842 | 863 | | | | |
| 99 | 885 | 907 | 929 | 951 | 973 | 994 | *016 | *038 | *060 | *081 | | | | |
| 200 | 30 103 | 125 | 146 | 168 | 190 | 211 | 233 | 255 | 276 | 298 | | | | |
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | | Prop. Pts. | | |

Table 3. Number Logarithms

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Prop. Pts. | | | |
|------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-------------------|--|--|--|
| 200 | 30 103 | 125 | 146 | 168 | 190 | 211 | 233 | 255 | 276 | 298 | | | | |
| 01 | 320 | 341 | 363 | 384 | 406 | 428 | 449 | 471 | 492 | 514 | | | | |
| 02 | 535 | 557 | 578 | 600 | 621 | 643 | 664 | 685 | 707 | 728 | | | | |
| 03 | 750 | 771 | 792 | 814 | 835 | 856 | 878 | 899 | 920 | 942 | | | | |
| 04 | 963 | 984 | *006 | *027 | *048 | *069 | *091 | *112 | *133 | *154 | | | | |
| 05 | 31 175 | 197 | 218 | 239 | 260 | 281 | 302 | 323 | 345 | 366 | | | | |
| 06 | 387 | 408 | 429 | 450 | 471 | 492 | 513 | 534 | 555 | 576 | | | | |
| 07 | 597 | 618 | 639 | 660 | 681 | 702 | 723 | 744 | 765 | 785 | | | | |
| 08 | 806 | 827 | 848 | 869 | 890 | 911 | 931 | 952 | 973 | 994 | | | | |
| 09 | 32 015 | 035 | 056 | 077 | 098 | 118 | 139 | 160 | 181 | 201 | | | | |
| 210 | 222 | 243 | 263 | 284 | 305 | 325 | 346 | 366 | 387 | 408 | | | | |
| 11 | 428 | 449 | 469 | 490 | 510 | 531 | 552 | 572 | 593 | 613 | | | | |
| 12 | 634 | 654 | 675 | 695 | 715 | 736 | 756 | 777 | 797 | 818 | | | | |
| 13 | 838 | 858 | 879 | 899 | 919 | 940 | 960 | 980 | *001 | *021 | | | | |
| 14 | 33 041 | 062 | 082 | 102 | 122 | 143 | 163 | 183 | 203 | 224 | | | | |
| 15 | 244 | 264 | 284 | 304 | 325 | 345 | 365 | 385 | 405 | 425 | | | | |
| 16 | 445 | 465 | 486 | 506 | 526 | 546 | 566 | 586 | 606 | 626 | | | | |
| 17 | 646 | 666 | 686 | 706 | 726 | 746 | 766 | 786 | 806 | 826 | | | | |
| 18 | 846 | 866 | 885 | 905 | 925 | 945 | 965 | 985 | *005 | *025 | | | | |
| 19 | 34 044 | 064 | 084 | 104 | 124 | 143 | 163 | 183 | 203 | 223 | | | | |
| 220 | 242 | 262 | 282 | 301 | 321 | 341 | 361 | 380 | 400 | 420 | | | | |
| 21 | 439 | 459 | 479 | 498 | 518 | 537 | 557 | 577 | 596 | 616 | | | | |
| 22 | 635 | 655 | 674 | 694 | 713 | 733 | 753 | 772 | 792 | 811 | | | | |
| 23 | 830 | 850 | 869 | 889 | 908 | 928 | 947 | 967 | 986 | *005 | | | | |
| 24 | 35 025 | 044 | 064 | 083 | 102 | 122 | 141 | 160 | 180 | 199 | | | | |
| 25 | 218 | 238 | 257 | 276 | 295 | 315 | 334 | 353 | 372 | 392 | | | | |
| 26 | 411 | 430 | 449 | 468 | 488 | 507 | 526 | 545 | 564 | 583 | | | | |
| 27 | 603 | 622 | 641 | 660 | 679 | 698 | 717 | 736 | 755 | 774 | | | | |
| 28 | 793 | 813 | 832 | 851 | 870 | 889 | 908 | 927 | 946 | 965 | | | | |
| 29 | 984 | *003 | *021 | *040 | *059 | *078 | *097 | *116 | *135 | *154 | | | | |
| 230 | 36 173 | 192 | 211 | 229 | 248 | 267 | 286 | 305 | 324 | 342 | | | | |
| 31 | 361 | 380 | 399 | 418 | 436 | 455 | 474 | 493 | 511 | 530 | | | | |
| 32 | 549 | 568 | 586 | 605 | 624 | 642 | 661 | 680 | 698 | 717 | | | | |
| 33 | 736 | 754 | 773 | 791 | 810 | 829 | 847 | 866 | 884 | 903 | | | | |
| 34 | 922 | 940 | 959 | 977 | 996 | *014 | *033 | *051 | *070 | *088 | | | | |
| 35 | 37 107 | 125 | 144 | 162 | 181 | 199 | 218 | 236 | 254 | 273 | | | | |
| 36 | 291 | 310 | 328 | 346 | 365 | 383 | 401 | 420 | 438 | 457 | | | | |
| 37 | 475 | 493 | 511 | 530 | 548 | 566 | 585 | 603 | 621 | 639 | | | | |
| 38 | 658 | 676 | 694 | 712 | 731 | 749 | 767 | 785 | 803 | 822 | | | | |
| 39 | 840 | 858 | 876 | 894 | 912 | 931 | 949 | 967 | 985 | *003 | | | | |
| 240 | 38 021 | 039 | 057 | 075 | 093 | 112 | 130 | 148 | 166 | 184 | | | | |
| 41 | 202 | 220 | 238 | 256 | 274 | 292 | 310 | 328 | 346 | 364 | | | | |
| 42 | 382 | 399 | 417 | 435 | 453 | 471 | 489 | 507 | 525 | 543 | | | | |
| 43 | 561 | 578 | 596 | 614 | 632 | 650 | 668 | 686 | 703 | 721 | | | | |
| 44 | 739 | 757 | 775 | 792 | 810 | 828 | 846 | 863 | 881 | 899 | | | | |
| 45 | 917 | 934 | 952 | 970 | 987 | *005 | *023 | *041 | *058 | *076 | | | | |
| 46 | 39 094 | 111 | 129 | 146 | 164 | 182 | 199 | 217 | 235 | 252 | | | | |
| 47 | 270 | 287 | 305 | 322 | 340 | 358 | 375 | 393 | 410 | 428 | | | | |
| 48 | 445 | 463 | 480 | 498 | 515 | 533 | 550 | 568 | 585 | 602 | | | | |
| 49 | 620 | 637 | 655 | 672 | 690 | 707 | 724 | 742 | 759 | 777 | | | | |
| 250 | 794 | 811 | 829 | 846 | 863 | 881 | 898 | 915 | 933 | 950 | | | | |
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Prop. Pts. | | | |

| | 22 | 21 | 20 |
|---|------|------|------|
| 1 | 2.2 | 2.1 | 2.0 |
| 2 | 4.4 | 4.2 | 4.0 |
| 3 | 6.6 | 6.3 | 6.0 |
| 4 | 8.8 | 8.4 | 8.0 |
| 5 | 11.0 | 10.5 | 10.0 |
| 6 | 13.2 | 12.6 | 12.0 |
| 7 | 15.4 | 14.7 | 14.0 |
| 8 | 17.6 | 16.8 | 16.0 |
| 9 | 19.8 | 18.9 | 18.0 |

| | 19 | 18 | 17 |
|---|------|------|------|
| 1 | 1.9 | 1.8 | 1.7 |
| 2 | 3.8 | 3.6 | 3.4 |
| 3 | 5.7 | 5.4 | 5.1 |
| 4 | 7.6 | 7.2 | 6.8 |
| 5 | 9.5 | 9.0 | 8.5 |
| 6 | 11.4 | 10.8 | 10.2 |
| 7 | 13.3 | 12.6 | 11.9 |
| 8 | 15.2 | 14.4 | 13.6 |
| 9 | 17.1 | 16.2 | 15.3 |

Table 3. Number Logarithms

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Prop. Pts. | | | |
|------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-------------------|-----------|-----------|-----------|
| 250 | 39 794 | 811 | 829 | 846 | 863 | 881 | 898 | 915 | 933 | 950 | | | | |
| 51 | 967 | 985 | *002 | *019 | *037 | *054 | *071 | *088 | *106 | *123 | | | | |
| 52 | 40 140 | 157 | 175 | 192 | 209 | 226 | 243 | 261 | 278 | 295 | | | | |
| 53 | 312 | 329 | 346 | 364 | 381 | 398 | 415 | 432 | 449 | 466 | | | | |
| 54 | 483 | 500 | 518 | 535 | 552 | 569 | 586 | 603 | 620 | 637 | | | | |
| 55 | 654 | 671 | 688 | 705 | 722 | 739 | 756 | 773 | 790 | 807 | | | | |
| 56 | 824 | 841 | 858 | 875 | 892 | 909 | 926 | 943 | 960 | 976 | | | | |
| 57 | 993 | *010 | *027 | *044 | *061 | *078 | *095 | *111 | *128 | *145 | | | | |
| 58 | 41 162 | 179 | 196 | 212 | 229 | 246 | 263 | 280 | 296 | 313 | | | | |
| 59 | 330 | 347 | 363 | 380 | 397 | 414 | 430 | 447 | 464 | 481 | | | | |
| 260 | 497 | 514 | 531 | 547 | 564 | 581 | 597 | 614 | 631 | 647 | | | | |
| 61 | 664 | 681 | 697 | 714 | 731 | 747 | 764 | 780 | 797 | 814 | | 18 | 17 | 16 |
| 62 | 830 | 847 | 863 | 880 | 896 | 913 | 929 | 946 | 963 | 979 | 1 | 1.8 | 1.7 | 1.6 |
| 63 | 996 | *012 | *029 | *045 | *062 | *078 | *095 | *111 | *127 | *144 | 2 | 3.6 | 3.4 | 3.2 |
| 64 | 42 160 | 177 | 193 | 210 | 226 | 243 | 259 | 275 | 292 | 308 | 3 | 5.4 | 5.1 | 4.8 |
| 65 | 325 | 341 | 357 | 374 | 390 | 406 | 423 | 439 | 455 | 472 | 4 | 7.2 | 6.8 | 6.4 |
| 66 | 488 | 504 | 521 | 537 | 553 | 570 | 586 | 602 | 619 | 635 | 5 | 9.0 | 8.5 | 8.0 |
| 67 | 651 | 667 | 684 | 700 | 716 | 732 | 749 | 765 | 781 | 797 | 6 | 10.8 | 10.2 | 9.6 |
| 68 | 813 | 830 | 846 | 862 | 878 | 894 | 911 | 927 | 943 | 959 | 7 | 12.6 | 11.9 | 11.2 |
| 69 | 975 | 991 | *008 | *024 | *040 | *056 | *072 | *088 | *104 | *120 | 8 | 14.4 | 13.6 | 12.8 |
| 270 | 43 136 | 152 | 169 | 185 | 201 | 217 | 233 | 249 | 265 | 281 | 9 | 16.2 | 15.3 | 14.4 |
| 71 | 297 | 313 | 329 | 345 | 361 | 377 | 393 | 409 | 425 | 441 | | | | |
| 72 | 457 | 473 | 489 | 505 | 521 | 537 | 553 | 569 | 584 | 600 | | | | |
| 73 | 616 | 632 | 648 | 664 | 680 | 696 | 712 | 727 | 743 | 759 | | | | |
| 74 | 775 | 791 | 807 | 823 | 838 | 854 | 870 | 886 | 902 | 917 | | | | |
| 75 | 933 | 949 | 965 | 981 | 996 | *012 | *028 | *044 | *059 | *075 | | | | |
| 76 | 44 091 | 107 | 122 | 138 | 154 | 170 | 185 | 201 | 217 | 232 | | | | |
| 77 | 248 | 264 | 279 | 295 | 311 | 326 | 342 | 358 | 373 | 389 | | | | |
| 78 | 404 | 420 | 436 | 451 | 467 | 483 | 498 | 514 | 529 | 545 | | | | |
| 79 | 560 | 576 | 592 | 607 | 623 | 638 | 654 | 669 | 685 | 700 | | | | |
| 280 | 716 | 731 | 747 | 762 | 778 | 793 | 809 | 824 | 840 | 855 | | | | |
| 81 | 871 | 886 | 902 | 917 | 932 | 948 | 963 | 979 | 994 | *010 | | 15 | 14 | |
| 82 | 45 025 | 040 | 056 | 071 | 086 | 102 | 117 | 133 | 148 | 163 | 1 | 1.5 | 1.4 | |
| 83 | 179 | 194 | 209 | 225 | 240 | 255 | 271 | 286 | 301 | 317 | 2 | 3.0 | 2.8 | |
| 84 | 332 | 347 | 362 | 378 | 393 | 408 | 423 | 439 | 454 | 469 | 3 | 4.5 | 4.2 | |
| 85 | 484 | 500 | 515 | 530 | 545 | 561 | 576 | 591 | 606 | 621 | 4 | 6.0 | 5.6 | |
| 86 | 637 | 652 | 667 | 682 | 697 | 712 | 728 | 743 | 758 | 773 | 5 | 7.5 | 7.0 | |
| 87 | 788 | 803 | 818 | 834 | 849 | 864 | 879 | 894 | 909 | 924 | 6 | 9.0 | 8.4 | |
| 88 | 939 | 954 | 969 | 984 | *000 | *015 | *030 | *045 | *060 | *075 | 7 | 10.5 | 9.8 | |
| 89 | 46 090 | 105 | 120 | 135 | 150 | 165 | 180 | 195 | 210 | 225 | 8 | 12.0 | 11.2 | |
| 290 | 240 | 255 | 270 | 285 | 300 | 315 | 330 | 345 | 359 | 374 | 9 | 13.5 | 12.6 | |
| 91 | 389 | 404 | 419 | 434 | 449 | 464 | 479 | 494 | 509 | 523 | | | | |
| 92 | 538 | 553 | 568 | 583 | 598 | 613 | 627 | 642 | 657 | 672 | | | | |
| 93 | 687 | 702 | 716 | 731 | 746 | 761 | 776 | 790 | 805 | 820 | | | | |
| 94 | 835 | 850 | 864 | 879 | 894 | 909 | 923 | 938 | 953 | 967 | | | | |
| 95 | 982 | 997 | *012 | *026 | *041 | *056 | *070 | *085 | *100 | *114 | | | | |
| 96 | 47 129 | 144 | 159 | 173 | 188 | 202 | 217 | 232 | 246 | 261 | | | | |
| 97 | 276 | 290 | 305 | 319 | 334 | 349 | 363 | 378 | 392 | 407 | | | | |
| 98 | 422 | 436 | 451 | 465 | 480 | 494 | 509 | 524 | 538 | 553 | | | | |
| 99 | 567 | 582 | 596 | 611 | 625 | 640 | 654 | 669 | 683 | 698 | | | | |
| 300 | 712 | 727 | 741 | 756 | 770 | 784 | 799 | 813 | 828 | 842 | | | | |
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Prop. Pts. | | | |

Table 3. Number Logarithms

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Prop. Pts. | | |
|------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|------------|-----------|-----------|
| 300 | 47 712 | 727 | 741 | 756 | 770 | 784 | 799 | 813 | 828 | 842 | | | |
| 01 | 857 | 871 | 885 | 900 | 914 | 929 | 943 | 958 | 972 | 986 | | | |
| 02 | 48 001 | 015 | 029 | 044 | 058 | 073 | 087 | 101 | 116 | 130 | | | |
| 03 | 144 | 159 | 173 | 187 | 202 | 216 | 230 | 244 | 259 | 273 | | | |
| 04 | 287 | 302 | 316 | 330 | 344 | 359 | 373 | 387 | 401 | 416 | | | |
| 05 | 430 | 444 | 458 | 473 | 487 | 501 | 515 | 530 | 544 | 558 | | | |
| 06 | 572 | 586 | 601 | 615 | 629 | 643 | 657 | 671 | 686 | 700 | | | |
| 07 | 714 | 728 | 742 | 756 | 770 | 785 | 799 | 813 | 827 | 841 | | | |
| 08 | 855 | 869 | 883 | 897 | 911 | 926 | 940 | 954 | 968 | 982 | | | |
| 09 | 996 | *010 | *024 | *038 | *052 | *066 | *080 | *094 | *108 | *122 | | | |
| 310 | 49 136 | 150 | 164 | 178 | 192 | 206 | 220 | 234 | 248 | 262 | | | |
| 11 | 276 | 290 | 304 | 318 | 332 | 346 | 360 | 374 | 388 | 402 | | 15 | 14 |
| 12 | 415 | 429 | 443 | 457 | 471 | 485 | 499 | 513 | 527 | 541 | 1 | 1.5 | 1.4 |
| 13 | 554 | 568 | 582 | 596 | 610 | 624 | 638 | 651 | 665 | 679 | 2 | 3.0 | 2.8 |
| 14 | 693 | 707 | 721 | 734 | 748 | 762 | 776 | 790 | 803 | 817 | 3 | 4.5 | 4.2 |
| 15 | 831 | 845 | 859 | 872 | 886 | 900 | 914 | 927 | 941 | 955 | 4 | 6.0 | 5.6 |
| 16 | 969 | 982 | 996 | *010 | *024 | *037 | *051 | *065 | *079 | *092 | 5 | 7.5 | 7.0 |
| 17 | 50 106 | 120 | 133 | 147 | 161 | 174 | 188 | 202 | 215 | 229 | 6 | 9.0 | 8.4 |
| 18 | 243 | 256 | 270 | 284 | 297 | 311 | 325 | 338 | 352 | 365 | 7 | 10.5 | 9.8 |
| 19 | 379 | 393 | 406 | 420 | 433 | 447 | 461 | 474 | 488 | 501 | 8 | 12.0 | 11.2 |
| 320 | 515 | 529 | 542 | 556 | 569 | 583 | 596 | 610 | 623 | 637 | 9 | 13.5 | 12.6 |
| 21 | 651 | 664 | 678 | 691 | 705 | 718 | 732 | 745 | 759 | 772 | | | |
| 22 | 786 | 799 | 813 | 826 | 840 | 853 | 866 | 880 | 893 | 907 | | | |
| 23 | 920 | 934 | 947 | 961 | 974 | 987 | *001 | *014 | *028 | *041 | | | |
| 24 | 51 055 | 068 | 081 | 095 | 108 | 121 | 135 | 148 | 162 | 175 | | | |
| 25 | 188 | 202 | 215 | 228 | 242 | 255 | 268 | 282 | 295 | 308 | | | |
| 26 | 322 | 335 | 348 | 362 | 375 | 388 | 402 | 415 | 428 | 441 | | | |
| 27 | 455 | 468 | 481 | 495 | 508 | 521 | 534 | 548 | 561 | 574 | | | |
| 28 | 587 | 601 | 614 | 627 | 640 | 654 | 667 | 680 | 693 | 706 | | | |
| 29 | 720 | 733 | 746 | 759 | 772 | 786 | 799 | 812 | 825 | 838 | | | |
| 330 | 851 | 865 | 878 | 891 | 904 | 917 | 930 | 943 | 957 | 970 | | | |
| 31 | 983 | 996 | *009 | *022 | *035 | *048 | *061 | *075 | *088 | *101 | | 13 | 12 |
| 32 | 52 114 | 127 | 140 | 153 | 166 | 179 | 192 | 205 | 218 | 231 | 1 | 1.3 | 1.2 |
| 33 | 244 | 257 | 270 | 284 | 297 | 310 | 323 | 336 | 349 | 362 | 2 | 2.6 | 2.4 |
| 34 | 375 | 388 | 401 | 414 | 427 | 440 | 453 | 466 | 479 | 492 | 3 | 3.9 | 3.6 |
| 35 | 504 | 517 | 530 | 543 | 556 | 569 | 582 | 595 | 608 | 621 | 4 | 5.2 | 4.8 |
| 36 | 634 | 647 | 660 | 673 | 686 | 699 | 711 | 724 | 737 | 750 | 5 | 6.5 | 6.0 |
| 37 | 763 | 776 | 789 | 802 | 815 | 827 | 840 | 853 | 866 | 879 | 6 | 7.8 | 7.2 |
| 38 | 892 | 905 | 917 | 930 | 943 | 956 | 969 | 982 | 994 | *007 | 7 | 9.1 | 8.4 |
| 39 | 53 020 | 033 | 046 | 058 | 071 | 084 | 097 | 110 | 122 | 135 | 8 | 10.4 | 9.6 |
| 340 | 148 | 161 | 173 | 186 | 199 | 212 | 224 | 237 | 250 | 263 | 9 | 11.7 | 10.8 |
| 41 | 275 | 288 | 301 | 314 | 326 | 339 | 352 | 364 | 377 | 390 | | | |
| 42 | 403 | 415 | 428 | 441 | 453 | 466 | 479 | 491 | 504 | 517 | | | |
| 43 | 529 | 542 | 555 | 567 | 580 | 593 | 605 | 618 | 631 | 643 | | | |
| 44 | 656 | 668 | 681 | 694 | 706 | 719 | 732 | 744 | 757 | 769 | | | |
| 45 | 782 | 794 | 807 | 820 | 832 | 845 | 857 | 870 | 882 | 895 | | | |
| 46 | 908 | 920 | 933 | 945 | 958 | 970 | 983 | 995 | *008 | *020 | | | |
| 47 | 54 033 | 045 | 058 | 070 | 083 | 095 | 108 | 120 | 133 | 145 | | | |
| 48 | 158 | 170 | 183 | 195 | 208 | 220 | 233 | 245 | 258 | 270 | | | |
| 49 | 283 | 295 | 307 | 320 | 332 | 345 | 357 | 370 | 382 | 394 | | | |
| 350 | 407 | 419 | 432 | 444 | 456 | 469 | 481 | 494 | 506 | 518 | | | |
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Prop. Pts. | | |

Table 3. Number Logarithms

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Prop. Pts. | | | |
|------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-------------------|--|--|--|
| 350 | 54 407 | 419 | 432 | 444 | 456 | 469 | 481 | 494 | 506 | 518 | | | | |
| 51 | 531 | 543 | 555 | 568 | 580 | 593 | 605 | 617 | 630 | 642 | | | | |
| 52 | 654 | 667 | 679 | 691 | 704 | 716 | 728 | 741 | 753 | 765 | | | | |
| 53 | 777 | 790 | 802 | 814 | 827 | 839 | 851 | 864 | 876 | 888 | | | | |
| 54 | 900 | 913 | 925 | 937 | 949 | 962 | 974 | 986 | 998 | *011 | | | | |
| 55 | 55 023 | 035 | 047 | 060 | 072 | 084 | 096 | 108 | 121 | 133 | | | | |
| 56 | 145 | 157 | 169 | 182 | 194 | 206 | 218 | 230 | 242 | 255 | | | | |
| 57 | 267 | 279 | 291 | 303 | 315 | 328 | 340 | 352 | 364 | 376 | | | | |
| 58 | 388 | 400 | 413 | 425 | 437 | 449 | 461 | 473 | 485 | 497 | | | | |
| 59 | 509 | 522 | 534 | 546 | 558 | 570 | 582 | 594 | 606 | 618 | | | | |
| 360 | 630 | 642 | 654 | 666 | 678 | 691 | 703 | 715 | 727 | 739 | | | | |
| 61 | 751 | 763 | 775 | 787 | 799 | 811 | 823 | 835 | 847 | 859 | | | | |
| 62 | 871 | 883 | 895 | 907 | 919 | 931 | 943 | 955 | 967 | 979 | | | | |
| 63 | 991 | *003 | *015 | *027 | *038 | *050 | *062 | *074 | *086 | *098 | | | | |
| 64 | 56 110 | 122 | 134 | 146 | 158 | 170 | 182 | 194 | 205 | 217 | | | | |
| 65 | 229 | 241 | 253 | 265 | 277 | 289 | 301 | 312 | 324 | 336 | | | | |
| 66 | 348 | 360 | 372 | 384 | 396 | 407 | 419 | 431 | 443 | 455 | | | | |
| 67 | 467 | 478 | 490 | 502 | 514 | 526 | 538 | 549 | 561 | 573 | | | | |
| 68 | 585 | 597 | 608 | 620 | 632 | 644 | 656 | 667 | 679 | 691 | | | | |
| 69 | 703 | 714 | 726 | 738 | 750 | 761 | 773 | 785 | 797 | 808 | | | | |
| 370 | 820 | 832 | 844 | 855 | 867 | 879 | 891 | 902 | 914 | 926 | | | | |
| 71 | 937 | 949 | 961 | 972 | 984 | 996 | *008 | *019 | *031 | *043 | | | | |
| 72 | 57 054 | 066 | 078 | 089 | 101 | 113 | 124 | 136 | 148 | 159 | | | | |
| 73 | 171 | 183 | 194 | 206 | 217 | 229 | 241 | 252 | 264 | 276 | | | | |
| 74 | 287 | 299 | 310 | 322 | 334 | 345 | 357 | 368 | 380 | 392 | | | | |
| 75 | 403 | 415 | 426 | 438 | 449 | 461 | 473 | 484 | 496 | 507 | | | | |
| 76 | 519 | 530 | 542 | 553 | 565 | 576 | 588 | 600 | 611 | 623 | | | | |
| 77 | 634 | 646 | 657 | 669 | 680 | 692 | 703 | 715 | 726 | 738 | | | | |
| 78 | 749 | 761 | 772 | 784 | 795 | 807 | 818 | 830 | 841 | 852 | | | | |
| 79 | 864 | 875 | 887 | 898 | 910 | 921 | 933 | 944 | 955 | 967 | | | | |
| 380 | 978 | 990 | *001 | *013 | *024 | *035 | *047 | *058 | *070 | *081 | | | | |
| 81 | 58 092 | 104 | 115 | 127 | 138 | 149 | 161 | 172 | 184 | 195 | | | | |
| 82 | 206 | 218 | 229 | 240 | 252 | 263 | 274 | 286 | 297 | 309 | | | | |
| 83 | 320 | 331 | 343 | 354 | 365 | 377 | 388 | 399 | 410 | 422 | | | | |
| 84 | 433 | 444 | 456 | 467 | 478 | 490 | 501 | 512 | 524 | 535 | | | | |
| 85 | 546 | 557 | 569 | 580 | 591 | 602 | 614 | 625 | 636 | 647 | | | | |
| 86 | 659 | 670 | 681 | 692 | 704 | 715 | 726 | 737 | 749 | 760 | | | | |
| 87 | 771 | 782 | 794 | 805 | 816 | 827 | 838 | 850 | 861 | 872 | | | | |
| 88 | 883 | 894 | 906 | 917 | 928 | 939 | 950 | 961 | 973 | 984 | | | | |
| 89 | 995 | *006 | *017 | *028 | *040 | *051 | *062 | *073 | *084 | *095 | | | | |
| 390 | 59 106 | 118 | 129 | 140 | 151 | 162 | 173 | 184 | 195 | 207 | | | | |
| 91 | 218 | 229 | 240 | 251 | 262 | 273 | 284 | 295 | 306 | 318 | | | | |
| 92 | 329 | 340 | 351 | 362 | 373 | 384 | 395 | 406 | 417 | 428 | | | | |
| 93 | 439 | 450 | 461 | 472 | 483 | 494 | 506 | 517 | 528 | 539 | | | | |
| 94 | 550 | 561 | 572 | 583 | 594 | 605 | 616 | 627 | 638 | 649 | | | | |
| 95 | 660 | 671 | 682 | 693 | 704 | 715 | 726 | 737 | 748 | 759 | | | | |
| 96 | 770 | 780 | 791 | 802 | 813 | 824 | 835 | 846 | 857 | 868 | | | | |
| 97 | 879 | 890 | 901 | 912 | 923 | 934 | 945 | 956 | 966 | 977 | | | | |
| 98 | 988 | 999 | *010 | *021 | *032 | *043 | *054 | *065 | *076 | *086 | | | | |
| 99 | 60 097 | 108 | 119 | 130 | 141 | 152 | 163 | 173 | 184 | 195 | | | | |
| 400 | 206 | 217 | 228 | 239 | 249 | 260 | 271 | 282 | 293 | 304 | | | | |
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Prop. Pts. | | | |

| | 13 | 12 |
|---|-----------|-----------|
| 1 | 1.3 | 1.2 |
| 2 | 2.6 | 2.4 |
| 3 | 3.9 | 3.6 |
| 4 | 5.2 | 4.8 |
| 5 | 6.5 | 6.0 |
| 6 | 7.8 | 7.2 |
| 7 | 9.1 | 8.4 |
| 8 | 10.4 | 9.6 |
| 9 | 11.7 | 10.8 |

| | 11 | 10 |
|---|-----------|-----------|
| 1 | 1.1 | 1.0 |
| 2 | 2.2 | 2.0 |
| 3 | 3.3 | 3.0 |
| 4 | 4.4 | 4.0 |
| 5 | 5.5 | 5.0 |
| 6 | 6.6 | 6.0 |
| 7 | 7.7 | 7.0 |
| 8 | 8.8 | 8.0 |
| 9 | 9.9 | 9.0 |

Table 3. Number Logarithms

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Prop. Pts. | | | |
|------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-------------------|-----------|----------|-----|
| 400 | 60 206 | 217 | 228 | 239 | 249 | 260 | 271 | 282 | 293 | 304 | | | | |
| 01 | 314 | 325 | 336 | 347 | 358 | 369 | 379 | 390 | 401 | 412 | | | | |
| 02 | 423 | 433 | 444 | 455 | 466 | 477 | 487 | 498 | 509 | 520 | | | | |
| 03 | 531 | 541 | 552 | 563 | 574 | 584 | 595 | 606 | 617 | 627 | | | | |
| 04 | 638 | 649 | 660 | 670 | 681 | 692 | 703 | 713 | 724 | 735 | | | | |
| 05 | 746 | 756 | 767 | 778 | 788 | 799 | 810 | 821 | 831 | 842 | | | | |
| 06 | 853 | 863 | 874 | 885 | 895 | 906 | 917 | 927 | 938 | 949 | | | | |
| 07 | 959 | 970 | 981 | 991 | *002 | *013 | *023 | *034 | *045 | *055 | | | | |
| 08 | 61 066 | 077 | 087 | 098 | 109 | 119 | 130 | 140 | 151 | 162 | | | | |
| 09 | 172 | 183 | 194 | 204 | 215 | 225 | 236 | 247 | 257 | 268 | | | | |
| 410 | 278 | 289 | 300 | 310 | 321 | 331 | 342 | 352 | 363 | 374 | | | | |
| 11 | 384 | 395 | 405 | 416 | 426 | 437 | 448 | 458 | 469 | 479 | | | | |
| 12 | 490 | 500 | 511 | 521 | 532 | 542 | 553 | 563 | 574 | 584 | | | | |
| 13 | 595 | 606 | 616 | 627 | 637 | 648 | 658 | 669 | 679 | 690 | | | | |
| 14 | 700 | 711 | 721 | 731 | 742 | 752 | 763 | 773 | 784 | 794 | | | | |
| 15 | 805 | 815 | 826 | 836 | 847 | 857 | 868 | 878 | 888 | 899 | | | | |
| 16 | 909 | 920 | 930 | 941 | 951 | 962 | 972 | 982 | 993 | *003 | | | | |
| 17 | 62 014 | 024 | 034 | 045 | 055 | 066 | 076 | 086 | 097 | 107 | | | | |
| 18 | 118 | 128 | 138 | 149 | 159 | 170 | 180 | 190 | 201 | 211 | | | | |
| 19 | 221 | 232 | 242 | 252 | 263 | 273 | 284 | 294 | 304 | 315 | | | | |
| 420 | 325 | 335 | 346 | 356 | 366 | 377 | 387 | 397 | 408 | 418 | | | | |
| 21 | 428 | 439 | 449 | 459 | 469 | 480 | 490 | 500 | 511 | 521 | 11 | 10 | 9 | |
| 22 | 531 | 542 | 552 | 562 | 572 | 583 | 593 | 603 | 613 | 624 | 1 | 1.1 | 1.0 | 0.9 |
| 23 | 634 | 644 | 655 | 665 | 675 | 685 | 696 | 706 | 716 | 726 | 2 | 2.2 | 2.0 | 1.8 |
| 24 | 737 | 747 | 757 | 767 | 778 | 788 | 798 | 808 | 818 | 829 | 3 | 3.3 | 3.0 | 2.7 |
| 25 | 839 | 849 | 859 | 870 | 880 | 890 | 900 | 910 | 921 | 931 | 4 | 4.4 | 4.0 | 3.6 |
| 26 | 941 | 951 | 961 | 972 | 982 | 992 | *002 | *012 | *022 | *033 | 5 | 5.5 | 5.0 | 4.5 |
| 27 | 63 043 | 053 | 063 | 073 | 083 | 094 | 104 | 114 | 124 | 134 | 6 | 6.6 | 6.0 | 5.4 |
| 28 | 144 | 155 | 165 | 175 | 185 | 195 | 205 | 215 | 225 | 236 | 7 | 7.7 | 7.0 | 6.3 |
| 29 | 246 | 256 | 266 | 276 | 286 | 296 | 306 | 317 | 327 | 337 | 8 | 8.8 | 8.0 | 7.2 |
| 430 | 347 | 357 | 367 | 377 | 387 | 397 | 407 | 417 | 428 | 438 | 9 | 9.9 | 9.0 | 8.1 |
| 31 | 448 | 458 | 468 | 478 | 488 | 498 | 508 | 518 | 528 | 538 | | | | |
| 32 | 548 | 558 | 568 | 579 | 589 | 599 | 609 | 619 | 629 | 639 | | | | |
| 33 | 649 | 659 | 669 | 679 | 689 | 699 | 709 | 719 | 729 | 739 | | | | |
| 34 | 749 | 759 | 769 | 779 | 789 | 799 | 809 | 819 | 829 | 839 | | | | |
| 35 | 849 | 859 | 869 | 879 | 889 | 899 | 909 | 919 | 929 | 939 | | | | |
| 36 | 949 | 959 | 969 | 979 | 988 | 998 | *008 | *018 | *028 | *038 | | | | |
| 37 | 64 048 | 058 | 068 | 078 | 088 | 098 | 108 | 118 | 128 | 137 | | | | |
| 38 | 147 | 157 | 167 | 177 | 187 | 197 | 207 | 217 | 227 | 237 | | | | |
| 39 | 246 | 256 | 266 | 276 | 286 | 296 | 306 | 316 | 326 | 335 | | | | |
| 440 | 345 | 355 | 365 | 375 | 385 | 395 | 404 | 414 | 424 | 434 | | | | |
| 41 | 444 | 454 | 464 | 473 | 483 | 493 | 503 | 513 | 523 | 532 | | | | |
| 42 | 542 | 552 | 562 | 572 | 582 | 591 | 601 | 611 | 621 | 631 | | | | |
| 43 | 640 | 650 | 660 | 670 | 680 | 689 | 699 | 709 | 719 | 729 | | | | |
| 44 | 738 | 748 | 758 | 768 | 777 | 787 | 797 | 807 | 816 | 826 | | | | |
| 45 | 836 | 846 | 856 | 865 | 875 | 885 | 895 | 904 | 914 | 924 | | | | |
| 46 | 933 | 943 | 953 | 963 | 972 | 982 | 992 | *002 | *011 | *021 | | | | |
| 47 | 65 031 | 040 | 050 | 060 | 070 | 079 | 089 | 099 | 108 | 118 | | | | |
| 48 | 128 | 137 | 147 | 157 | 167 | 176 | 186 | 196 | 205 | 215 | | | | |
| 49 | 225 | 234 | 244 | 254 | 263 | 273 | 283 | 292 | 302 | 312 | | | | |
| 450 | 321 | 331 | 341 | 350 | 360 | 369 | 379 | 389 | 398 | 408 | | | | |
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Prop. Pts. | | | |

Table 3. Number Logarithms

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Prop. Pts. | | |
|------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-------------------|--|--|
| 450 | 65 321 | 331 | 341 | 350 | 360 | 369 | 379 | 389 | 398 | 408 | | | |
| 51 | 418 | 427 | 437 | 447 | 456 | 466 | 475 | 485 | 495 | 504 | | | |
| 52 | 514 | 523 | 533 | 543 | 552 | 562 | 571 | 581 | 591 | 600 | | | |
| 53 | 610 | 619 | 629 | 639 | 648 | 658 | 667 | 677 | 686 | 696 | | | |
| 54 | 706 | 715 | 725 | 734 | 744 | 753 | 763 | 772 | 782 | 792 | | | |
| 55 | 801 | 811 | 820 | 830 | 839 | 849 | 858 | 868 | 877 | 887 | | | |
| 56 | 896 | 906 | 916 | 925 | 935 | 944 | 954 | 963 | 973 | 982 | | | |
| 57 | 992 | *001 | *011 | *020 | *030 | *039 | *049 | *058 | *068 | *077 | | | |
| 58 | 66 087 | 096 | 106 | 115 | 124 | 134 | 143 | 153 | 162 | 172 | | | |
| 59 | 181 | 191 | 200 | 210 | 219 | 229 | 238 | 247 | 257 | 266 | | | |
| 460 | 276 | 285 | 295 | 304 | 314 | 323 | 332 | 342 | 351 | 361 | | | |
| 61 | 370 | 380 | 389 | 398 | 408 | 417 | 427 | 436 | 445 | 455 | | | |
| 62 | 464 | 474 | 483 | 492 | 502 | 511 | 521 | 530 | 539 | 549 | | | |
| 63 | 558 | 567 | 577 | 586 | 596 | 605 | 614 | 624 | 633 | 642 | | | |
| 64 | 652 | 661 | 671 | 680 | 689 | 699 | 708 | 717 | 727 | 736 | | | |
| 65 | 745 | 755 | 764 | 773 | 783 | 792 | 801 | 811 | 820 | 829 | | | |
| 66 | 839 | 848 | 857 | 867 | 876 | 885 | 894 | 904 | 913 | 922 | | | |
| 67 | 932 | 941 | 950 | 960 | 969 | 978 | 987 | 997 | *006 | *015 | | | |
| 68 | 67 025 | 034 | 043 | 052 | 062 | 071 | 080 | 089 | 099 | 108 | | | |
| 69 | 117 | 127 | 136 | 145 | 154 | 164 | 173 | 182 | 191 | 201 | | | |
| 470 | 210 | 219 | 228 | 237 | 247 | 256 | 265 | 274 | 284 | 293 | | | |
| 71 | 302 | 311 | 321 | 330 | 339 | 348 | 357 | 367 | 376 | 385 | | | |
| 72 | 394 | 403 | 413 | 422 | 431 | 440 | 449 | 459 | 468 | 477 | | | |
| 73 | 486 | 495 | 504 | 514 | 523 | 532 | 541 | 550 | 560 | 569 | | | |
| 74 | 578 | 587 | 596 | 605 | 614 | 624 | 633 | 642 | 651 | 660 | | | |
| 75 | 669 | 679 | 688 | 697 | 706 | 715 | 724 | 733 | 742 | 752 | | | |
| 76 | 761 | 770 | 779 | 788 | 797 | 806 | 815 | 825 | 834 | 843 | | | |
| 77 | 852 | 861 | 870 | 879 | 888 | 897 | 906 | 916 | 925 | 934 | | | |
| 78 | 943 | 952 | 961 | 970 | 979 | 988 | 997 | *006 | *015 | *024 | | | |
| 79 | 68 034 | 043 | 052 | 061 | 070 | 079 | 088 | 097 | 106 | 115 | | | |
| 480 | 124 | 133 | 142 | 151 | 160 | 169 | 178 | 187 | 196 | 205 | | | |
| 81 | 215 | 224 | 233 | 242 | 251 | 260 | 269 | 278 | 287 | 296 | | | |
| 82 | 305 | 314 | 323 | 332 | 341 | 350 | 359 | 368 | 377 | 386 | | | |
| 83 | 395 | 404 | 413 | 422 | 431 | 440 | 449 | 458 | 467 | 476 | | | |
| 84 | 485 | 494 | 502 | 511 | 520 | 529 | 538 | 547 | 556 | 565 | | | |
| 85 | 574 | 583 | 592 | 601 | 610 | 619 | 628 | 637 | 646 | 655 | | | |
| 86 | 664 | 673 | 681 | 690 | 699 | 708 | 717 | 726 | 735 | 744 | | | |
| 87 | 753 | 762 | 771 | 780 | 789 | 797 | 806 | 815 | 824 | 833 | | | |
| 88 | 842 | 851 | 860 | 869 | 878 | 886 | 895 | 904 | 913 | 922 | | | |
| 89 | 931 | 940 | 949 | 958 | 966 | 975 | 984 | 993 | *002 | *011 | | | |
| 490 | 69 020 | 028 | 037 | 046 | 055 | 064 | 073 | 082 | 090 | 099 | | | |
| 91 | 108 | 117 | 126 | 135 | 144 | 152 | 161 | 170 | 179 | 188 | | | |
| 92 | 197 | 205 | 214 | 223 | 232 | 241 | 249 | 258 | 267 | 276 | | | |
| 93 | 285 | 294 | 302 | 311 | 320 | 329 | 338 | 346 | 355 | 364 | | | |
| 94 | 373 | 381 | 390 | 399 | 408 | 417 | 425 | 434 | 443 | 452 | | | |
| 95 | 461 | 469 | 478 | 487 | 496 | 504 | 513 | 522 | 531 | 539 | | | |
| 96 | 548 | 557 | 566 | 574 | 583 | 592 | 601 | 609 | 618 | 627 | | | |
| 97 | 636 | 644 | 653 | 662 | 671 | 679 | 688 | 697 | 705 | 714 | | | |
| 98 | 723 | 732 | 740 | 749 | 758 | 767 | 775 | 784 | 793 | 801 | | | |
| 99 | 810 | 819 | 827 | 836 | 845 | 854 | 862 | 871 | 880 | 888 | | | |
| 500 | 897 | 906 | 914 | 923 | 932 | 940 | 949 | 958 | 966 | 975 | | | |
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Prop. Pts. | | |

| | 10 | 9 | 8 |
|---|-----|-----|-----|
| 1 | 1.0 | 0.9 | 0.8 |
| 2 | 2.0 | 1.8 | 1.6 |
| 3 | 3.0 | 2.7 | 2.4 |
| 4 | 4.0 | 3.6 | 3.2 |
| 5 | 5.0 | 4.5 | 4.0 |
| 6 | 6.0 | 5.4 | 4.8 |
| 7 | 7.0 | 6.3 | 5.6 |
| 8 | 8.0 | 7.2 | 6.4 |
| 9 | 9.0 | 8.1 | 7.2 |

Table 3. Number Logarithms

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Prop. Pts. | | | |
|------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-------------------|-----|-----|-----|
| 500 | 69 897 | 906 | 914 | 923 | 932 | 940 | 949 | 958 | 966 | 975 | | | | |
| 01 | 984 | 992 | *001 | *010 | *018 | *027 | *036 | *044 | *053 | *062 | | | | |
| 02 | 70 070 | 079 | 088 | 096 | 105 | 114 | 122 | 131 | 140 | 148 | | | | |
| 03 | 157 | 165 | 174 | 183 | 191 | 200 | 209 | 217 | 226 | 234 | | | | |
| 04 | 243 | 252 | 260 | 269 | 278 | 286 | 295 | 303 | 312 | 321 | | | | |
| 05 | 329 | 338 | 346 | 355 | 364 | 372 | 381 | 389 | 398 | 406 | | | | |
| 06 | 415 | 424 | 432 | 441 | 449 | 458 | 467 | 475 | 484 | 492 | | | | |
| 07 | 501 | 509 | 518 | 526 | 535 | 544 | 552 | 561 | 569 | 578 | | | | |
| 08 | 586 | 595 | 603 | 612 | 621 | 629 | 638 | 646 | 655 | 663 | | | | |
| 09 | 672 | 680 | 689 | 697 | 706 | 714 | 723 | 731 | 740 | 749 | | | | |
| 510 | 757 | 766 | 774 | 783 | 791 | 800 | 808 | 817 | 825 | 834 | | | | |
| 11 | 842 | 851 | 859 | 868 | 876 | 885 | 893 | 902 | 910 | 919 | | | | |
| 12 | 927 | 935 | 944 | 952 | 961 | 969 | 978 | 986 | 995 | *003 | | | | |
| 13 | 71 012 | 020 | 029 | 037 | 046 | 054 | 063 | 071 | 079 | 088 | | | | |
| 14 | 096 | 105 | 113 | 122 | 130 | 139 | 147 | 155 | 164 | 172 | | | | |
| 15 | 181 | 189 | 198 | 206 | 214 | 223 | 231 | 240 | 248 | 257 | | | | |
| 16 | 265 | 273 | 282 | 290 | 299 | 307 | 315 | 324 | 332 | 341 | | | | |
| 17 | 349 | 357 | 366 | 374 | 383 | 391 | 399 | 408 | 416 | 425 | | | | |
| 18 | 433 | 441 | 450 | 458 | 466 | 475 | 483 | 492 | 500 | 508 | | | | |
| 19 | 517 | 525 | 533 | 542 | 550 | 559 | 567 | 575 | 584 | 592 | | | | |
| 520 | 600 | 609 | 617 | 625 | 634 | 642 | 650 | 659 | 667 | 675 | | | | |
| 21 | 684 | 692 | 700 | 709 | 717 | 725 | 734 | 742 | 750 | 759 | | | | |
| 22 | 767 | 775 | 784 | 792 | 800 | 809 | 817 | 825 | 834 | 842 | | | | |
| 23 | 850 | 858 | 867 | 875 | 883 | 892 | 900 | 908 | 917 | 925 | 1 | 9 | 8 | 7 |
| 24 | 933 | 941 | 950 | 958 | 966 | 975 | 983 | 991 | 999 | *008 | 2 | 0.9 | 0.8 | 0.7 |
| 25 | 72 016 | 024 | 032 | 041 | 049 | 057 | 066 | 074 | 082 | 090 | 3 | 1.8 | 1.6 | 1.4 |
| 26 | 099 | 107 | 115 | 123 | 132 | 140 | 148 | 156 | 165 | 173 | 4 | 2.7 | 2.4 | 2.1 |
| 27 | 181 | 189 | 198 | 206 | 214 | 222 | 230 | 239 | 247 | 255 | 5 | 3.6 | 3.2 | 2.8 |
| 28 | 263 | 272 | 280 | 288 | 296 | 304 | 313 | 321 | 329 | 337 | 6 | 4.5 | 4.0 | 3.5 |
| 29 | 346 | 354 | 362 | 370 | 378 | 387 | 395 | 403 | 411 | 419 | 7 | 5.4 | 4.8 | 4.2 |
| 530 | 428 | 436 | 444 | 452 | 460 | 469 | 477 | 485 | 493 | 501 | 8 | 6.3 | 5.6 | 4.9 |
| 31 | 509 | 518 | 526 | 534 | 542 | 550 | 558 | 567 | 575 | 583 | 9 | 8.1 | 7.2 | 6.3 |
| 32 | 591 | 599 | 607 | 616 | 624 | 632 | 640 | 648 | 656 | 665 | | | | |
| 33 | 673 | 681 | 689 | 697 | 705 | 713 | 722 | 730 | 738 | 746 | | | | |
| 34 | 754 | 762 | 770 | 779 | 787 | 795 | 803 | 811 | 819 | 827 | | | | |
| 35 | 835 | 843 | 852 | 860 | 868 | 876 | 884 | 892 | 900 | 908 | | | | |
| 36 | 916 | 925 | 933 | 941 | 949 | 957 | 965 | 973 | 981 | 989 | | | | |
| 37 | 997 | *006 | *014 | *022 | *030 | *038 | *046 | *054 | *062 | *070 | | | | |
| 38 | 73 078 | 086 | 094 | 102 | 111 | 119 | 127 | 135 | 143 | 151 | | | | |
| 39 | 159 | 167 | 175 | 183 | 191 | 199 | 207 | 215 | 223 | 231 | | | | |
| 540 | 239 | 247 | 255 | 263 | 272 | 280 | 288 | 296 | 304 | 312 | | | | |
| 41 | 320 | 328 | 336 | 344 | 352 | 360 | 368 | 376 | 384 | 392 | | | | |
| 42 | 400 | 408 | 416 | 424 | 432 | 440 | 448 | 456 | 464 | 472 | | | | |
| 43 | 480 | 488 | 496 | 504 | 512 | 520 | 528 | 536 | 544 | 552 | | | | |
| 44 | 560 | 568 | 576 | 584 | 592 | 600 | 608 | 616 | 624 | 632 | | | | |
| 45 | 640 | 648 | 656 | 664 | 672 | 679 | 687 | 695 | 703 | 711 | | | | |
| 46 | 719 | 727 | 735 | 743 | 751 | 759 | 767 | 775 | 783 | 791 | | | | |
| 47 | 799 | 807 | 815 | 823 | 830 | 838 | 846 | 854 | 862 | 870 | | | | |
| 48 | 878 | 886 | 894 | 902 | 910 | 918 | 926 | 933 | 941 | 949 | | | | |
| 49 | 957 | 965 | 973 | 981 | 989 | 997 | *005 | *013 | *020 | *028 | | | | |
| 550 | 74 036 | 044 | 052 | 060 | 068 | 076 | 084 | 092 | 099 | 107 | | | | |
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Prop. Pts. | | | |

Table 3. Number Logarithms

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Prop. Pts. |
|------------|--------|-----|-----|-----|------|------|------|------|------|------|------------|
| 550 | 74 036 | 044 | 052 | 060 | 068 | 076 | 084 | 092 | 099 | 107 | |
| 51 | 115 | 123 | 131 | 139 | 147 | 155 | 162 | 170 | 178 | 186 | |
| 52 | 194 | 202 | 210 | 218 | 225 | 233 | 241 | 249 | 257 | 265 | |
| 53 | 273 | 280 | 288 | 296 | 304 | 312 | 320 | 327 | 335 | 343 | |
| 54 | 351 | 359 | 367 | 374 | 382 | 390 | 398 | 406 | 414 | 421 | |
| 55 | 429 | 437 | 445 | 453 | 461 | 468 | 476 | 484 | 492 | 500 | |
| 56 | 507 | 515 | 523 | 531 | 539 | 547 | 554 | 562 | 570 | 578 | |
| 57 | 586 | 593 | 601 | 609 | 617 | 624 | 632 | 640 | 648 | 656 | |
| 58 | 663 | 671 | 679 | 687 | 695 | 702 | 710 | 718 | 726 | 733 | |
| 59 | 741 | 749 | 757 | 764 | 772 | 780 | 788 | 796 | 803 | 811 | |
| 560 | 819 | 827 | 834 | 842 | 850 | 858 | 865 | 873 | 881 | 889 | |
| 61 | 896 | 904 | 912 | 920 | 927 | 935 | 943 | 950 | 958 | 966 | |
| 62 | 974 | 981 | 989 | 997 | *005 | *012 | *020 | *028 | *035 | *043 | |
| 63 | 75 051 | 059 | 066 | 074 | 082 | 089 | 097 | 105 | 113 | 120 | |
| 64 | 128 | 136 | 143 | 151 | 159 | 166 | 174 | 182 | 189 | 197 | |
| 65 | 205 | 213 | 220 | 228 | 236 | 243 | 251 | 259 | 266 | 274 | |
| 66 | 282 | 289 | 297 | 305 | 312 | 320 | 328 | 335 | 343 | 351 | |
| 67 | 358 | 366 | 374 | 381 | 389 | 397 | 404 | 412 | 420 | 427 | |
| 68 | 435 | 442 | 450 | 458 | 465 | 473 | 481 | 488 | 496 | 504 | |
| 69 | 511 | 519 | 526 | 534 | 542 | 549 | 557 | 565 | 572 | 580 | |
| 570 | 587 | 595 | 603 | 610 | 618 | 626 | 633 | 641 | 648 | 656 | |
| 71 | 664 | 671 | 679 | 686 | 694 | 702 | 709 | 717 | 724 | 732 | |
| 72 | 740 | 747 | 755 | 762 | 770 | 778 | 785 | 793 | 800 | 808 | |
| 73 | 815 | 823 | 831 | 838 | 846 | 853 | 861 | 868 | 876 | 884 | |
| 74 | 891 | 899 | 906 | 914 | 921 | 929 | 937 | 944 | 952 | 959 | |
| 75 | 967 | 974 | 982 | 989 | 997 | *005 | *012 | *020 | *027 | *035 | |
| 76 | 76 042 | 050 | 057 | 065 | 072 | 080 | 087 | 095 | 103 | 110 | |
| 77 | 118 | 125 | 133 | 140 | 148 | 155 | 163 | 170 | 178 | 185 | |
| 78 | 193 | 200 | 208 | 215 | 223 | 230 | 238 | 245 | 253 | 260 | |
| 79 | 268 | 275 | 283 | 290 | 298 | 305 | 313 | 320 | 328 | 335 | |
| 580 | 343 | 350 | 358 | 365 | 373 | 380 | 388 | 395 | 403 | 410 | |
| 81 | 418 | 425 | 433 | 440 | 448 | 455 | 462 | 470 | 477 | 485 | |
| 82 | 492 | 500 | 507 | 515 | 522 | 530 | 537 | 545 | 552 | 559 | |
| 83 | 567 | 574 | 582 | 589 | 597 | 604 | 612 | 619 | 626 | 634 | |
| 84 | 641 | 649 | 656 | 664 | 671 | 678 | 686 | 693 | 701 | 708 | |
| 85 | 716 | 723 | 730 | 738 | 745 | 753 | 760 | 768 | 775 | 782 | |
| 86 | 790 | 797 | 805 | 812 | 819 | 827 | 834 | 842 | 849 | 856 | |
| 87 | 864 | 871 | 879 | 886 | 893 | 901 | 908 | 916 | 923 | 930 | |
| 88 | 938 | 945 | 953 | 960 | 967 | 975 | 982 | 989 | 997 | *004 | |
| 89 | 77 012 | 019 | 026 | 034 | 041 | 048 | 056 | 063 | 070 | 078 | |
| 590 | 085 | 093 | 100 | 107 | 115 | 122 | 129 | 137 | 144 | 151 | |
| 91 | 159 | 166 | 173 | 181 | 188 | 195 | 203 | 210 | 217 | 225 | |
| 92 | 232 | 240 | 247 | 254 | 262 | 269 | 276 | 283 | 291 | 298 | |
| 93 | 305 | 313 | 320 | 327 | 335 | 342 | 349 | 357 | 364 | 371 | |
| 94 | 379 | 386 | 393 | 401 | 408 | 415 | 422 | 430 | 437 | 444 | |
| 95 | 452 | 459 | 466 | 474 | 481 | 488 | 495 | 503 | 510 | 517 | |
| 96 | 525 | 532 | 539 | 546 | 554 | 561 | 568 | 576 | 583 | 590 | |
| 97 | 597 | 605 | 612 | 619 | 627 | 634 | 641 | 648 | 656 | 663 | |
| 98 | 670 | 677 | 685 | 692 | 699 | 706 | 714 | 721 | 728 | 735 | |
| 99 | 743 | 750 | 757 | 764 | 772 | 779 | 786 | 793 | 801 | 808 | |
| 600 | 815 | 822 | 830 | 837 | 844 | 851 | 859 | 866 | 873 | 880 | |
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Prop. Pts. |

| | 8 | 7 |
|---|-----|-----|
| 1 | 0.8 | 0.7 |
| 2 | 1.6 | 1.4 |
| 3 | 2.4 | 2.1 |
| 4 | 3.2 | 2.8 |
| 5 | 4.0 | 3.5 |
| 6 | 4.8 | 4.2 |
| 7 | 5.6 | 4.9 |
| 8 | 6.4 | 5.6 |
| 9 | 7.2 | 6.3 |

Table 3. Number Logarithms

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Prop. Pts. |
|------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-------------------|
| 600 | 77 815 | 822 | 830 | 837 | 844 | 851 | 859 | 866 | 873 | 880 | |
| 01 | 887 | 895 | 902 | 909 | 916 | 924 | 931 | 938 | 945 | 952 | |
| 02 | 960 | 967 | 974 | 981 | 988 | 996 | *003 | *010 | *017 | *025 | |
| 03 | 78 032 | 039 | 046 | 053 | 061 | 068 | 075 | 082 | 089 | 097 | |
| 04 | 104 | 111 | 118 | 125 | 132 | 140 | 147 | 154 | 161 | 168 | |
| 05 | 176 | 183 | 190 | 197 | 204 | 211 | 219 | 226 | 233 | 240 | |
| 06 | 247 | 254 | 262 | 269 | 276 | 283 | 290 | 297 | 305 | 312 | |
| 07 | 319 | 326 | 333 | 340 | 347 | 355 | 362 | 369 | 376 | 383 | |
| 08 | 390 | 398 | 405 | 412 | 419 | 426 | 433 | 440 | 447 | 455 | |
| 09 | 462 | 469 | 476 | 483 | 490 | 497 | 504 | 512 | 519 | 526 | |
| 610 | 533 | 540 | 547 | 554 | 561 | 569 | 576 | 583 | 590 | 597 | |
| 11 | 604 | 611 | 618 | 625 | 633 | 640 | 647 | 654 | 661 | 668 | |
| 12 | 675 | 682 | 689 | 696 | 704 | 711 | 718 | 725 | 732 | 739 | |
| 13 | 746 | 753 | 760 | 767 | 774 | 781 | 789 | 796 | 803 | 810 | |
| 14 | 817 | 824 | 831 | 838 | 845 | 852 | 859 | 866 | 873 | 880 | |
| 15 | 888 | 895 | 902 | 909 | 916 | 923 | 930 | 937 | 944 | 951 | |
| 16 | 958 | 965 | 972 | 979 | 986 | 993 | *000 | *007 | *014 | *021 | |
| 17 | 79 029 | 036 | 043 | 050 | 057 | 064 | 071 | 078 | 085 | 092 | |
| 18 | 099 | 106 | 113 | 120 | 127 | 134 | 141 | 148 | 155 | 162 | |
| 19 | 169 | 176 | 183 | 190 | 197 | 204 | 211 | 218 | 225 | 232 | |
| 620 | 239 | 246 | 253 | 260 | 267 | 274 | 281 | 288 | 295 | 302 | |
| 21 | 309 | 316 | 323 | 330 | 337 | 344 | 351 | 358 | 365 | 372 | |
| 22 | 379 | 386 | 393 | 400 | 407 | 414 | 421 | 428 | 435 | 442 | |
| 23 | 449 | 456 | 463 | 470 | 477 | 484 | 491 | 498 | 505 | 511 | |
| 24 | 518 | 525 | 532 | 539 | 546 | 553 | 560 | 567 | 574 | 581 | |
| 25 | 588 | 595 | 602 | 609 | 616 | 623 | 630 | 637 | 644 | 650 | |
| 26 | 657 | 664 | 671 | 678 | 685 | 692 | 699 | 706 | 713 | 720 | |
| 27 | 727 | 734 | 741 | 748 | 754 | 761 | 768 | 775 | 782 | 789 | |
| 28 | 796 | 803 | 810 | 817 | 824 | 831 | 837 | 844 | 851 | 858 | |
| 29 | 865 | 872 | 879 | 886 | 893 | 900 | 906 | 913 | 920 | 927 | |
| 630 | 934 | 941 | 948 | 955 | 962 | 969 | 975 | 982 | 989 | 996 | |
| 31 | 80 003 | 010 | 017 | 024 | 030 | 037 | 044 | 051 | 058 | 065 | |
| 32 | 072 | 079 | 085 | 092 | 099 | 106 | 113 | 120 | 127 | 134 | |
| 33 | 140 | 147 | 154 | 161 | 168 | 175 | 182 | 188 | 195 | 202 | |
| 34 | 209 | 216 | 223 | 229 | 236 | 243 | 250 | 257 | 264 | 271 | |
| 35 | 277 | 284 | 291 | 298 | 305 | 312 | 318 | 325 | 332 | 339 | |
| 36 | 346 | 353 | 359 | 366 | 373 | 380 | 387 | 393 | 400 | 407 | |
| 37 | 414 | 421 | 428 | 434 | 441 | 448 | 455 | 462 | 468 | 475 | |
| 38 | 482 | 489 | 496 | 502 | 509 | 516 | 523 | 530 | 536 | 543 | |
| 39 | 550 | 557 | 564 | 570 | 577 | 584 | 591 | 598 | 604 | 611 | |
| 640 | 618 | 625 | 632 | 638 | 645 | 652 | 659 | 665 | 672 | 679 | |
| 41 | 686 | 693 | 699 | 706 | 713 | 720 | 726 | 733 | 740 | 747 | |
| 42 | 754 | 760 | 767 | 774 | 781 | 787 | 794 | 801 | 808 | 814 | |
| 43 | 821 | 828 | 835 | 841 | 848 | 855 | 862 | 868 | 875 | 882 | |
| 44 | 889 | 895 | 902 | 909 | 916 | 922 | 929 | 936 | 943 | 949 | |
| 45 | 956 | 963 | 969 | 976 | 983 | 990 | 996 | *003 | *010 | *017 | |
| 46 | 81 023 | 030 | 037 | 043 | 050 | 057 | 064 | 070 | 077 | 084 | |
| 47 | 090 | 097 | 104 | 111 | 117 | 124 | 131 | 137 | 144 | 151 | |
| 48 | 158 | 164 | 171 | 178 | 184 | 191 | 198 | 204 | 211 | 218 | |
| 49 | 224 | 231 | 238 | 245 | 251 | 258 | 265 | 271 | 278 | 285 | |
| 650 | 291 | 298 | 305 | 311 | 318 | 325 | 331 | 338 | 345 | 351 | |
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Prop. Pts. |

| | 8 | 7 | 6 |
|---|-----|-----|-----|
| 1 | 0.8 | 0.7 | 0.6 |
| 2 | 1.6 | 1.4 | 1.2 |
| 3 | 2.4 | 2.1 | 1.8 |
| 4 | 3.2 | 2.8 | 2.4 |
| 5 | 4.0 | 3.5 | 3.0 |
| 6 | 4.8 | 4.2 | 3.6 |
| 7 | 5.6 | 4.9 | 4.2 |
| 8 | 6.4 | 5.6 | 4.8 |
| 9 | 7.2 | 6.3 | 5.4 |

Table 3. Number Logarithms

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Prop. Pts. |
|------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|------------|
| 650 | 81 291 | 298 | 305 | 311 | 318 | 325 | 331 | 338 | 345 | 351 | |
| 51 | 358 | 365 | 371 | 378 | 385 | 391 | 398 | 405 | 411 | 418 | |
| 52 | 425 | 431 | 438 | 445 | 451 | 458 | 465 | 471 | 478 | 485 | |
| 53 | 491 | 498 | 505 | 511 | 518 | 525 | 531 | 538 | 544 | 551 | |
| 54 | 558 | 564 | 571 | 578 | 584 | 591 | 598 | 604 | 611 | 617 | |
| 55 | 624 | 631 | 637 | 644 | 651 | 657 | 664 | 671 | 677 | 684 | |
| 56 | 690 | 697 | 704 | 710 | 717 | 723 | 730 | 737 | 743 | 750 | |
| 57 | 757 | 763 | 770 | 776 | 783 | 790 | 796 | 803 | 809 | 816 | |
| 58 | 823 | 829 | 836 | 842 | 849 | 856 | 862 | 869 | 875 | 882 | |
| 59 | 889 | 895 | 902 | 908 | 915 | 921 | 928 | 935 | 941 | 948 | |
| 660 | 954 | 961 | 968 | 974 | 981 | 987 | 994 | *000 | *007 | *014 | |
| 61 | 82 020 | 027 | 033 | 040 | 046 | 053 | 060 | 066 | 073 | 079 | |
| 62 | 086 | 092 | 099 | 105 | 112 | 119 | 125 | 132 | 138 | 145 | |
| 63 | 151 | 158 | 164 | 171 | 178 | 184 | 191 | 197 | 204 | 210 | |
| 64 | 217 | 223 | 230 | 236 | 243 | 249 | 256 | 263 | 269 | 276 | |
| 65 | 282 | 289 | 295 | 302 | 308 | 315 | 321 | 328 | 334 | 341 | |
| 66 | 347 | 354 | 360 | 367 | 373 | 380 | 387 | 393 | 400 | 406 | |
| 67 | 413 | 419 | 426 | 432 | 439 | 445 | 452 | 458 | 465 | 471 | |
| 68 | 478 | 484 | 491 | 497 | 504 | 510 | 517 | 523 | 530 | 536 | |
| 69 | 543 | 549 | 556 | 562 | 569 | 575 | 582 | 588 | 595 | 601 | |
| 670 | 607 | 614 | 620 | 627 | 633 | 640 | 646 | 653 | 659 | 666 | |
| 71 | 672 | 679 | 685 | 692 | 698 | 705 | 711 | 718 | 724 | 730 | |
| 72 | 737 | 743 | 750 | 756 | 763 | 769 | 776 | 782 | 789 | 795 | |
| 73 | 802 | 808 | 814 | 821 | 827 | 834 | 840 | 847 | 853 | 860 | |
| 74 | 866 | 872 | 879 | 885 | 892 | 898 | 905 | 911 | 918 | 924 | |
| 75 | 930 | 937 | 943 | 950 | 956 | 963 | 969 | 975 | 982 | 988 | |
| 76 | 995 | *001 | *008 | *014 | *020 | *027 | *033 | *040 | *046 | *052 | |
| 77 | 83 059 | 065 | 072 | 078 | 085 | 091 | 097 | 104 | 110 | 117 | |
| 78 | 123 | 129 | 136 | 142 | 149 | 155 | 161 | 168 | 174 | 181 | |
| 79 | 187 | 193 | 200 | 206 | 213 | 219 | 225 | 232 | 238 | 245 | |
| 680 | 251 | 257 | 264 | 270 | 276 | 283 | 289 | 296 | 302 | 308 | |
| 81 | 315 | 321 | 327 | 334 | 340 | 347 | 353 | 359 | 366 | 372 | |
| 82 | 378 | 385 | 391 | 398 | 404 | 410 | 417 | 423 | 429 | 436 | |
| 83 | 442 | 448 | 455 | 461 | 467 | 474 | 480 | 487 | 493 | 499 | |
| 84 | 506 | 512 | 518 | 525 | 531 | 537 | 544 | 550 | 556 | 563 | |
| 85 | 569 | 575 | 582 | 588 | 594 | 601 | 607 | 613 | 620 | 626 | |
| 86 | 632 | 639 | 645 | 651 | 658 | 664 | 670 | 677 | 683 | 689 | |
| 87 | 696 | 702 | 708 | 715 | 721 | 727 | 734 | 740 | 746 | 753 | |
| 88 | 759 | 765 | 771 | 778 | 784 | 790 | 797 | 803 | 809 | 816 | |
| 89 | 822 | 828 | 835 | 841 | 847 | 853 | 860 | 866 | 872 | 879 | |
| 690 | 885 | 891 | 897 | 904 | 910 | 916 | 923 | 929 | 935 | 942 | |
| 91 | 948 | 954 | 960 | 967 | 973 | 979 | 985 | 992 | 998 | *004 | |
| 92 | 84 011 | 017 | 023 | 029 | 036 | 042 | 048 | 055 | 061 | 067 | |
| 93 | 073 | 080 | 086 | 092 | 098 | 105 | 111 | 117 | 123 | 130 | |
| 94 | 136 | 142 | 148 | 155 | 161 | 167 | 173 | 180 | 186 | 192 | |
| 95 | 198 | 205 | 211 | 217 | 223 | 230 | 236 | 242 | 248 | 255 | |
| 96 | 261 | 267 | 273 | 280 | 286 | 292 | 298 | 305 | 311 | 317 | |
| 97 | 323 | 330 | 336 | 342 | 348 | 354 | 361 | 367 | 373 | 379 | |
| 98 | 386 | 392 | 398 | 404 | 410 | 417 | 423 | 429 | 435 | 442 | |
| 99 | 448 | 454 | 460 | 466 | 473 | 479 | 485 | 491 | 497 | 504 | |
| 700 | 510 | 516 | 522 | 528 | 535 | 541 | 547 | 553 | 559 | 566 | |
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | |
| | | | | | | | | | | | Prop. Pts. |

| | 7 | 6 |
|---|-----|-----|
| 1 | 0.7 | 0.6 |
| 2 | 1.4 | 1.2 |
| 3 | 2.1 | 1.8 |
| 4 | 2.8 | 2.4 |
| 5 | 3.5 | 3.0 |
| 6 | 4.2 | 3.6 |
| 7 | 4.9 | 4.2 |
| 8 | 5.6 | 4.8 |
| 9 | 6.3 | 5.4 |

Table 3. Number Logarithms

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Prop. Pts. | | |
|------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-------------------|--|--|
| 700 | 84 510 | 516 | 522 | 528 | 535 | 541 | 547 | 553 | 559 | 566 | | | |
| 01 | 572 | 578 | 584 | 590 | 597 | 603 | 609 | 615 | 621 | 628 | | | |
| 02 | 634 | 640 | 646 | 652 | 658 | 665 | 671 | 677 | 683 | 689 | | | |
| 03 | 696 | 702 | 708 | 714 | 720 | 726 | 733 | 739 | 745 | 751 | | | |
| 04 | 757 | 763 | 770 | 776 | 782 | 788 | 794 | 800 | 807 | 813 | | | |
| 05 | 819 | 825 | 831 | 837 | 844 | 850 | 856 | 862 | 868 | 874 | | | |
| 06 | 880 | 887 | 893 | 899 | 905 | 911 | 917 | 924 | 930 | 936 | | | |
| 07 | 942 | 948 | 954 | 960 | 967 | 973 | 979 | 985 | 991 | 997 | | | |
| 08 | 85 003 | 009 | 016 | 022 | 028 | 034 | 040 | 046 | 052 | 058 | | | |
| 09 | 065 | 071 | 077 | 083 | 089 | 095 | 101 | 107 | 114 | 120 | | | |
| 710 | 126 | 132 | 138 | 144 | 150 | 156 | 163 | 169 | 175 | 181 | | | |
| 11 | 187 | 193 | 199 | 205 | 211 | 217 | 224 | 230 | 236 | 242 | | | |
| 12 | 248 | 254 | 260 | 266 | 272 | 278 | 285 | 291 | 297 | 303 | | | |
| 13 | 309 | 315 | 321 | 327 | 333 | 339 | 345 | 352 | 358 | 364 | | | |
| 14 | 370 | 376 | 382 | 388 | 394 | 400 | 406 | 412 | 418 | 425 | | | |
| 15 | 431 | 437 | 443 | 449 | 455 | 461 | 467 | 473 | 479 | 485 | | | |
| 16 | 491 | 497 | 503 | 509 | 516 | 522 | 528 | 534 | 540 | 546 | | | |
| 17 | 552 | 558 | 564 | 570 | 576 | 582 | 588 | 594 | 600 | 606 | | | |
| 18 | 612 | 618 | 625 | 631 | 637 | 643 | 649 | 655 | 661 | 667 | | | |
| 19 | 673 | 679 | 685 | 691 | 697 | 703 | 709 | 715 | 721 | 727 | | | |
| 720 | 733 | 739 | 745 | 751 | 757 | 763 | 769 | 775 | 781 | 788 | | | |
| 21 | 794 | 800 | 806 | 812 | 818 | 824 | 830 | 836 | 842 | 848 | | | |
| 22 | 854 | 860 | 866 | 872 | 878 | 884 | 890 | 896 | 902 | 908 | | | |
| 23 | 914 | 920 | 926 | 932 | 938 | 944 | 950 | 956 | 962 | 968 | | | |
| 24 | 974 | 980 | 986 | 992 | 998 | *004 | *010 | *016 | *022 | *028 | | | |
| 25 | 86 034 | 040 | 046 | 052 | 058 | 064 | 070 | 076 | 082 | 088 | | | |
| 26 | 094 | 100 | 106 | 112 | 118 | 124 | 130 | 136 | 141 | 147 | | | |
| 27 | 153 | 159 | 165 | 171 | 177 | 183 | 189 | 195 | 201 | 207 | | | |
| 28 | 213 | 219 | 225 | 231 | 237 | 243 | 249 | 255 | 261 | 267 | | | |
| 29 | 273 | 279 | 285 | 291 | 297 | 303 | 308 | 314 | 320 | 326 | | | |
| 730 | 332 | 338 | 344 | 350 | 356 | 362 | 368 | 374 | 380 | 386 | | | |
| 31 | 392 | 398 | 404 | 410 | 415 | 421 | 427 | 433 | 439 | 445 | | | |
| 32 | 451 | 457 | 463 | 469 | 475 | 481 | 487 | 493 | 499 | 504 | | | |
| 33 | 510 | 516 | 522 | 528 | 534 | 540 | 546 | 552 | 558 | 564 | | | |
| 34 | 570 | 576 | 581 | 587 | 593 | 599 | 605 | 611 | 617 | 623 | | | |
| 35 | 629 | 635 | 641 | 646 | 652 | 658 | 664 | 670 | 676 | 682 | | | |
| 36 | 688 | 694 | 700 | 705 | 711 | 717 | 723 | 729 | 735 | 741 | | | |
| 37 | 747 | 753 | 759 | 764 | 770 | 776 | 782 | 788 | 794 | 800 | | | |
| 38 | 806 | 812 | 817 | 823 | 829 | 835 | 841 | 847 | 853 | 859 | | | |
| 39 | 864 | 870 | 876 | 882 | 888 | 894 | 900 | 906 | 911 | 917 | | | |
| 740 | 923 | 929 | 935 | 941 | 947 | 953 | 958 | 964 | 970 | 976 | | | |
| 41 | 982 | 988 | 994 | 999 | *005 | *011 | *017 | *023 | *029 | *035 | | | |
| 42 | 87 040 | 046 | 052 | 058 | 064 | 070 | 075 | 081 | 087 | 093 | | | |
| 43 | 099 | 105 | 111 | 116 | 122 | 128 | 134 | 140 | 146 | 151 | | | |
| 44 | 157 | 163 | 169 | 175 | 181 | 186 | 192 | 198 | 204 | 210 | | | |
| 45 | 216 | 221 | 227 | 233 | 239 | 245 | 251 | 256 | 262 | 268 | | | |
| 46 | 274 | 280 | 286 | 291 | 297 | 303 | 309 | 315 | 320 | 326 | | | |
| 47 | 332 | 338 | 344 | 349 | 355 | 361 | 367 | 373 | 379 | 384 | | | |
| 48 | 390 | 396 | 402 | 408 | 413 | 419 | 425 | 431 | 437 | 442 | | | |
| 49 | 448 | 454 | 460 | 466 | 471 | 477 | 483 | 489 | 495 | 500 | | | |
| 750 | 506 | 512 | 518 | 523 | 529 | 535 | 541 | 547 | 552 | 558 | | | |
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Prop. Pts. | | |

| | 7 | 6 | 5 |
|---|-----|-----|-----|
| 1 | 0.7 | 0.6 | 0.5 |
| 2 | 1.4 | 1.2 | 1.0 |
| 3 | 2.1 | 1.8 | 1.5 |
| 4 | 2.8 | 2.4 | 2.0 |
| 5 | 3.5 | 3.0 | 2.5 |
| 6 | 4.2 | 3.6 | 3.0 |
| 7 | 4.9 | 4.2 | 3.5 |
| 8 | 5.6 | 4.8 | 4.0 |
| 9 | 6.3 | 5.4 | 4.5 |

Table 3. Number Logarithms

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Prop. Pts. | | |
|------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|------------|--|--|
| 750 | 87 506 | 512 | 518 | 523 | 529 | 535 | 541 | 547 | 552 | 558 | | | |
| 51 | 564 | 570 | 576 | 581 | 587 | 593 | 599 | 604 | 610 | 616 | | | |
| 52 | 622 | 628 | 633 | 639 | 645 | 651 | 656 | 662 | 668 | 674 | | | |
| 53 | 679 | 685 | 691 | 697 | 703 | 708 | 714 | 720 | 726 | 731 | | | |
| 54 | 737 | 743 | 749 | 754 | 760 | 766 | 772 | 777 | 783 | 789 | | | |
| 55 | 795 | 800 | 806 | 812 | 818 | 823 | 829 | 835 | 841 | 846 | | | |
| 56 | 852 | 858 | 864 | 869 | 875 | 881 | 887 | 892 | 898 | 904 | | | |
| 57 | 910 | 915 | 921 | 927 | 933 | 938 | 944 | 950 | 955 | 961 | | | |
| 58 | 967 | 973 | 978 | 984 | 990 | 996 | *001 | *007 | *013 | *018 | | | |
| 59 | 88 024 | 030 | 036 | 041 | 047 | 053 | 058 | 064 | 070 | 076 | | | |
| 760 | 081 | 087 | 093 | 098 | 104 | 110 | 116 | 121 | 127 | 133 | | | |
| 61 | 138 | 144 | 150 | 156 | 161 | 167 | 173 | 178 | 184 | 190 | | | |
| 62 | 195 | 201 | 207 | 213 | 218 | 224 | 230 | 235 | 241 | 247 | | | |
| 63 | 252 | 258 | 264 | 270 | 275 | 281 | 287 | 292 | 298 | 304 | | | |
| 64 | 309 | 315 | 321 | 326 | 332 | 338 | 343 | 349 | 355 | 360 | | | |
| 65 | 366 | 372 | 377 | 383 | 389 | 395 | 400 | 406 | 412 | 417 | | | |
| 66 | 423 | 429 | 434 | 440 | 446 | 451 | 457 | 463 | 468 | 474 | | | |
| 67 | 480 | 485 | 491 | 497 | 502 | 508 | 513 | 519 | 525 | 530 | | | |
| 68 | 536 | 542 | 547 | 553 | 559 | 564 | 570 | 576 | 581 | 587 | | | |
| 69 | 593 | 598 | 604 | 610 | 615 | 621 | 627 | 632 | 638 | 643 | | | |
| 770 | 649 | 655 | 660 | 666 | 672 | 677 | 683 | 689 | 694 | 700 | | | |
| 71 | 705 | 711 | 717 | 722 | 728 | 734 | 739 | 745 | 750 | 756 | | | |
| 72 | 762 | 767 | 773 | 779 | 784 | 790 | 795 | 801 | 807 | 812 | | | |
| 73 | 818 | 824 | 829 | 835 | 840 | 846 | 852 | 857 | 863 | 868 | | | |
| 74 | 874 | 880 | 885 | 891 | 897 | 902 | 908 | 913 | 919 | 925 | | | |
| 75 | 930 | 936 | 941 | 947 | 953 | 958 | 964 | 969 | 975 | 981 | | | |
| 76 | 986 | 992 | 997 | *003 | *009 | *014 | *020 | *025 | *031 | *037 | | | |
| 77 | 89 042 | 048 | 053 | 059 | 064 | 070 | 076 | 081 | 087 | 092 | | | |
| 78 | 098 | 104 | 109 | 115 | 120 | 126 | 131 | 137 | 143 | 148 | | | |
| 79 | 154 | 159 | 165 | 170 | 176 | 182 | 187 | 193 | 198 | 204 | | | |
| 780 | 209 | 215 | 221 | 226 | 232 | 237 | 243 | 248 | 254 | 260 | | | |
| 81 | 265 | 271 | 276 | 282 | 287 | 293 | 298 | 304 | 310 | 315 | | | |
| 82 | 321 | 326 | 332 | 337 | 343 | 348 | 354 | 360 | 365 | 371 | | | |
| 83 | 376 | 382 | 387 | 393 | 398 | 404 | 409 | 415 | 421 | 426 | | | |
| 84 | 432 | 437 | 443 | 448 | 454 | 459 | 465 | 470 | 476 | 481 | | | |
| 85 | 487 | 492 | 498 | 504 | 509 | 515 | 520 | 526 | 531 | 537 | | | |
| 86 | 542 | 548 | 553 | 559 | 564 | 570 | 575 | 581 | 586 | 592 | | | |
| 87 | 597 | 603 | 609 | 614 | 620 | 625 | 631 | 636 | 642 | 647 | | | |
| 88 | 653 | 658 | 664 | 669 | 675 | 680 | 686 | 691 | 697 | 702 | | | |
| 89 | 708 | 713 | 719 | 724 | 730 | 735 | 741 | 746 | 752 | 757 | | | |
| 790 | 763 | 768 | 774 | 779 | 785 | 790 | 796 | 801 | 807 | 812 | | | |
| 91 | 818 | 823 | 829 | 834 | 840 | 845 | 851 | 856 | 862 | 867 | | | |
| 92 | 873 | 878 | 883 | 889 | 894 | 900 | 905 | 911 | 916 | 922 | | | |
| 93 | 927 | 933 | 938 | 944 | 949 | 955 | 960 | 966 | 971 | 977 | | | |
| 94 | 982 | 988 | 993 | 998 | *004 | *009 | *015 | *020 | *026 | *031 | | | |
| 95 | 90 037 | 042 | 048 | 053 | 059 | 064 | 069 | 075 | 080 | 086 | | | |
| 96 | 091 | 097 | 102 | 108 | 113 | 119 | 124 | 129 | 135 | 140 | | | |
| 97 | 146 | 151 | 157 | 162 | 168 | 173 | 179 | 184 | 189 | 195 | | | |
| 98 | 200 | 206 | 211 | 217 | 222 | 227 | 233 | 238 | 244 | 249 | | | |
| 99 | 255 | 260 | 266 | 271 | 276 | 282 | 287 | 293 | 298 | 304 | | | |
| 800 | 309 | 314 | 320 | 325 | 331 | 336 | 342 | 347 | 352 | 358 | | | |
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Prop. Pts. | | |

| | 6 | 5 |
|---|-----|-----|
| 1 | 0.6 | 0.5 |
| 2 | 1.2 | 1.0 |
| 3 | 1.8 | 1.5 |
| 4 | 2.4 | 2.0 |
| 5 | 3.0 | 2.5 |
| 6 | 3.6 | 3.0 |
| 7 | 4.2 | 3.5 |
| 8 | 4.8 | 4.0 |
| 9 | 5.4 | 4.5 |

Table 3. Number Logarithms

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Prop. Pts. |
|------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|------------|
| 800 | 90 309 | 314 | 320 | 325 | 331 | 336 | 342 | 347 | 352 | 358 | |
| 01 | 363 | 369 | 374 | 380 | 385 | 390 | 396 | 401 | 407 | 412 | |
| 02 | 417 | 423 | 428 | 434 | 439 | 445 | 450 | 455 | 461 | 466 | |
| 03 | 472 | 477 | 482 | 488 | 493 | 499 | 504 | 509 | 515 | 520 | |
| 04 | 526 | 531 | 536 | 542 | 547 | 553 | 558 | 563 | 569 | 574 | |
| 05 | 580 | 585 | 590 | 596 | 601 | 607 | 612 | 617 | 623 | 628 | |
| 06 | 634 | 639 | 644 | 650 | 655 | 660 | 666 | 671 | 677 | 682 | |
| 07 | 687 | 693 | 698 | 703 | 709 | 714 | 720 | 725 | 730 | 736 | |
| 08 | 741 | 747 | 752 | 757 | 763 | 768 | 773 | 779 | 784 | 789 | |
| 09 | 795 | 800 | 806 | 811 | 816 | 822 | 827 | 832 | 838 | 843 | |
| 810 | 849 | 854 | 859 | 865 | 870 | 875 | 881 | 886 | 891 | 897 | |
| 11 | 902 | 907 | 913 | 918 | 924 | 929 | 934 | 940 | 945 | 950 | |
| 12 | 956 | 961 | 966 | 972 | 977 | 982 | 988 | 993 | 998 | *004 | |
| 13 | 91 009 | 014 | 020 | 025 | 030 | 036 | 041 | 046 | 052 | 057 | |
| 14 | 062 | 068 | 073 | 078 | 084 | 089 | 094 | 100 | 105 | 110 | |
| 15 | 116 | 121 | 126 | 132 | 137 | 142 | 148 | 153 | 158 | 164 | |
| 16 | 169 | 174 | 180 | 185 | 190 | 196 | 201 | 206 | 212 | 217 | |
| 17 | 222 | 228 | 233 | 238 | 243 | 249 | 254 | 259 | 265 | 270 | |
| 18 | 275 | 281 | 286 | 291 | 297 | 302 | 307 | 312 | 318 | 323 | |
| 19 | 328 | 334 | 339 | 344 | 350 | 355 | 360 | 365 | 371 | 376 | |
| 820 | 381 | 387 | 392 | 397 | 403 | 408 | 413 | 418 | 424 | 429 | |
| 21 | 434 | 440 | 445 | 450 | 455 | 461 | 466 | 471 | 477 | 482 | |
| 22 | 487 | 492 | 498 | 503 | 508 | 514 | 519 | 524 | 529 | 535 | |
| 23 | 540 | 545 | 551 | 556 | 561 | 566 | 572 | 577 | 582 | 587 | |
| 24 | 593 | 598 | 603 | 609 | 614 | 619 | 624 | 630 | 635 | 640 | |
| 25 | 645 | 651 | 656 | 661 | 666 | 672 | 677 | 682 | 687 | 693 | |
| 26 | 698 | 703 | 709 | 714 | 719 | 724 | 730 | 735 | 740 | 745 | |
| 27 | 751 | 756 | 761 | 766 | 772 | 777 | 782 | 787 | 793 | 798 | |
| 28 | 803 | 808 | 814 | 819 | 824 | 829 | 834 | 840 | 845 | 850 | |
| 29 | 855 | 861 | 866 | 871 | 876 | 882 | 887 | 892 | 897 | 903 | |
| 830 | 908 | 913 | 918 | 924 | 929 | 934 | 939 | 944 | 950 | 955 | |
| 31 | 960 | 965 | 971 | 976 | 981 | 986 | 991 | 997 | *002 | *007 | |
| 32 | 92 012 | 018 | 023 | 028 | 033 | 038 | 044 | 049 | 054 | 059 | |
| 33 | 065 | 070 | 075 | 080 | 085 | 091 | 096 | 101 | 106 | 111 | |
| 34 | 117 | 122 | 127 | 132 | 137 | 143 | 148 | 153 | 158 | 163 | |
| 35 | 169 | 174 | 179 | 184 | 189 | 195 | 200 | 205 | 210 | 215 | |
| 36 | 221 | 226 | 231 | 236 | 241 | 247 | 252 | 257 | 262 | 267 | |
| 37 | 273 | 278 | 283 | 288 | 293 | 298 | 304 | 309 | 314 | 319 | |
| 38 | 324 | 330 | 335 | 340 | 345 | 350 | 355 | 361 | 366 | 371 | |
| 39 | 376 | 381 | 387 | 392 | 397 | 402 | 407 | 412 | 418 | 423 | |
| 840 | 428 | 433 | 438 | 443 | 449 | 454 | 459 | 464 | 469 | 474 | |
| 41 | 480 | 485 | 490 | 495 | 500 | 505 | 511 | 516 | 521 | 526 | |
| 42 | 531 | 536 | 542 | 547 | 552 | 557 | 562 | 567 | 572 | 578 | |
| 43 | 583 | 588 | 593 | 598 | 603 | 609 | 614 | 619 | 624 | 629 | |
| 44 | 634 | 639 | 645 | 650 | 655 | 660 | 665 | 670 | 675 | 681 | |
| 45 | 686 | 691 | 696 | 701 | 706 | 711 | 716 | 722 | 727 | 732 | |
| 46 | 737 | 742 | 747 | 752 | 758 | 763 | 768 | 773 | 778 | 783 | |
| 47 | 788 | 793 | 799 | 804 | 809 | 814 | 819 | 824 | 829 | 834 | |
| 48 | 840 | 845 | 850 | 855 | 860 | 865 | 870 | 875 | 881 | 886 | |
| 49 | 891 | 896 | 901 | 906 | 911 | 916 | 921 | 927 | 932 | 937 | |
| 850 | 942 | 947 | 952 | 957 | 962 | 967 | 973 | 978 | 983 | 988 | |
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Prop. Pts. |

| | 6 | 5 |
|---|-----|-----|
| 1 | 0.6 | 0.5 |
| 2 | 1.2 | 1.0 |
| 3 | 1.8 | 1.5 |
| 4 | 2.4 | 2.0 |
| 5 | 3.0 | 2.5 |
| 6 | 3.6 | 3.0 |
| 7 | 4.2 | 3.5 |
| 8 | 4.8 | 4.0 |
| 9 | 5.4 | 4.5 |

Table 3. Number Logarithms

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Prop. Pts. | | | |
|------------|--------|-----|------|------|------|------|------|------|------|------|------------|-----|-----|-----|
| 850 | 92 942 | 947 | 952 | 957 | 962 | 967 | 973 | 978 | 983 | 988 | | | | |
| 51 | 993 | 998 | *003 | *008 | *013 | *018 | *024 | *029 | *034 | *039 | | | | |
| 52 | 93 044 | 049 | 054 | 059 | 064 | 069 | 075 | 080 | 085 | 090 | | | | |
| 53 | 095 | 100 | 105 | 110 | 115 | 120 | 125 | 131 | 136 | 141 | | | | |
| 54 | 146 | 151 | 156 | 161 | 166 | 171 | 176 | 181 | 186 | 192 | | | | |
| 55 | 197 | 202 | 207 | 212 | 217 | 222 | 227 | 232 | 237 | 242 | | | | |
| 56 | 247 | 252 | 258 | 263 | 268 | 273 | 278 | 283 | 288 | 293 | | | | |
| 57 | 298 | 303 | 308 | 313 | 318 | 323 | 328 | 334 | 339 | 344 | | | | |
| 58 | 349 | 354 | 359 | 364 | 369 | 374 | 379 | 384 | 389 | 394 | | | | |
| 59 | 399 | 404 | 409 | 414 | 420 | 425 | 430 | 435 | 440 | 445 | | | | |
| 860 | 450 | 455 | 460 | 465 | 470 | 475 | 480 | 485 | 490 | 495 | | | | |
| 61 | 500 | 505 | 510 | 515 | 520 | 526 | 531 | 536 | 541 | 546 | | | | |
| 62 | 551 | 556 | 561 | 566 | 571 | 576 | 581 | 586 | 591 | 596 | | | | |
| 63 | 601 | 606 | 611 | 616 | 621 | 626 | 631 | 636 | 641 | 646 | | | | |
| 64 | 651 | 656 | 661 | 666 | 671 | 676 | 682 | 687 | 692 | 697 | | | | |
| 65 | 702 | 707 | 712 | 717 | 722 | 727 | 732 | 737 | 742 | 747 | | | | |
| 66 | 752 | 757 | 762 | 767 | 772 | 777 | 782 | 787 | 792 | 797 | | | | |
| 67 | 802 | 807 | 812 | 817 | 822 | 827 | 832 | 837 | 842 | 847 | | | | |
| 68 | 852 | 857 | 862 | 867 | 872 | 877 | 882 | 887 | 892 | 897 | | | | |
| 69 | 902 | 907 | 912 | 917 | 922 | 927 | 932 | 937 | 942 | 947 | | | | |
| 870 | 952 | 957 | 962 | 967 | 972 | 977 | 982 | 987 | 992 | 997 | | | | |
| 71 | 94 002 | 007 | 012 | 017 | 022 | 027 | 032 | 037 | 042 | 047 | | | | |
| 72 | 052 | 057 | 062 | 067 | 072 | 077 | 082 | 086 | 091 | 096 | | | | |
| 73 | 101 | 106 | 111 | 116 | 121 | 126 | 131 | 136 | 141 | 146 | | | | |
| 74 | 151 | 156 | 161 | 166 | 171 | 176 | 181 | 186 | 191 | 196 | | | | |
| 75 | 201 | 206 | 211 | 216 | 221 | 226 | 231 | 236 | 240 | 245 | | | | |
| 76 | 250 | 255 | 260 | 265 | 270 | 275 | 280 | 285 | 290 | 295 | | | | |
| 77 | 300 | 305 | 310 | 315 | 320 | 325 | 330 | 335 | 340 | 345 | | | | |
| 78 | 349 | 354 | 359 | 364 | 369 | 374 | 379 | 384 | 389 | 394 | | | | |
| 79 | 399 | 404 | 409 | 414 | 419 | 424 | 429 | 433 | 438 | 443 | | | | |
| 880 | 448 | 453 | 458 | 463 | 468 | 473 | 478 | 483 | 488 | 493 | | | | |
| 81 | 498 | 503 | 507 | 512 | 517 | 522 | 527 | 532 | 537 | 542 | | | | |
| 82 | 547 | 552 | 557 | 562 | 567 | 571 | 576 | 581 | 586 | 591 | | | | |
| 83 | 596 | 601 | 606 | 611 | 616 | 621 | 626 | 630 | 635 | 640 | | | | |
| 84 | 645 | 650 | 655 | 660 | 665 | 670 | 675 | 680 | 685 | 689 | | | | |
| 85 | 694 | 699 | 704 | 709 | 714 | 719 | 724 | 729 | 734 | 738 | | | | |
| 86 | 743 | 748 | 753 | 758 | 763 | 768 | 773 | 778 | 783 | 787 | | | | |
| 87 | 792 | 797 | 802 | 807 | 812 | 817 | 822 | 827 | 832 | 836 | | | | |
| 88 | 841 | 846 | 851 | 856 | 861 | 866 | 871 | 876 | 880 | 885 | | | | |
| 89 | 890 | 895 | 900 | 905 | 910 | 915 | 919 | 924 | 929 | 934 | | | | |
| 890 | 939 | 944 | 949 | 954 | 959 | 963 | 968 | 973 | 978 | 983 | | | | |
| 91 | 988 | 993 | 998 | *002 | *007 | *012 | *017 | *022 | *027 | *032 | | | | |
| 92 | 95 036 | 041 | 046 | 051 | 056 | 061 | 066 | 071 | 075 | 080 | | | | |
| 93 | 085 | 090 | 095 | 100 | 105 | 109 | 114 | 119 | 124 | 129 | | | | |
| 94 | 134 | 139 | 143 | 148 | 153 | 158 | 163 | 168 | 173 | 177 | | | | |
| 95 | 182 | 187 | 192 | 197 | 202 | 207 | 211 | 216 | 221 | 226 | | | | |
| 96 | 231 | 236 | 240 | 245 | 250 | 255 | 260 | 265 | 270 | 274 | | | | |
| 97 | 279 | 284 | 289 | 294 | 299 | 303 | 308 | 313 | 318 | 323 | | | | |
| 98 | 328 | 332 | 337 | 342 | 347 | 352 | 357 | 361 | 366 | 371 | | | | |
| 99 | 376 | 381 | 386 | 390 | 395 | 400 | 405 | 410 | 415 | 419 | | | | |
| 900 | 424 | 429 | 434 | 439 | 444 | 448 | 453 | 458 | 463 | 468 | | | | |
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Prop. Pts. | | | |
| | | | | | | | | | | | 1 | 0.6 | 0.5 | 0.4 |
| | | | | | | | | | | | 2 | 1.2 | 1.0 | 0.8 |
| | | | | | | | | | | | 3 | 1.8 | 1.5 | 1.2 |
| | | | | | | | | | | | 4 | 2.4 | 2.0 | 1.6 |
| | | | | | | | | | | | 5 | 3.0 | 2.5 | 2.0 |
| | | | | | | | | | | | 6 | 3.6 | 3.0 | 2.4 |
| | | | | | | | | | | | 7 | 4.2 | 3.5 | 2.8 |
| | | | | | | | | | | | 8 | 4.8 | 4.0 | 3.2 |
| | | | | | | | | | | | 9 | 5.4 | 4.5 | 3.6 |

Table 3. Number Logarithms

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Prop. Pts. | | |
|------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-------------------|--|--|
| 900 | 95 424 | 429 | 434 | 439 | 444 | 448 | 453 | 458 | 463 | 468 | | | |
| 01 | 472 | 477 | 482 | 487 | 492 | 497 | 501 | 506 | 511 | 516 | | | |
| 02 | 521 | 525 | 530 | 535 | 540 | 545 | 550 | 554 | 559 | 564 | | | |
| 03 | 569 | 574 | 578 | 583 | 588 | 593 | 598 | 602 | 607 | 612 | | | |
| 04 | 617 | 622 | 626 | 631 | 636 | 641 | 646 | 650 | 655 | 660 | | | |
| 05 | 665 | 670 | 674 | 679 | 684 | 689 | 694 | 698 | 703 | 708 | | | |
| 06 | 713 | 718 | 722 | 727 | 732 | 737 | 742 | 746 | 751 | 756 | | | |
| 07 | 761 | 766 | 770 | 775 | 780 | 785 | 789 | 794 | 799 | 804 | | | |
| 08 | 809 | 813 | 818 | 823 | 828 | 832 | 837 | 842 | 847 | 852 | | | |
| 09 | 856 | 861 | 866 | 871 | 875 | 880 | 885 | 890 | 895 | 899 | | | |
| 910 | 904 | 909 | 914 | 918 | 923 | 928 | 933 | 938 | 942 | 947 | | | |
| 11 | 952 | 957 | 961 | 966 | 971 | 976 | 980 | 985 | 990 | 995 | | | |
| 12 | 999 | *004 | *009 | *014 | *019 | *023 | *028 | *033 | *038 | *042 | | | |
| 13 | 96.047 | 052 | 057 | 061 | 066 | 071 | 076 | 080 | 085 | 090 | | | |
| 14 | 095 | 099 | 104 | 109 | 114 | 118 | 123 | 128 | 133 | 137 | | | |
| 15 | 142 | 147 | 152 | 156 | 161 | 166 | 171 | 175 | 180 | 185 | | | |
| 16 | 190 | 194 | 199 | 204 | 209 | 213 | 218 | 223 | 227 | 232 | | | |
| 17 | 237 | 242 | 246 | 251 | 256 | 261 | 265 | 270 | 275 | 280 | | | |
| 18 | 284 | 289 | 294 | 298 | 303 | 308 | 313 | 317 | 322 | 327 | | | |
| 19 | 332 | 336 | 341 | 346 | 350 | 355 | 360 | 365 | 369 | 374 | | | |
| 920 | 379 | 384 | 388 | 393 | 398 | 402 | 407 | 412 | 417 | 421 | | | |
| 21 | 426 | 431 | 435 | 440 | 445 | 450 | 454 | 459 | 464 | 468 | | | |
| 22 | 473 | 478 | 483 | 487 | 492 | 497 | 501 | 506 | 511 | 515 | | | |
| 23 | 520 | 525 | 530 | 534 | 539 | 544 | 548 | 553 | 558 | 562 | | | |
| 24 | 567 | 572 | 577 | 581 | 586 | 591 | 595 | 600 | 605 | 609 | | | |
| 25 | 614 | 619 | 624 | 628 | 633 | 638 | 642 | 647 | 652 | 656 | | | |
| 26 | 661 | 666 | 670 | 675 | 680 | 685 | 689 | 694 | 699 | 703 | | | |
| 27 | 708 | 713 | 717 | 722 | 727 | 731 | 736 | 741 | 745 | 750 | | | |
| 28 | 755 | 759 | 764 | 769 | 774 | 778 | 783 | 788 | 792 | 797 | | | |
| 29 | 802 | 806 | 811 | 816 | 820 | 825 | 830 | 834 | 839 | 844 | | | |
| 930 | 848 | 853 | 858 | 862 | 867 | 872 | 876 | 881 | 886 | 890 | | | |
| 31 | 895 | 900 | 904 | 909 | 914 | 918 | 923 | 928 | 932 | 937 | | | |
| 32 | 942 | 946 | 951 | 956 | 960 | 965 | 970 | 974 | 979 | 984 | | | |
| 33 | 988 | 993 | 997 | *002 | *007 | *011 | *016 | *021 | *025 | *030 | | | |
| 34 | 97.035 | 039 | 044 | 049 | 053 | 058 | 063 | 067 | 072 | 077 | | | |
| 35 | 081 | 086 | 090 | 095 | 100 | 104 | 109 | 114 | 118 | 123 | | | |
| 36 | 128 | 132 | 137 | 142 | 146 | 151 | 155 | 160 | 165 | 169 | | | |
| 37 | 174 | 179 | 183 | 188 | 192 | 197 | 202 | 206 | 211 | 216 | | | |
| 38 | 220 | 225 | 230 | 234 | 239 | 243 | 248 | 253 | 257 | 262 | | | |
| 39 | 267 | 271 | 276 | 280 | 285 | 290 | 294 | 299 | 304 | 308 | | | |
| 940 | 313 | 317 | 322 | 327 | 331 | 336 | 340 | 345 | 350 | 354 | | | |
| 41 | 359 | 364 | 368 | 373 | 377 | 382 | 387 | 391 | 396 | 400 | | | |
| 42 | 405 | 410 | 414 | 419 | 424 | 428 | 433 | 437 | 442 | 447 | | | |
| 43 | 451 | 456 | 460 | 465 | 470 | 474 | 479 | 483 | 488 | 493 | | | |
| 44 | 497 | 502 | 506 | 511 | 516 | 520 | 525 | 529 | 534 | 539 | | | |
| 45 | 543 | 548 | 552 | 557 | 562 | 566 | 571 | 575 | 580 | 585 | | | |
| 46 | 589 | 594 | 598 | 603 | 607 | 612 | 617 | 621 | 626 | 630 | | | |
| 47 | 635 | 640 | 644 | 649 | 653 | 658 | 663 | 667 | 672 | 676 | | | |
| 48 | 681 | 685 | 690 | 695 | 699 | 704 | 708 | 713 | 717 | 722 | | | |
| 49 | 727 | 731 | 736 | 740 | 745 | 749 | 754 | 759 | 763 | 768 | | | |
| 950 | 772 | 777 | 782 | 786 | 791 | 795 | 800 | 804 | 809 | 813 | | | |
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Prop. Pts. | | |

| | 5 | 4 |
|---|-----|-----|
| 1 | 0.5 | 0.4 |
| 2 | 1.0 | 0.8 |
| 3 | 1.5 | 1.2 |
| 4 | 2.0 | 1.6 |
| 5 | 2.5 | 2.0 |
| 6 | 3.0 | 2.4 |
| 7 | 3.5 | 2.8 |
| 8 | 4.0 | 3.2 |
| 9 | 4.5 | 3.6 |

Table 3. Number Logarithms

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Prop. Pts. | | |
|-------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-------------------|-----|-----|
| 950 | 97 772 | 777 | 782 | 786 | 791 | 795 | 800 | 804 | 809 | 813 | | | |
| 51 | 818 | 823 | 827 | 832 | 836 | 841 | 845 | 850 | 855 | 859 | | | |
| 52 | 864 | 868 | 873 | 877 | 882 | 886 | 891 | 896 | 900 | 905 | | | |
| 53 | 909 | 914 | 918 | 923 | 928 | 932 | 937 | 941 | 946 | 950 | | | |
| 54 | 955 | 959 | 964 | 968 | 973 | 978 | 982 | 987 | 991 | 996 | | | |
| 55 | 98 000 | 005 | 009 | 014 | 019 | 023 | 028 | 032 | 037 | 041 | | | |
| 56 | 046 | 050 | 055 | 059 | 064 | 068 | 073 | 078 | 082 | 087 | | | |
| 57 | 091 | 096 | 100 | 105 | 109 | 114 | 118 | 123 | 127 | 132 | | | |
| 58 | 137 | 141 | 146 | 150 | 155 | 159 | 164 | 168 | 173 | 177 | | | |
| 59 | 182 | 186 | 191 | 195 | 200 | 204 | 209 | 214 | 218 | 223 | | | |
| 960 | 227 | 232 | 236 | 241 | 245 | 250 | 254 | 259 | 263 | 268 | | | |
| 61 | 272 | 277 | 281 | 286 | 290 | 295 | 299 | 304 | 308 | 313 | | | |
| 62 | 318 | 322 | 327 | 331 | 336 | 340 | 345 | 349 | 354 | 358 | | | |
| 63 | 363 | 367 | 372 | 376 | 381 | 385 | 390 | 394 | 399 | 403 | | | |
| 64 | 408 | 412 | 417 | 421 | 426 | 430 | 435 | 439 | 444 | 448 | | | |
| 65 | 453 | 457 | 462 | 466 | 471 | 475 | 480 | 484 | 489 | 493 | | | |
| 66 | 498 | 502 | 507 | 511 | 516 | 520 | 525 | 529 | 534 | 538 | | | |
| 67 | 543 | 547 | 552 | 556 | 561 | 565 | 570 | 574 | 579 | 583 | | | |
| 68 | 588 | 592 | 597 | 601 | 605 | 610 | 614 | 619 | 623 | 628 | | | |
| 69 | 632 | 637 | 641 | 646 | 650 | 655 | 659 | 664 | 668 | 673 | | | |
| 970 | 677 | 682 | 686 | 691 | 695 | 700 | 704 | 709 | 713 | 717 | | | |
| 71 | 722 | 726 | 731 | 735 | 740 | 744 | 749 | 753 | 758 | 762 | | | |
| 72 | 767 | 771 | 776 | 780 | 784 | 789 | 793 | 798 | 802 | 807 | 1 | 5 | 4 |
| 73 | 811 | 816 | 820 | 825 | 829 | 834 | 838 | 843 | 847 | 851 | 2 | 1.0 | 0.8 |
| 74 | 856 | 860 | 865 | 869 | 874 | 878 | 883 | 887 | 892 | 896 | 3 | 1.5 | 1.2 |
| 75 | 900 | 905 | 909 | 914 | 918 | 923 | 927 | 932 | 936 | 941 | 4 | 2.0 | 1.6 |
| 76 | 945 | 949 | 954 | 958 | 963 | 967 | 972 | 976 | 981 | 985 | 5 | 2.5 | 2.0 |
| 77 | 989 | 994 | 998 | *003 | *007 | *012 | *016 | *021 | *025 | *029 | 6 | 3.0 | 2.4 |
| 78 | 99 034 | 038 | 043 | 047 | 052 | 056 | 061 | 065 | 069 | 074 | 7 | 3.5 | 2.8 |
| 79 | 078 | 083 | 087 | 092 | 096 | 100 | 105 | 109 | 114 | 118 | 8 | 4.0 | 3.2 |
| 980 | 123 | 127 | 131 | 136 | 140 | 145 | 149 | 154 | 158 | 162 | 9 | 4.5 | 3.6 |
| 81 | 167 | 171 | 176 | 180 | 185 | 189 | 193 | 198 | 202 | 207 | | | |
| 82 | 211 | 216 | 220 | 224 | 229 | 233 | 238 | 242 | 247 | 251 | | | |
| 83 | 255 | 260 | 264 | 269 | 273 | 277 | 282 | 286 | 291 | 295 | | | |
| 84 | 300 | 304 | 308 | 313 | 317 | 322 | 326 | 330 | 335 | 339 | | | |
| 85 | 344 | 348 | 352 | 357 | 361 | 366 | 370 | 374 | 379 | 383 | | | |
| 86 | 388 | 392 | 396 | 401 | 405 | 410 | 414 | 419 | 423 | 427 | | | |
| 87 | 432 | 436 | 441 | 445 | 449 | 454 | 458 | 463 | 467 | 471 | | | |
| 88 | 476 | 480 | 484 | 489 | 493 | 498 | 502 | 506 | 511 | 515 | | | |
| 89 | 520 | 524 | 528 | 533 | 537 | 542 | 546 | 550 | 555 | 559 | | | |
| 990 | 564 | 568 | 572 | 577 | 581 | 585 | 590 | 594 | 599 | 603 | | | |
| 91 | 607 | 612 | 616 | 621 | 625 | 629 | 634 | 638 | 642 | 647 | | | |
| 92 | 651 | 656 | 660 | 664 | 669 | 673 | 677 | 682 | 686 | 691 | | | |
| 93 | 695 | 699 | 704 | 708 | 712 | 717 | 721 | 726 | 730 | 734 | | | |
| 94 | 739 | 743 | 747 | 752 | 756 | 760 | 765 | 769 | 774 | 778 | | | |
| 95 | 782 | 787 | 791 | 795 | 800 | 804 | 808 | 813 | 817 | 822 | | | |
| 96 | 826 | 830 | 835 | 839 | 843 | 848 | 852 | 856 | 861 | 865 | | | |
| 97 | 870 | 874 | 878 | 883 | 887 | 891 | 896 | 900 | 904 | 909 | | | |
| 98 | 913 | 917 | 922 | 926 | 930 | 935 | 939 | 944 | 948 | 952 | | | |
| 99 | 957 | 961 | 965 | 970 | 974 | 978 | 983 | 987 | 991 | 996 | | | |
| 1000 | 00 000 | 004 | 009 | 013 | 017 | 022 | 026 | 030 | 035 | 039 | | | |
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Prop. Pts. | | |

| | Sin | Cos | Tan | Cot | Sec | Csc | |
|-----------|----------|----------|----------|----------|----------|----------|-----------|
| 0 | — | 0.00 000 | — | — | 0.00 000 | — | 60 |
| 1 | 6.46 373 | .00 000 | 6.46 373 | 3.53 627 | .00 000 | 3.53 627 | 59 |
| 2 | 6.76 476 | .00 000 | 6.76 476 | 3.23 524 | .00 000 | .23 524 | 58 |
| 3 | 6.94 085 | .00 000 | 6.94 085 | 3.05 915 | .00 000 | .05 915 | 57 |
| 4 | 7.06 579 | .00 000 | 7.06 579 | 2.93 421 | .00 000 | 2.93 421 | 56 |
| 5 | 7.16 270 | 0.00 000 | 7.16 270 | 2.83 730 | 0.00 000 | 2.83 730 | 55 |
| 6 | .24 188 | .00 000 | .24 188 | .75 812 | .00 000 | .75 812 | 54 |
| 7 | .30 882 | .00 000 | .30 882 | .69 118 | .00 000 | .69 118 | 53 |
| 8 | .36 682 | .00 000 | .36 682 | .63 318 | .00 000 | .63 318 | 52 |
| 9 | .41 797 | .00 000 | .41 797 | .58 203 | .00 000 | .58 203 | 51 |
| 10 | 7.46 373 | 0.00 000 | 7.46 373 | 2.53 627 | 0.00 000 | 2.53 627 | 50 |
| 11 | .50 512 | .00 000 | .50 512 | .49 488 | .00 000 | .49 488 | 49 |
| 12 | .54 291 | .00 000 | .54 291 | .45 709 | .00 000 | .45 709 | 48 |
| 13 | .57 767 | .00 000 | .57 767 | .42 233 | .00 000 | .42 233 | 47 |
| 14 | .60 985 | .00 000 | .60 986 | .39 014 | .00 000 | .39 015 | 46 |
| 15 | 7.63 982 | 0.00 000 | 7.63 982 | 2.36 018 | 0.00 000 | 2.36 018 | 45 |
| 16 | .66 784 | .00 000 | .66 785 | .33 215 | .00 000 | .33 216 | 44 |
| 17 | .69 417 | 9.99 999 | .69 418 | .30 582 | .00 001 | .30 583 | 43 |
| 18 | .71 900 | .99 999 | .71 900 | .28 100 | .00 001 | .28 100 | 42 |
| 19 | .74 248 | .99 999 | .74 248 | .25 752 | .00 001 | .25 752 | 41 |
| 20 | 7.76 475 | 9.99 999 | 7.76 476 | 2.23 524 | 0.00 001 | 2.23 525 | 40 |
| 21 | .78 594 | .99 999 | .78 595 | .21 405 | .00 001 | .21 406 | 39 |
| 22 | .80 615 | .99 999 | .80 615 | .19 385 | .00 001 | .19 385 | 38 |
| 23 | .82 545 | .99 999 | .82 546 | .17 454 | .00 001 | .17 455 | 37 |
| 24 | .84 393 | .99 999 | .84 394 | .15 606 | .00 001 | .15 607 | 36 |
| 25 | 7.86 166 | 9.99 999 | 7.86 167 | 2.13 833 | 0.00 001 | 2.13 834 | 35 |
| 26 | .87 870 | .99 999 | .87 871 | .12 129 | .00 001 | .12 130 | 34 |
| 27 | .89 509 | .99 999 | .89 510 | .10 490 | .00 001 | .10 491 | 33 |
| 28 | .91 088 | .99 999 | .91 089 | .08 911 | .00 001 | .08 912 | 32 |
| 29 | .92 612 | .99 998 | .92 613 | .07 387 | .00 002 | .07 388 | 31 |
| 30 | 7.94 084 | 9.99 998 | 7.94 086 | 2.05 914 | 0.00 002 | 2.05 916 | 30 |
| 31 | .95 508 | .99 998 | .95 510 | .04 490 | .00 002 | .04 492 | 29 |
| 32 | .96 887 | .99 998 | .96 889 | .03 111 | .00 002 | .03 113 | 28 |
| 33 | .98 223 | .99 998 | .98 225 | .01 775 | .00 002 | .01 777 | 27 |
| 34 | .99 520 | .99 998 | .99 522 | .00 478 | .00 002 | .00 480 | 26 |
| 35 | 8.00 779 | 9.99 998 | 8.00 781 | 1.99 219 | 0.00 002 | 1.99 221 | 25 |
| 36 | .02 002 | .99 998 | .02 004 | .97 996 | .00 002 | .97 998 | 24 |
| 37 | .03 192 | .99 997 | .03 194 | .96 806 | .00 003 | .96 808 | 23 |
| 38 | .04 350 | .99 997 | .04 353 | .95 647 | .00 003 | .95 650 | 22 |
| 39 | .05 478 | .99 997 | .05 481 | .94 519 | .00 003 | .94 522 | 21 |
| 40 | 8.06 578 | 9.99 997 | 8.06 581 | 1.93 419 | 0.00 003 | 1.93 422 | 20 |
| 41 | .07 650 | .99 997 | .07 653 | .92 347 | .00 003 | .92 350 | 19 |
| 42 | .08 696 | .99 997 | .08 700 | .91 300 | .00 003 | .91 304 | 18 |
| 43 | .09 718 | .99 997 | .09 722 | .90 278 | .00 003 | .90 282 | 17 |
| 44 | .10 717 | .99 996 | .10 720 | .89 280 | .00 004 | .89 283 | 16 |
| 45 | 8.11 693 | 9.99 996 | 8.11 696 | 1.88 304 | 0.00 004 | 1.88 307 | 15 |
| 46 | .12 647 | .99 996 | .12 651 | .87 349 | .00 004 | .87 353 | 14 |
| 47 | .13 581 | .99 996 | .13 585 | .86 415 | .00 004 | .86 419 | 13 |
| 48 | .14 495 | .99 996 | .14 500 | .85 500 | .00 004 | .85 505 | 12 |
| 49 | .15 391 | .99 996 | .15 395 | .84 605 | .00 004 | .84 609 | 11 |
| 50 | 8.16 268 | 9.99 995 | 8.16 273 | 1.83 727 | 0.00 005 | 1.83 732 | 10 |
| 51 | .17 128 | .99 995 | .17 133 | .82 867 | .00 005 | .82 872 | 9 |
| 52 | .17 971 | .99 995 | .17 976 | .82 024 | .00 005 | .82 029 | 8 |
| 53 | .18 798 | .99 995 | .18 804 | .81 196 | .00 005 | .81 202 | 7 |
| 54 | .19 610 | .99 995 | .19 616 | .80 384 | .00 005 | .80 390 | 6 |
| 55 | 8.20 407 | 9.99 994 | 8.20 413 | 1.79 587 | 0.00 006 | 1.79 593 | 5 |
| 56 | .21 189 | .99 994 | .21 195 | .78 805 | .00 006 | .78 811 | 4 |
| 57 | .21 958 | .99 994 | .21 964 | .78 036 | .00 006 | .78 042 | 3 |
| 58 | .22 713 | .99 994 | .22 720 | .77 280 | .00 006 | .77 287 | 2 |
| 59 | .23 456 | .99 994 | .23 462 | .76 538 | .00 006 | .76 544 | 1 |
| 60 | 8.24 186 | 9.99 993 | 8.24 192 | 1.75 808 | 0.00 007 | 1.75 814 | 0 |

Table 4. Trigonometric Logarithms

1° (181°)

(358°) 178°

| | Sin | Cos | Tan | Cot | Sec | Csc | |
|-----------|----------|----------|----------|----------|----------|----------|-----------|
| 0 | 8.24 186 | 9.99 993 | 8.24 192 | 1.75 808 | 0.00 007 | 1.75 814 | 60 |
| 1 | .24 903 | .99 993 | .24 910 | .75 090 | .00 007 | .75 097 | 59 |
| 2 | .25 609 | .99 993 | .25 616 | .74 384 | .00 007 | .74 391 | 58 |
| 3 | .26 304 | .99 993 | .26 312 | .73 688 | .00 007 | .73 696 | 57 |
| 4 | .26 988 | .99 992 | .26 996 | .73 004 | .00 008 | .73 012 | 56 |
| 5 | 8.27 661 | 9.99 992 | 8.27 669 | 1.72 331 | 0.00 008 | 1.72 339 | 55 |
| 6 | .28 324 | .99 992 | .28 332 | .71 668 | .00 008 | .71 676 | 54 |
| 7 | .28 977 | .99 992 | .28 986 | .71 014 | .00 008 | .71 023 | 53 |
| 8 | .29 621 | .99 992 | .29 629 | .70 371 | .00 008 | .70 379 | 52 |
| 9 | .30 255 | .99 991 | .30 263 | .69 737 | .00 009 | .69 745 | 51 |
| 10 | 8.30 879 | 9.99 991 | 8.30 888 | 1.69 112 | 0.00 009 | 1.69 121 | 50 |
| 11 | .31 495 | .99 991 | .31 505 | .68 495 | .00 009 | .68 505 | 49 |
| 12 | .32 103 | .99 990 | .32 112 | .67 888 | .00 010 | .67 897 | 48 |
| 13 | .32 702 | .99 990 | .32 711 | .67 289 | .00 010 | .67 298 | 47 |
| 14 | .33 292 | .99 990 | .33 302 | .66 698 | .00 010 | .66 708 | 46 |
| 15 | 8.33 875 | 9.99 990 | 8.33 886 | 1.66 114 | 0.00 010 | 1.66 125 | 45 |
| 16 | .34 450 | .99 989 | .34 461 | .65 539 | .00 011 | .65 550 | 44 |
| 17 | .35 018 | .99 989 | .35 029 | .64 971 | .00 011 | .64 982 | 43 |
| 18 | .35 578 | .99 989 | .35 590 | .64 410 | .00 011 | .64 422 | 42 |
| 19 | .36 131 | .99 989 | .36 143 | .63 857 | .00 011 | .63 869 | 41 |
| 20 | 8.36 678 | 9.99 988 | 8.36 689 | 1.63 311 | 0.00 012 | 1.63 322 | 40 |
| 21 | .37 217 | .99 988 | .37 229 | .62 771 | .00 012 | .62 783 | 39 |
| 22 | .37 750 | .99 988 | .37 762 | .62 238 | .00 012 | .62 250 | 38 |
| 23 | .38 276 | .99 987 | .38 289 | .61 711 | .00 013 | .61 724 | 37 |
| 24 | .38 796 | .99 987 | .38 809 | .61 191 | .00 013 | .61 204 | 36 |
| 25 | 8.39 310 | 9.99 987 | 8.39 323 | 1.60 677 | 0.00 013 | 1.60 690 | 35 |
| 26 | .39 818 | .99 986 | .39 832 | .60 168 | .00 014 | .60 182 | 34 |
| 27 | .40 320 | .99 986 | .40 334 | .59 666 | .00 014 | .59 680 | 33 |
| 28 | .40 816 | .99 986 | .40 830 | .59 170 | .00 014 | .59 184 | 32 |
| 29 | .41 307 | .99 985 | .41 321 | .58 679 | .00 015 | .58 693 | 31 |
| 30 | 8.41 792 | 9.99 985 | 8.41 807 | 1.58 193 | 0.00 015 | 1.58 208 | 30 |
| 31 | .42 272 | .99 985 | .42 287 | .57 713 | .00 015 | .57 728 | 29 |
| 32 | .42 746 | .99 984 | .42 762 | .57 238 | .00 016 | .57 254 | 28 |
| 33 | .43 216 | .99 984 | .43 232 | .56 768 | .00 016 | .56 784 | 27 |
| 34 | .43 680 | .99 984 | .43 696 | .56 304 | .00 016 | .56 320 | 26 |
| 35 | 8.44 139 | 9.99 983 | 8.44 156 | 1.55 844 | 0.00 017 | 1.55 861 | 25 |
| 36 | .44 594 | .99 983 | .44 611 | .55 389 | .00 017 | .55 406 | 24 |
| 37 | .45 044 | .99 983 | .45 061 | .54 939 | .00 017 | .54 956 | 23 |
| 38 | .45 489 | .99 982 | .45 507 | .54 493 | .00 018 | .54 511 | 22 |
| 39 | .45 930 | .99 982 | .45 948 | .54 052 | .00 018 | .54 070 | 21 |
| 40 | 8.46 366 | 9.99 982 | 8.46 385 | 1.53 615 | 0.00 018 | 1.53 634 | 20 |
| 41 | .46 799 | .99 981 | .46 817 | .53 183 | .00 019 | .53 201 | 19 |
| 42 | .47 226 | .99 981 | .47 245 | .52 755 | .00 019 | .52 774 | 18 |
| 43 | .47 650 | .99 981 | .47 669 | .52 331 | .00 019 | .52 350 | 17 |
| 44 | .48 069 | .99 980 | .48 089 | .51 911 | .00 020 | .51 931 | 16 |
| 45 | 8.48 485 | 9.99 980 | 8.48 505 | 1.51 495 | 0.00 020 | 1.51 515 | 15 |
| 46 | .48 896 | .99 979 | .48 917 | .51 083 | .00 021 | .51 104 | 14 |
| 47 | .49 304 | .99 979 | .49 325 | .50 675 | .00 021 | .50 696 | 13 |
| 48 | .49 708 | .99 979 | .49 729 | .50 271 | .00 021 | .50 292 | 12 |
| 49 | .50 108 | .99 978 | .50 130 | .49 870 | .00 022 | .49 892 | 11 |
| 50 | 8.50 504 | 9.99 978 | 8.50 527 | 1.49 473 | 0.00 022 | 1.49 496 | 10 |
| 51 | .50 897 | .99 977 | .50 920 | .49 080 | .00 023 | .49 103 | 9 |
| 52 | .51 287 | .99 977 | .51 310 | .48 690 | .00 023 | .48 713 | 8 |
| 53 | .51 673 | .99 977 | .51 696 | .48 304 | .00 023 | .48 327 | 7 |
| 54 | .52 055 | .99 976 | .52 079 | .47 921 | .00 024 | .47 945 | 6 |
| 55 | 8.52 434 | 9.99 976 | 8.52 459 | 1.47 541 | 0.00 024 | 1.47 566 | 5 |
| 56 | .52 810 | .99 975 | .52 835 | .47 165 | .00 025 | .47 190 | 4 |
| 57 | .53 183 | .99 975 | .53 208 | .46 792 | .00 025 | .46 817 | 3 |
| 58 | .53 552 | .99 974 | .53 578 | .46 422 | .00 026 | .46 448 | 2 |
| 59 | .53 919 | .99 974 | .53 945 | .46 055 | .00 026 | .46 081 | 1 |
| 60 | 8.54 282 | 9.99 974 | 8.54 308 | 1.45 692 | 0.00 026 | 1.45 718 | 0 |
| | Cos | Sin | Cot | Tan | Csc | Sec | ' |

91° (271°)

(268°) 88°

Table 4. Trigonometric Logarithms

2° (182°)

(357°) 177°

| | Sin | Cos | Tan | Cot | Sec | Csc | |
|-----------|----------|----------|----------|----------|----------|----------|-----------|
| 0 | 8.54 282 | 9.99 974 | 8.54 308 | 1.45 692 | 0.00 026 | 1.45 718 | 60 |
| 1 | .54 642 | .99 973 | .54 669 | .45 331 | .00 027 | .45 358 | 59 |
| 2 | .54 999 | .99 973 | .55 027 | .44 973 | .00 027 | .45 001 | 58 |
| 3 | .55 354 | .99 972 | .55 382 | .44 618 | .00 028 | .44 646 | 57 |
| 4 | .55 705 | .99 972 | .55 734 | .44 266 | .00 028 | .44 295 | 56 |
| 5 | 8.56 054 | 9.99 971 | 8.56 083 | 1.43 917 | 0.00 029 | 1.43 946 | 55 |
| 6 | .56 400 | .99 971 | .56 429 | .43 571 | .00 029 | .43 600 | 54 |
| 7 | .56 743 | .99 970 | .56 773 | .43 227 | .00 030 | .43 257 | 53 |
| 8 | .57 084 | .99 970 | .57 114 | .42 886 | .00 030 | .42 916 | 52 |
| 9 | .57 421 | .99 969 | .57 452 | .42 548 | .00 031 | .42 579 | 51 |
| 10 | 8.57 757 | 9.99 969 | 8.57 788 | 1.42 212 | 0.00 031 | 1.42 243 | 50 |
| 11 | .58 089 | .99 968 | .58 121 | .41 879 | .00 032 | .41 911 | 49 |
| 12 | .58 419 | .99 968 | .58 451 | .41 549 | .00 032 | .41 581 | 48 |
| 13 | .58 747 | .99 967 | .58 779 | .41 221 | .00 033 | .41 253 | 47 |
| 14 | .59 072 | .99 967 | .59 105 | .40 895 | .00 033 | .40 928 | 46 |
| 15 | 8.59 395 | 9.99 967 | 8.59 428 | 1.40 572 | 0.00 033 | 1.40 605 | 45 |
| 16 | .59 715 | .99 966 | .59 749 | .40 251 | .00 034 | .40 285 | 44 |
| 17 | .60 033 | .99 966 | .60 068 | .39 932 | .00 034 | .39 967 | 43 |
| 18 | .60 349 | .99 965 | .60 384 | .39 616 | .00 035 | .39 651 | 42 |
| 19 | .60 662 | .99 964 | .60 698 | .39 302 | .00 036 | .39 338 | 41 |
| 20 | 8.60 973 | 9.99 964 | 8.61 009 | 1.38 991 | 0.00 036 | 1.39 027 | 40 |
| 21 | .61 282 | .99 963 | .61 319 | .38 681 | .00 037 | .38 718 | 39 |
| 22 | .61 589 | .99 963 | .61 626 | .38 374 | .00 037 | .38 411 | 38 |
| 23 | .61 894 | .99 962 | .61 931 | .38 069 | .00 038 | .38 106 | 37 |
| 24 | .62 196 | .99 962 | .62 234 | .37 766 | .00 038 | .37 804 | 36 |
| 25 | 8.62 497 | 9.99 961 | 8.62 535 | 1.37 465 | 0.00 039 | 1.37 503 | 35 |
| 26 | .62 795 | .99 961 | .62 834 | .37 166 | .00 039 | .37 205 | 34 |
| 27 | .63 091 | .99 960 | .63 131 | .36 869 | .00 040 | .36 909 | 33 |
| 28 | .63 385 | .99 960 | .63 426 | .36 574 | .00 040 | .36 615 | 32 |
| 29 | .63 678 | .99 959 | .63 718 | .36 282 | .00 041 | .36 322 | 31 |
| 30 | 8.63 968 | 9.99 959 | 8.64 009 | 1.35 991 | 0.00 041 | 1.36 032 | 30 |
| 31 | .64 256 | .99 958 | .64 298 | .35 702 | .00 042 | .35 744 | 29 |
| 32 | .64 543 | .99 958 | .64 585 | .35 415 | .00 042 | .35 457 | 28 |
| 33 | .64 827 | .99 957 | .64 870 | .35 130 | .00 043 | .35 173 | 27 |
| 34 | .65 110 | .99 956 | .65 154 | .34 846 | .00 044 | .34 890 | 26 |
| 35 | 8.65 391 | 9.99 956 | 8.65 435 | 1.34 565 | 0.00 044 | 1.34 609 | 25 |
| 36 | .65 670 | .99 955 | .65 715 | .34 285 | .00 045 | .34 330 | 24 |
| 37 | .65 947 | .99 955 | .65 993 | .34 007 | .00 045 | .34 053 | 23 |
| 38 | .66 223 | .99 954 | .66 269 | .33 731 | .00 046 | .33 777 | 22 |
| 39 | .66 497 | .99 954 | .66 543 | .33 457 | .00 046 | .33 503 | 21 |
| 40 | 8.66 769 | 9.99 953 | 8.66 816 | 1.33 184 | 0.00 047 | 1.33 231 | 20 |
| 41 | .67 039 | .99 952 | .67 087 | .32 913 | .00 048 | .32 961 | 19 |
| 42 | .67 308 | .99 952 | .67 356 | .32 644 | .00 048 | .32 692 | 18 |
| 43 | .67 575 | .99 951 | .67 624 | .32 376 | .00 049 | .32 425 | 17 |
| 44 | .67 841 | .99 951 | .67 890 | .32 110 | .00 049 | .32 159 | 16 |
| 45 | 8.68 104 | 9.99 950 | 8.68 154 | 1.31 846 | 0.00 050 | 1.31 896 | 15 |
| 46 | .68 367 | .99 949 | .68 417 | .31 583 | .00 051 | .31 633 | 14 |
| 47 | .68 627 | .99 949 | .68 678 | .31 322 | .00 051 | .31 373 | 13 |
| 48 | .68 886 | .99 948 | .68 938 | .31 062 | .00 052 | .31 114 | 12 |
| 49 | .69 144 | .99 948 | .69 196 | .30 804 | .00 052 | .30 856 | 11 |
| 50 | 8.69 400 | 9.99 947 | 8.69 453 | 1.30 547 | 0.00 053 | 1.30 600 | 10 |
| 51 | .69 654 | .99 946 | .69 708 | .30 292 | .00 054 | .30 346 | 9 |
| 52 | .69 907 | .99 946 | .69 962 | .30 038 | .00 054 | .30 093 | 8 |
| 53 | .70 159 | .99 945 | .70 214 | .29 786 | .00 055 | .29 841 | 7 |
| 54 | .70 409 | .99 944 | .70 465 | .29 535 | .00 056 | .29 591 | 6 |
| 55 | 8.70 658 | 9.99 944 | 8.70 714 | 1.29 286 | 0.00 056 | 1.29 342 | 5 |
| 56 | .70 905 | .99 943 | .70 962 | .29 038 | .00 057 | .29 095 | 4 |
| 57 | .71 151 | .99 942 | .71 208 | .28 792 | .00 058 | .28 849 | 3 |
| 58 | .71 395 | .99 942 | .71 453 | .28 547 | .00 058 | .28 605 | 2 |
| 59 | .71 638 | .99 941 | .71 697 | .28 303 | .00 059 | .28 362 | 1 |
| 60 | 8.71 880 | 9.99 940 | 8.71 940 | 1.28 060 | 0.00 060 | 1.28 120 | 0 |
| | Cos | Sin | Cot | Tan | Csc | Sec | ' |

Table 4. Trigonometric Logarithms

3° (183°)

(356°) 176°

| | Sin | Cos | Tan | Cot | Sec | Csc | |
|-----------|------------|------------|------------|------------|------------|------------|-----------|
| 0 | 8.71 880 | 9.99 940 | 8.71 940 | 1.28 060 | 0.00 060 | 1.28 120 | 60 |
| 1 | .72 120 | .99 940 | .72 181 | .27 819 | .00 060 | .27 880 | 59 |
| 2 | .72 359 | .99 939 | .72 420 | .27 580 | .00 061 | .27 641 | 58 |
| 3 | .72 597 | .99 938 | .72 659 | .27 341 | .00 062 | .27 403 | 57 |
| 4 | .72 834 | .99 938 | .72 896 | .27 104 | .00 062 | .27 166 | 56 |
| 5 | 8.73 069 | 9.99 937 | 8.73 132 | 1.26 868 | 0.00 063 | 1.26 931 | 55 |
| 6 | .73 303 | .99 936 | .73 366 | .26 634 | .00 064 | .26 697 | 54 |
| 7 | .73 535 | .99 936 | .73 600 | .26 400 | .00 064 | .26 465 | 53 |
| 8 | .73 767 | .99 935 | .73 832 | .26 168 | .00 065 | .26 233 | 52 |
| 9 | .73 997 | .99 934 | .74 063 | .25 937 | .00 066 | .26 003 | 51 |
| 10 | 8.74 226 | 9.99 934 | 8.74 292 | 1.25 708 | 0.00 066 | 1.25 774 | 50 |
| 11 | .74 454 | .99 933 | .74 521 | .25 479 | .00 067 | .25 546 | 49 |
| 12 | .74 680 | .99 932 | .74 748 | .25 252 | .00 068 | .25 320 | 48 |
| 13 | .74 906 | .99 932 | .74 974 | .25 026 | .00 068 | .25 094 | 47 |
| 14 | .75 130 | .99 931 | .75 199 | .24 801 | .00 069 | .24 870 | 46 |
| 15 | 8.75 353 | 9.99 930 | 8.75 423 | 1.24 577 | 0.00 070 | 1.24 647 | 45 |
| 16 | .75 575 | .99 929 | .75 645 | .24 355 | .00 071 | .24 425 | 44 |
| 17 | .75 795 | .99 929 | .75 867 | .24 133 | .00 071 | .24 205 | 43 |
| 18 | .76 015 | .99 928 | .76 087 | .23 913 | .00 072 | .23 985 | 42 |
| 19 | .76 234 | .99 927 | .76 306 | .23 694 | .00 073 | .23 766 | 41 |
| 20 | 8.76 451 | 9.99 926 | 8.76 525 | 1.23 475 | 0.00 074 | 1.23 549 | 40 |
| 21 | .76 667 | .99 926 | .76 742 | .23 258 | .00 074 | .23 333 | 39 |
| 22 | .76 883 | .99 925 | .76 958 | .23 042 | .00 075 | .23 117 | 38 |
| 23 | .77 097 | .99 924 | .77 173 | .22 827 | .00 076 | .22 903 | 37 |
| 24 | .77 310 | .99 923 | .77 387 | .22 613 | .00 077 | .22 690 | 36 |
| 25 | 8.77 522 | 9.99 923 | 8.77 600 | 1.22 400 | 0.00 077 | 1.22 478 | 35 |
| 26 | .77 733 | .99 922 | .77 811 | .22 189 | .00 078 | .22 267 | 34 |
| 27 | .77 943 | .99 921 | .78 022 | .21 978 | .00 079 | .22 057 | 33 |
| 28 | .78 152 | .99 920 | .78 232 | .21 768 | .00 080 | .21 848 | 32 |
| 29 | .78 360 | .99 920 | .78 441 | .21 559 | .00 080 | .21 640 | 31 |
| 30 | 8.78 568 | 9.99 919 | 8.78 649 | 1.21 351 | 0.00 081 | 1.21 432 | 30 |
| 31 | .78 774 | .99 918 | .78 855 | .21 145 | .00 082 | .21 226 | 29 |
| 32 | .78 979 | .99 917 | .79 061 | .20 939 | .00 083 | .21 021 | 28 |
| 33 | .79 183 | .99 917 | .79 266 | .20 734 | .00 083 | .20 817 | 27 |
| 34 | .79 386 | .99 916 | .79 470 | .20 530 | .00 084 | .20 614 | 26 |
| 35 | 8.79 588 | 9.99 915 | 8.79 673 | 1.20 327 | 0.00 085 | 1.20 412 | 25 |
| 36 | .79 789 | .99 914 | .79 875 | .20 125 | .00 086 | .20 211 | 24 |
| 37 | .79 990 | .99 913 | .80 076 | .19 924 | .00 087 | .20 010 | 23 |
| 38 | .80 189 | .99 913 | .80 277 | .19 723 | .00 087 | .19 811 | 22 |
| 39 | .80 388 | .99 912 | .80 476 | .19 524 | .00 088 | .19 612 | 21 |
| 40 | 8.80 585 | 9.99 911 | 8.80 674 | 1.19 326 | 0.00 089 | 1.19 415 | 20 |
| 41 | .80 782 | .99 910 | .80 872 | .19 128 | .00 090 | .19 218 | 19 |
| 42 | .80 978 | .99 909 | .81 068 | .18 932 | .00 091 | .19 022 | 18 |
| 43 | .81 173 | .99 909 | .81 264 | .18 736 | .00 091 | .18 827 | 17 |
| 44 | .81 367 | .99 908 | .81 459 | .18 541 | .00 092 | .18 633 | 16 |
| 45 | 8.81 560 | 9.99 907 | 8.81 653 | 1.18 347 | 0.00 093 | 1.18 440 | 15 |
| 46 | .81 752 | .99 906 | .81 846 | .18 154 | .00 094 | .18 248 | 14 |
| 47 | .81 944 | .99 905 | .82 038 | .17 962 | .00 095 | .18 056 | 13 |
| 48 | .82 134 | .99 904 | .82 230 | .17 770 | .00 096 | .17 866 | 12 |
| 49 | .82 324 | .99 904 | .82 420 | .17 580 | .00 096 | .17 676 | 11 |
| 50 | 8.82 513 | 9.99 903 | 8.82 610 | 1.17 390 | 0.00 097 | 1.17 487 | 10 |
| 51 | .82 701 | .99 902 | .82 799 | .17 201 | .00 098 | .17 299 | 9 |
| 52 | .82 888 | .99 901 | .82 987 | .17 013 | .00 099 | .17 112 | 8 |
| 53 | .83 075 | .99 900 | .83 175 | .16 825 | .00 100 | .16 925 | 7 |
| 54 | .83 261 | .99 899 | .83 361 | .16 639 | .00 101 | .16 739 | 6 |
| 55 | 8.83 446 | 9.99 898 | 8.83 547 | 1.16 453 | 0.00 102 | 1.16 554 | 5 |
| 56 | .83 630 | .99 898 | .83 732 | .16 268 | .00 102 | .16 370 | 4 |
| 57 | .83 813 | .99 897 | .83 916 | .16 084 | .00 103 | .16 187 | 3 |
| 58 | .83 996 | .99 896 | .84 100 | .15 900 | .00 104 | .16 004 | 2 |
| 59 | .84 177 | .99 895 | .84 282 | .15 718 | .00 105 | .15 823 | 1 |
| 60 | 8.84 358 | 9.99 894 | 8.84 464 | 1.15 536 | 0.00 106 | 1.15 642 | 0 |
| | Cos | Sin | Cot | Tan | Csc | Sec | ' |

93° (273°)

(266°) 86°

4° (184°)

(355°) 175°

| | Sin | Cos | Tan | Cot | Sec | Csc | |
|----|----------|----------|----------|----------|----------|----------|----|
| 0 | 8.84 358 | 9.99 894 | 8.84 464 | 1.15 536 | 0.00 106 | 1.15 642 | 60 |
| 1 | .84 539 | .99 893 | .84 646 | .15 354 | .00 107 | .15 461 | 59 |
| 2 | .84 718 | .99 892 | .84 826 | .15 174 | .00 108 | .15 282 | 58 |
| 3 | .84 897 | .99 891 | .85 006 | .14 994 | .00 109 | .15 103 | 57 |
| 4 | .85 075 | .99 891 | .85 185 | .14 815 | .00 109 | .14 925 | 56 |
| 5 | 8.85 252 | 9.99 890 | 8.85 363 | 1.14 637 | 0.00 110 | 1.14 748 | 55 |
| 6 | .85 429 | .99 889 | .85 540 | .14 460 | .00 111 | .14 571 | 54 |
| 7 | .85 605 | .99 888 | .85 717 | .14 283 | .00 112 | .14 395 | 53 |
| 8 | .85 780 | .99 887 | .85 893 | .14 107 | .00 113 | .14 220 | 52 |
| 9 | .85 955 | .99 886 | .86 069 | .13 931 | .00 114 | .14 045 | 51 |
| 10 | 8.86 128 | 9.99 885 | 8.86 243 | 1.13 757 | 0.00 115 | 1.13 872 | 50 |
| 11 | .86 301 | .99 884 | .86 417 | .13 583 | .00 116 | .13 699 | 49 |
| 12 | .86 474 | .99 883 | .86 591 | .13 409 | .00 117 | .13 526 | 48 |
| 13 | .86 645 | .99 882 | .86 763 | .13 237 | .00 118 | .13 355 | 47 |
| 14 | .86 816 | .99 881 | .86 935 | .13 065 | .00 119 | .13 184 | 46 |
| 15 | 8.86 987 | 9.99 880 | 8.87 106 | 1.12 894 | 0.00 120 | 1.13 013 | 45 |
| 16 | .87 156 | .99 879 | .87 277 | .12 723 | .00 121 | .12 844 | 44 |
| 17 | .87 325 | .99 879 | .87 447 | .12 553 | .00 121 | .12 675 | 43 |
| 18 | .87 494 | .99 878 | .87 616 | .12 384 | .00 122 | .12 506 | 42 |
| 19 | .87 661 | .99 877 | .87 785 | .12 215 | .00 123 | .12 339 | 41 |
| 20 | 8.87 829 | 9.99 876 | 8.87 953 | 1.12 047 | 0.00 124 | 1.12 171 | 40 |
| 21 | .87 995 | .99 875 | .88 120 | .11 880 | .00 125 | .12 005 | 39 |
| 22 | .88 161 | .99 874 | .88 287 | .11 713 | .00 126 | .11 839 | 38 |
| 23 | .88 326 | .99 873 | .88 453 | .11 547 | .00 127 | .11 674 | 37 |
| 24 | .88 490 | .99 872 | .88 618 | .11 382 | .00 128 | .11 510 | 36 |
| 25 | 8.88 654 | 9.99 871 | 8.88 783 | 1.11 217 | 0.00 129 | 1.11 346 | 35 |
| 26 | .88 817 | .99 870 | .88 948 | .11 052 | .00 130 | .11 183 | 34 |
| 27 | .88 980 | .99 869 | .89 111 | .10 889 | .00 131 | .11 020 | 33 |
| 28 | .89 142 | .99 868 | .89 274 | .10 726 | .00 132 | .10 858 | 32 |
| 29 | .89 304 | .99 867 | .89 437 | .10 563 | .00 133 | .10 696 | 31 |
| 30 | 8.89 464 | 9.99 866 | 8.89 598 | 1.10 402 | 0.00 134 | 1.10 536 | 30 |
| 31 | .89 625 | .99 865 | .89 760 | .10 240 | .00 135 | .10 375 | 29 |
| 32 | .89 784 | .99 864 | .89 920 | .10 080 | .00 136 | .10 216 | 28 |
| 33 | .89 943 | .99 863 | .90 080 | .09 920 | .00 137 | .10 057 | 27 |
| 34 | .90 102 | .99 862 | .90 240 | .09 760 | .00 138 | .09 898 | 26 |
| 35 | 8.90 260 | 9.99 861 | 8.90 399 | 1.09 601 | 0.00 139 | 1.09 740 | 25 |
| 36 | .90 417 | .99 860 | .90 557 | .09 443 | .00 140 | .09 583 | 24 |
| 37 | .90 574 | .99 859 | .90 715 | .09 285 | .00 141 | .09 426 | 23 |
| 38 | .90 730 | .99 858 | .90 872 | .09 128 | .00 142 | .09 270 | 22 |
| 39 | .90 885 | .99 857 | .91 029 | .08 971 | .00 143 | .09 115 | 21 |
| 40 | 8.91 040 | 9.99 856 | 8.91 185 | 1.08 815 | 0.00 144 | 1.08 960 | 20 |
| 41 | .91 195 | .99 855 | .91 340 | .08 660 | .00 145 | .08 805 | 19 |
| 42 | .91 349 | .99 854 | .91 495 | .08 505 | .00 146 | .08 651 | 18 |
| 43 | .91 502 | .99 853 | .91 650 | .08 350 | .00 147 | .08 498 | 17 |
| 44 | .91 655 | .99 852 | .91 803 | .08 197 | .00 148 | .08 345 | 16 |
| 45 | 8.91 807 | 9.99 851 | 8.91 957 | 1.08 043 | 0.00 149 | 1.08 193 | 15 |
| 46 | .91 959 | .99 850 | .92 110 | .07 890 | .00 150 | .08 041 | 14 |
| 47 | .92 110 | .99 848 | .92 262 | .07 738 | .00 152 | .07 890 | 13 |
| 48 | .92 261 | .99 847 | .92 414 | .07 586 | .00 153 | .07 739 | 12 |
| 49 | .92 411 | .99 846 | .92 565 | .07 435 | .00 154 | .07 589 | 11 |
| 50 | 8.92 561 | 9.99 845 | 8.92 716 | 1.07 284 | 0.00 155 | 1.07 439 | 10 |
| 51 | .92 710 | .99 844 | .92 866 | .07 134 | .00 156 | .07 290 | 9 |
| 52 | .92 859 | .99 843 | .93 016 | .06 984 | .00 157 | .07 141 | 8 |
| 53 | .93 007 | .99 842 | .93 165 | .06 835 | .00 158 | .06 993 | 7 |
| 54 | .93 154 | .99 841 | .93 313 | .06 687 | .00 159 | .06 846 | 6 |
| 55 | 8.93 301 | 9.99 840 | 8.93 462 | 1.06 538 | 0.00 160 | 1.06 699 | 5 |
| 56 | .93 448 | .99 839 | .93 609 | .06 391 | .00 161 | .06 552 | 4 |
| 57 | .93 594 | .99 838 | .93 756 | .06 244 | .00 162 | .06 406 | 3 |
| 58 | .93 740 | .99 837 | .93 903 | .06 097 | .00 163 | .06 260 | 2 |
| 59 | .93 885 | .99 836 | .94 049 | .05 951 | .00 164 | .06 115 | 1 |
| 60 | 8.94 030 | 9.99 834 | 8.94 195 | 1.05 805 | 0.00 166 | 1.05 970 | 0 |
| | Cos | Sin | Cot | Tan | Csc | Sec | ' |

94° (274°)

(265°) 85°

Table 4. Trigonometric Logarithms

5° (185°)

(354°) 174°

| | Sin | Cos | Tan | Cot | Sec | Csc | |
|-----------|------------|------------|------------|------------|------------|------------|-----------|
| 0 | 8.94 030 | 9.99 834 | 8.94 195 | 1.05 805 | 0.00 166 | 1.05 970 | 60 |
| 1 | .94 174 | .99 833 | .94 340 | .05 660 | .00 167 | .05 826 | 59 |
| 2 | .94 317 | .99 832 | .94 485 | .05 515 | .00 168 | .05 683 | 58 |
| 3 | .94 461 | .99 831 | .94 630 | .05 370 | .00 169 | .05 539 | 57 |
| 4 | .94 603 | .99 830 | .94 773 | .05 227 | .00 170 | .05 397 | 56 |
| 5 | 8.94 746 | 9.99 829 | 8.94 917 | 1.05 083 | 0.00 171 | 1.05 254 | 55 |
| 6 | .94 887 | .99 828 | .95 060 | .04 940 | .00 172 | .05 113 | 54 |
| 7 | .95 029 | .99 827 | .95 202 | .04 798 | .00 173 | .04 971 | 53 |
| 8 | .95 170 | .99 825 | .95 344 | .04 656 | .00 175 | .04 830 | 52 |
| 9 | .95 310 | .99 824 | .95 486 | .04 514 | .00 176 | .04 690 | 51 |
| 10 | 8.95 450 | 9.99 823 | 8.95 627 | 1.04 373 | 0.00 177 | 1.04 550 | 50 |
| 11 | .95 589 | .99 822 | .95 767 | .04 233 | .00 178 | .04 411 | 49 |
| 12 | .95 728 | .99 821 | .95 908 | .04 092 | .00 179 | .04 272 | 48 |
| 13 | .95 867 | .99 820 | .96 047 | .03 953 | .00 180 | .04 133 | 47 |
| 14 | .96 005 | .99 819 | .96 187 | .03 813 | .00 181 | .03 995 | 46 |
| 15 | 8.96 143 | 9.99 817 | 8.96 325 | 1.03 675 | 0.00 183 | 1.03 857 | 45 |
| 16 | .96 280 | .99 816 | .96 464 | .03 536 | .00 184 | .03 720 | 44 |
| 17 | .96 417 | .99 815 | .96 602 | .03 398 | .00 185 | .03 583 | 43 |
| 18 | .96 553 | .99 814 | .96 739 | .03 261 | .00 186 | .03 447 | 42 |
| 19 | .96 689 | .99 813 | .96 877 | .03 123 | .00 187 | .03 311 | 41 |
| 20 | 8.96 825 | 9.99 812 | 8.97 013 | 1.02 987 | 0.00 188 | 1.03 175 | 40 |
| 21 | .96 960 | .99 810 | .97 150 | .02 850 | .00 190 | .03 040 | 39 |
| 22 | .97 095 | .99 809 | .97 285 | .02 715 | .00 191 | .02 905 | 38 |
| 23 | .97 229 | .99 808 | .97 421 | .02 579 | .00 192 | .02 771 | 37 |
| 24 | .97 363 | .99 807 | .97 556 | .02 444 | .00 193 | .02 637 | 36 |
| 25 | 8.97 496 | 9.99 806 | 8.97 691 | 1.02 309 | 0.00 194 | 1.02 504 | 35 |
| 26 | .97 629 | .99 804 | .97 825 | .02 175 | .00 196 | .02 371 | 34 |
| 27 | .97 762 | .99 803 | .97 959 | .02 041 | .00 197 | .02 238 | 33 |
| 28 | .97 894 | .99 802 | .98 092 | .01 908 | .00 198 | .02 106 | 32 |
| 29 | .98 026 | .99 801 | .98 225 | .01 775 | .00 199 | .01 974 | 31 |
| 30 | 8.98 157 | 9.99 800 | 8.98 358 | 1.01 642 | 0.00 200 | 1.01 843 | 30 |
| 31 | .98 288 | .99 798 | .98 490 | .01 510 | .00 202 | .01 712 | 29 |
| 32 | .98 419 | .99 797 | .98 622 | .01 378 | .00 203 | .01 581 | 28 |
| 33 | .98 549 | .99 796 | .98 753 | .01 247 | .00 204 | .01 451 | 27 |
| 34 | .98 679 | .99 795 | .98 884 | .01 116 | .00 205 | .01 321 | 26 |
| 35 | 8.98 808 | 9.99 793 | 8.99 015 | 1.00 985 | 0.00 207 | 1.01 192 | 25 |
| 36 | .98 937 | .99 792 | .99 145 | .00 855 | .00 208 | .01 063 | 24 |
| 37 | .99 066 | .99 791 | .99 275 | .00 725 | .00 209 | .00 934 | 23 |
| 38 | .99 194 | .99 790 | .99 405 | .00 595 | .00 210 | .00 806 | 22 |
| 39 | .99 322 | .99 788 | .99 534 | .00 466 | .00 212 | .00 678 | 21 |
| 40 | 8.99 450 | 9.99 787 | 8.99 662 | 1.00 338 | 0.00 213 | 1.00 550 | 20 |
| 41 | .99 577 | .99 786 | .99 791 | .00 209 | .00 214 | .00 423 | 19 |
| 42 | .99 704 | .99 785 | .99 919 | .00 081 | .00 215 | .00 296 | 18 |
| 43 | .99 830 | .99 783 | 9.00 046 | 0.99 954 | .00 217 | .00 170 | 17 |
| 44 | .99 956 | .99 782 | .00 174 | .99 826 | .00 218 | .00 044 | 16 |
| 45 | 9.00 082 | 9.99 781 | 9.00 301 | 0.99 699 | 0.00 219 | 0.99 918 | 15 |
| 46 | .00 207 | .99 780 | .00 427 | .99 573 | .00 220 | .99 793 | 14 |
| 47 | .00 332 | .99 778 | .00 553 | .99 447 | .00 222 | .99 668 | 13 |
| 48 | .00 456 | .99 777 | .00 679 | .99 321 | .00 223 | .99 544 | 12 |
| 49 | .00 581 | .99 776 | .00 805 | .99 195 | .00 224 | .99 419 | 11 |
| 50 | 9.00 704 | 9.99 775 | 9.00 930 | 0.99 070 | 0.00 225 | 0.99 296 | 10 |
| 51 | .00 828 | .99 773 | .01 055 | .98 945 | .00 227 | .99 172 | 9 |
| 52 | .00 951 | .99 772 | .01 179 | .98 821 | .00 228 | .99 049 | 8 |
| 53 | .01 074 | .99 771 | .01 303 | .98 697 | .00 229 | .98 926 | 7 |
| 54 | .01 196 | .99 769 | .01 427 | .98 573 | .00 231 | .98 804 | 6 |
| 55 | 9.01 318 | 9.99 768 | 9.01 550 | 0.98 450 | 0.00 232 | 0.98 682 | 5 |
| 56 | .01 440 | .99 767 | .01 673 | .98 327 | .00 233 | .98 560 | 4 |
| 57 | .01 561 | .99 765 | .01 796 | .98 204 | .00 235 | .98 439 | 3 |
| 58 | .01 682 | .99 764 | .01 918 | .98 082 | .00 236 | .98 318 | 2 |
| 59 | .01 803 | .99 763 | .02 040 | .97 960 | .00 237 | .98 197 | 1 |
| 60 | 9.01 923 | 9.99 761 | 9.02 162 | 0.97 838 | 0.00 239 | 0.98 077 | 0 |
| | Cos | Sin | Cot | Tan | Csc | Sec | ' |

95° (275°)

(264°) 84°

6° (186°)

(353°) 173°

| | Sin | Cos | Tan | Cot | Sec | Csc | |
|-----------|----------|----------|----------|----------|----------|----------|-----------|
| 0 | 9.01 923 | 9.99 761 | 9.02 162 | 0.97 838 | 0.00 239 | 0.98 077 | 60 |
| 1 | .02 043 | .99 760 | .02 283 | .97 717 | .00 240 | .97 957 | 59 |
| 2 | .02 163 | .99 759 | .02 404 | .97 596 | .00 241 | .97 837 | 58 |
| 3 | .02 283 | .99 757 | .02 525 | .97 475 | .00 243 | .97 717 | 57 |
| 4 | .02 402 | .99 756 | .02 645 | .97 355 | .00 244 | .97 598 | 56 |
| 5 | 9.02 520 | 9.99 755 | 9.02 766 | 0.97 234 | 0.00 245 | 0.97 480 | 55 |
| 6 | .02 639 | .99 753 | .02 885 | .97 115 | .00 247 | .97 361 | 54 |
| 7 | .02 757 | .99 752 | .03 005 | .96 995 | .00 248 | .97 243 | 53 |
| 8 | .02 874 | .99 751 | .03 124 | .96 876 | .00 249 | .97 126 | 52 |
| 9 | .02 992 | .99 749 | .03 242 | .96 758 | .00 251 | .97 008 | 51 |
| 10 | 9.03 109 | 9.99 748 | 9.03 361 | 0.96 639 | 0.00 252 | 0.96 891 | 50 |
| 11 | .03 226 | .99 747 | .03 479 | .96 521 | .00 253 | .96 774 | 49 |
| 12 | .03 342 | .99 745 | .03 597 | .96 403 | .00 255 | .96 658 | 48 |
| 13 | .03 458 | .99 744 | .03 714 | .96 286 | .00 256 | .96 542 | 47 |
| 14 | .03 574 | .99 742 | .03 832 | .96 168 | .00 258 | .96 426 | 46 |
| 15 | 9.03 690 | 9.99 741 | 9.03 948 | 0.96 052 | 0.00 259 | 0.96 310 | 45 |
| 16 | .03 805 | .99 740 | .04 065 | .95 935 | .00 260 | .96 195 | 44 |
| 17 | .03 920 | .99 738 | .04 181 | .95 819 | .00 262 | .96 080 | 43 |
| 18 | .04 034 | .99 737 | .04 297 | .95 703 | .00 263 | .95 966 | 42 |
| 19 | .04 149 | .99 736 | .04 413 | .95 587 | .00 264 | .95 851 | 41 |
| 20 | 9.04 262 | 9.99 734 | 9.04 528 | 0.95 472 | 0.00 266 | 0.95 738 | 40 |
| 21 | .04 376 | .99 733 | .04 643 | .95 357 | .00 267 | .95 624 | 39 |
| 22 | .04 490 | .99 731 | .04 758 | .95 242 | .00 269 | .95 510 | 38 |
| 23 | .04 603 | .99 730 | .04 873 | .95 127 | .00 270 | .95 397 | 37 |
| 24 | .04 715 | .99 728 | .04 987 | .95 013 | .00 272 | .95 285 | 36 |
| 25 | 9.04 828 | 9.99 727 | 9.05 101 | 0.94 899 | 0.00 273 | 0.95 172 | 35 |
| 26 | .04 940 | .99 726 | .05 214 | .94 786 | .00 274 | .95 060 | 34 |
| 27 | .05 052 | .99 724 | .05 328 | .94 672 | .00 276 | .94 948 | 33 |
| 28 | .05 164 | .99 723 | .05 441 | .94 559 | .00 277 | .94 836 | 32 |
| 29 | .05 275 | .99 721 | .05 553 | .94 447 | .00 279 | .94 725 | 31 |
| 30 | 9.05 386 | 9.99 720 | 9.05 666 | 0.94 334 | 0.00 280 | 0.94 614 | 30 |
| 31 | .05 497 | .99 718 | .05 778 | .94 222 | .00 282 | .94 503 | 29 |
| 32 | .05 607 | .99 717 | .05 890 | .94 110 | .00 283 | .94 393 | 28 |
| 33 | .05 717 | .99 716 | .06 002 | .93 998 | .00 284 | .94 283 | 27 |
| 34 | .05 827 | .99 714 | .06 113 | .93 887 | .00 286 | .94 173 | 26 |
| 35 | 9.05 937 | 9.99 713 | 9.06 224 | 0.93 776 | 0.00 287 | 0.94 063 | 25 |
| 36 | .06 046 | .99 711 | .06 335 | .93 665 | .00 289 | .93 954 | 24 |
| 37 | .06 155 | .99 710 | .06 445 | .93 555 | .00 290 | .93 845 | 23 |
| 38 | .06 264 | .99 708 | .06 556 | .93 444 | .00 292 | .93 736 | 22 |
| 39 | .06 372 | .99 707 | .06 666 | .93 334 | .00 293 | .93 628 | 21 |
| 40 | 9.06 481 | 9.99 705 | 9.06 775 | 0.93 225 | 0.00 295 | 0.93 519 | 20 |
| 41 | .06 589 | .99 704 | .06 885 | .93 115 | .00 296 | .93 411 | 19 |
| 42 | .06 696 | .99 702 | .06 994 | .93 006 | .00 298 | .93 304 | 18 |
| 43 | .06 804 | .99 701 | .07 103 | .92 897 | .00 299 | .93 196 | 17 |
| 44 | .06 911 | .99 699 | .07 211 | .92 789 | .00 301 | .93 089 | 16 |
| 45 | 9.07 018 | 9.99 698 | 9.07 320 | 0.92 680 | 0.00 302 | 0.92 982 | 15 |
| 46 | .07 124 | .99 696 | .07 428 | .92 572 | .00 304 | .92 876 | 14 |
| 47 | .07 231 | .99 695 | .07 536 | .92 464 | .00 305 | .92 769 | 13 |
| 48 | .07 337 | .99 693 | .07 643 | .92 357 | .00.307 | .92 663 | 12 |
| 49 | .07 442 | .99 692 | .07 751 | .92 249 | .00 308 | .92 558 | 11 |
| 50 | 9.07 548 | 9.99 690 | 9.07 858 | 0.92 142 | 0.00 310 | 0.92 452 | 10 |
| 51 | .07 653 | .99 689 | .07 964 | .92 036 | .00 311 | .92 347 | 9 |
| 52 | .07 758 | .99 687 | .08 071 | .91 929 | .00 313 | .92 242 | 8 |
| 53 | .07 863 | .99 686 | .08 177 | .91 823 | .00 314 | .92 137 | 7 |
| 54 | .07 968 | .99 684 | .08 283 | .91 717 | .00 316 | .92 032 | 6 |
| 55 | 9.08 072 | 9.99 683 | 9.08 389 | 0.91 611 | 0.00 317 | 0.91 928 | 5 |
| 56 | .08 176 | .99 681 | .08 495 | .91 505 | .00 319 | .91 824 | 4 |
| 57 | .08 280 | .99 680 | .08 600 | .91 400 | .00 320 | .91 720 | 3 |
| 58 | .08 383 | .99 678 | .08 705 | .91 295 | .00 322 | .91 617 | 2 |
| 59 | .08 486 | .99 677 | .08 810 | .91 190 | .00 323 | .91 514 | 1 |
| 60 | 9.08 589 | 9.99 675 | 9.08 914 | 0.91 086 | 0.00 325 | 0.91 411 | 0 |
| | Cos | Sin | Cot | Tan | Csc | Sec | ' |

Table 4. Trigonometric Logarithms

7° (187°)

(352°) 172°

| / | Sin | Cos | Tan | Cot | Sec | Csc | / |
|-----------|------------|------------|------------|------------|------------|------------|-----------|
| 0 | 9.08 589 | 9.99 675 | 9.08 914 | 0.91 086 | 0.00 325 | 0.91 411 | 60 |
| 1 | .08 692 | .99 674 | .09 019 | .90 981 | .00 326 | .91 308 | 59 |
| 2 | .08 795 | .99 672 | .09 123 | .90 877 | .00 328 | .91 205 | 58 |
| 3 | .08 897 | .99 670 | .09 227 | .90 773 | .00 330 | .91 103 | 57 |
| 4 | .08 999 | .99 669 | .09 330 | .90 670 | .00 331 | .91 001 | 56 |
| 5 | 9.09 101 | 9.99 667 | 9.09 434 | 0.90 566 | 0.00 333 | 0.90 899 | 55 |
| 6 | .09 202 | .99 666 | .09 537 | .90 463 | .00 334 | .90 798 | 54 |
| 7 | .09 304 | .99 664 | .09 640 | .90 360 | .00 336 | .90 696 | 53 |
| 8 | .09 405 | .99 663 | .09 742 | .90 258 | .00 337 | .90 595 | 52 |
| 9 | .09 506 | .99 661 | .09 845 | .90 155 | .00 339 | .90 494 | 51 |
| 10 | 9.09 606 | 9.99 659 | 9.09 947 | 0.90 053 | 0.00 341 | 0.90 394 | 50 |
| 11 | .09 707 | .99 658 | .10 049 | .89 951 | .00 342 | .90 293 | 49 |
| 12 | .09 807 | .99 656 | .10 150 | .89 850 | .00 344 | .90 193 | 48 |
| 13 | .09 907 | .99 655 | .10 252 | .89 748 | .00 345 | .90 093 | 47 |
| 14 | .10 006 | .99 653 | .10 353 | .89 647 | .00 347 | .89 994 | 46 |
| 15 | 9.10 106 | 9.99 651 | 9.10 454 | 0.89 546 | 0.00 349 | 0.89 894 | 45 |
| 16 | .10 205 | .99 650 | .10 555 | .89 445 | .00 350 | .89 795 | 44 |
| 17 | .10 304 | .99 648 | .10 656 | .89 344 | .00 352 | .89 696 | 43 |
| 18 | .10 402 | .99 647 | .10 756 | .89 244 | .00 353 | .89 598 | 42 |
| 19 | .10 501 | .99 645 | .10 856 | .89 144 | .00 355 | .89 499 | 41 |
| 20 | 9.10 599 | 9.99 643 | 9.10 956 | 0.89 044 | 0.00 357 | 0.89 401 | 40 |
| 21 | .10 697 | .99 642 | .11 056 | .88 944 | .00 358 | .89 303 | 39 |
| 22 | .10 795 | .99 640 | .11 155 | .88 845 | .00 360 | .89 205 | 38 |
| 23 | .10 893 | .99 638 | .11 254 | .88 746 | .00 362 | .89 107 | 37 |
| 24 | .10 990 | .99 637 | .11 353 | .88 647 | .00 363 | .89 010 | 36 |
| 25 | 9.11 087 | 9.99 635 | 9.11 452 | 0.88 548 | 0.00 365 | 0.88 913 | 35 |
| 26 | .11 184 | .99 633 | .11 551 | .88 449 | .00 367 | .88 816 | 34 |
| 27 | .11 281 | .99 632 | .11 649 | .88 351 | .00 368 | .88 719 | 33 |
| 28 | .11 377 | .99 630 | .11 747 | .88 253 | .00 370 | .88 623 | 32 |
| 29 | .11 474 | .99 629 | .11 845 | .88 155 | .00 371 | .88 526 | 31 |
| 30 | 9.11 570 | 9.99 627 | 9.11 943 | 0.88 057 | 0.00 373 | 0.88 430 | 30 |
| 31 | .11 666 | .99 625 | .12 040 | .87 960 | .00 375 | .88 334 | 29 |
| 32 | .11 761 | .99 624 | .12 138 | .87 862 | .00 376 | .88 239 | 28 |
| 33 | .11 857 | .99 622 | .12 235 | .87 765 | .00 378 | .88 143 | 27 |
| 34 | .11 952 | .99 620 | .12 332 | .87 668 | .00 380 | .88 048 | 26 |
| 35 | 9.12 047 | 9.99 618 | 9.12 428 | 0.87 572 | 0.00 382 | 0.87 953 | 25 |
| 36 | .12 142 | .99 617 | .12 525 | .87 475 | .00 383 | .87 858 | 24 |
| 37 | .12 236 | .99 615 | .12 621 | .87 379 | .00 385 | .87 764 | 23 |
| 38 | .12 331 | .99 613 | .12 717 | .87 283 | .00 387 | .87 669 | 22 |
| 39 | .12 425 | .99 612 | .12 813 | .87 187 | .00 388 | .87 575 | 21 |
| 40 | 9.12 519 | 9.99 610 | 9.12 909 | 0.87 091 | 0.00 390 | 0.87 481 | 20 |
| 41 | .12 612 | .99 608 | .13 004 | .86 996 | .00 392 | .87 388 | 19 |
| 42 | .12 706 | .99 607 | .13 099 | .86 901 | .00 393 | .87 294 | 18 |
| 43 | .12 799 | .99 605 | .13 194 | .86 806 | .00 395 | .87 201 | 17 |
| 44 | .12 892 | .99 603 | .13 289 | .86 711 | .00 397 | .87 108 | 16 |
| 45 | 9.12 985 | 9.99 601 | 9.13 384 | 0.86 616 | 0.00 399 | 0.87 015 | 15 |
| 46 | .13 078 | .99 600 | .13 478 | .86 522 | .00 400 | .86 922 | 14 |
| 47 | .13 171 | .99 598 | .13 573 | .86 427 | .00 402 | .86 829 | 13 |
| 48 | .13 263 | .99 596 | .13 667 | .86 333 | .00 404 | .86 737 | 12 |
| 49 | .13 355 | .99 595 | .13 761 | .86 239 | .00 405 | .86 645 | 11 |
| 50 | 9.13 447 | 9.99 593 | 9.13 854 | 0.86 146 | 0.00 407 | 0.86 553 | 10 |
| 51 | .13 539 | .99 591 | .13 948 | .86 052 | .00 409 | .86 461 | 9 |
| 52 | .13 630 | .99 589 | .14 041 | .85 959 | .00 411 | .86 370 | 8 |
| 53 | .13 722 | .99 588 | .14 134 | .85 866 | .00 412 | .86 278 | 7 |
| 54 | .13 813 | .99 586 | .14 227 | .85 773 | .00 414 | .86 187 | 6 |
| 55 | 9.13 904 | 9.99 584 | 9.14 320 | 0.85 680 | 0.00 416 | 0.86 096 | 5 |
| 56 | .13 994 | .99 582 | .14 412 | .85 588 | .00 418 | .86 006 | 4 |
| 57 | .14 085 | .99 581 | .14 504 | .85 496 | .00 419 | .85 915 | 3 |
| 58 | .14 175 | .99 579 | .14 597 | .85 403 | .00 421 | .85 825 | 2 |
| 59 | .14 266 | .99 577 | .14 688 | .85 312 | .00 423 | .85 734 | 1 |
| 60 | 9.14 356 | 9.99 575 | 9.14 780 | 0.85 220 | 0.00 425 | 0.85 644 | 0 |
| | Cos | Sin | Cot | Tan | Csc | Sec | / |

97° (277°)

(262°) 82°

8° (188°)

(351°) 171°

| | Sin | Cos | Tan | Cot | Sec | Csc | |
|-----------|----------|----------|----------|----------|----------|----------|-----------|
| 0 | 9.14 356 | 9.99 575 | 9.14 780 | 0.85 220 | 0.00 425 | 0.85 644 | 60 |
| 1 | .14 445 | .99 574 | .14 872 | .85 128 | .00 426 | .85 555 | 59 |
| 2 | .14 535 | .99 572 | .14 963 | .85 037 | .00 428 | .85 465 | 58 |
| 3 | .14 624 | .99 570 | .15 054 | .84 946 | .00 430 | .85 376 | 57 |
| 4 | .14 714 | .99 568 | .15 145 | .84 855 | .00 432 | .85 286 | 56 |
| 5 | 9.14 803 | 9.99 566 | 9.15 236 | 0.84 764 | 0.00 434 | 0.85 197 | 55 |
| 6 | .14 891 | .99 565 | .15 327 | .84 673 | .00 435 | .85 109 | 54 |
| 7 | .14 980 | .99 563 | .15 417 | .84 583 | .00 437 | .85 020 | 53 |
| 8 | .15 069 | .99 561 | .15 508 | .84 492 | .00 439 | .84 931 | 52 |
| 9 | .15 157 | .99 559 | .15 598 | .84 402 | .00 441 | .84 843 | 51 |
| 10 | 9.15 245 | 9.99 557 | 9.15 688 | 0.84 312 | 0.00 443 | 0.84 755 | 50 |
| 11 | .15 333 | .99 556 | .15 777 | .84 223 | .00 444 | .84 667 | 49 |
| 12 | .15 421 | .99 554 | .15 867 | .84 133 | .00 446 | .84 579 | 48 |
| 13 | .15 508 | .99 552 | .15 956 | .84 044 | .00 448 | .84 492 | 47 |
| 14 | .15 596 | .99 550 | .16 046 | .83 954 | .00 450 | .84 404 | 46 |
| 15 | 9.15 683 | 9.99 548 | 9.16 135 | 0.83 865 | 0.00 452 | 0.84 317 | 45 |
| 16 | .15 770 | .99 546 | .16 224 | .83 776 | .00 454 | .84 230 | 44 |
| 17 | .15 857 | .99 545 | .16 312 | .83 688 | .00 455 | .84 143 | 43 |
| 18 | .15 944 | .99 543 | .16 401 | .83 599 | .00 457 | .84 056 | 42 |
| 19 | .16 030 | .99 541 | .16 489 | .83 511 | .00 459 | .83 970 | 41 |
| 20 | 9.16 116 | 9.99 539 | 9.16 577 | 0.83 423 | 0.00 461 | 0.83 884 | 40 |
| 21 | .16 203 | .99 537 | .16 665 | .83 335 | .00 463 | .83 797 | 39 |
| 22 | .16 289 | .99 535 | .16 753 | .83 247 | .00 465 | .83 711 | 38 |
| 23 | .16 374 | .99 533 | .16 841 | .83 159 | .00 467 | .83 626 | 37 |
| 24 | .16 460 | .99 532 | .16 928 | .83 072 | .00 468 | .83 540 | 36 |
| 25 | 9.16 545 | 9.99 530 | 9.17 016 | 0.82 984 | 0.00 470 | 0.83 455 | 35 |
| 26 | .16 631 | .99 528 | .17 103 | .82 897 | .00 472 | .83 369 | 34 |
| 27 | .16 716 | .99 526 | .17 190 | .82 810 | .00 474 | .83 284 | 33 |
| 28 | .16 801 | .99 524 | .17 277 | .82 723 | .00 476 | .83 199 | 32 |
| 29 | .16 886 | .99 522 | .17 363 | .82 637 | .00 478 | .83 114 | 31 |
| 30 | 9.16 970 | 9.99 520 | 9.17 450 | 0.82 550 | 0.00 480 | 0.83 030 | 30 |
| 31 | .17 055 | .99 518 | .17 536 | .82 464 | .00 482 | .82 945 | 29 |
| 32 | .17 139 | .99 517 | .17 622 | .82 378 | .00 483 | .82 861 | 28 |
| 33 | .17 223 | .99 515 | .17 708 | .82 292 | .00 485 | .82 777 | 27 |
| 34 | .17 307 | .99 513 | .17 794 | .82 206 | .00 487 | .82 693 | 26 |
| 35 | 9.17 391 | 9.99 511 | 9.17 880 | 0.82 120 | 0.00 489 | 0.82 609 | 25 |
| 36 | .17 474 | .99 509 | .17 965 | .82 035 | .00 491 | .82 526 | 24 |
| 37 | .17 558 | .99 507 | .18 051 | .81 949 | .00 493 | .82 442 | 23 |
| 38 | .17 641 | .99 505 | .18 136 | .81 864 | .00 495 | .82 359 | 22 |
| 39 | .17 724 | .99 503 | .18 221 | .81 779 | .00 497 | .82 276 | 21 |
| 40 | 9.17 807 | 9.99 501 | 9.18 306 | 0.81 694 | 0.00 499 | 0.82 193 | 20 |
| 41 | .17 890 | .99 499 | .18 391 | .81 609 | .00 501 | .82 110 | 19 |
| 42 | .17 973 | .99 497 | .18 475 | .81 525 | .00 503 | .82 027 | 18 |
| 43 | .18 055 | .99 495 | .18 560 | .81 440 | .00 505 | .81 945 | 17 |
| 44 | .18 137 | .99 494 | .18 644 | .81 356 | .00 506 | .81 863 | 16 |
| 45 | 9.18 220 | 9.99 492 | 9.18 728 | 0.81 272 | 0.00 508 | 0.81 780 | 15 |
| 46 | .18 302 | .99 490 | .18 812 | .81 188 | .00 510 | .81 698 | 14 |
| 47 | .18 383 | .99 488 | .18 896 | .81 104 | .00 512 | .81 617 | 13 |
| 48 | .18 465 | .99 486 | .18 979 | .81 021 | .00 514 | .81 535 | 12 |
| 49 | .18 547 | .99 484 | .19 063 | .80 937 | .00 516 | .81 453 | 11 |
| 50 | 9.18 628 | 9.99 482 | 9.19 146 | 0.80 854 | 0.00 518 | 0.81 372 | 10 |
| 51 | .18 709 | .99 480 | .19 229 | .80 771 | .00 520 | .81 291 | 9 |
| 52 | .18 790 | .99 478 | .19 312 | .80 688 | .00 522 | .81 210 | 8 |
| 53 | .18 871 | .99 476 | .19 395 | .80 605 | .00 524 | .81 129 | 7 |
| 54 | .18 952 | .99 474 | .19 478 | .80 522 | .00 526 | .81 048 | 6 |
| 55 | 9.19 033 | 9.99 472 | 9.19 561 | 0.80 439 | 0.00 528 | 0.80 967 | 5 |
| 56 | .19 113 | .99 470 | .19 643 | .80 357 | .00 530 | .80 887 | 4 |
| 57 | .19 193 | .99 468 | .19 725 | .80 275 | .00 532 | .80 807 | 3 |
| 58 | .19 273 | .99 466 | .19 807 | .80 193 | .00 534 | .80 727 | 2 |
| 59 | .19 353 | .99 464 | .19 889 | .80 111 | .00 536 | .80 647 | 1 |
| 60 | 9.19 433 | 9.99 462 | 9.19 971 | 0.80 029 | 0.00 538 | 0.80 567 | 0 |
| | Cos | Sin | Cot | Tan | Csc | Sec | ' |

98° (278°)

(261°) 81°

Table 4. Trigonometric Logarithms

9° (189°)

(350°) 170°

| | Sin | Cos | Tan | Cot | Sec | Csc | |
|-----------|------------|------------|------------|------------|------------|------------|-----------|
| 0 | 9.19 433 | 9.99 462 | 9.19 971 | 0.80 029 | 0.00 538 | 0.80 567 | 60 |
| 1 | .19 513 | .99 460 | .20 053 | .79 947 | .00 540 | .80 487 | 59 |
| 2 | .19 592 | .99 458 | .20 134 | .79 866 | .00 542 | .80 408 | 58 |
| 3 | .19 672 | .99 456 | .20 216 | .79 784 | .00 544 | .80 328 | 57 |
| 4 | .19 751 | .99 454 | .20 297 | .79 703 | .00 546 | .80 249 | 56 |
| 5 | 9.19 830 | 9.99 452 | 9.20 378 | 0.79 622 | 0.00 548 | 0.80 170 | 55 |
| 6 | .19 909 | .99 450 | .20 459 | .79 541 | .00 550 | .80 091 | 54 |
| 7 | .19 988 | .99 448 | .20 540 | .79 460 | .00 552 | .80 012 | 53 |
| 8 | .20 067 | .99 446 | .20 621 | .79 379 | .00 554 | .79 933 | 52 |
| 9 | .20 145 | .99 444 | .20 701 | .79 299 | .00 556 | .79 855 | 51 |
| 10 | 9.20 223 | 9.99 442 | 9.20 782 | 0.79 218 | 0.00 558 | 0.79 777 | 50 |
| 11 | .20 302 | .99 440 | .20 862 | .79 138 | .00 560 | .79 698 | 49 |
| 12 | .20 380 | .99 438 | .20 942 | .79 058 | .00 562 | .79 620 | 48 |
| 13 | .20 458 | .99 436 | .21 022 | .78 978 | .00 564 | .79 542 | 47 |
| 14 | .20 535 | .99 434 | .21 102 | .78 898 | .00 566 | .79 465 | 46 |
| 15 | 9.20 613 | 9.99 432 | 9.21 182 | 0.78 818 | 0.00 568 | 0.79 387 | 45 |
| 16 | .20 691 | .99 429 | .21 261 | .78 739 | .00 571 | .79 309 | 44 |
| 17 | .20 768 | .99 427 | .21 341 | .78 659 | .00 573 | .79 232 | 43 |
| 18 | .20 845 | .99 425 | .21 420 | .78 580 | .00 575 | .79 155 | 42 |
| 19 | .20 922 | .99 423 | .21 499 | .78 501 | .00 577 | .79 078 | 41 |
| 20 | 9.20 999 | 9.99 421 | 9.21 578 | 0.78 422 | 0.00 579 | 0.79 001 | 40 |
| 21 | .21 076 | .99 419 | .21 657 | .78 343 | .00 581 | .78 924 | 39 |
| 22 | .21 153 | .99 417 | .21 736 | .78 264 | .00 583 | .78 847 | 38 |
| 23 | .21 229 | .99 415 | .21 814 | .78 186 | .00 585 | .78 771 | 37 |
| 24 | .21 306 | .99 413 | .21 893 | .78 107 | .00 587 | .78 694 | 36 |
| 25 | 9.21 382 | 9.99 411 | 9.21 971 | 0.78 029 | 0.00 589 | 0.78 618 | 35 |
| 26 | .21 458 | .99 409 | .22 049 | .77 951 | .00 591 | .78 542 | 34 |
| 27 | .21 534 | .99 407 | .22 127 | .77 873 | .00 593 | .78 466 | 33 |
| 28 | .21 610 | .99 404 | .22 205 | .77 795 | .00 596 | .78 390 | 32 |
| 29 | .21 685 | .99 402 | .22 283 | .77 717 | .00 598 | .78 315 | 31 |
| 30 | 9.21 761 | 9.99 400 | 9.22 361 | 0.77 639 | 0.00 600 | 0.78 239 | 30 |
| 31 | .21 836 | .99 398 | .22 438 | .77 562 | .00 602 | .78 164 | 29 |
| 32 | .21 912 | .99 396 | .22 516 | .77 484 | .00 604 | .78 088 | 28 |
| 33 | .21 987 | .99 394 | .22 593 | .77 407 | .00 606 | .78 013 | 27 |
| 34 | .22 062 | .99 392 | .22 670 | .77 330 | .00 608 | .77 938 | 26 |
| 35 | 9.22 137 | 9.99 390 | 9.22 747 | 0.77 253 | 0.00 610 | 0.77 863 | 25 |
| 36 | .22 211 | .99 388 | .22 824 | .77 176 | .00 612 | .77 789 | 24 |
| 37 | .22 286 | .99 385 | .22 901 | .77 099 | .00 615 | .77 714 | 23 |
| 38 | .22 361 | .99 383 | .22 977 | .77 023 | .00 617 | .77 639 | 22 |
| 39 | .22 435 | .99 381 | .23 054 | .76 946 | .00 619 | .77 565 | 21 |
| 40 | 9.22 509 | 9.99 379 | 9.23 130 | 0.76 870 | 0.00 621 | 0.77 491 | 20 |
| 41 | .22 583 | .99 377 | .23 206 | .76 794 | .00 623 | .77 417 | 19 |
| 42 | .22 657 | .99 375 | .23 283 | .76 717 | .00 625 | .77 343 | 18 |
| 43 | .22 731 | .99 372 | .23 359 | .76 641 | .00 628 | .77 269 | 17 |
| 44 | .22 805 | .99 370 | .23 435 | .76 565 | .00 630 | .77 195 | 16 |
| 45 | 9.22 878 | 9.99 368 | 9.23 510 | 0.76 490 | 0.00 632 | 0.77 122 | 15 |
| 46 | .22 952 | .99 366 | .23 586 | .76 414 | .00 634 | .77 048 | 14 |
| 47 | .23 025 | .99 364 | .23 661 | .76 339 | .00 636 | .76 975 | 13 |
| 48 | .23 098 | .99 362 | .23 737 | .76 263 | .00 638 | .76 902 | 12 |
| 49 | .23 171 | .99 359 | .23 812 | .76 188 | .00 641 | .76 829 | 11 |
| 50 | 9.23 244 | 9.99 357 | 9.23 887 | 0.76 113 | 0.00 643 | 0.76 756 | 10 |
| 51 | .23 317 | .99 355 | .23 962 | .76 038 | .00 645 | .76 683 | 9 |
| 52 | .23 390 | .99 353 | .24 037 | .75 963 | .00 647 | .76 610 | 8 |
| 53 | .23 462 | .99 351 | .24 112 | .75 888 | .00 649 | .76 538 | 7 |
| 54 | .23 535 | .99 348 | .24 186 | .75 814 | .00 652 | .76 465 | 6 |
| 55 | 9.23 607 | 9.99 346 | 9.24 261 | 0.75 739 | 0.00 654 | 0.76 393 | 5 |
| 56 | .23 679 | .99 344 | .24 335 | .75 665 | .00 656 | .76 321 | 4 |
| 57 | .23 752 | .99 342 | .24 410 | .75 590 | .00 658 | .76 248 | 3 |
| 58 | .23 823 | .99 340 | .24 484 | .75 516 | .00 660 | .76 177 | 2 |
| 59 | .23 895 | .99 337 | .24 558 | .75 442 | .00 663 | .76 105 | 1 |
| 60 | 9.23 967 | 9.99 335 | 9.24 632 | 0.75 368 | 0.00 665 | 0.76 033 | 0 |
| | Cos | Sin | Cot | Tan | Csc | Sec | |

99° (279°)

(260°) 80°

10° (190°)

(349°) 169°

| | Sin | Cos | Tan | Cot | Sec | Csc | |
|----|----------|----------|----------|----------|----------|----------|----|
| 0 | 9.23 967 | 9.99 335 | 9.24 632 | 0.75 368 | 0.00 665 | 0.76 033 | 60 |
| 1 | .24 039 | .99 333 | .24 706 | .75 294 | .00 667 | .75 961 | 59 |
| 2 | .24 110 | .99 331 | .24 779 | .75 221 | .00 669 | .75 890 | 58 |
| 3 | .24 181 | .99 328 | .24 853 | .75 147 | .00 672 | .75 819 | 57 |
| 4 | .24 253 | .99 326 | .24 926 | .75 074 | .00 674 | .75 747 | 56 |
| 5 | 9.24 324 | 9.99 324 | 9.25 000 | 0.75 000 | 0.00 676 | 0.75 676 | 55 |
| 6 | .24 395 | .99 322 | .25 073 | .74 927 | .00 678 | .75 605 | 54 |
| 7 | .24 466 | .99 319 | .25 146 | .74 854 | .00 681 | .75 534 | 53 |
| 8 | .24 536 | .99 317 | .25 219 | .74 781 | .00 683 | .75 464 | 52 |
| 9 | .24 607 | .99 315 | .25 292 | .74 708 | .00 685 | .75 393 | 51 |
| 10 | 9.24 677 | 9.99 313 | 9.25 365 | 0.74 635 | 0.00 687 | 0.75 323 | 50 |
| 11 | .24 748 | .99 310 | .25 437 | .74 563 | .00 690 | .75 252 | 49 |
| 12 | .24 818 | .99 308 | .25 510 | .74 490 | .00 692 | .75 182 | 48 |
| 13 | .24 888 | .99 306 | .25 582 | .74 418 | .00 694 | .75 112 | 47 |
| 14 | .24 958 | .99 304 | .25 655 | .74 345 | .00 696 | .75 042 | 46 |
| 15 | 9.25 028 | 9.99 301 | 9.25 727 | 0.74 273 | 0.00 699 | 0.74 972 | 45 |
| 16 | .25 098 | .99 299 | .25 799 | .74 201 | .00 701 | .74 902 | 44 |
| 17 | .25 168 | .99 297 | .25 871 | .74 129 | .00 703 | .74 832 | 43 |
| 18 | .25 237 | .99 294 | .25 943 | .74 057 | .00 706 | .74 763 | 42 |
| 19 | .25 307 | .99 292 | .26 015 | .73 985 | .00 708 | .74 693 | 41 |
| 20 | 9.25 376 | 9.99 290 | 9.26 086 | 0.73 914 | 0.00 710 | 0.74 624 | 40 |
| 21 | .25 445 | .99 288 | .26 158 | .73 842 | .00 712 | .74 555 | 39 |
| 22 | .25 514 | .99 285 | .26 229 | .73 771 | .00 715 | .74 486 | 38 |
| 23 | .25 583 | .99 283 | .26 301 | .73 699 | .00 717 | .74 417 | 37 |
| 24 | .25 652 | .99 281 | .26 372 | .73 628 | .00 719 | .74 348 | 36 |
| 25 | 9.25 721 | 9.99 278 | 9.26 443 | 0.73 557 | 0.00 722 | 0.74 279 | 35 |
| 26 | .25 790 | .99 276 | .26 514 | .73 486 | .00 724 | .74 210 | 34 |
| 27 | .25 858 | .99 274 | .26 585 | .73 415 | .00 726 | .74 142 | 33 |
| 28 | .25 927 | .99 271 | .26 655 | .73 345 | .00 729 | .74 073 | 32 |
| 29 | .25 995 | .99 269 | .26 726 | .73 274 | .00 731 | .74 005 | 31 |
| 30 | 9.26 063 | 9.99 267 | 9.26 797 | 0.73 203 | 0.00 733 | 0.73 937 | 30 |
| 31 | .26 131 | .99 264 | .26 867 | .73 133 | .00 736 | .73 869 | 29 |
| 32 | .26 199 | .99 262 | .26 937 | .73 063 | .00 738 | .73 801 | 28 |
| 33 | .26 267 | .99 260 | .27 008 | .72 992 | .00 740 | .73 733 | 27 |
| 34 | .26 335 | .99 257 | .27 078 | .72 922 | .00 743 | .73 665 | 26 |
| 35 | 9.26 403 | 9.99 255 | 9.27 148 | 0.72 852 | 0.00 745 | 0.73 597 | 25 |
| 36 | .26 470 | .99 252 | .27 218 | .72 782 | .00 748 | .73 530 | 24 |
| 37 | .26 538 | .99 250 | .27 288 | .72 712 | .00 750 | .73 462 | 23 |
| 38 | .26 605 | .99 248 | .27 357 | .72 643 | .00 752 | .73 395 | 22 |
| 39 | .26 672 | .99 245 | .27 427 | .72 573 | .00 755 | .73 328 | 21 |
| 40 | 9.26 739 | 9.99 243 | 9.27 496 | 0.72 504 | 0.00 757 | 0.73 261 | 20 |
| 41 | .26 806 | .99 241 | .27 566 | .72 434 | .00 759 | .73 194 | 19 |
| 42 | .26 873 | .99 238 | .27 635 | .72 365 | .00 762 | .73 127 | 18 |
| 43 | .26 940 | .99 236 | .27 704 | .72 296 | .00 764 | .73 060 | 17 |
| 44 | .27 007 | .99 233 | .27 773 | .72 227 | .00 767 | .72 993 | 16 |
| 45 | 9.27 073 | 9.99 231 | 9.27 842 | 0.72 158 | 0.00 769 | 0.72 927 | 15 |
| 46 | .27 140 | .99 229 | .27 911 | .72 089 | .00 771 | .72 860 | 14 |
| 47 | .27 206 | .99 226 | .27 980 | .72 020 | .00 774 | .72 794 | 13 |
| 48 | .27 273 | .99 224 | .28 049 | .71 951 | .00 776 | .72 727 | 12 |
| 49 | .27 339 | .99 221 | .28 117 | .71 883 | .00 779 | .72 661 | 11 |
| 50 | 9.27 405 | 9.99 219 | 9.28 186 | 0.71 814 | 0.00 781 | 0.72 595 | 10 |
| 51 | .27 471 | .99 217 | .28 254 | .71 746 | .00 783 | .72 529 | 9 |
| 52 | .27 537 | .99 214 | .28 323 | .71 677 | .00 786 | .72 463 | 8 |
| 53 | .27 602 | .99 212 | .28 391 | .71 609 | .00 788 | .72 398 | 7 |
| 54 | .27 668 | .99 209 | .28 459 | .71 541 | .00 791 | .72 332 | 6 |
| 55 | 9.27 734 | 9.99 207 | 9.28 527 | 0.71 473 | 0.00 793 | 0.72 266 | 5 |
| 56 | .27 799 | .99 204 | .28 595 | .71 405 | .00 796 | .72 201 | 4 |
| 57 | .27 864 | .99 202 | .28 662 | .71 338 | .00 798 | .72 136 | 3 |
| 58 | .27 930 | .99 200 | .28 730 | .71 270 | .00 800 | .72 070 | 2 |
| 59 | .27 995 | .99 197 | .28 798 | .71 202 | .00 803 | .72 005 | 1 |
| 60 | 9.28 060 | 9.99 195 | 9.28 865 | 0.71 135 | 0.00 805 | 0.71 940 | 0 |
| | Cos | Sin | Cot | Tan | Csc | Sec | |

100° (280°)

(259°) 79°

Table 4. Trigonometric Logarithms

11° (191°)

(348°) 168°

| | Sin | Cos | Tan | Cot | Sec | Csc | |
|-----------|------------|------------|------------|------------|------------|------------|-----------|
| 0 | 9.28 060 | 9.99 195 | 9.28 865 | 0.71 135 | 0.00 805 | 0.71 940 | 60 |
| 1 | .28 125 | .99 192 | .28 933 | .71 067 | .00 808 | .71 875 | 59 |
| 2 | .28 190 | .99 190 | .29 000 | .71 000 | .00 810 | .71 810 | 58 |
| 3 | .28 254 | .99 187 | .29 067 | .70 933 | .00 813 | .71 746 | 57 |
| 4 | .28 319 | .99 185 | .29 134 | .70 866 | .00 815 | .71 681 | 56 |
| 5 | 9.28 384 | 9.99 182 | 9.29 201 | 0.70 799 | 0.00 818 | 0.71 616 | 55 |
| 6 | .28 448 | .99 180 | .29 268 | .70 732 | .00 820 | .71 552 | 54 |
| 7 | .28 512 | .99 177 | .29 335 | .70 665 | .00 823 | .71 488 | 53 |
| 8 | .28 577 | .99 175 | .29 402 | .70 598 | .00 825 | .71 423 | 52 |
| 9 | .28 641 | .99 172 | .29 468 | .70 532 | .00 828 | .71 359 | 51 |
| 10 | 9.28 705 | 9.99 170 | 9.29 535 | 0.70 465 | 0.00 830 | 0.71 295 | 50 |
| 11 | .28 769 | .99 167 | .29 601 | .70 399 | .00 833 | .71 231 | 49 |
| 12 | .28 833 | .99 165 | .29 668 | .70 332 | .00 835 | .71 167 | 48 |
| 13 | .28 896 | .99 162 | .29 734 | .70 266 | .00 838 | .71 104 | 47 |
| 14 | .28 960 | .99 160 | .29 800 | .70 200 | .00 840 | .71 040 | 46 |
| 15 | 9.29 024 | 9.99 157 | 9.29 866 | 0.70 134 | 0.00 843 | 0.70 976 | 45 |
| 16 | .29 087 | .99 155 | .29 932 | .70 068 | .00 845 | .70 913 | 44 |
| 17 | .29 150 | .99 152 | .29 998 | .70 002 | .00 848 | .70 850 | 43 |
| 18 | .29 214 | .99 150 | .30 064 | .69 936 | .00 850 | .70 786 | 42 |
| 19 | .29 277 | .99 147 | .30 130 | .69 870 | .00 853 | .70 723 | 41 |
| 20 | 9.29 340 | 9.99 145 | 9.30 195 | 0.69 805 | 0.00 855 | 0.70 660 | 40 |
| 21 | .29 403 | .99 142 | .30 261 | .69 739 | .00 858 | .70 597 | 39 |
| 22 | .29 466 | .99 140 | .30 326 | .69 674 | .00 860 | .70 534 | 38 |
| 23 | .29 529 | .99 137 | .30 391 | .69 609 | .00 863 | .70 471 | 37 |
| 24 | .29 591 | .99 135 | .30 457 | .69 543 | .00 865 | .70 409 | 36 |
| 25 | 9.29 654 | 9.99 132 | 9.30 522 | 0.69 478 | 0.00 868 | 0.70 346 | 35 |
| 26 | .29 716 | .99 130 | .30 587 | .69 413 | .00 870 | .70 284 | 34 |
| 27 | .29 779 | .99 127 | .30 652 | .69 348 | .00 873 | .70 221 | 33 |
| 28 | .29 841 | .99 124 | .30 717 | .69 283 | .00 876 | .70 159 | 32 |
| 29 | .29 903 | .99 122 | .30 782 | .69 218 | .00 878 | .70 097 | 31 |
| 30 | 9.29 966 | 9.99 119 | 9.30 846 | 0.69 154 | 0.00 881 | 0.70 034 | 30 |
| 31 | .30 028 | .99 117 | .30 911 | .69 089 | .00 883 | .69 972 | 29 |
| 32 | .30 090 | .99 114 | .30 975 | .69 025 | .00 886 | .69 910 | 28 |
| 33 | .30 151 | .99 112 | .31 040 | .68 960 | .00 888 | .69 849 | 27 |
| 34 | .30 213 | .99 109 | .31 104 | .68 896 | .00 891 | .69 787 | 26 |
| 35 | 9.30 275 | 9.99 106 | 9.31 168 | 0.68 832 | 0.00 894 | 0.69 725 | 25 |
| 36 | .30 336 | .99 104 | .31 233 | .68 767 | .00 896 | .69 664 | 24 |
| 37 | .30 398 | .99 101 | .31 297 | .68 703 | .00 899 | .69 602 | 23 |
| 38 | .30 459 | .99 099 | .31 361 | .68 639 | .00 901 | .69 541 | 22 |
| 39 | .30 521 | .99 096 | .31 425 | .68 575 | .00 904 | .69 479 | 21 |
| 40 | 9.30 582 | 9.99 093 | 9.31 489 | 0.68 511 | 0.00 907 | 0.69 418 | 20 |
| 41 | .30 643 | .99 091 | .31 552 | .68 448 | .00 909 | .69 357 | 19 |
| 42 | .30 704 | .99 088 | .31 616 | .68 384 | .00 912 | .69 296 | 18 |
| 43 | .30 765 | .99 086 | .31 679 | .68 321 | .00 914 | .69 235 | 17 |
| 44 | .30 826 | .99 083 | .31 743 | .68 257 | .00 917 | .69 174 | 16 |
| 45 | 9.30 887 | 9.99 080 | 9.31 806 | 0.68 194 | 0.00 920 | 0.69 113 | 15 |
| 46 | .30 947 | .99 078 | .31 870 | .68 130 | .00 922 | .69 053 | 14 |
| 47 | .31 008 | .99 075 | .31 933 | .68 067 | .00 925 | .68 992 | 13 |
| 48 | .31 068 | .99 072 | .31 996 | .68 004 | .00 928 | .68 932 | 12 |
| 49 | .31 129 | .99 070 | .32 059 | .67 941 | .00 930 | .68 871 | 11 |
| 50 | 9.31 189 | 9.99 067 | 9.32 122 | 0.67 878 | 0.00 933 | 0.68 811 | 10 |
| 51 | .31 250 | .99 064 | .32 185 | .67 815 | .00 936 | .68 750 | 9 |
| 52 | .31 310 | .99 062 | .32 248 | .67 752 | .00 938 | .68 690 | 8 |
| 53 | .31 370 | .99 059 | .32 311 | .67 689 | .00 941 | .68 630 | 7 |
| 54 | .31 430 | .99 056 | .32 373 | .67 627 | .00 944 | .68 570 | 6 |
| 55 | 9.31 490 | 9.99 054 | 9.32 436 | 0.67 564 | 0.00 946 | 0.68 510 | 5 |
| 56 | .31 549 | .99 051 | .32 498 | .67 502 | .00 949 | .68 451 | 4 |
| 57 | .31 609 | .99 048 | .32 561 | .67 439 | .00 952 | .68 391 | 3 |
| 58 | .31 669 | .99 046 | .32 623 | .67 377 | .00 954 | .68 331 | 2 |
| 59 | .31 728 | .99 043 | .32 685 | .67 315 | .00 957 | .68 272 | 1 |
| 60 | 9.31 788 | 9.99 040 | 9.32 747 | 0.67 253 | 0.00 960 | 0.68 212 | 0 |
| | Cos | Sin | Cot | Tan | Csc | Sec | |

101° (281°)

(258°) 78°

Table 4. Trigonometric Logarithms

12° (192°)

(347°) 167°

| | Sin | Cos | Tan | Cot | Sec | Csc | |
|-----------|----------|----------|----------|----------|----------|----------|-----------|
| 0 | 9.31 788 | 9.99 040 | 9.32 747 | 0.67 253 | 0.00 960 | 0.68 212 | 60 |
| 1 | .31 847 | .99 038 | .32 810 | .67 190 | .00 962 | .68 153 | 59 |
| 2 | .31 907 | .99 035 | .32 872 | .67 128 | .00 965 | .68 093 | 58 |
| 3 | .31 966 | .99 032 | .32 933 | .67 067 | .00 968 | .68 034 | 57 |
| 4 | .32 025 | .99 030 | .32 995 | .67 005 | .00 970 | .67 975 | 56 |
| 5 | 9.32 084 | 9.99 027 | 9.33 057 | 0.66 943 | 0.00 973 | 0.67 916 | 55 |
| 6 | .32 143 | .99 024 | .33 119 | .66 881 | .00 976 | .67 857 | 54 |
| 7 | .32 202 | .99 022 | .33 180 | .66 820 | .00 978 | .67 798 | 53 |
| 8 | .32 261 | .99 019 | .33 242 | .66 758 | .00 981 | .67 739 | 52 |
| 9 | .32 319 | .99 016 | .33 303 | .66 697 | .00 984 | .67 681 | 51 |
| 10 | 9.32 378 | 9.99 013 | 9.33 365 | 0.66 635 | 0.00 987 | 0.67 622 | 50 |
| 11 | .32 437 | .99 011 | .33 426 | .66 574 | .00 989 | .67 563 | 49 |
| 12 | .32 495 | .99 008 | .33 487 | .66 513 | .00 992 | .67 505 | 48 |
| 13 | .32 553 | .99 005 | .33 548 | .66 452 | .00 995 | .67 447 | 47 |
| 14 | .32 612 | .99 002 | .33 609 | .66 391 | .00 998 | .67 388 | 46 |
| 15 | 9.32 670 | 9.99 000 | 9.33 670 | 0.66 330 | 0.01 000 | 0.67 330 | 45 |
| 16 | .32 728 | .98 997 | .33 731 | .66 269 | .01 003 | .67 272 | 44 |
| 17 | .32 786 | .98 994 | .33 792 | .66 208 | .01 006 | .67 214 | 43 |
| 18 | .32 844 | .98 991 | .33 853 | .66 147 | .01 009 | .67 156 | 42 |
| 19 | .32 902 | .98 989 | .33 913 | .66 087 | .01 011 | .67 098 | 41 |
| 20 | 9.32 960 | 9.98 986 | 9.33 974 | 0.66 026 | 0.01 014 | 0.67 040 | 40 |
| 21 | .33 018 | .98 983 | .34 034 | .65 966 | .01 017 | .66 982 | 39 |
| 22 | .33 075 | .98 980 | .34 095 | .65 905 | .01 020 | .66 925 | 38 |
| 23 | .33 133 | .98 978 | .34 155 | .65 845 | .01 022 | .66 867 | 37 |
| 24 | .33 190 | .98 975 | .34 215 | .65 785 | .01 025 | .66 810 | 36 |
| 25 | 9.33 248 | 9.98 972 | 9.34 276 | 0.65 724 | 0.01 028 | 0.66 752 | 35 |
| 26 | .33 305 | .98 969 | .34 336 | .65 664 | .01 031 | .66 695 | 34 |
| 27 | .33 362 | .98 967 | .34 396 | .65 604 | .01 033 | .66 638 | 33 |
| 28 | .33 420 | .98 964 | .34 456 | .65 544 | .01 036 | .66 580 | 32 |
| 29 | .33 477 | .98 961 | .34 516 | .65 484 | .01 039 | .66 523 | 31 |
| 30 | 9.33 534 | 9.98 958 | 9.34 576 | 0.65 424 | 0.01 042 | 0.66 466 | 30 |
| 31 | .33 591 | .98 955 | .34 635 | .65 365 | .01 045 | .66 409 | 29 |
| 32 | .33 647 | .98 953 | .34 695 | .65 305 | .01 047 | .66 353 | 28 |
| 33 | .33 704 | .98 950 | .34 755 | .65 245 | .01 050 | .66 296 | 27 |
| 34 | .33 761 | .98 947 | .34 814 | .65 186 | .01 053 | .66 239 | 26 |
| 35 | 9.33 818 | 9.98 944 | 9.34 874 | 0.65 126 | 0.01 056 | 0.66 182 | 25 |
| 36 | .33 874 | .98 941 | .34 933 | .65 067 | .01 059 | .66 126 | 24 |
| 37 | .33 931 | .98 938 | .34 992 | .65 008 | .01 062 | .66 069 | 23 |
| 38 | .33 987 | .98 936 | .35 051 | .64 949 | .01 064 | .66 013 | 22 |
| 39 | .34 043 | .98 933 | .35 111 | .64 889 | .01 067 | .65 957 | 21 |
| 40 | 9.34 100 | 9.98 930 | 9.35 170 | 0.64 830 | 0.01 070 | 0.65 900 | 20 |
| 41 | .34 156 | .98 927 | .35 229 | .64 771 | .01 073 | .65 844 | 19 |
| 42 | .34 212 | .98 924 | .35 288 | .64 712 | .01 076 | .65 788 | 18 |
| 43 | .34 268 | .98 921 | .35 347 | .64 653 | .01 079 | .65 732 | 17 |
| 44 | .34 324 | .98 919 | .35 405 | .64 595 | .01 081 | .65 676 | 16 |
| 45 | 9.34 380 | 9.98 916 | 9.35 464 | 0.64 536 | 0.01 084 | 0.65 620 | 15 |
| 46 | .34 436 | .98 913 | .35 523 | .64 477 | .01 087 | .65 564 | 14 |
| 47 | .34 491 | .98 910 | .35 581 | .64 419 | .01 090 | .65 509 | 13 |
| 48 | .34 547 | .98 907 | .35 640 | .64 360 | .01 093 | .65 453 | 12 |
| 49 | .34 602 | .98 904 | .35 698 | .64 302 | .01 096 | .65 398 | 11 |
| 50 | 9.34 658 | 9.98 901 | 9.35 757 | 0.64 243 | 0.01 099 | 0.65 342 | 10 |
| 51 | .34 713 | .98 898 | .35 815 | .64 185 | .01 102 | .65 287 | 9 |
| 52 | .34 769 | .98 896 | .35 873 | .64 127 | .01 104 | .65 231 | 8 |
| 53 | .34 824 | .98 893 | .35 931 | .64 069 | .01 107 | .65 176 | 7 |
| 54 | .34 879 | .98 890 | .35 989 | .64 011 | .01 110 | .65 121 | 6 |
| 55 | 9.34 934 | 9.98 887 | 9.36 047 | 0.63 953 | 0.01 113 | 0.65 066 | 5 |
| 56 | .34 989 | .98 884 | .36 105 | .63 895 | .01 116 | .65 011 | 4 |
| 57 | .35 044 | .98 881 | .36 163 | .63 837 | .01 119 | .64 956 | 3 |
| 58 | .35 099 | .98 878 | .36 221 | .63 779 | .01 122 | .64 901 | 2 |
| 59 | .35 154 | .98 875 | .36 279 | .63 721 | .01 125 | .64 846 | 1 |
| 60 | 9.35 209 | 9.98 872 | 9.36 336 | 0.63 664 | 0.01 128 | 0.64 791 | 0 |
| | Cos | Sin | Cot | Tan | Csc | Sec | |

102° (282°)

(257°) 77°

Table 4. Trigonometric Logarithms

13° (193°)

(346°) 166°

| | Sin | Cos | Tan | Cot | Sec | Csc | |
|-----------|------------|------------|------------|------------|------------|------------|-----------|
| 0 | 9.35 209 | 9.98 872 | 9.36 336 | 0.63 664 | 0.01 128 | 0.64 791 | 60 |
| 1 | .35 263 | .98 869 | .36 394 | .63 606 | .01 131 | .64 737 | 59 |
| 2 | .35 318 | .98 867 | .36 452 | .63 548 | .01 133 | .64 682 | 58 |
| 3 | .35 373 | .98 864 | .36 509 | .63 491 | .01 136 | .64 627 | 57 |
| 4 | .35 427 | .98 861 | .36 566 | .63 434 | .01 139 | .64 573 | 56 |
| 5 | 9.35 481 | 9.98 858 | 9.36 624 | 0.63 376 | 0.01 142 | 0.64 519 | 55 |
| 6 | .35 536 | .98 855 | .36 681 | .63 319 | .01 145 | .64 464 | 54 |
| 7 | .35 590 | .98 852 | .36 738 | .63 262 | .01 148 | .64 410 | 53 |
| 8 | .35 644 | .98 849 | .36 795 | .63 205 | .01 151 | .64 356 | 52 |
| 9 | .35 698 | .98 846 | .36 852 | .63 148 | .01 154 | .64 302 | 51 |
| 10 | 9.35 752 | 9.98 843 | 9.36 909 | 0.63 091 | 0.01 157 | 0.64 248 | 50 |
| 11 | .35 806 | .98 840 | .36 966 | .63 034 | .01 160 | .64 194 | 49 |
| 12 | .35 860 | .98 837 | .37 023 | .62 977 | .01 163 | .64 140 | 48 |
| 13 | .35 914 | .98 834 | .37 080 | .62 920 | .01 166 | .64 086 | 47 |
| 14 | .35 968 | .98 831 | .37 137 | .62 863 | .01 169 | .64 032 | 46 |
| 15 | 9.36 022 | 9.98 828 | 9.37 193 | 0.62 807 | 0.01 172 | 0.63 978 | 45 |
| 16 | .36 075 | .98 825 | .37 250 | .62 750 | .01 175 | .63 925 | 44 |
| 17 | .36 129 | .98 822 | .37 306 | .62 694 | .01 178 | .63 871 | 43 |
| 18 | .36 182 | .98 819 | .37 363 | .62 637 | .01 181 | .63 818 | 42 |
| 19 | .36 236 | .98 816 | .37 419 | .62 581 | .01 184 | .63 764 | 41 |
| 20 | 9.36 289 | 9.98 813 | 9.37 476 | 0.62 524 | 0.01 187 | 0.63 711 | 40 |
| 21 | .36 342 | .98 810 | .37 532 | .62 468 | .01 190 | .63 658 | 39 |
| 22 | .36 395 | .98 807 | .37 588 | .62 412 | .01 193 | .63 605 | 38 |
| 23 | .36 449 | .98 804 | .37 644 | .62 356 | .01 196 | .63 551 | 37 |
| 24 | .36 502 | .98 801 | .37 700 | .62 300 | .01 199 | .63 498 | 36 |
| 25 | 9.36 555 | 9.98 798 | 9.37 756 | 0.62 244 | 0.01 202 | 0.63 445 | 35 |
| 26 | .36 608 | .98 795 | .37 812 | .62 188 | .01 205 | .63 392 | 34 |
| 27 | .36 660 | .98 792 | .37 868 | .62 132 | .01 208 | .63 340 | 33 |
| 28 | .36 713 | .98 789 | .37 924 | .62 076 | .01 211 | .63 287 | 32 |
| 29 | .36 766 | .98 786 | .37 980 | .62 020 | .01 214 | .63 234 | 31 |
| 30 | 9.36 819 | 9.98 783 | 9.38 035 | 0.61 965 | 0.01 217 | 0.63 181 | 30 |
| 31 | .36 871 | .98 780 | .38 091 | .61 909 | .01 220 | .63 129 | 29 |
| 32 | .36 924 | .98 777 | .38 147 | .61 853 | .01 223 | .63 076 | 28 |
| 33 | .36 976 | .98 774 | .38 202 | .61 798 | .01 226 | .63 024 | 27 |
| 34 | .37 028 | .98 771 | .38 257 | .61 743 | .01 229 | .62 972 | 26 |
| 35 | 9.37 081 | 9.98 768 | 9.38 313 | 0.61 687 | 0.01 232 | 0.62 919 | 25 |
| 36 | .37 133 | .98 765 | .38 368 | .61 632 | .01 235 | .62 867 | 24 |
| 37 | .37 185 | .98 762 | .38 423 | .61 577 | .01 238 | .62 815 | 23 |
| 38 | .37 237 | .98 759 | .38 479 | .61 521 | .01 241 | .62 763 | 22 |
| 39 | .37 289 | .98 756 | .38 534 | .61 466 | .01 244 | .62 711 | 21 |
| 40 | 9.37 341 | 9.98 753 | 9.38 589 | 0.61 411 | 0.01 247 | 0.62 659 | 20 |
| 41 | .37 393 | .98 750 | .38 644 | .61 356 | .01 250 | .62 607 | 19 |
| 42 | .37 445 | .98 746 | .38 699 | .61 301 | .01 254 | .62 555 | 18 |
| 43 | .37 497 | .98 743 | .38 754 | .61 246 | .01 257 | .62 503 | 17 |
| 44 | .37 549 | .98 740 | .38 808 | .61 192 | .01 260 | .62 451 | 16 |
| 45 | 9.37 600 | 9.98 737 | 9.38 863 | 0.61 137 | 0.01 263 | 0.62 400 | 15 |
| 46 | .37 652 | .98 734 | .38 918 | .61 082 | .01 266 | .62 348 | 14 |
| 47 | .37 703 | .98 731 | .38 972 | .61 028 | .01 269 | .62 297 | 13 |
| 48 | .37 755 | .98 728 | .39 027 | .60 973 | .01 272 | .62 245 | 12 |
| 49 | .37 806 | .98 725 | .39 082 | .60 918 | .01 275 | .62 194 | 11 |
| 50 | 9.37 858 | 9.98 722 | 9.39 136 | 0.60 864 | 0.01 278 | 0.62 142 | 10 |
| 51 | .37 909 | .98 719 | .39 190 | .60 810 | .01 281 | .62 091 | 9 |
| 52 | .37 960 | .98 715 | .39 245 | .60 755 | .01 285 | .62 040 | 8 |
| 53 | .38 011 | .98 712 | .39 299 | .60 701 | .01 288 | .61 989 | 7 |
| 54 | .38 062 | .98 709 | .39 353 | .60 647 | .01 291 | .61 938 | 6 |
| 55 | 9.38 113 | 9.98 706 | 9.39 407 | 0.60 593 | 0.01 294 | 0.61 887 | 5 |
| 56 | .38 164 | .98 703 | .39 461 | .60 539 | .01 297 | .61 836 | 4 |
| 57 | .38 215 | .98 700 | .39 515 | .60 485 | .01 300 | .61 785 | 3 |
| 58 | .38 266 | .98 697 | .39 569 | .60 431 | .01 303 | .61 734 | 2 |
| 59 | .38 317 | .98 694 | .39 623 | .60 377 | .01 306 | .61 683 | 1 |
| 60 | 9.38 368 | 9.98 690 | 9.39 677 | 0.60 323 | 0.01 310 | 0.61 632 | 0 |
| | Cos | Sin | Cot | Tan | Csc | Sec | ' |

103° (283°)

(256°) 76°

14° (194°)

(345°) 165°

| ' | Sin | Cos | Tan | Cot | Sec | Csc | ' |
|-----------|----------|----------|----------|----------|----------|----------|-----------|
| 0 | 9.38 368 | 9.98 690 | 9.39 677 | 0.60 323 | 0.01 310 | 0.61 632 | 60 |
| 1 | .38 418 | .98 687 | .39 731 | .60 269 | .01 313 | .61 582 | 59 |
| 2 | .38 469 | .98 684 | .39 785 | .60 215 | .01 316 | .61 531 | 58 |
| 3 | .38 519 | .98 681 | .39 838 | .60 162 | .01 319 | .61 481 | 57 |
| 4 | .38 570 | .98 678 | .39 892 | .60 108 | .01 322 | .61 430 | 56 |
| 5 | 9.38 620 | 9.98 675 | 9.39 945 | 0.60 055 | 0.01 325 | 0.61 380 | 55 |
| 6 | .38 670 | .98 671 | .39 999 | .60 001 | .01 329 | .61 330 | 54 |
| 7 | .38 721 | .98 668 | .40 052 | .59 948 | .01 332 | .61 279 | 53 |
| 8 | .38 771 | .98 665 | .40 106 | .59 894 | .01 335 | .61 229 | 52 |
| 9 | .38 821 | .98 662 | .40 159 | .59 841 | .01 338 | .61 179 | 51 |
| 10 | 9.38 871 | 9.98 659 | 9.40 212 | 0.59 788 | 0.01 341 | 0.61 129 | 50 |
| 11 | .38 921 | .98 656 | .40 266 | .59 734 | .01 344 | .61 079 | 49 |
| 12 | .38 971 | .98 652 | .40 319 | .59 681 | .01 348 | .61 029 | 48 |
| 13 | .39 021 | .98 649 | .40 372 | .59 628 | .01 351 | .60 979 | 47 |
| 14 | .39 071 | .98 646 | .40 425 | .59 575 | .01 354 | .60 929 | 46 |
| 15 | 9.39 121 | 9.98 643 | 9.40 478 | 0.59 522 | 0.01 357 | 0.60 879 | 45 |
| 16 | .39 170 | .98 640 | .40 531 | .59 469 | .01 360 | .60 830 | 44 |
| 17 | .39 220 | .98 636 | .40 584 | .59 416 | .01 364 | .60 780 | 43 |
| 18 | .39 270 | .98 633 | .40 636 | .59 364 | .01 367 | .60 730 | 42 |
| 19 | .39 319 | .98 630 | .40 689 | .59 311 | .01 370 | .60 681 | 41 |
| 20 | 9.39 369 | 9.98 627 | 9.40 742 | 0.59 258 | 0.01 373 | 0.60 631 | 40 |
| 21 | .39 418 | .98 623 | .40 795 | .59 205 | .01 377 | .60 582 | 39 |
| 22 | .39 467 | .98 620 | .40 847 | .59 153 | .01 380 | .60 533 | 38 |
| 23 | .39 517 | .98 617 | .40 900 | .59 100 | .01 383 | .60 483 | 37 |
| 24 | .39 566 | .98 614 | .40 952 | .59 048 | .01 386 | .60 434 | 36 |
| 25 | 9.39 615 | 9.98 610 | 9.41 005 | 0.58 995 | 0.01 390 | 0.60 385 | 35 |
| 26 | .39 664 | .98 607 | .41 057 | .58 943 | .01 393 | .60 336 | 34 |
| 27 | .39 713 | .98 604 | .41 109 | .58 891 | .01 396 | .60 287 | 33 |
| 28 | .39 762 | .98 601 | .41 161 | .58 839 | .01 399 | .60 238 | 32 |
| 29 | .39 811 | .98 597 | .41 214 | .58 786 | .01 403 | .60 189 | 31 |
| 30 | 9.39 860 | 9.98 594 | 9.41 266 | 0.58 734 | 0.01 406 | 0.60 140 | 30 |
| 31 | .39 909 | .98 591 | .41 318 | .58 682 | .01 409 | .60 091 | 29 |
| 32 | .39 958 | .98 588 | .41 370 | .58 630 | .01 412 | .60 042 | 28 |
| 33 | .40 006 | .98 584 | .41 422 | .58 578 | .01 416 | .59 994 | 27 |
| 34 | .40 055 | .98 581 | .41 474 | .58 526 | .01 419 | .59 945 | 26 |
| 35 | 9.40 103 | 9.98 578 | 9.41 526 | 0.58 474 | 0.01 422 | 0.59 897 | 25 |
| 36 | .40 152 | .98 574 | .41 578 | .58 422 | .01 426 | .59 848 | 24 |
| 37 | .40 200 | .98 571 | .41 629 | .58 371 | .01 429 | .59 800 | 23 |
| 38 | .40 249 | .98 568 | .41 681 | .58 319 | .01 432 | .59 751 | 22 |
| 39 | .40 297 | .98 565 | .41 733 | .58 267 | .01 435 | .59 703 | 21 |
| 40 | 9.40 346 | 9.98 561 | 9.41 784 | 0.58 216 | 0.01 439 | 0.59 654 | 20 |
| 41 | .40 394 | .98 558 | .41 836 | .58 164 | .01 442 | .59 606 | 19 |
| 42 | .40 442 | .98 555 | .41 887 | .58 113 | .01 445 | .59 558 | 18 |
| 43 | .40 490 | .98 551 | .41 939 | .58 061 | .01 449 | .59 510 | 17 |
| 44 | .40 538 | .98 548 | .41 990 | .58 010 | .01 452 | .59 462 | 16 |
| 45 | 9.40 586 | 9.98 545 | 9.42 041 | 0.57 959 | 0.01 455 | 0.59 414 | 15 |
| 46 | .40 634 | .98 541 | .42 093 | .57 907 | .01 459 | .59 366 | 14 |
| 47 | .40 682 | .98 538 | .42 144 | .57 856 | .01 462 | .59 318 | 13 |
| 48 | .40 730 | .98 535 | .42 195 | .57 805 | .01 465 | .59 270 | 12 |
| 49 | .40 778 | .98 531 | .42 246 | .57 754 | .01 469 | .59 222 | 11 |
| 50 | 9.40 825 | 9.98 528 | 9.42 297 | 0.57 703 | 0.01 472 | 0.59 175 | 10 |
| 51 | .40 873 | .98 525 | .42 348 | .57 652 | .01 475 | .59 127 | 9 |
| 52 | .40 921 | .98 521 | .42 399 | .57 601 | .01 479 | .59 079 | 8 |
| 53 | .40 968 | .98 518 | .42 450 | .57 550 | .01 482 | .59 032 | 7 |
| 54 | .41 016 | .98 515 | .42 501 | .57 499 | .01 485 | .58 984 | 6 |
| 55 | 9.41 063 | 9.98 511 | 9.42 552 | 0.57 448 | 0.01 489 | 0.58 937 | 5 |
| 56 | .41 111 | .98 508 | .42 603 | .57 397 | .01 492 | .58 889 | 4 |
| 57 | .41 158 | .98 505 | .42 653 | .57 347 | .01 495 | .58 842 | 3 |
| 58 | .41 205 | .98 501 | .42 704 | .57 296 | .01 499 | .58 795 | 2 |
| 59 | .41 252 | .98 498 | .42 755 | .57 245 | .01 502 | .58 748 | 1 |
| 60 | 9.41 300 | 9.98 494 | 9.42 805 | 0.57 195 | 0.01 506 | 0.58 700 | 0 |
| | Cos | Sin | Cot | Tan | Csc | Sec | ' |

104° (284°)

(255°) 75°

Table 4. Trigonometric Logarithms

15° (195°)

(344°) 164°

| | Sin | Cos | Tan | Cot | Sec | Csc | |
|-----------|----------|----------|----------|----------|----------|----------|-----------|
| 0 | 9.41 300 | 9.98 494 | 9.42 805 | 0.57 195 | 0.01 506 | 0.58 700 | 60 |
| 1 | .41 347 | .98 491 | .42 856 | .57 144 | .01 509 | .58 653 | 59 |
| 2 | .41 394 | .98 488 | .42 906 | .57 094 | .01 512 | .58 606 | 58 |
| 3 | .41 441 | .98 484 | .42 957 | .57 043 | .01 516 | .58 559 | 57 |
| 4 | .41 488 | .98 481 | .43 007 | .56 993 | .01 519 | .58 512 | 56 |
| 5 | 9.41 535 | 9.98 477 | 9.43 057 | 0.56 943 | 0.01 523 | 0.58 465 | 55 |
| 6 | .41 582 | .98 474 | .43 108 | .56 892 | .01 526 | .58 418 | 54 |
| 7 | .41 628 | .98 471 | .43 158 | .56 842 | .01 529 | .58 372 | 53 |
| 8 | .41 675 | .98 467 | .43 208 | .56 792 | .01 533 | .58 325 | 52 |
| 9 | .41 722 | .98 464 | .43 258 | .56 742 | .01 536 | .58 278 | 51 |
| 10 | 9.41 768 | 9.98 460 | 9.43 308 | 0.56 692 | 0.01 540 | 0.58 232 | 50 |
| 11 | .41 815 | .98 457 | .43 358 | .56 642 | .01 543 | .58 185 | 49 |
| 12 | .41 861 | .98 453 | .43 408 | .56 592 | .01 547 | .58 139 | 48 |
| 13 | .41 908 | .98 450 | .43 458 | .56 542 | .01 550 | .58 092 | 47 |
| 14 | .41 954 | .98 447 | .43 508 | .56 492 | .01 553 | .58 046 | 46 |
| 15 | 9.42 001 | 9.98 443 | 9.43 558 | 0.56 442 | 0.01 557 | 0.57 999 | 45 |
| 16 | .42 047 | .98 440 | .43 607 | .56 393 | .01 560 | .57 953 | 44 |
| 17 | .42 093 | .98 436 | .43 657 | .56 343 | .01 564 | .57 907 | 43 |
| 18 | .42 140 | .98 433 | .43 707 | .56 293 | .01 567 | .57 860 | 42 |
| 19 | .42 186 | .98 429 | .43 756 | .56 244 | .01 571 | .57 814 | 41 |
| 20 | 9.42 232 | 9.98 426 | 9.43 806 | 0.56 194 | 0.01 574 | 0.57 768 | 40 |
| 21 | .42 278 | .98 422 | .43 855 | .56 145 | .01 578 | .57 722 | 39 |
| 22 | .42 324 | .98 419 | .43 905 | .56 095 | .01 581 | .57 676 | 38 |
| 23 | .42 370 | .98 415 | .43 954 | .56 046 | .01 585 | .57 630 | 37 |
| 24 | .42 416 | .98 412 | .44 004 | .55 996 | .01 588 | .57 584 | 36 |
| 25 | 9.42 461 | 9.98 409 | 9.44 053 | 0.55 947 | 0.01 591 | 0.57 539 | 35 |
| 26 | .42 507 | .98 405 | .44 102 | .55 898 | .01 595 | .57 493 | 34 |
| 27 | .42 553 | .98 402 | .44 151 | .55 849 | .01 598 | .57 447 | 33 |
| 28 | .42 599 | .98 398 | .44 201 | .55 799 | .01 602 | .57 401 | 32 |
| 29 | .42 644 | .98 395 | .44 250 | .55 750 | .01 605 | .57 356 | 31 |
| 30 | 9.42 690 | 9.98 391 | 9.44 299 | 0.55 701 | 0.01 609 | 0.57 310 | 30 |
| 31 | .42 735 | .98 388 | .44 348 | .55 652 | .01 612 | .57 265 | 29 |
| 32 | .42 781 | .98 384 | .44 397 | .55 603 | .01 616 | .57 219 | 28 |
| 33 | .42 826 | .98 381 | .44 446 | .55 554 | .01 619 | .57 174 | 27 |
| 34 | .42 872 | .98 377 | .44 495 | .55 505 | .01 623 | .57 128 | 26 |
| 35 | 9.42 917 | 9.98 373 | 9.44 544 | 0.55 456 | 0.01 627 | 0.57 083 | 25 |
| 36 | .42 962 | .98 370 | .44 592 | .55 408 | .01 630 | .57 038 | 24 |
| 37 | .43 008 | .98 366 | .44 641 | .55 359 | .01 634 | .56 992 | 23 |
| 38 | .43 053 | .98 363 | .44 690 | .55 310 | .01 637 | .56 947 | 22 |
| 39 | .43 098 | .98 359 | .44 738 | .55 262 | .01 641 | .56 902 | 21 |
| 40 | 9.43 143 | 9.98 356 | 9.44 787 | 0.55 213 | 0.01 644 | 0.56 857 | 20 |
| 41 | .43 188 | .98 352 | .44 836 | .55 164 | .01 648 | .56 812 | 19 |
| 42 | .43 233 | .98 349 | .44 884 | .55 116 | .01 651 | .56 767 | 18 |
| 43 | .43 278 | .98 345 | .44 933 | .55 067 | .01 655 | .56 722 | 17 |
| 44 | .43 323 | .98 342 | .44 981 | .55 019 | .01 658 | .56 677 | 16 |
| 45 | 9.43 367 | 9.98 338 | 9.45 029 | 0.54 971 | 0.01 662 | 0.56 633 | 15 |
| 46 | .43 412 | .98 334 | .45 078 | .54 922 | .01 666 | .56 588 | 14 |
| 47 | .43 457 | .98 331 | .45 126 | .54 874 | .01 669 | .56 543 | 13 |
| 48 | .43 502 | .98 327 | .45 174 | .54 826 | .01 673 | .56 498 | 12 |
| 49 | .43 546 | .98 324 | .45 222 | .54 778 | .01 676 | .56 454 | 11 |
| 50 | 9.43 591 | 9.98 320 | 9.45 271 | 0.54 729 | 0.01 680 | 0.56 409 | 10 |
| 51 | .43 635 | .98 317 | .45 319 | .54 681 | .01 683 | .56 365 | 9 |
| 52 | .43 680 | .98 313 | .45 367 | .54 633 | .01 687 | .56 320 | 8 |
| 53 | .43 724 | .98 309 | .45 415 | .54 585 | .01 691 | .56 276 | 7 |
| 54 | .43 769 | .98 306 | .45 463 | .54 537 | .01 694 | .56 231 | 6 |
| 55 | 9.43 813 | 9.98 302 | 9.45 511 | 0.54 489 | 0.01 698 | 0.56 187 | 5 |
| 56 | .43 857 | .98 299 | .45 559 | .54 441 | .01 701 | .56 143 | 4 |
| 57 | .43 901 | .98 295 | .45 606 | .54 394 | .01 705 | .56 099 | 3 |
| 58 | .43 946 | .98 291 | .45 654 | .54 346 | .01 709 | .56 054 | 2 |
| 59 | .43 990 | .98 288 | .45 702 | .54 298 | .01 712 | .56 010 | 1 |
| 60 | 9.44 034 | 9.98 284 | 9.45 750 | 0.54 250 | 0.01 716 | 0.55 966 | 0 |
| | Cos | Sin | Cot | Tan | Csc | Sec | ' |

105° (285°)

(254°) 74°

Table 4. Trigonometric Logarithms

16° (196°)

(343°) 163°

| | Sin | Cos | Tan | Cot | Sec | Csc | |
|-----------|----------|----------|----------|----------|----------|----------|-----------|
| 0 | 9.44 034 | 9.98 284 | 9.45 750 | 0.54 250 | 0.01 716 | 0.55 966 | 60 |
| 1 | .44 078 | .98 281 | .45 797 | .54 203 | .01 719 | .55 922 | 59 |
| 2 | .44 122 | .98 277 | .45 845 | .54 155 | .01 723 | .55 878 | 58 |
| 3 | .44 166 | .98 273 | .45 892 | .54 108 | .01 727 | .55 834 | 57 |
| 4 | .44 210 | .98 270 | .45 940 | .54 060 | .01 730 | .55 790 | 56 |
| 5 | 9.44 253 | 9.98 266 | 9.45 987 | 0.54 013 | 0.01 734 | 0.55 747 | 55 |
| 6 | .44 297 | .98 262 | .46 035 | .53 965 | .01 738 | .55 703 | 54 |
| 7 | .44 341 | .98 259 | .46 082 | .53 918 | .01 741 | .55 659 | 53 |
| 8 | .44 385 | .98 255 | .46 130 | .53 870 | .01 745 | .55 615 | 52 |
| 9 | .44 428 | .98 251 | .46 177 | .53 823 | .01 749 | .55 572 | 51 |
| 10 | 9.44 472 | 9.98 248 | 9.46 224 | 0.53 776 | 0.01 752 | 0.55 528 | 50 |
| 11 | .44 516 | .98 244 | .46 271 | .53 729 | .01 756 | .55 484 | 49 |
| 12 | .44 559 | .98 240 | .46 319 | .53 681 | .01 760 | .55 441 | 48 |
| 13 | .44 602 | .98 237 | .46 366 | .53 634 | .01 763 | .55 398 | 47 |
| 14 | .44 646 | .98 233 | .46 413 | .53 587 | .01 767 | .55 354 | 46 |
| 15 | 9.44 689 | 9.98 229 | 9.46 460 | 0.53 540 | 0.01 771 | 0.55 311 | 45 |
| 16 | .44 733 | .98 226 | .46 507 | .53 493 | .01 774 | .55 267 | 44 |
| 17 | .44 776 | .98 222 | .46 554 | .53 446 | .01 778 | .55 224 | 43 |
| 18 | .44 819 | .98 218 | .46 601 | .53 399 | .01 782 | .55 181 | 42 |
| 19 | .44 862 | .98 215 | .46 648 | .53 352 | .01 785 | .55 138 | 41 |
| 20 | 9.44 905 | 9.98 211 | 9.46 694 | 0.53 306 | 0.01 789 | 0.55 095 | 40 |
| 21 | .44 948 | .98 207 | .46 741 | .53 259 | .01 793 | .55 052 | 39 |
| 22 | .44 992 | .98 204 | .46 788 | .53 212 | .01 796 | .55 008 | 38 |
| 23 | .45 035 | .98 200 | .46 835 | .53 165 | .01 800 | .54 965 | 37 |
| 24 | .45 077 | .98 196 | .46 881 | .53 119 | .01 804 | .54 923 | 36 |
| 25 | 9.45 120 | 9.98 192 | 9.46 928 | 0.53 072 | 0.01 808 | 0.54 880 | 35 |
| 26 | .45 163 | .98 189 | .46 975 | .53 025 | .01 811 | .54 837 | 34 |
| 27 | .45 206 | .98 185 | .47 021 | .52 979 | .01 815 | .54 794 | 33 |
| 28 | .45 249 | .98 181 | .47 068 | .52 932 | .01 819 | .54 751 | 32 |
| 29 | .45 292 | .98 177 | .47 114 | .52 886 | .01 823 | .54 708 | 31 |
| 30 | 9.45 334 | 9.98 174 | 9.47 160 | 0.52 840 | 0.01 826 | 0.54 666 | 30 |
| 31 | .45 377 | .98 170 | .47 207 | .52 793 | .01 830 | .54 623 | 29 |
| 32 | .45 419 | .98 166 | .47 253 | .52 747 | .01 834 | .54 581 | 28 |
| 33 | .45 462 | .98 162 | .47 299 | .52 701 | .01 838 | .54 538 | 27 |
| 34 | .45 504 | .98 159 | .47 346 | .52 654 | .01 841 | .54 496 | 26 |
| 35 | 9.45 547 | 9.98 155 | 9.47 392 | 0.52 608 | 0.01 845 | 0.54 453 | 25 |
| 36 | .45 589 | .98 151 | .47 438 | .52 562 | .01 849 | .54 411 | 24 |
| 37 | .45 632 | .98 147 | .47 484 | .52 516 | .01 853 | .54 368 | 23 |
| 38 | .45 674 | .98 144 | .47 530 | .52 470 | .01 856 | .54 326 | 22 |
| 39 | .45 716 | .98 140 | .47 576 | .52 424 | .01 860 | .54 284 | 21 |
| 40 | 9.45 758 | 9.98 136 | 9.47 622 | 0.52 378 | 0.01 864 | 0.54 242 | 20 |
| 41 | .45 801 | .98 132 | .47 668 | .52 332 | .01 868 | .54 199 | 19 |
| 42 | .45 843 | .98 129 | .47 714 | .52 286 | .01 871 | .54 157 | 18 |
| 43 | .45 885 | .98 125 | .47 760 | .52 240 | .01 875 | .54 115 | 17 |
| 44 | .45 927 | .98 121 | .47 806 | .52 194 | .01 879 | .54 073 | 16 |
| 45 | 9.45 969 | 9.98 117 | 9.47 852 | 0.52 148 | 0.01 883 | 0.54 031 | 15 |
| 46 | .46 011 | .98 113 | .47 897 | .52 103 | .01 887 | .53 989 | 14 |
| 47 | .46 053 | .98 110 | .47 943 | .52 057 | .01 890 | .53 947 | 13 |
| 48 | .46 095 | .98 106 | .47 989 | .52 011 | .01 894 | .53 905 | 12 |
| 49 | .46 136 | .98 102 | .48 035 | .51 965 | .01 898 | .53 864 | 11 |
| 50 | 9.46 178 | 9.98 098 | 9.48 080 | 0.51 920 | 0.01 902 | 0.53 822 | 10 |
| 51 | .46 220 | .98 094 | .48 126 | .51 874 | .01 906 | .53 780 | 9 |
| 52 | .46 262 | .98 090 | .48 171 | .51 829 | .01 910 | .53 738 | 8 |
| 53 | .46 303 | .98 087 | .48 217 | .51 783 | .01 913 | .53 697 | 7 |
| 54 | .46 345 | .98 083 | .48 262 | .51 738 | .01 917 | .53 655 | 6 |
| 55 | 9.46 386 | 9.98 079 | 9.48 307 | 0.51 693 | 0.01 921 | 0.53 614 | 5 |
| 56 | .46 428 | .98 075 | .48 353 | .51 647 | .01 925 | .53 572 | 4 |
| 57 | .46 469 | .98 071 | .48 398 | .51 602 | .01 929 | .53 531 | 3 |
| 58 | .46 511 | .98 067 | .48 443 | .51 557 | .01 933 | .53 489 | 2 |
| 59 | .46 552 | .98 063 | .48 489 | .51 511 | .01 937 | .53 448 | 1 |
| 60 | 9.46 594 | 9.98 060 | 9.48 534 | 0.51 466 | 0.01 940 | 0.53 406 | 0 |
| | Cos | Sin | Cot | Tan | Csc | Sec | ' |

106° (286°)

(253°) 73°

Table 4. Trigonometric Logarithms

17° (197°)

(342°) 162°

| | Sin | Cos | Tan | Cot | Sec | Csc | |
|-----------|------------|------------|------------|------------|------------|------------|-----------|
| 0 | 9.46 594 | 9.98 060 | 9.48 534 | 0.51 466 | 0.01 940 | 0.53 406 | 60 |
| 1 | .46 635 | .98 056 | .48 579 | .51 421 | .01 944 | .53 365 | 59 |
| 2 | .46 676 | .98 052 | .48 624 | .51 376 | .01 948 | .53 324 | 58 |
| 3 | .46 717 | .98 048 | .48 669 | .51 331 | .01 952 | .53 283 | 57 |
| 4 | .46 758 | .98 044 | .48 714 | .51 286 | .01 956 | .53 242 | 56 |
| 5 | 9.46 800 | 9.98 040 | 9.48 759 | 0.51 241 | 0.01 960 | 0.53 200 | 55 |
| 6 | .46 841 | .98 036 | .48 804 | .51 196 | .01 964 | .53 159 | 54 |
| 7 | .46 882 | .98 032 | .48 849 | .51 151 | .01 968 | .53 118 | 53 |
| 8 | .46 923 | .98 029 | .48 894 | .51 106 | .01 971 | .53 077 | 52 |
| 9 | .46 964 | .98 025 | .48 939 | .51 061 | .01 975 | .53 036 | 51 |
| 10 | 9.47 005 | 9.98 021 | 9.48 984 | 0.51 016 | 0.01 979 | 0.52 995 | 50 |
| 11 | .47 045 | .98 017 | .49 029 | .50 971 | .01 983 | .52 955 | 49 |
| 12 | .47 086 | .98 013 | .49 073 | .50 927 | .01 987 | .52 914 | 48 |
| 13 | .47 127 | .98 009 | .49 118 | .50 882 | .01 991 | .52 873 | 47 |
| 14 | .47 168 | .98 005 | .49 163 | .50 837 | .01 995 | .52 832 | 46 |
| 15 | 9.47 209 | 9.98 001 | 9.49 207 | 0.50 793 | 0.01 999 | 0.52 791 | 45 |
| 16 | .47 249 | .97 997 | .49 252 | .50 748 | .02 003 | .52 751 | 44 |
| 17 | .47 290 | .97 993 | .49 296 | .50 704 | .02 007 | .52 710 | 43 |
| 18 | .47 330 | .97 989 | .49 341 | .50 659 | .02 011 | .52 670 | 42 |
| 19 | .47 371 | .97 986 | .49 385 | .50 615 | .02 014 | .52 629 | 41 |
| 20 | 9.47 411 | 9.97 982 | 9.49 430 | 0.50 570 | 0.02 018 | 0.52 589 | 40 |
| 21 | .47 452 | .97 978 | .49 474 | .50 526 | .02 022 | .52 548 | 39 |
| 22 | .47 492 | .97 974 | .49 519 | .50 481 | .02 026 | .52 508 | 38 |
| 23 | .47 533 | .97 970 | .49 563 | .50 437 | .02 030 | .52 467 | 37 |
| 24 | .47 573 | .97 966 | .49 607 | .50 393 | .02 034 | .52 427 | 36 |
| 25 | 9.47 613 | 9.97 962 | 9.49 652 | 0.50 348 | 0.02 038 | 0.52 387 | 35 |
| 26 | .47 654 | .97 958 | .49 696 | .50 304 | .02 042 | .52 346 | 34 |
| 27 | .47 694 | .97 954 | .49 740 | .50 260 | .02 046 | .52 306 | 33 |
| 28 | .47 734 | .97 950 | .49 784 | .50 216 | .02 050 | .52 266 | 32 |
| 29 | .47 774 | .97 946 | .49 828 | .50 172 | .02 054 | .52 226 | 31 |
| 30 | 9.47 814 | 9.97 942 | 9.49 872 | 0.50 128 | 0.02 058 | 0.52 186 | 30 |
| 31 | .47 854 | .97 938 | .49 916 | .50 084 | .02 062 | .52 146 | 29 |
| 32 | .47 894 | .97 934 | .49 960 | .50 040 | .02 066 | .52 106 | 28 |
| 33 | .47 934 | .97 930 | .50 004 | .49 996 | .02 070 | .52 066 | 27 |
| 34 | .47 974 | .97 926 | .50 048 | .49 952 | .02 074 | .52 026 | 26 |
| 35 | 9.48 014 | 9.97 922 | 9.50 092 | 0.49 908 | 0.02 078 | 0.51 986 | 25 |
| 36 | .48 054 | .97 918 | .50 136 | .49 864 | .02 082 | .51 946 | 24 |
| 37 | .48 094 | .97 914 | .50 180 | .49 820 | .02 086 | .51 906 | 23 |
| 38 | .48 133 | .97 910 | .50 223 | .49 777 | .02 090 | .51 867 | 22 |
| 39 | .48 173 | .97 906 | .50 267 | .49 733 | .02 094 | .51 827 | 21 |
| 40 | 9.48 213 | 9.97 902 | 9.50 311 | 0.49 689 | 0.02 098 | 0.51 787 | 20 |
| 41 | .48 252 | .97 898 | .50 355 | .49 645 | .02 102 | .51 748 | 19 |
| 42 | .48 292 | .97 894 | .50 398 | .49 602 | .02 106 | .51 708 | 18 |
| 43 | .48 332 | .97 890 | .50 442 | .49 558 | .02 110 | .51 668 | 17 |
| 44 | .48 371 | .97 886 | .50 485 | .49 515 | .02 114 | .51 629 | 16 |
| 45 | 9.48 411 | 9.97 882 | 9.50 529 | 0.49 471 | 0.02 118 | 0.51 589 | 15 |
| 46 | .48 450 | .97 878 | .50 572 | .49 428 | .02 122 | .51 550 | 14 |
| 47 | .48 490 | .97 874 | .50 616 | .49 384 | .02 126 | .51 510 | 13 |
| 48 | .48 529 | .97 870 | .50 659 | .49 341 | .02 130 | .51 471 | 12 |
| 49 | .48 568 | .97 866 | .50 703 | .49 297 | .02 134 | .51 432 | 11 |
| 50 | 9.48 607 | 9.97 861 | 9.50 746 | 0.49 254 | 0.02 139 | 0.51 393 | 10 |
| 51 | .48 647 | .97 857 | .50 789 | .49 211 | .02 143 | .51 353 | 9 |
| 52 | .48 686 | .97 853 | .50 833 | .49 167 | .02 147 | .51 314 | 8 |
| 53 | .48 725 | .97 849 | .50 876 | .49 124 | .02 151 | .51 275 | 7 |
| 54 | .48 764 | .97 845 | .50 919 | .49 081 | .02 155 | .51 236 | 6 |
| 55 | 9.48 803 | 9.97 841 | 9.50 962 | 0.49 038 | 0.02 159 | 0.51 197 | 5 |
| 56 | .48 842 | .97 837 | .51 005 | .48 995 | .02 163 | .51 158 | 4 |
| 57 | .48 881 | .97 833 | .51 048 | .48 952 | .02 167 | .51 119 | 3 |
| 58 | .48 920 | .97 829 | .51 092 | .48 908 | .02 171 | .51 080 | 2 |
| 59 | .48 959 | .97 825 | .51 135 | .48 865 | .02 175 | .51 041 | 1 |
| 60 | 9.48 998 | 9.97 821 | 9.51 178 | 0.48 822 | 0.02 179 | 0.51 002 | 0 |
| | Cos | Sin | Cot | Tan | Csc | Sec | ' |

107° (287°)

(252°) 72°

Table 4. Trigonometric Logarithms

18° (198°)

(341°) 161°

| | Sin | Cos | Tan | Cot | Sec | Csc | |
|-----------|----------|----------|----------|----------|----------|----------|-----------|
| 0 | 9.48 998 | 9.97 821 | 9.51 178 | 0.48 822 | 0.02 179 | 0.51 002 | 60 |
| 1 | .49 037 | .97 817 | .51 221 | .48 779 | .02 183 | .50 963 | 59 |
| 2 | .49 076 | .97 812 | .51 264 | .48 736 | .02 188 | .50 924 | 58 |
| 3 | .49 115 | .97 808 | .51 306 | .48 694 | .02 192 | .50 885 | 57 |
| 4 | .49 153 | .97 804 | .51 349 | .48 651 | .02 196 | .50 847 | 56 |
| 5 | 9.49 192 | 9.97 800 | 9.51 392 | 0.48 608 | 0.02 200 | 0.50 808 | 55 |
| 6 | .49 231 | .97 796 | .51 435 | .48 565 | .02 204 | .50 769 | 54 |
| 7 | .49 269 | .97 792 | .51 478 | .48 522 | .02 208 | .50 731 | 53 |
| 8 | .49 308 | .97 788 | .51 520 | .48 480 | .02 212 | .50 692 | 52 |
| 9 | .49 347 | .97 784 | .51 563 | .48 437 | .02 216 | .50 653 | 51 |
| 10 | 9.49 385 | 9.97 779 | 9.51 606 | 0.48 394 | 0.02 221 | 0.50 615 | 50 |
| 11 | .49 424 | .97 775 | .51 648 | .48 352 | .02 225 | .50 576 | 49 |
| 12 | .49 462 | .97 771 | .51 691 | .48 309 | .02 229 | .50 538 | 48 |
| 13 | .49 500 | .97 767 | .51 734 | .48 266 | .02 233 | .50 500 | 47 |
| 14 | .49 539 | .97 763 | .51 776 | .48 224 | .02 237 | .50 461 | 46 |
| 15 | 9.49 577 | 9.97 759 | 9.51 819 | 0.48 181 | 0.02 241 | 0.50 423 | 45 |
| 16 | .49 615 | .97 754 | .51 861 | .48 139 | .02 246 | .50 385 | 44 |
| 17 | .49 654 | .97 750 | .51 903 | .48 097 | .02 250 | .50 346 | 43 |
| 18 | .49 692 | .97 746 | .51 946 | .48 054 | .02 254 | .50 308 | 42 |
| 19 | .49 730 | .97 742 | .51 988 | .48 012 | .02 258 | .50 270 | 41 |
| 20 | 9.49 768 | 9.97 738 | 9.52 031 | 0.47 969 | 0.02 262 | 0.50 232 | 40 |
| 21 | .49 806 | .97 734 | .52 073 | .47 927 | .02 266 | .50 194 | 39 |
| 22 | .49 844 | .97 729 | .52 115 | .47 885 | .02 271 | .50 156 | 38 |
| 23 | .49 882 | .97 725 | .52 157 | .47 843 | .02 275 | .50 118 | 37 |
| 24 | .49 920 | .97 721 | .52 200 | .47 800 | .02 279 | .50 080 | 36 |
| 25 | 9.49 958 | 9.97 717 | 9.52 242 | 0.47 758 | 0.02 283 | 0.50 042 | 35 |
| 26 | .49 996 | .97 713 | .52 284 | .47 716 | .02 287 | .50 004 | 34 |
| 27 | .50 034 | .97 708 | .52 326 | .47 674 | .02 292 | .49 966 | 33 |
| 28 | .50 072 | .97 704 | .52 368 | .47 632 | .02 296 | .49 928 | 32 |
| 29 | .50 110 | .97 700 | .52 410 | .47 590 | .02 300 | .49 890 | 31 |
| 30 | 9.50 148 | 9.97 696 | 9.52 452 | 0.47 548 | 0.02 304 | 0.49 852 | 30 |
| 31 | .50 185 | .97 691 | .52 494 | .47 506 | .02 309 | .49 815 | 29 |
| 32 | .50 223 | .97 687 | .52 536 | .47 464 | .02 313 | .49 777 | 28 |
| 33 | .50 261 | .97 683 | .52 578 | .47 422 | .02 317 | .49 739 | 27 |
| 34 | .50 298 | .97 679 | .52 620 | .47 380 | .02 321 | .49 702 | 26 |
| 35 | 9.50 336 | 9.97 674 | 9.52 661 | 0.47 339 | 0.02 326 | 0.49 664 | 25 |
| 36 | .50 374 | .97 670 | .52 703 | .47 297 | .02 330 | .49 626 | 24 |
| 37 | .50 411 | .97 666 | .52 745 | .47 255 | .02 334 | .49 589 | 23 |
| 38 | .50 449 | .97 662 | .52 787 | .47 213 | .02 338 | .49 551 | 22 |
| 39 | .50 486 | .97 657 | .52 829 | .47 171 | .02 343 | .49 514 | 21 |
| 40 | 9.50 523 | 9.97 653 | 9.52 870 | 0.47 130 | 0.02 347 | 0.49 477 | 20 |
| 41 | .50 561 | .97 649 | .52 912 | .47 088 | .02 351 | .49 439 | 19 |
| 42 | .50 598 | .97 645 | .52 953 | .47 047 | .02 355 | .49 402 | 18 |
| 43 | .50 635 | .97 640 | .52 995 | .47 005 | .02 360 | .49 365 | 17 |
| 44 | .50 673 | .97 636 | .53 037 | .46 963 | .02 364 | .49 327 | 16 |
| 45 | 9.50 710 | 9.97 632 | 9.53 078 | 0.46 922 | 0.02 368 | 0.49 290 | 15 |
| 46 | .50 747 | .97 628 | .53 120 | .46 880 | .02 372 | .49 253 | 14 |
| 47 | .50 784 | .97 623 | .53 161 | .46 839 | .02 377 | .49 216 | 13 |
| 48 | .50 821 | .97 619 | .53 202 | .46 798 | .02 381 | .49 179 | 12 |
| 49 | .50 858 | .97 615 | .53 244 | .46 756 | .02 385 | .49 142 | 11 |
| 50 | 9.50 896 | 9.97 610 | 9.53 285 | 0.46 715 | 0.02 390 | 0.49 104 | 10 |
| 51 | .50 933 | .97 606 | .53 327 | .46 673 | .02 394 | .49 067 | 9 |
| 52 | .50 970 | .97 602 | .53 368 | .46 632 | .02 398 | .49 030 | 8 |
| 53 | .51 007 | .97 597 | .53 409 | .46 591 | .02 403 | .48 993 | 7 |
| 54 | .51 043 | .97 593 | .53 450 | .46 550 | .02 407 | .48 957 | 6 |
| 55 | 9.51 080 | 9.97 589 | 9.53 492 | 0.46 508 | 0.02 411 | 0.48 920 | 5 |
| 56 | .51 117 | .97 584 | .53 533 | .46 467 | .02 416 | .48 883 | 4 |
| 57 | .51 154 | .97 580 | .53 574 | .46 426 | .02 420 | .48 846 | 3 |
| 58 | .51 191 | .97 576 | .53 615 | .46 385 | .02 424 | .48 809 | 2 |
| 59 | .51 227 | .97 571 | .53 656 | .46 344 | .02 429 | .48 773 | 1 |
| 60 | 9.51 264 | 9.97 567 | 9.53 697 | 0.46 303 | 0.02 433 | 0.48 736 | 0 |
| | Cos | Sin | Cot | Tan | Csc | Sec | ' |

108° (288°)

(251°) 71°

19° (199°)

(340°) 160°

| ' | Sin | Cos | Tan | Cot | Sec | Csc | ' |
|-----------|----------|----------|----------|----------|----------|----------|-----------|
| 0 | 9.51 264 | 9.97 567 | 9.53 697 | 0.46 303 | 0.02 433 | 0.48 736 | 60 |
| 1 | .51 301 | .97 563 | .53 738 | .46 262 | .02 437 | .48 699 | 59 |
| 2 | .51 338 | .97 558 | .53 779 | .46 221 | .02 442 | .48 662 | 58 |
| 3 | .51 374 | .97 554 | .53 820 | .46 180 | .02 446 | .48 626 | 57 |
| 4 | .51 411 | .97 550 | .53 861 | .46 139 | .02 450 | .48 589 | 56 |
| 5 | 9.51 447 | 9.97 545 | 9.53 902 | 0.46 098 | 0.02 455 | 0.48 553 | 55 |
| 6 | .51 484 | .97 541 | .53 943 | .46 057 | .02 459 | .48 516 | 54 |
| 7 | .51 520 | .97 536 | .53 984 | .46 016 | .02 464 | .48 480 | 53 |
| 8 | .51 557 | .97 532 | .54 025 | .45 975 | .02 468 | .48 443 | 52 |
| 9 | .51 593 | .97 528 | .54 065 | .45 935 | .02 472 | .48 407 | 51 |
| 10 | 9.51 629 | 9.97 523 | 9.54 106 | 0.45 894 | 0.02 477 | 0.48 371 | 50 |
| 11 | .51 666 | .97 519 | .54 147 | .45 853 | .02 481 | .48 334 | 49 |
| 12 | .51 702 | .97 515 | .54 187 | .45 813 | .02 485 | .48 298 | 48 |
| 13 | .51 738 | .97 510 | .54 228 | .45 772 | .02 490 | .48 262 | 47 |
| 14 | .51 774 | .97 506 | .54 269 | .45 731 | .02 494 | .48 226 | 46 |
| 15 | 9.51 811 | 9.97 501 | 9.54 309 | 0.45 691 | 0.02 499 | 0.48 189 | 45 |
| 16 | .51 847 | .97 497 | .54 350 | .45 650 | .02 503 | .48 153 | 44 |
| 17 | .51 883 | .97 492 | .54 390 | .45 610 | .02 508 | .48 117 | 43 |
| 18 | .51 919 | .97 488 | .54 431 | .45 569 | .02 512 | .48 081 | 42 |
| 19 | .51 955 | .97 484 | .54 471 | .45 529 | .02 516 | .48 045 | 41 |
| 20 | 9.51 991 | 9.97 479 | 9.54 512 | 0.45 488 | 0.02 521 | 0.48 009 | 40 |
| 21 | .52 027 | .97 475 | .54 552 | .45 448 | .02 525 | .47 973 | 39 |
| 22 | .52 063 | .97 470 | .54 593 | .45 407 | .02 530 | .47 937 | 38 |
| 23 | .52 099 | .97 466 | .54 633 | .45 367 | .02 534 | .47 901 | 37 |
| 24 | .52 135 | .97 461 | .54 673 | .45 327 | .02 539 | .47 865 | 36 |
| 25 | 9.52 171 | 9.97 457 | 9.54 714 | 0.45 286 | 0.02 543 | 0.47 829 | 35 |
| 26 | .52 207 | .97 453 | .54 754 | .45 246 | .02 547 | .47 793 | 34 |
| 27 | .52 242 | .97 448 | .54 794 | .45 206 | .02 552 | .47 758 | 33 |
| 28 | .52 278 | .97 444 | .54 835 | .45 165 | .02 556 | .47 722 | 32 |
| 29 | .52 314 | .97 439 | .54 875 | .45 125 | .02 561 | .47 686 | 31 |
| 30 | 9.52 350 | 9.97 435 | 9.54 915 | 0.45 085 | 0.02 565 | 0.47 650 | 30 |
| 31 | .52 385 | .97 430 | .54 955 | .45 045 | .02 570 | .47 615 | 29 |
| 32 | .52 421 | .97 426 | .54 995 | .45 005 | .02 574 | .47 579 | 28 |
| 33 | .52 456 | .97 421 | .55 035 | .44 965 | .02 579 | .47 544 | 27 |
| 34 | .52 492 | .97 417 | .55 075 | .44 925 | .02 583 | .47 508 | 26 |
| 35 | 9.52 527 | 9.97 412 | 9.55 115 | 0.44 885 | 0.02 588 | 0.47 473 | 25 |
| 36 | .52 563 | .97 408 | .55 155 | .44 845 | .02 592 | .47 437 | 24 |
| 37 | .52 598 | .97 403 | .55 195 | .44 805 | .02 597 | .47 402 | 23 |
| 38 | .52 634 | .97 399 | .55 235 | .44 765 | .02 601 | .47 366 | 22 |
| 39 | .52 669 | .97 394 | .55 275 | .44 725 | .02 606 | .47 331 | 21 |
| 40 | 9.52 705 | 9.97 390 | 9.55 315 | 0.44 685 | 0.02 610 | 0.47 295 | 20 |
| 41 | .52 740 | .97 385 | .55 355 | .44 645 | .02 615 | .47 260 | 19 |
| 42 | .52 775 | .97 381 | .55 395 | .44 605 | .02 619 | .47 225 | 18 |
| 43 | .52 811 | .97 376 | .55 434 | .44 566 | .02 624 | .47 189 | 17 |
| 44 | .52 846 | .97 372 | .55 474 | .44 526 | .02 628 | .47 154 | 16 |
| 45 | 9.52 881 | 9.97 367 | 9.55 514 | 0.44 486 | 0.02 633 | 0.47 119 | 15 |
| 46 | .52 916 | .97 363 | .55 554 | .44 446 | .02 637 | .47 084 | 14 |
| 47 | .52 951 | .97 358 | .55 593 | .44 407 | .02 642 | .47 049 | 13 |
| 48 | .52 986 | .97 353 | .55 633 | .44 367 | .02 647 | .47 014 | 12 |
| 49 | .53 021 | .97 349 | .55 673 | .44 327 | .02 651 | .46 979 | 11 |
| 50 | 9.53 056 | 9.97 344 | 9.55 712 | 0.44 288 | 0.02 656 | 0.46 944 | 10 |
| 51 | .53 092 | .97 340 | .55 752 | .44 248 | .02 660 | .46 908 | 9 |
| 52 | .53 126 | .97 335 | .55 791 | .44 209 | .02 665 | .46 874 | 8 |
| 53 | .53 161 | .97 331 | .55 831 | .44 169 | .02 669 | .46 839 | 7 |
| 54 | .53 196 | .97 326 | .55 870 | .44 130 | .02 674 | .46 804 | 6 |
| 55 | 9.53 231 | 9.97 322 | 9.55 910 | 0.44 090 | 0.02 678 | 0.46 769 | 5 |
| 56 | .53 266 | .97 317 | .55 949 | .44 051 | .02 683 | .46 734 | 4 |
| 57 | .53 301 | .97 312 | .55 989 | .44 011 | .02 688 | .46 699 | 3 |
| 58 | .53 336 | .97 308 | .56 028 | .43 972 | .02 692 | .46 664 | 2 |
| 59 | .53 370 | .97 303 | .56 067 | .43 933 | .02 697 | .46 630 | 1 |
| 60 | 9.53 405 | 9.97 299 | 9.56 107 | 9.43 893 | 0.02 701 | 0.46 595 | 0 |
| | Cos | Sin | Cot | Tan | Csc | Sec | ' |

109° (289°)

(250°) 70°

20° (200°)

(339°) 159°

| | Sin | Cos | Tan | Cot | Sec | Csc | |
|-----------|----------|----------|----------|----------|----------|----------|-----------|
| 0 | 9.53 405 | 9.97 299 | 9.56 107 | 0.43 893 | 0.02 701 | 0.46 595 | 60 |
| 1 | .53 440 | .97 294 | .56 146 | .43 854 | .02 706 | .46 560 | 59 |
| 2 | .53 475 | .97 289 | .56 185 | .43 815 | .02 711 | .46 525 | 58 |
| 3 | .53 509 | .97 285 | .56 224 | .43 776 | .02 715 | .46 491 | 57 |
| 4 | .53 544 | .97 280 | .56 264 | .43 736 | .02 720 | .46 456 | 56 |
| 5 | 9.53 578 | 9.97 276 | 9.56 303 | 0.43 697 | 0.02 724 | 0.46 422 | 55 |
| 6 | .53 613 | .97 271 | .56 342 | .43 658 | .02 729 | .46 387 | 54 |
| 7 | .53 647 | .97 266 | .56 381 | .43 619 | .02 734 | .46 353 | 53 |
| 8 | .53 682 | .97 262 | .56 420 | .43 580 | .02 738 | .46 318 | 52 |
| 9 | .53 716 | .97 257 | .56 459 | .43 541 | .02 743 | .46 284 | 51 |
| 10 | 9.53 751 | 9.97 252 | 9.56 498 | 0.43 502 | 0.02 748 | 0.46 249 | 50 |
| 11 | .53 785 | .97 248 | .56 537 | .43 463 | .02 752 | .46 215 | 49 |
| 12 | .53 819 | .97 243 | .56 576 | .43 424 | .02 757 | .46 181 | 48 |
| 13 | .53 854 | .97 238 | .56 615 | .43 385 | .02 762 | .46 146 | 47 |
| 14 | .53 888 | .97 234 | .56 654 | .43 346 | .02 766 | .46 112 | 46 |
| 15 | 9.53 922 | 9.97 229 | 9.56 693 | 0.43 307 | 0.02 771 | 0.46 078 | 45 |
| 16 | .53 957 | .97 224 | .56 732 | .43 268 | .02 776 | .46 043 | 44 |
| 17 | .53 991 | .97 220 | .56 771 | .43 229 | .02 780 | .46 009 | 43 |
| 18 | .54 025 | .97 215 | .56 810 | .43 190 | .02 785 | .45 975 | 42 |
| 19 | .54 059 | .97 210 | .56 849 | .43 151 | .02 790 | .45 941 | 41 |
| 20 | 9.54 093 | 9.97 206 | 9.56 887 | 0.43 113 | 0.02 794 | 0.45 907 | 40 |
| 21 | .54 127 | .97 201 | .56 926 | .43 074 | .02 799 | .45 873 | 39 |
| 22 | .54 161 | .97 196 | .56 965 | .43 035 | .02 804 | .45 839 | 38 |
| 23 | .54 195 | .97 192 | .57 004 | .42 996 | .02 808 | .45 805 | 37 |
| 24 | .54 229 | .97 187 | .57 042 | .42 958 | .02 813 | .45 771 | 36 |
| 25 | 9.54 263 | 9.97 182 | 9.57 081 | 0.42 919 | 0.02 818 | 0.45 737 | 35 |
| 26 | .54 297 | .97 178 | .57 120 | .42 880 | .02 822 | .45 703 | 34 |
| 27 | .54 331 | .97 173 | .57 158 | .42 842 | .02 827 | .45 669 | 33 |
| 28 | .54 365 | .97 168 | .57 197 | .42 803 | .02 832 | .45 635 | 32 |
| 29 | .54 399 | .97 163 | .57 235 | .42 765 | .02 837 | .45 601 | 31 |
| 30 | 9.54 433 | 9.97 159 | 9.57 274 | 0.42 726 | 0.02 841 | 0.45 567 | 30 |
| 31 | .54 466 | .97 154 | .57 312 | .42 688 | .02 846 | .45 534 | 29 |
| 32 | .54 500 | .97 149 | .57 351 | .42 649 | .02 851 | .45 500 | 28 |
| 33 | .54 534 | .97 145 | .57 389 | .42 611 | .02 855 | .45 466 | 27 |
| 34 | .54 567 | .97 140 | .57 428 | .42 572 | .02 860 | .45 433 | 26 |
| 35 | 9.54 601 | 9.97 135 | 9.57 466 | 0.42 534 | 0.02 865 | 0.45 399 | 25 |
| 36 | .54 635 | .97 130 | .57 504 | .42 496 | .02 870 | .45 365 | 24 |
| 37 | .54 668 | .97 126 | .57 543 | .42 457 | .02 874 | .45 332 | 23 |
| 38 | .54 702 | .97 121 | .57 581 | .42 419 | .02 879 | .45 298 | 22 |
| 39 | .54 735 | .97 116 | .57 619 | .42 381 | .02 884 | .45 265 | 21 |
| 40 | 9.54 769 | 9.97 111 | 9.57 658 | 0.42 342 | 0.02 889 | 0.45 231 | 20 |
| 41 | .54 802 | .97 107 | .57 696 | .42 304 | .02 893 | .45 198 | 19 |
| 42 | .54 836 | .97 102 | .57 734 | .42 266 | .02 898 | .45 164 | 18 |
| 43 | .54 869 | .97 097 | .57 772 | .42 228 | .02 903 | .45 131 | 17 |
| 44 | .54 903 | .97 092 | .57 810 | .42 190 | .02 908 | .45 097 | 16 |
| 45 | 9.54 936 | 9.97 087 | 9.57 849 | 0.42 151 | 0.02 913 | 0.45 064 | 15 |
| 46 | .54 969 | .97 083 | .57 887 | .42 113 | .02 917 | .45 031 | 14 |
| 47 | .55 003 | .97 078 | .57 925 | .42 075 | .02 922 | .44 997 | 13 |
| 48 | .55 036 | .97 073 | .57 963 | .42 037 | .02 927 | .44 964 | 12 |
| 49 | .55 069 | .97 068 | .58 001 | .41 999 | .02 932 | .44 931 | 11 |
| 50 | 9.55 102 | 9.97 063 | 9.58 039 | 0.41 961 | 0.02 937 | 0.44 898 | 10 |
| 51 | .55 136 | .97 059 | .58 077 | .41 923 | .02 941 | .44 864 | 9 |
| 52 | .55 169 | .97 054 | .58 115 | .41 885 | .02 946 | .44 831 | 8 |
| 53 | .55 202 | .97 049 | .58 153 | .41 847 | .02 951 | .44 798 | 7 |
| 54 | .55 235 | .97 044 | .58 191 | .41 809 | .02 956 | .44 765 | 6 |
| 55 | 9.55 268 | 9.97 039 | 9.58 229 | 0.41 771 | 0.02 961 | 0.44 732 | 5 |
| 56 | .55 301 | .97 035 | .58 267 | .41 733 | .02 965 | .44 699 | 4 |
| 57 | .55 334 | .97 030 | .58 304 | .41 696 | .02 970 | .44 666 | 3 |
| 58 | .55 367 | .97 025 | .58 342 | .41 658 | .02 975 | .44 633 | 2 |
| 59 | .55 400 | .97 020 | .58 380 | .41 620 | .02 980 | .44 600 | 1 |
| 60 | 9.55 433 | 9.97 015 | 9.58 418 | 0.41 582 | 0.02 985 | 0.44 567 | 0 |
| | Cos | Sin | Cot | Tan | Csc | Sec | |

110° (290°)

(249°) 69°

Table 4. Trigonometric Logarithms

21° (201°)

(338°) 158°

| | Sin | Cos | Tan | Cot | Sec | Csc | |
|-----------|------------|------------|------------|------------|------------|------------|-----------|
| 0 | 9.55 433 | 9.97 015 | 9.58 418 | 0.41 582 | 0.02 985 | 0.44 567 | 60 |
| 1 | .55 466 | .97 010 | .58 455 | .41 545 | .02 990 | .44 534 | 59 |
| 2 | .55 499 | .97 005 | .58 493 | .41 507 | .02 995 | .44 501 | 58 |
| 3 | .55 532 | .97 001 | .58 531 | .41 469 | .02 999 | .44 468 | 57 |
| 4 | .55 564 | .96 996 | .58 569 | .41 431 | .03 004 | .44 436 | 56 |
| 5 | 9.55 597 | 9.96 991 | 9.58 606 | 0.41 394 | 0.03 009 | 0.44 403 | 55 |
| 6 | .55 630 | .96 986 | .58 644 | .41 356 | .03 014 | .44 370 | 54 |
| 7 | .55 663 | .96 981 | .58 681 | .41 319 | .03 019 | .44 337 | 53 |
| 8 | .55 695 | .96 976 | .58 719 | .41 281 | .03 024 | .44 305 | 52 |
| 9 | .55 728 | .96 971 | .58 757 | .41 243 | .03 029 | .44 272 | 51 |
| 10 | 9.55 761 | 9.96 966 | 9.58 794 | 0.41 206 | 0.03 034 | 0.44 239 | 50 |
| 11 | .55 793 | .96 962 | .58 832 | .41 168 | .03 038 | .44 207 | 49 |
| 12 | .55 826 | .96 957 | .58 869 | .41 131 | .03 043 | .44 174 | 48 |
| 13 | .55 858 | .96 952 | .58 907 | .41 093 | .03 048 | .44 142 | 47 |
| 14 | .55 891 | .96 947 | .58 944 | .41 056 | .03 053 | .44 109 | 46 |
| 15 | 9.55 923 | 9.96 942 | 9.58 981 | 0.41 019 | 0.03 058 | 0.44 077 | 45 |
| 16 | .55 956 | .96 937 | .59 019 | .40 981 | .03 063 | .44 044 | 44 |
| 17 | .55 988 | .96 932 | .59 056 | .40 944 | .03 068 | .44 012 | 43 |
| 18 | .56 021 | .96 927 | .59 094 | .40 906 | .03 073 | .43 979 | 42 |
| 19 | .56 053 | .96 922 | .59 131 | .40 869 | .03 078 | .43 947 | 41 |
| 20 | 9.56 085 | 9.96 917 | 9.59 168 | 0.40 832 | 0.03 083 | 0.43 915 | 40 |
| 21 | .56 118 | .96 912 | .59 205 | .40 795 | .03 088 | .43 882 | 39 |
| 22 | .56 150 | .96 907 | .59 243 | .40 757 | .03 093 | .43 850 | 38 |
| 23 | .56 182 | .96 903 | .59 280 | .40 720 | .03 097 | .43 818 | 37 |
| 24 | .56 215 | .96 898 | .59 317 | .40 683 | .03 102 | .43 785 | 36 |
| 25 | 9.56 247 | 9.96 893 | 9.59 354 | 0.40 646 | 0.03 107 | 0.43 753 | 35 |
| 26 | .56 279 | .96 888 | .59 391 | .40 609 | .03 112 | .43 721 | 34 |
| 27 | .56 311 | .96 883 | .59 429 | .40 571 | .03 117 | .43 689 | 33 |
| 28 | .56 343 | .96 878 | .59 466 | .40 534 | .03 122 | .43 657 | 32 |
| 29 | .56 375 | .96 873 | .59 503 | .40 497 | .03 127 | .43 625 | 31 |
| 30 | 9.56 408 | 9.96 868 | 9.59 540 | 0.40 460 | 0.03 132 | 0.43 592 | 30 |
| 31 | .56 440 | .96 863 | .59 577 | .40 423 | .03 137 | .43 560 | 29 |
| 32 | .56 472 | .96 858 | .59 614 | .40 386 | .03 142 | .43 528 | 28 |
| 33 | .56 504 | .96 853 | .59 651 | .40 349 | .03 147 | .43 496 | 27 |
| 34 | .56 536 | .96 848 | .59 688 | .40 312 | .03 152 | .43 464 | 26 |
| 35 | 9.56 568 | 9.96 843 | 9.59 725 | 0.40 275 | 0.03 157 | 0.43 432 | 25 |
| 36 | .56 599 | .96 838 | .59 762 | .40 238 | .03 162 | .43 401 | 24 |
| 37 | .56 631 | .96 833 | .59 799 | .40 201 | .03 167 | .43 369 | 23 |
| 38 | .56 663 | .96 828 | .59 835 | .40 165 | .03 172 | .43 337 | 22 |
| 39 | .56 695 | .96 823 | .59 872 | .40 128 | .03 177 | .43 305 | 21 |
| 40 | 9.56 727 | 9.96 818 | 9.59 909 | 0.40 091 | 0.03 182 | 0.43 273 | 20 |
| 41 | .56 759 | .96 813 | .59 946 | .40 054 | .03 187 | .43 241 | 19 |
| 42 | .56 790 | .96 808 | .59 983 | .40 017 | .03 192 | .43 210 | 18 |
| 43 | .56 822 | .96 803 | .60 019 | .39 981 | .03 197 | .43 178 | 17 |
| 44 | .56 854 | .96 798 | .60 056 | .39 944 | .03 202 | .43 146 | 16 |
| 45 | 9.56 886 | 9.96 793 | 9.60 093 | 0.39 907 | 0.03 207 | 0.43 114 | 15 |
| 46 | .56 917 | .96 788 | .60 130 | .39 870 | .03 212 | .43 083 | 14 |
| 47 | .56 949 | .96 783 | .60 166 | .39 834 | .03 217 | .43 051 | 13 |
| 48 | .56 980 | .96 778 | .60 203 | .39 797 | .03 222 | .43 020 | 12 |
| 49 | .57 012 | .96 772 | .60 240 | .39 760 | .03 228 | .42 988 | 11 |
| 50 | 9.57 044 | 9.96 767 | 9.60 276 | 0.39 724 | 0.03 233 | 0.42 956 | 10 |
| 51 | .57 075 | .96 762 | .60 313 | .39 687 | .03 238 | .42 925 | 9 |
| 52 | .57 107 | .96 757 | .60 349 | .39 651 | .03 243 | .42 893 | 8 |
| 53 | .57 138 | .96 752 | .60 386 | .39 614 | .03 248 | .42 862 | 7 |
| 54 | .57 169 | .96 747 | .60 422 | .39 578 | .03 253 | .42 831 | 6 |
| 55 | 9.57 201 | 9.96 742 | 9.60 459 | 0.39 541 | 0.03 258 | 0.42 799 | 5 |
| 56 | .57 232 | .96 737 | .60 495 | .39 505 | .03 263 | .42 768 | 4 |
| 57 | .57 264 | .96 732 | .60 532 | .39 468 | .03 268 | .42 736 | 3 |
| 58 | .57 295 | .96 727 | .60 568 | .39 432 | .03 273 | .42 705 | 2 |
| 59 | .57 326 | .96 722 | .60 605 | .39 395 | .03 278 | .42 674 | 1 |
| 60 | 9.57 358 | 9.96 717 | 9.60 641 | 0.39 359 | 0.03 283 | 0.42 642 | 0 |
| | Cos | Sin | Cot | Tan | Csc | Sec | ' |

111° (291°)

(248°) 68°

22° (202°)

(337°) 157°

| | Sin | Cos | Tan | Cot | Sec | Csc | |
|-----------|----------|----------|----------|----------|----------|----------|-----------|
| 0 | 9.57 358 | 9.96 717 | 9.60 641 | 0.39 359 | 0.03 283 | 0.42 642 | 60 |
| 1 | .57 389 | .96 711 | .60 677 | .39 323 | .03 289 | .42 611 | 59 |
| 2 | .57 420 | .96 706 | .60 714 | .39 286 | .03 294 | .42 580 | 58 |
| 3 | .57 451 | .96 701 | .60 750 | .39 250 | .03 299 | .42 549 | 57 |
| 4 | .57 482 | .96 696 | .60 786 | .39 214 | .03 304 | .42 518 | 56 |
| 5 | 9.57 514 | 9.96 691 | 9.60 823 | 0.39 177 | 0.03 309 | 0.42 486 | 55 |
| 6 | .57 545 | .96 686 | .60 859 | .39 141 | .03 314 | .42 455 | 54 |
| 7 | .57 576 | .96 681 | .60 895 | .39 105 | .03 319 | .42 424 | 53 |
| 8 | .57 607 | .96 676 | .60 931 | .39 069 | .03 324 | .42 393 | 52 |
| 9 | .57 638 | .96 670 | .60 967 | .39 033 | .03 330 | .42 362 | 51 |
| 10 | 9.57 669 | 9.96 665 | 9.61 004 | 9.38 996 | 0.03 335 | 0.42 331 | 50 |
| 11 | .57 700 | .96 660 | .61 040 | .38 960 | .03 340 | .42 300 | 49 |
| 12 | .57 731 | .96 655 | .61 076 | .38 924 | .03 345 | .42 269 | 48 |
| 13 | .57 762 | .96 650 | .61 112 | .38 888 | .03 350 | .42 238 | 47 |
| 14 | .57 793 | .96 645 | .61 148 | .38 852 | .03 355 | .42 207 | 46 |
| 15 | 9.57 824 | 9.96 640 | 9.61 184 | 0.38 816 | 0.03 360 | 0.42 176 | 45 |
| 16 | .57 855 | .96 634 | .61 220 | .38 780 | .03 366 | .42 145 | 44 |
| 17 | .57 885 | .96 629 | .61 256 | .38 744 | .03 371 | .42 115 | 43 |
| 18 | .57 916 | .96 624 | .61 292 | .38 708 | .03 376 | .42 084 | 42 |
| 19 | .57 947 | .96 619 | .61 328 | .38 672 | .03 381 | .42 053 | 41 |
| 20 | 9.57 978 | 9.96 614 | 9.61 364 | 0.38 636 | 0.03 386 | 0.42 022 | 40 |
| 21 | .58 008 | .96 608 | .61 400 | .38 600 | .03 392 | .41 992 | 39 |
| 22 | .58 039 | .96 603 | .61 436 | .38 564 | .03 397 | .41 961 | 38 |
| 23 | .58 070 | .96 598 | .61 472 | .38 528 | .03 402 | .41 930 | 37 |
| 24 | .58 101 | .96 593 | .61 508 | .38 492 | .03 407 | .41 899 | 36 |
| 25 | 9.58 131 | 9.96 588 | 9.61 544 | 0.38 456 | 0.03 412 | 0.41 869 | 35 |
| 26 | .58 162 | .96 582 | .61 579 | .38 421 | .03 418 | .41 838 | 34 |
| 27 | .58 192 | .96 577 | .61 615 | .38 385 | .03 423 | .41 808 | 33 |
| 28 | .58 223 | .96 572 | .61 651 | .38 349 | .03 428 | .41 777 | 32 |
| 29 | .58 253 | .96 567 | .61 687 | .38 313 | .03 433 | .41 747 | 31 |
| 30 | 9.58 284 | 9.96 562 | 9.61 722 | 0.38 278 | 0.03 438 | 0.41 716 | 30 |
| 31 | .58 314 | .96 556 | .61 758 | .38 242 | .03 444 | .41 686 | 29 |
| 32 | .58 345 | .96 551 | .61 794 | .38 206 | .03 449 | .41 655 | 28 |
| 33 | .58 375 | .96 546 | .61 830 | .38 170 | .03 454 | .41 625 | 27 |
| 34 | .58 406 | .96 541 | .61 865 | .38 135 | .03 459 | .41 594 | 26 |
| 35 | 9.58 436 | 9.96 535 | 9.61 901 | 0.38 099 | 0.03 465 | 0.41 564 | 25 |
| 36 | .58 467 | .96 530 | .61 936 | .38 064 | .03 470 | .41 533 | 24 |
| 37 | .58 497 | .96 525 | .61 972 | .38 028 | .03 475 | .41 503 | 23 |
| 38 | .58 527 | .96 520 | .62 008 | .37 992 | .03 480 | .41 473 | 22 |
| 39 | .58 557 | .96 514 | .62 043 | .37 957 | .03 486 | .41 443 | 21 |
| 40 | 9.58 588 | 9.96 509 | 9.62 079 | 0.37 921 | 0.03 491 | 0.41 412 | 20 |
| 41 | .58 618 | .96 504 | .62 114 | .37 886 | .03 496 | .41 382 | 19 |
| 42 | .58 648 | .96 498 | .62 150 | .37 850 | .03 502 | .41 352 | 18 |
| 43 | .58 678 | .96 493 | .62 185 | .37 815 | .03 507 | .41 322 | 17 |
| 44 | .58 709 | .96 488 | .62 221 | .37 779 | .03 512 | .41 291 | 16 |
| 45 | 9.58 739 | 9.96 483 | 9.62 256 | 0.37 744 | 0.03 517 | 0.41 261 | 15 |
| 46 | .58 769 | .96 477 | .62 292 | .37 708 | .03 523 | .41 231 | 14 |
| 47 | .58 799 | .96 472 | .62 327 | .37 673 | .03 528 | .41 201 | 13 |
| 48 | .58 829 | .96 467 | .62 362 | .37 638 | .03 533 | .41 171 | 12 |
| 49 | .58 859 | .96 461 | .62 398 | .37 602 | .03 539 | .41 141 | 11 |
| 50 | 9.58 889 | 9.96 456 | 9.62 433 | 0.37 567 | 0.03 544 | 0.41 111 | 10 |
| 51 | .58 919 | .96 451 | .62 468 | .37 532 | .03 549 | .41 081 | 9 |
| 52 | .58 949 | .96 445 | .62 504 | .37 496 | .03 555 | .41 051 | 8 |
| 53 | .58 979 | .96 440 | .62 539 | .37 461 | .03 560 | .41 021 | 7 |
| 54 | .59 009 | .96 435 | .62 574 | .37 426 | .03 565 | .40 991 | 6 |
| 55 | 9.59 039 | 9.96 429 | 9.62 609 | 0.37 391 | 0.03 571 | 0.40 961 | 5 |
| 56 | .59 069 | .96 424 | .62 645 | .37 355 | .03 576 | .40 931 | 4 |
| 57 | .59 098 | .96 419 | .62 680 | .37 320 | .03 581 | .40 902 | 3 |
| 58 | .59 128 | .96 413 | .62 715 | .37 285 | .03 587 | .40 872 | 2 |
| 59 | .59 158 | .96 408 | .62 750 | .37 250 | .03 592 | .40 842 | 1 |
| 60 | 9.59 188 | 9.96 403 | 9.62 785 | 0.37 215 | 0.03 597 | 0.40 812 | 0 |
| | Cos | Sin | Cot | Tan | Csc | Sec | ' |

112° (292°)

(247°) 67°

23° (203°)

(336°) 156°

| | Sin | Cos | Tan | Cot | Sec | Csc | |
|-----------|------------|------------|------------|------------|------------|------------|-----------|
| 0 | 9.59 188 | 9.96 403 | 9.62 785 | 0.37 215 | 0.03 597 | 0.40 812 | 60 |
| 1 | .59 218 | .96 397 | .62 820 | .37 180 | .03 603 | .40 782 | 59 |
| 2 | .59 247 | .96 392 | .62 855 | .37 145 | .03 608 | .40 753 | 58 |
| 3 | .59 277 | .96 387 | .62 890 | .37 110 | .03 613 | .40 723 | 57 |
| 4 | .59 307 | .96 381 | .62 926 | .37 074 | .03 619 | .40 693 | 56 |
| 5 | 9.59 336 | 9.96 376 | 9.62 961 | 0.37 039 | 0.03 624 | 0.40 664 | 55 |
| 6 | .59 366 | .96 370 | .62 996 | .37 004 | .03 630 | .40 634 | 54 |
| 7 | .59 396 | .96 365 | .63 031 | .36 969 | .03 635 | .40 604 | 53 |
| 8 | .59 425 | .96 360 | .63 066 | .36 934 | .03 640 | .40 575 | 52 |
| 9 | .59 455 | .96 354 | .63 101 | .36 899 | .03 646 | .40 545 | 51 |
| 10 | 9.59 484 | 9.96 349 | 9.63 135 | 0.36 865 | 0.03 651 | 0.40 516 | 50 |
| 11 | .59 514 | .96 343 | .63 170 | .36 830 | .03 657 | .40 486 | 49 |
| 12 | .59 543 | .96 338 | .63 205 | .36 795 | .03 662 | .40 457 | 48 |
| 13 | .59 573 | .96 333 | .63 240 | .36 760 | .03 667 | .40 427 | 47 |
| 14 | .59 602 | .96 327 | .63 275 | .36 725 | .03 673 | .40 398 | 46 |
| 15 | 9.59 632 | 9.96 322 | 9.63 310 | 0.36 690 | 0.03 678 | 0.40 368 | 45 |
| 16 | .59 661 | .96 316 | .63 345 | .36 655 | .03 684 | .40 339 | 44 |
| 17 | .59 690 | .96 311 | .63 379 | .36 621 | .03 689 | .40 310 | 43 |
| 18 | .59 720 | .96 305 | .63 414 | .36 586 | .03 695 | .40 280 | 42 |
| 19 | .59 749 | .96 300 | .63 449 | .36 551 | .03 700 | .40 251 | 41 |
| 20 | 9.59 778 | 9.96 294 | 9.63 484 | 0.36 516 | 0.03 706 | 0.40 222 | 40 |
| 21 | .59 808 | .96 289 | .63 519 | .36 481 | .03 711 | .40 192 | 39 |
| 22 | .59 837 | .96 284 | .63 553 | .36 447 | .03 716 | .40 163 | 38 |
| 23 | .59 866 | .96 278 | .63 588 | .36 412 | .03 722 | .40 134 | 37 |
| 24 | .59 895 | .96 273 | .63 623 | .36 377 | .03 727 | .40 105 | 36 |
| 25 | 9.59 924 | 9.96 267 | 9.63 657 | 0.36 343 | 0.03 733 | 0.40 076 | 35 |
| 26 | .59 954 | .96 262 | .63 692 | .36 308 | .03 738 | .40 046 | 34 |
| 27 | .59 983 | .96 256 | .63 726 | .36 274 | .03 744 | .40 017 | 33 |
| 28 | .60 012 | .96 251 | .63 761 | .36 239 | .03 749 | .39 988 | 32 |
| 29 | .60 041 | .96 245 | .63 796 | .36 204 | .03 755 | .39 959 | 31 |
| 30 | 9.60 070 | 9.96 240 | 9.63 830 | 0.36 170 | 0.03 760 | .39 930 | 30 |
| 31 | .60 099 | .96 234 | .63 865 | .36 135 | .03 766 | .39 901 | 29 |
| 32 | .60 128 | .96 229 | .63 899 | .36 101 | .03 771 | .39 872 | 28 |
| 33 | .60 157 | .96 223 | .63 934 | .36 066 | .03 777 | .39 843 | 27 |
| 34 | .60 186 | .96 218 | .63 968 | .36 032 | .03 782 | .39 814 | 26 |
| 35 | 9.60 215 | 9.96 212 | 9.64 003 | 0.35 997 | 0.03 788 | 0.39 785 | 25 |
| 36 | .60 244 | .96 207 | .64 037 | .35 963 | .03 793 | .39 756 | 24 |
| 37 | .60 273 | .96 201 | .64 072 | .35 928 | .03 799 | .39 727 | 23 |
| 38 | .60 302 | .96 196 | .64 106 | .35 894 | .03 804 | .39 698 | 22 |
| 39 | .60 331 | .96 190 | .64 140 | .35 860 | .03 810 | .39 669 | 21 |
| 40 | 9.60 359 | 9.96 185 | 9.64 175 | 0.35 825 | 0.03 815 | 0.39 641 | 20 |
| 41 | .60 388 | .96 179 | .64 209 | .35 791 | .03 821 | .39 612 | 19 |
| 42 | .60 417 | .96 174 | .64 243 | .35 757 | .03 826 | .39 583 | 18 |
| 43 | .60 446 | .96 168 | .64 278 | .35 722 | .03 832 | .39 554 | 17 |
| 44 | .60 474 | .96 162 | .64 312 | .35 688 | .03 838 | .39 526 | 16 |
| 45 | 9.60 503 | 9.96 157 | 9.64 346 | 0.35 654 | 0.03 843 | 0.39 497 | 15 |
| 46 | .60 532 | .96 151 | .64 381 | .35 619 | .03 849 | .39 468 | 14 |
| 47 | .60 561 | .96 146 | .64 415 | .35 585 | .03 854 | .39 439 | 13 |
| 48 | .60 589 | .96 140 | .64 449 | .35 551 | .03 860 | .39 411 | 12 |
| 49 | .60 618 | .96 135 | .64 483 | .35 517 | .03 865 | .39 382 | 11 |
| 50 | 9.60 646 | 9.96 129 | 9.64 517 | 0.35 483 | 0.03 871 | 0.39 354 | 10 |
| 51 | .60 675 | .96 123 | .64 552 | .35 448 | .03 877 | .39 325 | 9 |
| 52 | .60 704 | .96 118 | .64 586 | .35 414 | .03 882 | .39 296 | 8 |
| 53 | .60 732 | .96 112 | .64 620 | .35 380 | .03 888 | .39 268 | 7 |
| 54 | .60 761 | .96 107 | .64 654 | .35 346 | .03 893 | .39 239 | 6 |
| 55 | 9.60 789 | 9.96 101 | 9.64 688 | 0.35 312 | 0.03 899 | 0.39 211 | 5 |
| 56 | .60 818 | .96 095 | .64 722 | .35 278 | .03 905 | .39 182 | 4 |
| 57 | .60 846 | .96 090 | .64 756 | .35 244 | .03 910 | .39 154 | 3 |
| 58 | .60 875 | .96 084 | .64 790 | .35 210 | .03 916 | .39 125 | 2 |
| 59 | .60 903 | .96 079 | .64 824 | .35 176 | .03 921 | .39 097 | 1 |
| 60 | 9.60 931 | 9.96 073 | 9.64 858 | 0.35 142 | 0.03 927 | 0.39 069 | 0 |
| | Cos | Sin | Cot | Tan | Csc | Sec | ' |

113° (293°)

(246°) 66°

24° (204°)

(335°) 155°

| | Sin | Cos | Tan | Cot | Sec | Csc | |
|-----------|----------|----------|----------|----------|----------|----------|-----------|
| 0 | 9.60 931 | 9.96 073 | 9.64 858 | 0.35 142 | 0.03 927 | 0.39 069 | 60 |
| 1 | .60 960 | .96 067 | .64 892 | .35 108 | .03 933 | .39 040 | 59 |
| 2 | .60 988 | .96 062 | .64 926 | .35 074 | .03 938 | .39 012 | 58 |
| 3 | .61 016 | .96 056 | .64 960 | .35 040 | .03 944 | .38 984 | 57 |
| 4 | .61 045 | .96 050 | .64 994 | .35 006 | .03 950 | .38 955 | 56 |
| 5 | 9.61 073 | 9.96 045 | 9.65 028 | 0.34 972 | 0.03 955 | 0.38 927 | 55 |
| 6 | .61 101 | .96 039 | .65 062 | .34 938 | .03 961 | .38 899 | 54 |
| 7 | .61 129 | .96 034 | .65 096 | .34 904 | .03 966 | .38 871 | 53 |
| 8 | .61 158 | .96 028 | .65 130 | .34 870 | .03 972 | .38 842 | 52 |
| 9 | .61 186 | .96 022 | .65 164 | .34 836 | .03 978 | .38 814 | 51 |
| 10 | 9.61 214 | 9.96 017 | 9.65 197 | 0.34 803 | 0.03 983 | 0.38 786 | 50 |
| 11 | .61 242 | .96 011 | .65 231 | .34 769 | .03 989 | .38 758 | 49 |
| 12 | .61 270 | .96 005 | .65 265 | .34 735 | .03 995 | .38 730 | 48 |
| 13 | .61 298 | .96 000 | .65 299 | .34 701 | .04 000 | .38 702 | 47 |
| 14 | .61 326 | .95 994 | .65 333 | .34 667 | .04 006 | .38 674 | 46 |
| 15 | 9.61 354 | 9.95 988 | 9.65 366 | 0.34 634 | 0.04 012 | 0.38 646 | 45 |
| 16 | .61 382 | .95 982 | .65 400 | .34 600 | .04 018 | .38 618 | 44 |
| 17 | .61 411 | .95 977 | .65 434 | .34 566 | .04 023 | .38 589 | 43 |
| 18 | .61 438 | .95 971 | .65 467 | .34 533 | .04 029 | .38 562 | 42 |
| 19 | .61 466 | .95 965 | .65 501 | .34 499 | .04 035 | .38 534 | 41 |
| 20 | 9.61 494 | 9.95 960 | 9.65 535 | 0.34 465 | 0.04 040 | 0.38 506 | 40 |
| 21 | .61 522 | .95 954 | .65 568 | .34 432 | .04 046 | .38 478 | 39 |
| 22 | .61 550 | .95 948 | .65 602 | .34 398 | .04 052 | .38 450 | 38 |
| 23 | .61 578 | .95 942 | .65 636 | .34 364 | .04 058 | .38 422 | 37 |
| 24 | .61 606 | .95 937 | .65 669 | .34 331 | .04 063 | .38 394 | 36 |
| 25 | 9.61 634 | 9.95 931 | 9.65 703 | 0.34 297 | 0.04 069 | 0.38 366 | 35 |
| 26 | .61 662 | .95 925 | .65 736 | .34 264 | .04 075 | .38 338 | 34 |
| 27 | .61 689 | .95 920 | .65 770 | .34 230 | .04 080 | .38 311 | 33 |
| 28 | .61 717 | .95 914 | .65 803 | .34 197 | .04 086 | .38 283 | 32 |
| 29 | .61 745 | .95 908 | .65 837 | .34 163 | .04 092 | .38 255 | 31 |
| 30 | 9.61 773 | 9.95 902 | 9.65 870 | 0.34 130 | 0.04 098 | 0.38 227 | 30 |
| 31 | .61 800 | .95 897 | .65 904 | .34 096 | .04 103 | .38 200 | 29 |
| 32 | .61 828 | .95 891 | .65 937 | .34 063 | .04 109 | .38 172 | 28 |
| 33 | .61 856 | .95 885 | .65 971 | .34 029 | .04 115 | .38 144 | 27 |
| 34 | .61 883 | .95 879 | .66 004 | .33 996 | .04 121 | .38 117 | 26 |
| 35 | 9.61 911 | 9.95 873 | 9.66 038 | 0.33 962 | 0.04 127 | 0.38 089 | 25 |
| 36 | .61 939 | .95 868 | .66 071 | .33 929 | .04 132 | .38 061 | 24 |
| 37 | .61 966 | .95 862 | .66 104 | .33 896 | .04 138 | .38 034 | 23 |
| 38 | .61 994 | .95 856 | .66 138 | .33 862 | .04 144 | .38 006 | 22 |
| 39 | .62 021 | .95 850 | .66 171 | .33 829 | .04 150 | .37 979 | 21 |
| 40 | 9.62 049 | 9.95 844 | 9.66 204 | 0.33 796 | 0.04 156 | 0.37 951 | 20 |
| 41 | .62 076 | .95 839 | .66 238 | .33 762 | .04 161 | .37 924 | 19 |
| 42 | .62 104 | .95 833 | .66 271 | .33 729 | .04 167 | .37 896 | 18 |
| 43 | .62 131 | .95 827 | .66 304 | .33 696 | .04 173 | .37 869 | 17 |
| 44 | .62 159 | .95 821 | .66 337 | .33 663 | .04 179 | .37 841 | 16 |
| 45 | 9.62 186 | 9.95 815 | 9.66 371 | 0.33 629 | 0.04 185 | 0.37 814 | 15 |
| 46 | .62 214 | .95 810 | .66 404 | .33 596 | .04 190 | .37 786 | 14 |
| 47 | .62 241 | .95 804 | .66 437 | .33 563 | .04 196 | .37 759 | 13 |
| 48 | .62 268 | .95 798 | .66 470 | .33 530 | .04 202 | .37 732 | 12 |
| 49 | .62 296 | .95 792 | .66 503 | .33 497 | .04 208 | .37 704 | 11 |
| 50 | 9.62 323 | 9.95 786 | 9.66 537 | 0.33 463 | 0.04 214 | 0.37 677 | 10 |
| 51 | .62 350 | .95 780 | .66 570 | .33 430 | .04 220 | .37 650 | 9 |
| 52 | .62 377 | .95 775 | .66 603 | .33 397 | .04 225 | .37 623 | 8 |
| 53 | .62 405 | .95 769 | .66 636 | .33 364 | .04 231 | .37 595 | 7 |
| 54 | .62 432 | .95 763 | .66 669 | .33 331 | .04 237 | .37 568 | 6 |
| 55 | 9.62 459 | 9.95 757 | 9.66 702 | 0.33 298 | 0.04 243 | 0.37 541 | 5 |
| 56 | .62 486 | .95 751 | .66 735 | .33 265 | .04 249 | .37 514 | 4 |
| 57 | .62 513 | .95 745 | .66 768 | .33 232 | .04 255 | .37 487 | 3 |
| 58 | .62 541 | .95 739 | .66 801 | .33 199 | .04 261 | .37 459 | 2 |
| 59 | .62 568 | .95 733 | .66 834 | .33 166 | .04 267 | .37 432 | 1 |
| 60 | 9.62 595 | 9.95 728 | 9.66 867 | 0.33 133 | 0.04 272 | 0.37 405 | 0 |
| | Cos | Sin | Cot | Tan | Csc | Sec | ' |

114° (294°)

(245°) 65°

Table 4. Trigonometric Logarithms

25° (205°)

(334°) 154°

| | Sin | Cos | Tan | Cot | Sec | Csc | |
|-----------|----------|----------|----------|----------|----------|----------|-----------|
| 0 | 9.62 595 | 9.95 728 | 9.66 867 | 0.33 133 | 0.04 272 | 0.37 405 | 60 |
| 1 | .62 622 | .95 722 | .66 900 | .33 100 | .04 278 | .37 378 | 59 |
| 2 | .62 649 | .95 716 | .66 933 | .33 067 | .04 284 | .37 351 | 58 |
| 3 | .62 676 | .95 710 | .66 966 | .33 034 | .04 290 | .37 324 | 57 |
| 4 | .62 703 | .95 704 | .66 999 | .33 001 | .04 296 | .37 297 | 56 |
| 5 | 9.62 730 | 9.95 698 | 9.67 032 | 0.32 968 | 0.04 302 | 0.37 270 | 55 |
| 6 | .62 757 | .95 692 | .67 065 | .32 935 | .04 308 | .37 243 | 54 |
| 7 | .62 784 | .95 686 | .67 098 | .32 902 | .04 314 | .37 216 | 53 |
| 8 | .62 811 | .95 680 | .67 131 | .32 869 | .04 320 | .37 189 | 52 |
| 9 | .62 838 | .95 674 | .67 163 | .32 837 | .04 326 | .37 162 | 51 |
| 10 | 9.62 865 | 9.95 668 | 9.67 196 | 0.32 804 | 0.04 332 | 0.37 135 | 50 |
| 11 | .62 892 | .95 663 | .67 229 | .32 771 | .04 337 | .37 108 | 49 |
| 12 | .62 918 | .95 657 | .67 262 | .32 738 | .04 343 | .37 082 | 48 |
| 13 | .62 945 | .95 651 | .67 295 | .32 705 | .04 349 | .37 055 | 47 |
| 14 | .62 972 | .95 645 | .67 327 | .32 673 | .04 355 | .37 028 | 46 |
| 15 | 9.62 999 | 9.95 639 | 9.67 360 | 0.32 640 | 0.04 361 | 0.37 001 | 45 |
| 16 | .63 026 | .95 633 | .67 393 | .32 607 | .04 367 | .36 974 | 44 |
| 17 | .63 052 | .95 627 | .67 426 | .32 574 | .04 373 | .36 948 | 43 |
| 18 | .63 079 | .95 621 | .67 458 | .32 542 | .04 379 | .36 921 | 42 |
| 19 | .63 106 | .95 615 | .67 491 | .32 509 | .04 385 | .36 894 | 41 |
| 20 | 9.63 133 | 9.95 609 | 9.67 524 | 0.32 476 | 0.04 391 | 0.36 867 | 40 |
| 21 | .63 159 | .95 603 | .67 556 | .32 444 | .04 397 | .36 841 | 39 |
| 22 | .63 186 | .95 597 | .67 589 | .32 411 | .04 403 | .36 814 | 38 |
| 23 | .63 213 | .95 591 | .67 622 | .32 378 | .04 409 | .36 787 | 37 |
| 24 | .63 239 | .95 585 | .67 654 | .32 346 | .04 415 | .36 761 | 36 |
| 25 | 9.63 266 | 9.95 579 | 9.67 687 | 0.32 313 | 0.04 421 | 0.36 734 | 35 |
| 26 | .63 292 | .95 573 | .67 719 | .32 281 | .04 427 | .36 708 | 34 |
| 27 | .63 319 | .95 567 | .67 752 | .32 248 | .04 433 | .36 681 | 33 |
| 28 | .63 345 | .95 561 | .67 785 | .32 215 | .04 439 | .36 655 | 32 |
| 29 | .63 372 | .95 555 | .67 817 | .32 183 | .04 445 | .36 628 | 31 |
| 30 | 9.63 398 | 9.95 549 | 9.67 850 | 0.32 150 | 0.04 451 | 0.36 602 | 30 |
| 31 | .63 425 | .95 543 | .67 882 | .32 118 | .04 457 | .36 575 | 29 |
| 32 | .63 451 | .95 537 | .67 915 | .32 085 | .04 463 | .36 549 | 28 |
| 33 | .63 478 | .95 531 | .67 947 | .32 053 | .04 469 | .36 522 | 27 |
| 34 | .63 504 | .95 525 | .67 980 | .32 020 | .04 475 | .36 496 | 26 |
| 35 | 9.63 531 | 9.95 519 | 9.68 012 | 0.31 988 | 0.04 481 | 0.36 469 | 25 |
| 36 | .63 557 | .95 513 | .68 044 | .31 956 | .04 487 | .36 443 | 24 |
| 37 | .63 583 | .95 507 | .68 077 | .31 923 | .04 493 | .36 417 | 23 |
| 38 | .63 610 | .95 500 | .68 109 | .31 891 | .04 500 | .36 390 | 22 |
| 39 | .63 636 | .95 494 | .68 142 | .31 858 | .04 506 | .36 364 | 21 |
| 40 | 9.63 662 | 9.95 488 | 9.68 174 | 0.31 826 | 0.04 512 | 0.36 338 | 20 |
| 41 | .63 689 | .95 482 | .68 206 | .31 794 | .04 518 | .36 311 | 19 |
| 42 | .63 715 | .95 476 | .68 239 | .31 761 | .04 524 | .36 285 | 18 |
| 43 | .63 741 | .95 470 | .68 271 | .31 729 | .04 530 | .36 259 | 17 |
| 44 | .63 767 | .95 464 | .68 303 | .31 697 | .04 536 | .36 233 | 16 |
| 45 | 9.63 794 | 9.95 458 | 9.68 336 | 0.31 664 | 0.04 542 | 0.36 206 | 15 |
| 46 | .63 820 | .95 452 | .68 368 | .31 632 | .04 548 | .36 180 | 14 |
| 47 | .63 846 | .95 446 | .68 400 | .31 600 | .04 554 | .36 154 | 13 |
| 48 | .63 872 | .95 440 | .68 432 | .31 568 | .04 560 | .36 128 | 12 |
| 49 | .63 898 | .95 434 | .68 465 | .31 535 | .04 566 | .36 102 | 11 |
| 50 | 9.63 924 | 9.95 427 | 9.68 497 | 0.31 503 | 0.04 573 | 0.36 076 | 10 |
| 51 | .63 950 | .95 421 | .68 529 | .31 471 | .04 579 | .36 050 | 9 |
| 52 | .63 976 | .95 415 | .68 561 | .31 439 | .04 585 | .36 024 | 8 |
| 53 | .64 002 | .95 409 | .68 593 | .31 407 | .04 591 | .35 998 | 7 |
| 54 | .64 028 | .95 403 | .68 626 | .31 374 | .04 597 | .35 972 | 6 |
| 55 | 9.64 054 | 9.95 397 | 9.68 658 | 0.31 342 | 0.04 603 | 0.35 946 | 5 |
| 56 | .64 080 | .95 391 | .68 690 | .31 310 | .04 609 | .35 920 | 4 |
| 57 | .64 106 | .95 384 | .68 722 | .31 278 | .04 616 | .35 894 | 3 |
| 58 | .64 132 | .95 378 | .68 754 | .31 246 | .04 622 | .35 868 | 2 |
| 59 | .64 158 | .95 372 | .68 786 | .31 214 | .04 628 | .35 842 | 1 |
| 60 | 9.64 184 | 9.95 366 | 9.68 818 | 0.31 182 | 0.04 634 | 0.35 816 | 0 |
| | Cos | Sin | Cot | Tan | Csc | Sec | ' |

115° (295°)

(244°) 64°

| | Sin | Cos | Tan | Cot | Sec | Csc | |
|----|----------|----------|----------|----------|----------|----------|----|
| 0 | 9.64 184 | 9.95 366 | 9.68 818 | 0.31 182 | 0.04 634 | 0.35 816 | 60 |
| 1 | .64 210 | .95 360 | .68 850 | .31 150 | .04 640 | .35 790 | 59 |
| 2 | .64 236 | .95 354 | .68 882 | .31 118 | .04 646 | .35 764 | 58 |
| 3 | .64 262 | .95 348 | .68 914 | .31 086 | .04 652 | .35 738 | 57 |
| 4 | .64 288 | .95 341 | .68 946 | .31 054 | .04 659 | .35 712 | 56 |
| 5 | 9.64 313 | 9.95 335 | 9.68 978 | 0.31 022 | 0.04 665 | 0.35 687 | 55 |
| 6 | .64 339 | .95 329 | .69 010 | .30 990 | .04 671 | .35 661 | 54 |
| 7 | .64 365 | .95 323 | .69 042 | .30 958 | .04 677 | .35 635 | 53 |
| 8 | .64 391 | .95 317 | .69 074 | .30 926 | .04 683 | .35 609 | 52 |
| 9 | .64 417 | .95 310 | .69 106 | .30 894 | .04 690 | .35 583 | 51 |
| 10 | 9.64 442 | 9.95 304 | 9.69 138 | 0.30 862 | 0.04 696 | 0.35 558 | 50 |
| 11 | .64 468 | .95 298 | .69 170 | .30 830 | .04 702 | .35 532 | 49 |
| 12 | .64 494 | .95 292 | .69 202 | .30 798 | .04 708 | .35 506 | 48 |
| 13 | .64 519 | .95 286 | .69 234 | .30 766 | .04 714 | .35 481 | 47 |
| 14 | .64 545 | .95 279 | .69 266 | .30 734 | .04 721 | .35 455 | 46 |
| 15 | 9.64 571 | 9.95 273 | 9.69 298 | 0.30 702 | 0.04 727 | 0.35 429 | 45 |
| 16 | .64 596 | .95 267 | .69 329 | .30 671 | .04 733 | .35 404 | 44 |
| 17 | .64 622 | .95 261 | .69 361 | .30 639 | .04 739 | .35 378 | 43 |
| 18 | .64 647 | .95 254 | .69 393 | .30 607 | .04 746 | .35 353 | 42 |
| 19 | .64 673 | .95 248 | .69 425 | .30 575 | .04 752 | .35 327 | 41 |
| 20 | 9.64 698 | 9.95 242 | 9.69 457 | 0.30 543 | 0.04 758 | 0.35 302 | 40 |
| 21 | .64 724 | .95 236 | .69 488 | .30 512 | .04 764 | .35 276 | 39 |
| 22 | .64 749 | .95 229 | .69 520 | .30 480 | .04 771 | .35 251 | 38 |
| 23 | .64 775 | .95 223 | .69 552 | .30 448 | .04 777 | .35 225 | 37 |
| 24 | .64 800 | .95 217 | .69 584 | .30 416 | .04 783 | .35 200 | 36 |
| 25 | 9.64 826 | 9.95 211 | 9.69 615 | 0.30 385 | 0.04 789 | 0.35 174 | 35 |
| 26 | .64 851 | .95 204 | .69 647 | .30 353 | .04 796 | .35 149 | 34 |
| 27 | .64 877 | .95 198 | .69 679 | .30 321 | .04 802 | .35 123 | 33 |
| 28 | .64 902 | .95 192 | .69 710 | .30 290 | .04 808 | .35 098 | 32 |
| 29 | .64 927 | .95 185 | .69 742 | .30 258 | .04 815 | .35 073 | 31 |
| 30 | 9.64 953 | 9.95 179 | 9.69 774 | 0.30 226 | 0.04 821 | 0.35 047 | 30 |
| 31 | .64 978 | .95 173 | .69 805 | .30 195 | .04 827 | .35 022 | 29 |
| 32 | .65 003 | .95 167 | .69 837 | .30 163 | .04 833 | .34 997 | 28 |
| 33 | .65 029 | .95 160 | .69 868 | .30 132 | .04 840 | .34 971 | 27 |
| 34 | .65 054 | .95 154 | .69 900 | .30 100 | .04 846 | .34 946 | 26 |
| 35 | 9.65 079 | 9.95 148 | 9.69 932 | 0.30 068 | 0.04 852 | 0.34 921 | 25 |
| 36 | .65 104 | .95 141 | .69 963 | .30 037 | .04 859 | .34 896 | 24 |
| 37 | .65 130 | .95 135 | .69 995 | .30 005 | .04 865 | .34 870 | 23 |
| 38 | .65 155 | .95 129 | .70 026 | .29 974 | .04 871 | .34 845 | 22 |
| 39 | .65 180 | .95 122 | .70 058 | .29 942 | .04 878 | .34 820 | 21 |
| 40 | 9.65 205 | 9.95 116 | 9.70 089 | 0.29 911 | 0.04 884 | 0.34 795 | 20 |
| 41 | .65 230 | .95 110 | .70 121 | .29 879 | .04 890 | .34 770 | 19 |
| 42 | .65 255 | .95 103 | .70 152 | .29 848 | .04 897 | .34 745 | 18 |
| 43 | .65 281 | .95 097 | .70 184 | .29 816 | .04 903 | .34 719 | 17 |
| 44 | .65 306 | .95 090 | .70 215 | .29 785 | .04 910 | .34 694 | 16 |
| 45 | 9.65 331 | 9.95 084 | 9.70 247 | 0.29 753 | 0.04 916 | 0.34 669 | 15 |
| 46 | .65 356 | .95 078 | .70 278 | .29 722 | .04 922 | .34 644 | 14 |
| 47 | .65 381 | .95 071 | .70 309 | .29 691 | .04 929 | .34 619 | 13 |
| 48 | .65 406 | .95 065 | .70 341 | .29 659 | .04 935 | .34 594 | 12 |
| 49 | .65 431 | .95 059 | .70 372 | .29 628 | .04 941 | .34 569 | 11 |
| 50 | 9.65 456 | 9.95 052 | 9.70 404 | 0.29 596 | 0.04 948 | 0.34 544 | 10 |
| 51 | .65 481 | .95 046 | .70 435 | .29 565 | .04 954 | .34 519 | 9 |
| 52 | .65 506 | .95 039 | .70 466 | .29 534 | .04 961 | .34 494 | 8 |
| 53 | .65 531 | .95 033 | .70 498 | .29 502 | .04 967 | .34 469 | 7 |
| 54 | .65 556 | .95 027 | .70 529 | .29 471 | .04 973 | .34 444 | 6 |
| 55 | 9.65 580 | 9.95 020 | 9.70 560 | 0.29 440 | 0.04 980 | 0.34 420 | 5 |
| 56 | .65 605 | .95 014 | .70 592 | .29 408 | .04 986 | .34 395 | 4 |
| 57 | .65 630 | .95 007 | .70 623 | .29 377 | .04 993 | .34 370 | 3 |
| 58 | .65 655 | .95 001 | .70 654 | .29 346 | .04 999 | .34 345 | 2 |
| 59 | .65 680 | .94 995 | .70 685 | .29 315 | .05 005 | .34 320 | 1 |
| 60 | 9.65 705 | 9.94 988 | 9.70 717 | 0.29 283 | 0.05 012 | 0.34 295 | 0 |

Table 4. Trigonometric Logarithms

27° (207°)

(332°) 152°

| | Sin | Cos | Tan | Cot | Sec | Csc | |
|-----------|------------|------------|------------|------------|------------|------------|-----------|
| 0 | 9.65 705 | 9.94 988 | 9.70 717 | 0.29 283 | 0.05 012 | 0.34 295 | 60 |
| 1 | .65 729 | .94 982 | .70 748 | .29 252 | .05 018 | .34 271 | 59 |
| 2 | .65 754 | .94 975 | .70 779 | .29 221 | .05 025 | .34 246 | 58 |
| 3 | .65 779 | .94 969 | .70 810 | .29 190 | .05 031 | .34 221 | 57 |
| 4 | .65 804 | .94 962 | .70 841 | .29 159 | .05 038 | .34 196 | 56 |
| 5 | 9.65 828 | 9.94 956 | 9.70 873 | 0.29 127 | 0.05 044 | 0.34 172 | 55 |
| 6 | .65 853 | .94 949 | .70 904 | .29 096 | .05 051 | .34 147 | 54 |
| 7 | .65 878 | .94 943 | .70 935 | .29 065 | .05 057 | .34 122 | 53 |
| 8 | .65 902 | .94 936 | .70 966 | .29 034 | .05 064 | .34 098 | 52 |
| 9 | .65 927 | .94 930 | .70 997 | .29 003 | .05 070 | .34 073 | 51 |
| 10 | 9.65 952 | 9.94 923 | 9.71 028 | 0.28 972 | 0.05 077 | 0.34 048 | 50 |
| 11 | .65 976 | .94 917 | .71 059 | .28 941 | .05 083 | .34 024 | 49 |
| 12 | .66 001 | .94 911 | .71 090 | .28 910 | .05 089 | .33 999 | 48 |
| 13 | .66 025 | .94 904 | .71 121 | .28 879 | .05 096 | .33 975 | 47 |
| 14 | .66 050 | .94 898 | .71 153 | .28 847 | .05 102 | .33 950 | 46 |
| 15 | 9.66 075 | 9.94 891 | 9.71 184 | 0.28 816 | 0.05 109 | 0.33 925 | 45 |
| 16 | .66 099 | .94 885 | .71 215 | .28 785 | .05 115 | .33 901 | 44 |
| 17 | .66 124 | .94 878 | .71 246 | .28 754 | .05 122 | .33 876 | 43 |
| 18 | .66 148 | .94 871 | .71 277 | .28 723 | .05 129 | .33 852 | 42 |
| 19 | .66 173 | .94 865 | .71 308 | .28 692 | .05 135 | .33 827 | 41 |
| 20 | 9.66 197 | 9.94 858 | 9.71 339 | 0.28 661 | 0.05 142 | 0.33 803 | 40 |
| 21 | .66 221 | .94 852 | .71 370 | .28 630 | .05 148 | .33 779 | 39 |
| 22 | .66 246 | .94 845 | .71 401 | .28 599 | .05 155 | .33 754 | 38 |
| 23 | .66 270 | .94 839 | .71 431 | .28 569 | .05 161 | .33 730 | 37 |
| 24 | .66 295 | .94 832 | .71 462 | .28 538 | .05 168 | .33 705 | 36 |
| 25 | 9.66 319 | 9.94 826 | 9.71 493 | 0.28 507 | 0.05 174 | 0.33 681 | 35 |
| 26 | .66 343 | .94 819 | .71 524 | .28 476 | .05 181 | .33 657 | 34 |
| 27 | .66 368 | .94 813 | .71 555 | .28 445 | .05 187 | .33 632 | 33 |
| 28 | .66 392 | .94 806 | .71 586 | .28 414 | .05 194 | .33 608 | 32 |
| 29 | .66 416 | .94 799 | .71 617 | .28 383 | .05 201 | .33 584 | 31 |
| 30 | 9.66 441 | 9.94 793 | 9.71 648 | 0.28 352 | 0.05 207 | 0.33 559 | 30 |
| 31 | .66 465 | .94 786 | .71 679 | .28 321 | .05 214 | .33 535 | 29 |
| 32 | .66 489 | .94 780 | .71 709 | .28 291 | .05 220 | .33 511 | 28 |
| 33 | .66 513 | .94 773 | .71 740 | .28 260 | .05 227 | .33 487 | 27 |
| 34 | .66 537 | .94 767 | .71 771 | .28 229 | .05 233 | .33 463 | 26 |
| 35 | 9.66 562 | 9.94 760 | 9.71 802 | 0.28 198 | 0.05 240 | 0.33 438 | 25 |
| 36 | .66 586 | .94 753 | .71 833 | .28 167 | .05 247 | .33 414 | 24 |
| 37 | .66 610 | .94 747 | .71 863 | .28 137 | .05 253 | .33 390 | 23 |
| 38 | .66 634 | .94 740 | .71 894 | .28 106 | .05 260 | .33 366 | 22 |
| 39 | .66 658 | .94 734 | .71 925 | .28 075 | .05 266 | .33 342 | 21 |
| 40 | 9.66 682 | 9.94 727 | 9.71 955 | 0.28 045 | 0.05 273 | 0.33 318 | 20 |
| 41 | .66 706 | .94 720 | .71 986 | .28 014 | .05 280 | .33 294 | 19 |
| 42 | .66 731 | .94 714 | .72 017 | .27 983 | .05 286 | .33 269 | 18 |
| 43 | .66 755 | .94 707 | .72 048 | .27 952 | .05 293 | .33 245 | 17 |
| 44 | .66 779 | .94 700 | .72 078 | .27 922 | .05 300 | .33 221 | 16 |
| 45 | 9.66 803 | 9.94 694 | 9.72 109 | 0.27 891 | 0.05 306 | 0.33 197 | 15 |
| 46 | .66 827 | .94 687 | .72 140 | .27 860 | .05 313 | .33 173 | 14 |
| 47 | .66 851 | .94 680 | .72 170 | .27 830 | .05 320 | .33 149 | 13 |
| 48 | .66 875 | .94 674 | .72 201 | .27 799 | .05 326 | .33 125 | 12 |
| 49 | .66 899 | .94 667 | .72 231 | .27 769 | .05 333 | .33 101 | 11 |
| 50 | 9.66 922 | 9.94 660 | 9.72 262 | 0.27 738 | 0.05 340 | 0.33 078 | 10 |
| 51 | .66 946 | .94 654 | .72 293 | .27 707 | .05 346 | .33 054 | 9 |
| 52 | .66 970 | .94 647 | .72 323 | .27 677 | .05 353 | .33 030 | 8 |
| 53 | .66 994 | .94 640 | .72 354 | .27 646 | .05 360 | .33 006 | 7 |
| 54 | .67 018 | .94 634 | .72 384 | .27 616 | .05 366 | .32 982 | 6 |
| 55 | 9.67 042 | 9.94 627 | 9.72 415 | 0.27 585 | 0.05 373 | 0.32 958 | 5 |
| 56 | .67 066 | .94 620 | .72 445 | .27 555 | .05 380 | .32 934 | 4 |
| 57 | .67 090 | .94 614 | .72 476 | .27 524 | .05 386 | .32 910 | 3 |
| 58 | .67 113 | .94 607 | .72 506 | .27 494 | .05 393 | .32 887 | 2 |
| 59 | .67 137 | .94 600 | .72 537 | .27 463 | .05 400 | .32 863 | 1 |
| 60 | 9.67 161 | 9.94 593 | 9.72 567 | 0.27 433 | 0.05 407 | 0.32 839 | 0 |
| | Cos | Sin | Cot | Tan | Csc | Sec | ' |

117° (297°)

(242°) 62°

28° (208°)

(331°) 151°

| | Sin | Cos | Tan | Cot | Sec | Csc | |
|-----------|------------|------------|------------|------------|------------|------------|-----------|
| 0 | 9.67 161 | 9.94 593 | 9.72 567 | 0.27 433 | 0.05 407 | 0.32 839 | 60 |
| 1 | .67 185 | .94 587 | .72 598 | .27 402 | .05 413 | .32 815 | 59 |
| 2 | .67 208 | .94 580 | .72 628 | .27 372 | .05 420 | .32 792 | 58 |
| 3 | .67 232 | .94 573 | .72 659 | .27 341 | .05 427 | .32 768 | 57 |
| 4 | .67 256 | .94 567 | .72 689 | .27 311 | .05 433 | .32 744 | 56 |
| 5 | 9.67 280 | 9.94 560 | 9.72 720 | 0.27 280 | 0.05 440 | 0.32 720 | 55 |
| 6 | .67 303 | .94 553 | .72 750 | .27 250 | .05 447 | .32 697 | 54 |
| 7 | .67 327 | .94 546 | .72 780 | .27 220 | .05 454 | .32 673 | 53 |
| 8 | .67 350 | .94 540 | .72 811 | .27 189 | .05 460 | .32 650 | 52 |
| 9 | .67 374 | .94 533 | .72 841 | .27 159 | .05 467 | .32 626 | 51 |
| 10 | 9.67 398 | 9.94 526 | 9.72 872 | 0.27 128 | 0.05 474 | 0.32 602 | 50 |
| 11 | .67 421 | .94 519 | .72 902 | .27 098 | .05 481 | .32 579 | 49 |
| 12 | .67 445 | .94 513 | .72 932 | .27 068 | .05 487 | .32 555 | 48 |
| 13 | .67 468 | .94 506 | .72 963 | .27 037 | .05 494 | .32 532 | 47 |
| 14 | .67 492 | .94 499 | .72 993 | .27 007 | .05 501 | .32 508 | 46 |
| 15 | 9.67 515 | 9.94 492 | 9.73 023 | 0.26 977 | 0.05 508 | 0.32 485 | 45 |
| 16 | .67 539 | .94 485 | .73 054 | .26 946 | .05 515 | .32 461 | 44 |
| 17 | .67 562 | .94 479 | .73 084 | .26 916 | .05 521 | .32 438 | 43 |
| 18 | .67 586 | .94 472 | .73 114 | .26 886 | .05 528 | .32 414 | 42 |
| 19 | .67 609 | .94 465 | .73 144 | .26 856 | .05 535 | .32 391 | 41 |
| 20 | 9.67 633 | 9.94 458 | 9.73 175 | 0.26 825 | 0.05 542 | 0.32 367 | 40 |
| 21 | .67 656 | .94 451 | .73 205 | .26 795 | .05 549 | .32 344 | 39 |
| 22 | .67 680 | .94 445 | .73 235 | .26 765 | .05 555 | .32 320 | 38 |
| 23 | .67 703 | .94 438 | .73 265 | .26 735 | .05 562 | .32 297 | 37 |
| 24 | .67 726 | .94 431 | .73 295 | .26 705 | .05 569 | .32 274 | 36 |
| 25 | 9.67 750 | 9.94 424 | 9.73 326 | 0.26 674 | 0.05 576 | 0.32 250 | 35 |
| 26 | .67 773 | .94 417 | .73 356 | .26 644 | .05 583 | .32 227 | 34 |
| 27 | .67 796 | .94 410 | .73 386 | .26 614 | .05 590 | .32 204 | 33 |
| 28 | .67 820 | .94 404 | .73 416 | .26 584 | .05 596 | .32 180 | 32 |
| 29 | .67 843 | .94 397 | .73 446 | .26 554 | .05 603 | .32 157 | 31 |
| 30 | 9.67 866 | 9.94 390 | 9.73 476 | 0.26 524 | 0.05 610 | 0.32 134 | 30 |
| 31 | .67 890 | .94 383 | .73 507 | .26 493 | .05 617 | .32 110 | 29 |
| 32 | .67 913 | .94 376 | .73 537 | .26 463 | .05 624 | .32 087 | 28 |
| 33 | .67 936 | .94 369 | .73 567 | .26 433 | .05 631 | .32 064 | 27 |
| 34 | .67 959 | .94 362 | .73 597 | .26 403 | .05 638 | .32 041 | 26 |
| 35 | 9.67 982 | 9.94 355 | 9.73 627 | 0.26 373 | 0.05 645 | 0.32 018 | 25 |
| 36 | .68 006 | .94 349 | .73 657 | .26 343 | .05 651 | .31 994 | 24 |
| 37 | .68 029 | .94 342 | .73 687 | .26 313 | .05 658 | .31 971 | 23 |
| 38 | .68 052 | .94 335 | .73 717 | .26 283 | .05 665 | .31 948 | 22 |
| 39 | .68 075 | .94 328 | .73 747 | .26 253 | .05 672 | .31 925 | 21 |
| 40 | 9.68 098 | 9.94 321 | 9.73 777 | 0.26 223 | 0.05 679 | 0.31 902 | 20 |
| 41 | .68 121 | .94 314 | .73 807 | .26 193 | .05 686 | .31 879 | 19 |
| 42 | .68 144 | .94 307 | .73 837 | .26 163 | .05 693 | .31 856 | 18 |
| 43 | .68 167 | .94 300 | .73 867 | .26 133 | .05 700 | .31 833 | 17 |
| 44 | .68 190 | .94 293 | .73 897 | .26 103 | .05 707 | .31 810 | 16 |
| 45 | 9.68 213 | 9.94 286 | 9.73 927 | 0.26 073 | 0.05 714 | 0.31 787 | 15 |
| 46 | .68 237 | .94 279 | .73 957 | .26 043 | .05 721 | .31 763 | 14 |
| 47 | .68 260 | .94 273 | .73 987 | .26 013 | .05 727 | .31 740 | 13 |
| 48 | .68 283 | .94 266 | .74 017 | .25 983 | .05 734 | .31 717 | 12 |
| 49 | .68 305 | .94 259 | .74 047 | .25 953 | .05 741 | .31 695 | 11 |
| 50 | 9.68 328 | 9.94 252 | 9.74 077 | 0.25 923 | 0.05 748 | 0.31 672 | 10 |
| 51 | .68 351 | .94 245 | .74 107 | .25 893 | .05 755 | .31 649 | 9 |
| 52 | .68 374 | .94 238 | .74 137 | .25 863 | .05 762 | .31 626 | 8 |
| 53 | .68 397 | .94 231 | .74 166 | .25 834 | .05 769 | .31 603 | 7 |
| 54 | .68 420 | .94 224 | .74 196 | .25 804 | .05 776 | .31 580 | 6 |
| 55 | 9.68 443 | 9.94 217 | 9.74 226 | 0.25 774 | 0.05 783 | 0.31 557 | 5 |
| 56 | .68 466 | .94 210 | .74 256 | .25 744 | .05 790 | .31 534 | 4 |
| 57 | .68 489 | .94 203 | .74 286 | .25 714 | .05 797 | .31 511 | 3 |
| 58 | .68 512 | .94 196 | .74 316 | .25 684 | .05 804 | .31 488 | 2 |
| 59 | .68 534 | .94 189 | .74 345 | .25 655 | .05 811 | .31 466 | 1 |
| 60 | 9.68 557 | 9.94 182 | 9.74 375 | 0.25 625 | 0.05 818 | 0.31 443 | 0 |
| | Cos | Sin | Cot | Tan | Csc | Sec | ' |

118° (298°)

(241°) 61°

Table 4. Trigonometric Logarithms

29° (209°)

(330°) 150°

| | Sin | Cos | Tan | Cot | Sec | Csc | |
|-----------|----------|----------|----------|----------|----------|----------|-----------|
| 0 | 9.68 557 | 9.94 182 | 9.74 375 | 0.25 625 | 0.05 818 | 0.31 443 | 60 |
| 1 | .68 580 | .94 175 | .74 405 | .25 595 | .05 825 | .31 420 | 59 |
| 2 | .68 603 | .94 168 | .74 435 | .25 565 | .05 832 | .31 397 | 58 |
| 3 | .68 625 | .94 161 | .74 465 | .25 535 | .05 839 | .31 375 | 57 |
| 4 | .68 648 | .94 154 | .74 494 | .25 506 | .05 846 | .31 352 | 56 |
| 5 | 9.68 671 | 9.94 147 | 9.74 524 | 0.25 476 | 0.05 853 | 0.31 329 | 55 |
| 6 | .68 694 | .94 140 | .74 554 | .25 446 | .05 860 | .31 306 | 54 |
| 7 | .68 716 | .94 133 | .74 583 | .25 417 | .05 867 | .31 284 | 53 |
| 8 | .68 739 | .94 126 | .74 613 | .25 387 | .05 874 | .31 261 | 52 |
| 9 | .68 762 | .94 119 | .74 643 | .25 357 | .05 881 | .31 238 | 51 |
| 10 | 9.68 784 | 9.94 112 | 9.74 673 | 0.25 327 | 0.05 888 | 0.31 216 | 50 |
| 11 | .68 807 | .94 105 | .74 702 | .25 298 | .05 895 | .31 193 | 49 |
| 12 | .68 829 | .94 098 | .74 732 | .25 268 | .05 902 | .31 171 | 48 |
| 13 | .68 852 | .94 090 | .74 762 | .25 238 | .05 910 | .31 148 | 47 |
| 14 | .68 875 | .94 083 | .74 791 | .25 209 | .05 917 | .31 125 | 46 |
| 15 | 9.68 897 | 9.94 076 | 9.74 821 | 0.25 179 | 0.05 924 | 0.31 103 | 45 |
| 16 | .68 920 | .94 069 | .74 851 | .25 149 | .05 931 | .31 080 | 44 |
| 17 | .68 942 | .94 062 | .74 880 | .25 120 | .05 938 | .31 058 | 43 |
| 18 | .68 965 | .94 055 | .74 910 | .25 090 | .05 945 | .31 035 | 42 |
| 19 | .68 987 | .94 048 | .74 939 | .25 061 | .05 952 | .31 013 | 41 |
| 20 | 9.69 010 | 9.94 041 | 9.74 969 | 0.25 031 | 0.05 959 | 0.30 990 | 40 |
| 21 | .69 032 | .94 034 | .74 998 | .25 002 | .05 966 | .30 968 | 39 |
| 22 | .69 055 | .94 027 | .75 028 | .24 972 | .05 973 | .30 945 | 38 |
| 23 | .69 077 | .94 020 | .75 058 | .24 942 | .05 980 | .30 923 | 37 |
| 24 | .69 100 | .94 012 | .75 087 | .24 913 | .05 988 | .30 900 | 36 |
| 25 | 9.69 122 | 9.94 005 | 9.75 117 | 0.24 883 | 0.05 995 | 0.30 878 | 35 |
| 26 | .69 144 | .93 998 | .75 146 | .24 854 | .06 002 | .30 856 | 34 |
| 27 | .69 167 | .93 991 | .75 176 | .24 824 | .06 009 | .30 833 | 33 |
| 28 | .69 189 | .93 984 | .75 205 | .24 795 | .06 016 | .30 811 | 32 |
| 29 | .69 212 | .93 977 | .75 235 | .24 765 | .06 023 | .30 788 | 31 |
| 30 | 9.69 234 | 9.93 970 | 9.75 264 | 0.24 736 | 0.06 030 | 0.30 766 | 30 |
| 31 | .69 256 | .93 963 | .75 294 | .24 706 | .06 037 | .30 744 | 29 |
| 32 | .69 279 | .93 955 | .75 323 | .24 677 | .06 045 | .30 721 | 28 |
| 33 | .69 301 | .93 948 | .75 353 | .24 647 | .06 052 | .30 699 | 27 |
| 34 | .69 323 | .93 941 | .75 382 | .24 618 | .06 059 | .30 677 | 26 |
| 35 | 9.69 345 | 9.93 934 | 9.75 411 | 0.24 589 | 0.06 066 | 0.30 655 | 25 |
| 36 | .69 368 | .93 927 | .75 441 | .24 559 | .06 073 | .30 632 | 24 |
| 37 | .69 390 | .93 920 | .75 470 | .24 530 | .06 080 | .30 610 | 23 |
| 38 | .69 412 | .93 912 | .75 500 | .24 500 | .06 088 | .30 588 | 22 |
| 39 | .69 434 | .93 905 | .75 529 | .24 471 | .06 095 | .30 566 | 21 |
| 40 | 9.69 456 | 9.93 898 | 9.75 558 | 0.24 442 | 0.06 102 | 0.30 544 | 20 |
| 41 | .69 479 | .93 891 | .75 588 | .24 412 | .06 109 | .30 521 | 19 |
| 42 | .69 501 | .93 884 | .75 617 | .24 383 | .06 116 | .30 499 | 18 |
| 43 | .69 523 | .93 876 | .75 647 | .24 353 | .06 124 | .30 477 | 17 |
| 44 | .69 545 | .93 869 | .75 676 | .24 324 | .06 131 | .30 455 | 16 |
| 45 | 9.69 567 | 9.93 862 | 9.75 705 | 0.24 295 | 0.06 138 | 0.30 433 | 15 |
| 46 | .69 589 | .93 855 | .75 735 | .24 265 | .06 145 | .30 411 | 14 |
| 47 | .69 611 | .93 847 | .75 764 | .24 236 | .06 153 | .30 389 | 13 |
| 48 | .69 633 | .93 840 | .75 793 | .24 207 | .06 160 | .30 367 | 12 |
| 49 | .69 655 | .93 833 | .75 822 | .24 178 | .06 167 | .30 345 | 11 |
| 50 | 9.69 677 | 9.93 826 | 9.75 852 | 0.24 148 | 0.06 174 | 0.30 323 | 10 |
| 51 | .69 699 | .93 819 | .75 881 | .24 119 | .06 181 | .30 301 | 9 |
| 52 | .69 721 | .93 811 | .75 910 | .24 090 | .06 189 | .30 279 | 8 |
| 53 | .69 743 | .93 804 | .75 939 | .24 061 | .06 196 | .30 257 | 7 |
| 54 | .69 765 | .93 797 | .75 969 | .24 031 | .06 203 | .30 235 | 6 |
| 55 | 9.69 787 | 9.93 789 | 9.75 998 | 0.24 002 | 0.06 211 | 0.30 213 | 5 |
| 56 | .69 809 | .93 782 | .76 027 | .23 973 | .06 218 | .30 191 | 4 |
| 57 | .69 831 | .93 775 | .76 056 | .23 944 | .06 225 | .30 169 | 3 |
| 58 | .69 853 | .93 768 | .76 086 | .23 914 | .06 232 | .30 147 | 2 |
| 59 | .69 875 | .93 760 | .76 115 | .23 885 | .06 240 | .30 125 | 1 |
| 60 | 9.69 897 | 9.93 753 | 9.76 144 | 0.23 856 | 0.06 247 | 0.30 103 | 0 |
| | Cos | Sin | Cot | Tan | Csc | Sec | |

119° (299°)

(240°) 60°

30° (210°)

(329°) 149°

| | Sin | Cos | Tan | Cot | Sec | Csc | |
|-----------|----------|----------|----------|----------|----------|----------|-----------|
| 0 | 9.69 897 | 9.93 753 | 9.76 144 | 0.23 856 | 0.06 247 | 0.30 103 | 60 |
| 1 | .69 919 | .93 746 | .76 173 | .23 827 | .06 254 | .30 081 | 59 |
| 2 | .69 941 | .93 738 | .76 202 | .23 798 | .06 262 | .30 059 | 58 |
| 3 | .69 963 | .93 731 | .76 231 | .23 769 | .06 269 | .30 037 | 57 |
| 4 | .69 984 | .93 724 | .76 261 | .23 739 | .06 276 | .30 016 | 56 |
| 5 | 9.70 006 | 9.93 717 | 9.76 290 | 0.23 710 | 0.06 283 | 0.29 994 | 55 |
| 6 | .70 028 | .93 709 | .76 319 | .23 681 | .06 291 | .29 972 | 54 |
| 7 | .70 050 | .93 702 | .76 348 | .23 652 | .06 298 | .29 950 | 53 |
| 8 | .70 072 | .93 695 | .76 377 | .23 623 | .06 305 | .29 928 | 52 |
| 9 | .70 093 | .93 687 | .76 406 | .23 594 | .06 313 | .29 907 | 51 |
| 10 | 9.70 115 | 9.93 680 | 9.76 435 | 0.23 565 | 0.06 320 | 0.29 885 | 50 |
| 11 | .70 137 | .93 673 | .76 464 | .23 536 | .06 327 | .29 863 | 49 |
| 12 | .70 159 | .93 665 | .76 493 | .23 507 | .06 335 | .29 841 | 48 |
| 13 | .70 180 | .93 658 | .76 522 | .23 478 | .06 342 | .29 820 | 45 |
| 14 | .70 202 | .93 650 | .76 551 | .23 449 | .06 350 | .29 798 | 46 |
| 15 | 9.70 224 | 9.93 643 | 9.76 580 | 0.23 420 | 0.06 357 | 0.29 776 | 45 |
| 16 | .70 245 | .93 636 | .76 609 | .23 391 | .06 364 | .29 755 | 44 |
| 17 | .70 267 | .93 628 | .76 639 | .23 361 | .06 372 | .29 733 | 43 |
| 18 | .70 288 | .93 621 | .76 668 | .23 332 | .06 379 | .29 712 | 42 |
| 19 | .70 310 | .93 614 | .76 697 | .23 303 | .06 386 | .29 690 | 41 |
| 20 | 9.70 332 | 9.93 606 | 9.76 725 | 0.23 275 | 0.06 394 | 0.29 668 | 40 |
| 21 | .70 353 | .93 599 | .76 754 | .23 246 | .06 401 | .29 647 | 39 |
| 22 | .70 375 | .93 591 | .76 783 | .23 217 | .06 409 | .29 625 | 38 |
| 23 | .70 396 | .93 584 | .76 812 | .23 188 | .06 416 | .29 604 | 37 |
| 24 | .70 418 | .93 577 | .76 841 | .23 159 | .06 423 | .29 582 | 36 |
| 25 | 9.70 439 | 9.93 569 | 9.76 870 | 0.23 130 | 0.06 431 | 0.29 561 | 35 |
| 26 | .70 461 | .93 562 | .76 899 | .23 101 | .06 438 | .29 539 | 34 |
| 27 | .70 482 | .93 554 | .76 928 | .23 072 | .06 446 | .29 518 | 33 |
| 28 | .70 504 | .93 547 | .76 957 | .23 043 | .06 453 | .29 496 | 32 |
| 29 | .70 525 | .93 539 | .76 986 | .23 014 | .06 461 | .29 475 | 31 |
| 30 | 9.70 547 | 9.93 532 | 9.77 015 | 0.22 985 | 0.06 468 | 0.29 453 | 30 |
| 31 | .70 568 | .93 525 | .77 044 | .22 956 | .06 475 | .29 432 | 29 |
| 32 | .70 590 | .93 517 | .77 073 | .22 927 | .06 483 | .29 410 | 28 |
| 33 | .70 611 | .93 510 | .77 101 | .22 899 | .06 490 | .29 389 | 27 |
| 34 | .70 633 | .93 502 | .77 130 | .22 870 | .06 498 | .29 367 | 26 |
| 35 | 9.70 654 | 9.93 495 | 9.77 159 | 0.22 841 | 0.06 505 | 0.29 346 | 25 |
| 36 | .70 675 | .93 487 | .77 188 | .22 812 | .06 513 | .29 325 | 24 |
| 37 | .70 697 | .93 480 | .77 217 | .22 783 | .06 520 | .29 303 | 23 |
| 38 | .70 718 | .93 472 | .77 246 | .22 754 | .06 528 | .29 282 | 22 |
| 39 | .70 739 | .93 465 | .77 274 | .22 726 | .06 535 | .29 261 | 21 |
| 40 | 9.70 761 | 9.93 457 | 9.77 303 | 0.22 697 | 0.06 543 | 0.29 239 | 20 |
| 41 | .70 782 | .93 450 | .77 332 | .22 668 | .06 550 | .29 218 | 19 |
| 42 | .70 803 | .93 442 | .77 361 | .22 639 | .06 558 | .29 197 | 18 |
| 43 | .70 824 | .93 435 | .77 390 | .22 610 | .06 565 | .29 176 | 17 |
| 44 | .70 846 | .93 427 | .77 418 | .22 582 | .06 573 | .29 154 | 16 |
| 45 | 9.70 867 | 9.93 420 | 9.77 447 | 0.22 553 | 0.06 580 | 0.29 133 | 15 |
| 46 | .70 888 | .93 412 | .77 476 | .22 524 | .06 588 | .29 112 | 14 |
| 47 | .70 909 | .93 405 | .77 505 | .22 495 | .06 595 | .29 091 | 13 |
| 48 | .70 931 | .93 397 | .77 533 | .22 467 | .06 603 | .29 069 | 12 |
| 49 | .70 952 | .93 390 | .77 562 | .22 438 | .06 610 | .29 048 | 11 |
| 50 | 9.70 973 | 9.93 382 | 9.77 591 | 0.22 409 | 0.06 618 | 0.29 027 | 10 |
| 51 | .70 994 | .93 375 | .77 619 | .22 381 | .06 625 | .29 006 | 9 |
| 52 | .71 015 | .93 367 | .77 648 | .22 352 | .06 633 | .28 985 | 8 |
| 53 | .71 036 | .93 360 | .77 677 | .22 323 | .06 640 | .28 964 | 7 |
| 54 | .71 058 | .93 352 | .77 706 | .22 294 | .06 648 | .28 942 | 6 |
| 55 | 9.71 079 | 9.93 344 | 9.77 734 | 0.22 266 | 0.06 656 | 0.28 921 | 5 |
| 56 | .71 100 | .93 337 | .77 763 | .22 237 | .06 663 | .28 900 | 4 |
| 57 | .71 121 | .93 329 | .77 791 | .22 209 | .06 671 | .28 879 | 3 |
| 58 | .71 142 | .93 322 | .77 820 | .22 180 | .06 678 | .28 858 | 2 |
| 59 | .71 163 | .93 314 | .77 849 | .22 151 | .06 686 | .28 837 | 1 |
| 60 | 9.71 184 | 9.93 307 | 9.77 877 | 0.22 123 | 0.06 693 | 0.28 816 | 0 |

120° (300°)

(239°) 59°

Cos Sin Cot Tan Csc Sec

Table 4. Trigonometric Logarithms

31° (211°)

(328°) 148°

| | Sin | Cos | Tan | Cot | Sec | Csc | |
|-----------|----------|----------|----------|----------|----------|----------|-----------|
| 0 | 9.71 184 | 9.93 307 | 9.77 877 | 0.22 123 | 0.06 693 | 0.28 816 | 60 |
| 1 | .71 205 | .93 299 | .77 906 | .22 094 | .06 701 | .28 795 | 59 |
| 2 | .71 226 | .93 291 | .77 935 | .22 065 | .06 709 | .28 774 | 58 |
| 3 | .71 247 | .93 284 | .77 963 | .22 037 | .06 716 | .28 753 | 57 |
| 4 | .71 268 | .93 276 | .77 992 | .22 008 | .06 724 | .28 732 | 56 |
| 5 | 9.71 289 | 9.93 269 | 9.78 020 | 0.21 980 | 0.06 731 | 0.28 711 | 55 |
| 6 | .71 310 | .93 261 | .78 049 | .21 951 | .06 739 | .28 690 | 54 |
| 7 | .71 331 | .93 253 | .78 077 | .21 923 | .06 747 | .28 669 | 53 |
| 8 | .71 352 | .93 246 | .78 106 | .21 894 | .06 754 | .28 648 | 52 |
| 9 | .71 373 | .93 238 | .78 135 | .21 865 | .06 762 | .28 627 | 51 |
| 10 | 9.71 393 | 9.93 230 | 9.78 163 | 0.21 837 | 0.06 770 | 0.28 607 | 50 |
| 11 | .71 414 | .93 223 | .78 192 | .21 808 | .06 777 | .28 586 | 49 |
| 12 | .71 435 | .93 215 | .78 220 | .21 780 | .06 785 | .28 565 | 48 |
| 13 | .71 456 | .93 207 | .78 249 | .21 751 | .06 793 | .28 544 | 47 |
| 14 | .71 477 | .93 200 | .78 277 | .21 723 | .06 800 | .28 523 | 46 |
| 15 | 9.71 498 | 9.93 192 | 9.78 306 | 0.21 694 | 0.06 808 | 0.28 502 | 45 |
| 16 | .71 519 | .93 184 | .78 334 | .21 666 | .06 816 | .28 481 | 44 |
| 17 | .71 539 | .93 177 | .78 363 | .21 637 | .06 823 | .28 461 | 43 |
| 18 | .71 560 | .93 169 | .78 391 | .21 609 | .06 831 | .28 440 | 42 |
| 19 | .71 581 | .93 161 | .78 419 | .21 581 | .06 839 | .28 419 | 41 |
| 20 | 9.71 602 | 9.93 154 | .78 448 | 0.21 552 | 0.06 846 | 0.28 398 | 40 |
| 21 | .71 622 | .93 146 | .78 476 | .21 524 | .06 854 | .28 378 | 39 |
| 22 | .71 643 | .93 138 | .78 505 | .21 495 | .06 862 | .28 357 | 38 |
| 23 | .71 664 | .93 131 | .78 533 | .21 467 | .06 869 | .28 336 | 37 |
| 24 | .71 685 | .93 123 | .78 562 | .21 438 | .06 877 | .28 315 | 36 |
| 25 | 9.71 705 | 9.93 115 | 9.78 590 | 0.21 410 | 0.06 885 | 0.28 295 | 35 |
| 26 | .71 726 | .93 108 | .78 618 | .21 382 | .06 892 | .28 274 | 34 |
| 27 | .71 747 | .93 100 | .78 647 | .21 353 | .06 900 | .28 253 | 33 |
| 28 | .71 767 | .93 092 | .78 675 | .21 325 | .06 908 | .28 233 | 32 |
| 29 | .71 788 | .93 084 | .78 704 | .21 296 | .06 916 | .28 212 | 31 |
| 30 | 9.71 809 | 9.93 077 | 9.78 732 | 0.21 268 | 0.06 923 | 0.28 191 | 30 |
| 31 | .71 829 | .93 069 | .78 760 | .21 240 | .06 931 | .28 171 | 29 |
| 32 | .71 850 | .93 061 | .78 789 | .21 211 | .06 939 | .28 150 | 28 |
| 33 | .71 870 | .93 053 | .78 817 | .21 183 | .06 947 | .28 130 | 27 |
| 34 | .71 891 | .93 046 | .78 845 | .21 155 | .06 954 | .28 109 | 26 |
| 35 | 9.71 911 | 9.93 038 | 9.78 874 | 0.21 126 | 0.06 962 | 0.28 089 | 25 |
| 36 | .71 932 | .93 030 | .78 902 | .21 098 | .06 970 | .28 068 | 24 |
| 37 | .71 952 | .93 022 | .78 930 | .21 070 | .06 978 | .28 048 | 23 |
| 38 | .71 973 | .93 014 | .78 959 | .21 041 | .06 986 | .28 027 | 22 |
| 39 | .71 994 | .93 007 | .78 987 | .21 013 | .06 993 | .28 006 | 21 |
| 40 | 9.72 014 | 9.92 999 | 9.79 015 | 0.20 985 | 0.07 001 | 0.27 986 | 20 |
| 41 | .72 034 | .92 991 | .79 043 | .20 957 | .07 009 | .27 966 | 19 |
| 42 | .72 055 | .92 983 | .79 072 | .20 928 | .07 017 | .27 945 | 18 |
| 43 | .72 075 | .92 976 | .79 100 | .20 900 | .07 024 | .27 925 | 17 |
| 44 | .72 096 | .92 968 | .79 128 | .20 872 | .07 032 | .27 904 | 16 |
| 45 | 9.72 116 | 9.92 960 | 9.79 156 | 0.20 844 | 0.07 040 | 0.27 884 | 15 |
| 46 | .72 137 | .92 952 | .79 185 | .20 815 | .07 048 | .27 863 | 14 |
| 47 | .72 157 | .92 944 | .79 213 | .20 787 | .07 056 | .27 843 | 13 |
| 48 | .72 177 | .92 936 | .79 241 | .20 759 | .07 064 | .27 823 | 12 |
| 49 | .72 198 | .92 929 | .79 269 | .20 731 | .07 071 | .27 802 | 11 |
| 50 | 9.72 218 | 9.92 921 | 9.79 297 | 0.20 703 | 0.07 079 | 0.27 782 | 10 |
| 51 | .72 238 | .92 913 | .79 326 | .20 674 | .07 087 | .27 762 | 9 |
| 52 | .72 259 | .92 905 | .79 354 | .20 646 | .07 095 | .27 741 | 8 |
| 53 | .72 279 | .92 897 | .79 382 | .20 618 | .07 103 | .27 721 | 7 |
| 54 | .72 299 | .92 889 | .79 410 | .20 590 | .07 111 | .27 701 | 6 |
| 55 | 9.72 320 | 9.92 881 | 9.79 438 | 0.20 562 | 0.07 119 | 0.27 680 | 5 |
| 56 | .72 340 | .92 874 | .79 466 | .20 534 | .07 126 | .27 660 | 4 |
| 57 | .72 360 | .92 866 | .79 495 | .20 505 | .07 134 | .27 640 | 3 |
| 58 | .72 381 | .92 858 | .79 523 | .20 477 | .07 142 | .27 619 | 2 |
| 59 | .72 401 | .92 850 | .79 551 | .20 449 | .07 150 | .27 599 | 1 |
| 60 | 9.72 421 | 9.92 842 | 9.79 579 | 0.20 421 | 0.07 158 | 0.27 579 | 0 |
| | Cos | Sin | Cot | Tan | Csc | Sec | ' |

121° (301°)

(238°) 58°

32° (212°)

(327°) 147°

| | Sin | Cos | Tan | Cot | Sec | Csc | |
|-----------|------------|------------|------------|------------|------------|------------|-----------|
| 0 | 9.72 421 | 9.92 842 | 9.79 579 | 0.20 421 | 0.07 158 | 0.27 579 | 60 |
| 1 | .72 441 | .92 834 | .79 607 | .20 393 | .07 166 | .27 559 | 59 |
| 2 | .72 461 | .92 826 | .79 635 | .20 365 | .07 174 | .27 539 | 58 |
| 3 | .72 482 | .92 818 | .79 663 | .20 337 | .07 182 | .27 518 | 57 |
| 4 | .72 502 | .92 810 | .79 691 | .20 309 | .07 190 | .27 498 | 56 |
| 5 | 9.72 522 | 9.92 803 | 9.79 719 | 0.20 281 | 0.07 197 | 0.27 478 | 55 |
| 6 | .72 542 | .92 795 | .79 747 | .20 253 | .07 205 | .27 458 | 54 |
| 7 | .72 562 | .92 787 | .79 776 | .20 224 | .07 213 | .27 438 | 53 |
| 8 | .72 582 | .92 779 | .79 804 | .20 196 | .07 221 | .27 418 | 52 |
| 9 | .72 602 | .92 771 | .79 832 | .20 168 | .07 229 | .27 398 | 51 |
| 10 | 9.72 622 | 9.92 763 | 9.79 860 | 0.20 140 | 0.07 237 | 0.27 378 | 50 |
| 11 | .72 643 | .92 755 | .79 888 | .20 112 | .07 245 | .27 357 | 49 |
| 12 | .72 663 | .92 747 | .79 916 | .20 084 | .07 253 | .27 337 | 48 |
| 13 | .72 683 | .92 739 | .79 944 | .20 056 | .07 261 | .27 317 | 47 |
| 14 | .72 703 | .92 731 | .79 972 | .20 028 | .07 269 | .27 297 | 46 |
| 15 | 9.72 723 | 9.92 723 | 9.80 000 | 0.20 000 | 0.07 277 | 0.27 277 | 45 |
| 16 | .72 743 | .92 715 | .80 028 | .19 972 | .07 285 | .27 257 | 44 |
| 17 | .72 763 | .92 707 | .80 056 | .19 944 | .07 293 | .27 237 | 43 |
| 18 | .72 783 | .92 699 | .80 084 | .19 916 | .07 301 | .27 217 | 42 |
| 19 | .72 803 | .92 691 | .80 112 | .19 888 | .07 309 | .27 197 | 41 |
| 20 | 9.72 823 | 9.92 683 | 9.80 140 | 0.19 860 | 0.07 317 | 0.27 177 | 40 |
| 21 | .72 843 | .92 675 | .80 168 | .19 832 | .07 325 | .27 157 | 39 |
| 22 | .72 863 | .92 667 | .80 195 | .19 805 | .07 333 | .27 137 | 38 |
| 23 | .72 883 | .92 659 | .80 223 | .19 777 | .07 341 | .27 117 | 37 |
| 24 | .72 902 | .92 651 | .80 251 | .19 749 | .07 349 | .27 098 | 36 |
| 25 | 9.72 922 | 9.92 643 | 9.80 279 | 0.19 721 | 0.07 357 | 0.27 078 | 35 |
| 26 | .72 942 | .92 635 | .80 307 | .19 693 | .07 365 | .27 058 | 34 |
| 27 | .72 962 | .92 627 | .80 335 | .19 665 | .07 373 | .27 038 | 33 |
| 28 | .72 982 | .92 619 | .80 363 | .19 637 | .07 381 | .27 018 | 32 |
| 29 | .73 002 | .92 611 | .80 391 | .19 609 | .07 389 | .26 998 | 31 |
| 30 | 9.73 022 | 0.92 603 | 9.80 419 | 0.19 581 | 0.07 397 | 0.26 978 | 30 |
| 31 | .73 041 | .92 595 | .80 447 | .19 553 | .07 405 | .26 959 | 29 |
| 32 | .73 061 | .92 587 | .80 474 | .19 526 | .07 413 | .26 939 | 28 |
| 33 | .73 081 | .92 579 | .80 502 | .19 498 | .07 421 | .26 919 | 27 |
| 34 | .73 101 | .92 571 | .80 530 | .19 470 | .07 429 | .26 899 | 26 |
| 35 | 9.73 121 | 9.92 563 | 9.80 558 | 0.19 442 | 0.07 437 | 0.26 879 | 25 |
| 36 | .73 140 | .92 555 | .80 586 | .19 414 | .07 445 | .26 860 | 24 |
| 37 | .73 160 | .92 546 | .80 614 | .19 386 | .07 454 | .26 840 | 23 |
| 38 | .73 180 | .92 538 | .80 642 | .19 358 | .07 462 | .26 820 | 22 |
| 39 | .73 200 | .92 530 | .80 669 | .19 331 | .07 470 | .26 800 | 21 |
| 40 | 9.73 219 | 9.92 522 | 9.80 697 | 0.19 303 | 0.07 478 | 0.26 781 | 20 |
| 41 | .73 239 | .92 514 | .80 725 | .19 275 | .07 486 | .26 761 | 19 |
| 42 | .73 259 | .92 506 | .80 753 | .19 247 | .07 494 | .26 741 | 18 |
| 43 | .73 278 | .92 498 | .80 781 | .19 219 | .07 502 | .26 722 | 17 |
| 44 | .73 298 | .92 490 | .80 808 | .19 192 | .07 510 | .26 702 | 16 |
| 45 | 9.73 318 | 9.92 482 | 9.80 836 | 0.19 164 | 0.07 518 | 0.26 682 | 15 |
| 46 | .73 337 | .92 473 | .80 864 | .19 136 | .07 527 | .26 663 | 14 |
| 47 | .73 357 | .92 465 | .80 892 | .19 108 | .07 535 | .26 643 | 13 |
| 48 | .73 377 | .92 457 | .80 919 | .19 081 | .07 543 | .26 623 | 12 |
| 49 | .73 396 | .92 449 | .80 947 | .19 053 | .07 551 | .26 604 | 11 |
| 50 | 9.73 416 | 9.92 441 | 9.80 975 | 0.19 025 | 0.07 559 | 0.26 584 | 10 |
| 51 | .73 435 | .92 433 | .81 003 | .18 997 | .07 567 | .26 565 | 9 |
| 52 | .73 455 | .92 425 | .81 030 | .18 970 | .07 575 | .26 545 | 8 |
| 53 | .73 474 | .92 416 | .81 058 | .18 942 | .07 584 | .26 526 | 7 |
| 54 | .73 494 | .92 408 | .81 086 | .18 914 | .07 592 | .26 506 | 6 |
| 55 | 9.73 513 | 9.92 400 | 9.81 113 | 0.18 887 | 0.07 600 | 0.26 487 | 5 |
| 56 | .73 533 | .92 392 | .81 141 | .18 859 | .07 608 | .26 467 | 4 |
| 57 | .73 552 | .92 384 | .81 169 | .18 831 | .07 616 | .26 448 | 3 |
| 58 | .73 572 | .92 376 | .81 196 | .18 804 | .07 624 | .26 428 | 2 |
| 59 | .73 591 | .92 367 | .81 224 | .18 776 | .07 633 | .26 409 | 1 |
| 60 | 9.73 611 | 9.92 359 | 9.81 252 | 0.18 748 | 0.07 641 | 0.26 389 | 0 |
| | Cos | Sin | Cot | Tan | Csc | Sec | ' |

122° (302°)

(237°) 57°

Table 4. Trigonometric Logarithms

229

33° (213°)

(326°) 146°

| | Sin | Cos | Tan | Cot | Sec | Csc | |
|-----------|----------|----------|----------|----------|----------|----------|-----------|
| 0 | 9.73 611 | 9.92 359 | 9.81 252 | 0.18 748 | 0.07 641 | 0.26 389 | 60 |
| 1 | .73 630 | .92 351 | .81 279 | .18 721 | .07 649 | .26 370 | 59 |
| 2 | .73 650 | .92 343 | .81 307 | .18 693 | .07 657 | .26 350 | 58 |
| 3 | .73 669 | .92 335 | .81 335 | .18 665 | .07 665 | .26 331 | 57 |
| 4 | .73 689 | .92 326 | .81 362 | .18 638 | .07 674 | .26 311 | 56 |
| 5 | 9.73 708 | 9.92 318 | 9.81 390 | 0.18 610 | 0.07 682 | 0.26 292 | 55 |
| 6 | .73 727 | .92 310 | .81 418 | .18 582 | .07 690 | .26 273 | 54 |
| 7 | .73 747 | .92 302 | .81 445 | .18 555 | .07 698 | .26 253 | 53 |
| 8 | .73 766 | .92 293 | .81 473 | .18 527 | .07 707 | .26 234 | 52 |
| 9 | .73 785 | .92 285 | .81 500 | .18 500 | .07 715 | .26 215 | 51 |
| 10 | 9.73 805 | 9.92 277 | 9.81 528 | 0.18 472 | 0.07 723 | 0.26 195 | 50 |
| 11 | .73 824 | .92 269 | .81 556 | .18 444 | .07 731 | .26 176 | 49 |
| 12 | .73 843 | .92 260 | .81 583 | .18 417 | .07 740 | .26 157 | 48 |
| 13 | .73 863 | .92 252 | .81 611 | .18 389 | .07 748 | .26 137 | 47 |
| 14 | .73 882 | .92 244 | .81 638 | .18 362 | .07 756 | .26 118 | 46 |
| 15 | 9.73 901 | 9.92 235 | 9.81 666 | 0.18 334 | 0.07 765 | 0.26 099 | 45 |
| 16 | .73 921 | .92 227 | .81 693 | .18 307 | .07 773 | .26 079 | 44 |
| 17 | .73 940 | .92 219 | .81 721 | .18 279 | .07 781 | .26 060 | 43 |
| 18 | .73 959 | .92 211 | .81 748 | .18 252 | .07 789 | .26 041 | 42 |
| 19 | .73 978 | .92 202 | .81 776 | .18 224 | .07 798 | .26 022 | 41 |
| 20 | 9.73 997 | 9.92 194 | 9.81 803 | 0.18 197 | 0.07 806 | 0.26 003 | 40 |
| 21 | .74 017 | .92 186 | .81 831 | .18 169 | .07 814 | .25 983 | 39 |
| 22 | .74 036 | .92 177 | .81 858 | .18 142 | .07 823 | .25 964 | 38 |
| 23 | .74 055 | .92 169 | .81 886 | .18 114 | .07 831 | .25 945 | 37 |
| 24 | .74 074 | .92 161 | .81 913 | .18 087 | .07 839 | .25 926 | 36 |
| 25 | 9.74 093 | 9.92 152 | 9.81 941 | 0.18 059 | 0.07 848 | 0.25 907 | 35 |
| 26 | .74 113 | .92 144 | .81 968 | .18 032 | .07 856 | .25 887 | 34 |
| 27 | .74 132 | .92 136 | .81 996 | .18 004 | .07 864 | .25 868 | 33 |
| 28 | .74 151 | .92 127 | .82 023 | .17 977 | .07 873 | .25 849 | 32 |
| 29 | .74 170 | .92 119 | .82 051 | .17 949 | .07 881 | .25 830 | 31 |
| 30 | 9.74 189 | 9.92 111 | 9.82 078 | 0.17 922 | 0.07 889 | 0.25 811 | 30 |
| 31 | .74 208 | .92 102 | .82 106 | .17 894 | .07 898 | .25 792 | 29 |
| 32 | .74 227 | .92 094 | .82 133 | .17 867 | .07 906 | .25 773 | 28 |
| 33 | .74 246 | .92 086 | .82 161 | .17 839 | .07 914 | .25 754 | 27 |
| 34 | .74 265 | .92 077 | .82 188 | .17 812 | .07 923 | .25 735 | 26 |
| 35 | 9.74 284 | 9.92 069 | 9.82 215 | 0.17 785 | 0.07 931 | 0.25 716 | 25 |
| 36 | .74 303 | .92 060 | .82 243 | .17 757 | .07 940 | .25 697 | 24 |
| 37 | .74 322 | .92 052 | .82 270 | .17 730 | .07 948 | .25 678 | 23 |
| 38 | .74 341 | .92 044 | .82 298 | .17 702 | .07 956 | .25 659 | 22 |
| 39 | .74 360 | .92 035 | .82 325 | .17 675 | .07 965 | .25 640 | 21 |
| 40 | 9.74 379 | 9.92 027 | 9.82 352 | 0.17 648 | 0.07 973 | 0.25 621 | 20 |
| 41 | .74 398 | .92 018 | .82 380 | .17 620 | .07 982 | .25 602 | 19 |
| 42 | .74 417 | .92 010 | .82 407 | .17 593 | .07 990 | .25 583 | 18 |
| 43 | .74 436 | .92 002 | .82 435 | .17 565 | .07 998 | .25 564 | 17 |
| 44 | .74 455 | .91 993 | .82 462 | .17 538 | .08 007 | .25 545 | 16 |
| 45 | 9.74 474 | 9.91 985 | 9.82 489 | 0.17 511 | 0.08 015 | 0.25 526 | 15 |
| 46 | .74 493 | .91 976 | .82 517 | .17 483 | .08 024 | .25 507 | 14 |
| 47 | .74 512 | .91 968 | .82 544 | .17 456 | .08 032 | .25 488 | 13 |
| 48 | .74 531 | .91 959 | .82 571 | .17 429 | .08 041 | .25 469 | 12 |
| 49 | .74 549 | .91 951 | .82 599 | .17 401 | .08 049 | .25 451 | 11 |
| 50 | 9.74 568 | 9.91 942 | 9.82 626 | 0.17 374 | 0.08 058 | 0.25 432 | 10 |
| 51 | .74 587 | .91 934 | .82 653 | .17 347 | .08 066 | .25 413 | 9 |
| 52 | .74 606 | .91 925 | .82 681 | .17 319 | .08 075 | .25 394 | 8 |
| 53 | .74 625 | .91 917 | .82 708 | .17 292 | .08 083 | .25 375 | 7 |
| 54 | .74 644 | .91 908 | .82 735 | .17 265 | .08 092 | .25 356 | 6 |
| 55 | 9.74 662 | 9.91 900 | 9.82 762 | 0.17 238 | 0.08 100 | 0.25 338 | 5 |
| 56 | .74 681 | .91 891 | .82 790 | .17 210 | .08 109 | .25 319 | 4 |
| 57 | .74 700 | .91 883 | .82 817 | .17 183 | .08 117 | .25 300 | 3 |
| 58 | .74 719 | .91 874 | .82 844 | .17 156 | .08 126 | .25 281 | 2 |
| 59 | .74 737 | .91 866 | .82 871 | .17 129 | .08 134 | .25 263 | 1 |
| 60 | 9.74 756 | 9.91 857 | 9.82 899 | 0.17 101 | 0.08 143 | 0.25 244 | 0 |
| | Cos | Sin | Cot | Tan | Csc | Sec | ' |

123° (303°)

(236°) 56°

34° (214°)

(325°) 145°

| | Sin | Cos | Tan | Cot | Sec | Csc | |
|----|----------|----------|----------|----------|----------|----------|-----------|
| 0 | 9.74 756 | 9.91 857 | 9.82 899 | 0.17 101 | 0.08 143 | 0.25 244 | 60 |
| 1 | .74 775 | .91 849 | .82 926 | .17 074 | .08 151 | .25 225 | 59 |
| 2 | .74 794 | .91 840 | .82 953 | .17 047 | .08 160 | .25 206 | 58 |
| 3 | .74 812 | .91 832 | .82 980 | .17 020 | .08 168 | .25 188 | 57 |
| 4 | .74 831 | .91 823 | .83 008 | .16 992 | .08 177 | .25 169 | 56 |
| 5 | 9.74 850 | 9.91 815 | 9.83 035 | 0.16 965 | 0.08 185 | 0.25 150 | 55 |
| 6 | .74 868 | .91 806 | .83 062 | .16 938 | .08 194 | .25 132 | 54 |
| 7 | .74 887 | .91 798 | .83 089 | .16 911 | .08 202 | .25 113 | 53 |
| 8 | .74 906 | .91 789 | .83 117 | .16 883 | .08 211 | .25 094 | 52 |
| 9 | .74 924 | .91 781 | .83 144 | .16 856 | .08 219 | .25 076 | 51 |
| 10 | 9.74 943 | 9.91 772 | 9.83 171 | 0.16 829 | 0.08 228 | 0.25 057 | 50 |
| 11 | .74 961 | .91 763 | .83 198 | .16 802 | .08 237 | .25 039 | 49 |
| 12 | .74 980 | .91 755 | .83 225 | .16 775 | .08 245 | .25 020 | 48 |
| 13 | .74 999 | .91 746 | .83 252 | .16 748 | .08 254 | .25 001 | 47 |
| 14 | .75 017 | .91 738 | .83 280 | .16 720 | .08 262 | .24 983 | 46 |
| 15 | 9.75 036 | 9.91 729 | 9.83 307 | 0.16 693 | 0.08 271 | 0.24 964 | 45 |
| 16 | .75 054 | .91 720 | .83 334 | .16 666 | .08 280 | .24 946 | 44 |
| 17 | .75 073 | .91 712 | .83 361 | .16 639 | .08 288 | .24 927 | 43 |
| 18 | .75 091 | .91 703 | .83 388 | .16 612 | .08 297 | .24 909 | 42 |
| 19 | .75 110 | .91 695 | .83 415 | .16 585 | .08 305 | .24 890 | 41 |
| 20 | 9.75 128 | 9.91 686 | 9.83 442 | 0.16 558 | 0.08 314 | 0.24 872 | 40 |
| 21 | .75 147 | .91 677 | .83 470 | .16 530 | .08 323 | .24 853 | 39 |
| 22 | .75 165 | .91 669 | .83 497 | .16 503 | .08 331 | .24 835 | 38 |
| 23 | .75 184 | .91 660 | .83 524 | .16 476 | .08 340 | .24 816 | 37 |
| 24 | .75 202 | .91 651 | .83 551 | .16 449 | .08 349 | .24 798 | 36 |
| 25 | 9.75 221 | 9.91 643 | 9.83 578 | 0.16 422 | 0.08 357 | 0.24 779 | 35 |
| 26 | .75 239 | .91 634 | .83 605 | .16 395 | .08 366 | .24 761 | 34 |
| 27 | .75 258 | .91 625 | .83 632 | .16 368 | .08 375 | .24 742 | 33 |
| 28 | .75 276 | .91 617 | .83 659 | .16 341 | .08 383 | .24 724 | 32 |
| 29 | .75 294 | .91 608 | .83 686 | .16 314 | .08 392 | .24 706 | 31 |
| 30 | 9.75 313 | 9.91 599 | 9.83 713 | 0.16 287 | 0.08 401 | 0.24 687 | 30 |
| 31 | .75 331 | .91 591 | .83 740 | .16 260 | .08 409 | .24 669 | 29 |
| 32 | .75 350 | .91 582 | .83 768 | .16 232 | .08 418 | .24 650 | 28 |
| 33 | .75 368 | .91 573 | .83 795 | .16 205 | .08 427 | .24 632 | 27 |
| 34 | .75 386 | .91 565 | .83 822 | .16 178 | .08 435 | .24 614 | 26 |
| 35 | 9.75 405 | 9.91 556 | 9.83 849 | 0.16 151 | 0.08 444 | 0.24 595 | 25 |
| 36 | .75 423 | .91 547 | .83 876 | .16 124 | .08 453 | .24 577 | 24 |
| 37 | .75 441 | .91 538 | .83 903 | .16 097 | .08 462 | .24 559 | 23 |
| 38 | .75 459 | .91 530 | .83 930 | .16 070 | .08 470 | .24 541 | 22 |
| 39 | .75 478 | .91 521 | .83 957 | .16 043 | .08 479 | .24 522 | 21 |
| 40 | 9.75 496 | 9.91 512 | 9.83 984 | 0.16 016 | 0.08 488 | 0.24 504 | 20 |
| 41 | .75 514 | .91 504 | .84 011 | .15 989 | .08 496 | .24 486 | 19 |
| 42 | .75 533 | .91 495 | .84 038 | .15 962 | .08 505 | .24 467 | 18 |
| 43 | .75 551 | .91 486 | .84 065 | .15 935 | .08 514 | .24 449 | 17 |
| 44 | .75 569 | .91 477 | .84 092 | .15 908 | .08 523 | .24 431 | 16 |
| 45 | 9.75 587 | 9.91 469 | 9.84 119 | 0.15 881 | 0.08 531 | 0.24 413 | 15 |
| 46 | .75 605 | .91 460 | .84 146 | .15 854 | .08 540 | .24 395 | 14 |
| 47 | .75 624 | .91 451 | .84 173 | .15 827 | .08 549 | .24 376 | 13 |
| 48 | .75 642 | .91 442 | .84 200 | .15 800 | .08 558 | .24 358 | 12 |
| 49 | .75 660 | .91 433 | .84 227 | .15 773 | .08 567 | .24 340 | 11 |
| 50 | 9.75 678 | 9.91 425 | 9.84 254 | 0.15 746 | 0.08 575 | 0.24 322 | 10 |
| 51 | .75 696 | .91 416 | .84 280 | .15 720 | .08 584 | .24 304 | 9 |
| 52 | .75 714 | .91 407 | .84 307 | .15 693 | .08 593 | .24 286 | 8 |
| 53 | .75 733 | .91 398 | .84 334 | .15 666 | .08 602 | .24 267 | 7 |
| 54 | .75 751 | .91 389 | .84 361 | .15 639 | .08 611 | .24 249 | 6 |
| 55 | 9.75 769 | 9.91 381 | 9.84 388 | 0.15 612 | 0.08 619 | 0.24 231 | 5 |
| 56 | .75 787 | .91 372 | .84 415 | .15 585 | .08 628 | .24 213 | 4 |
| 57 | .75 805 | .91 363 | .84 442 | .15 558 | .08 637 | .24 195 | 3 |
| 58 | .75 823 | .91 354 | .84 469 | .15 531 | .08 646 | .24 177 | 2 |
| 59 | .75 841 | .91 345 | .84 496 | .15 504 | .08 655 | .24 159 | 1 |
| 60 | 9.75 859 | 9.91 336 | 9.84 523 | 0.15 477 | 0.08 664 | 0.24 141 | 0 |
| | Cos | Sin | Cot | Tan | Csc | Sec | |

124° (304°)

(235°) 55°

Table 4. Trigonometric Logarithms

35° (215°)

(324°) 144°

| | Sin | Cos | Tan | Cot | Sec | Csc | |
|-----------|----------|----------|----------|----------|----------|----------|-----------|
| 0 | 9.75 859 | 9.91 336 | 9.84 523 | 0.15 477 | 0.08 664 | 0.24 141 | 60 |
| 1 | .75 877 | .91 328 | .84 550 | .15 450 | .08 672 | .24 123 | 59 |
| 2 | .75 895 | .91 319 | .84 576 | .15 424 | .08 681 | .24 105 | 58 |
| 3 | .75 913 | .91 310 | .84 603 | .15 397 | .08 690 | .24 087 | 57 |
| 4 | .75 931 | .91 301 | .84 630 | .15 370 | .08 699 | .24 069 | 56 |
| 5 | 9.75 949 | 9.91 292 | 9.84 657 | 0.15 343 | 0.08 708 | 0.24 051 | 55 |
| 6 | .75 967 | .91 283 | .84 684 | .15 316 | .08 717 | .24 033 | 54 |
| 7 | .75 985 | .91 274 | .84 711 | .15 289 | .08 726 | .24 015 | 53 |
| 8 | .76 003 | .91 266 | .84 738 | .15 262 | .08 734 | .23 997 | 52 |
| 9 | .76 021 | .91 257 | .84 764 | .15 236 | .08 743 | .23 979 | 51 |
| 10 | 9.76 039 | 9.91 248 | 9.84 791 | 0.15 209 | 0.08 752 | 0.23 961 | 50 |
| 11 | .76 057 | .91 239 | .84 818 | .15 182 | .08 761 | .23 943 | 49 |
| 12 | .76 075 | .91 230 | .84 845 | .15 155 | .08 770 | .23 925 | 48 |
| 13 | .76 093 | .91 221 | .84 872 | .15 128 | .08 779 | .23 907 | 47 |
| 14 | .76 111 | .91 212 | .84 899 | .15 101 | .08 788 | .23 889 | 46 |
| 15 | 9.76 129 | 9.91 203 | 9.84 925 | 0.15 075 | 0.08 797 | 0.23 871 | 45 |
| 16 | .76 146 | .91 194 | .84 952 | .15 048 | .08 806 | .23 854 | 44 |
| 17 | .76 164 | .91 185 | .84 979 | .15 021 | .08 815 | .23 836 | 43 |
| 18 | .76 182 | .91 176 | .85 006 | .14 994 | .08 824 | .23 818 | 42 |
| 19 | .76 200 | .91 167 | .85 033 | .14 967 | .08 833 | .23 800 | 41 |
| 20 | 9.76 218 | 9.91 158 | 9.85 059 | 0.14 941 | 0.08 842 | 0.23 782 | 40 |
| 21 | .76 236 | .91 149 | .85 086 | .14 914 | .08 851 | .23 764 | 39 |
| 22 | .76 253 | .91 141 | .85 113 | .14 887 | .08 859 | .23 747 | 38 |
| 23 | .76 271 | .91 132 | .85 140 | .14 860 | .08 868 | .23 729 | 37 |
| 24 | .76 289 | .91 123 | .85 166 | .14 834 | .08 877 | .23 711 | 36 |
| 25 | 9.76 307 | 9.91 114 | 9.85 193 | 0.14 807 | 0.08 886 | 0.23 693 | 35 |
| 26 | .76 324 | .91 105 | .85 220 | .14 780 | .08 895 | .23 676 | 34 |
| 27 | .76 342 | .91 096 | .85 247 | .14 753 | .08 904 | .23 658 | 33 |
| 28 | .76 360 | .91 087 | .85 273 | .14 727 | .08 913 | .23 640 | 32 |
| 29 | .76 378 | .91 078 | .85 300 | .14 700 | .08 922 | .23 622 | 31 |
| 30 | 9.76 395 | 9.91 069 | 9.85 327 | 0.14 673 | 0.08 931 | 0.23 605 | 30 |
| 31 | .76 413 | .91 060 | .85 354 | .14 646 | .08 940 | .23 587 | 29 |
| 32 | .76 431 | .91 051 | .85 380 | .14 620 | .08 949 | .23 569 | 28 |
| 33 | .76 448 | .91 042 | .85 407 | .14 593 | .08 958 | .23 552 | 27 |
| 34 | .76 466 | .91 033 | .85 434 | .14 566 | .08 967 | .23 534 | 26 |
| 35 | 9.76 484 | 9.91 023 | 9.85 460 | 0.14 540 | 0.08 977 | 0.23 516 | 25 |
| 36 | .76 501 | .91 014 | .85 487 | .14 513 | .08 986 | .23 499 | 24 |
| 37 | .76 519 | .91 005 | .85 514 | .14 486 | .08 995 | .23 481 | 23 |
| 38 | .76 537 | .90 996 | .85 540 | .14 460 | .09 004 | .23 463 | 22 |
| 39 | .76 554 | .90 987 | .85 567 | .14 433 | .09 013 | .23 446 | 21 |
| 40 | 9.76 572 | 9.90 978 | 9.85 594 | 0.14 406 | 0.09 022 | 0.23 428 | 20 |
| 41 | .76 590 | .90 969 | .85 620 | .14 380 | .09 031 | .23 410 | 19 |
| 42 | .76 607 | .90 960 | .85 647 | .14 353 | .09 040 | .23 393 | 18 |
| 43 | .76 625 | .90 951 | .85 674 | .14 326 | .09 049 | .23 375 | 17 |
| 44 | .76 642 | .90 942 | .85 700 | .14 300 | .09 058 | .23 358 | 16 |
| 45 | 9.76 660 | 9.90 933 | 9.85 727 | 0.14 273 | 0.09 067 | 0.23 340 | 15 |
| 46 | .76 677 | .90 924 | .85 754 | .14 246 | .09 076 | .23 323 | 14 |
| 47 | .76 695 | .90 915 | .85 780 | .14 220 | .09 085 | .23 305 | 13 |
| 48 | .76 712 | .90 906 | .85 807 | .14 193 | .09 094 | .23 288 | 12 |
| 49 | .76 730 | .90 896 | .85 834 | .14 166 | .09 104 | .23 270 | 11 |
| 50 | 9.76 747 | 9.90 887 | 9.85 860 | 0.14 140 | 0.09 113 | 0.23 253 | 10 |
| 51 | .76 765 | .90 878 | .85 887 | .14 113 | .09 122 | .23 235 | 9 |
| 52 | .76 782 | .90 869 | .85 913 | .14 087 | .09 131 | .23 218 | 8 |
| 53 | .76 800 | .90 860 | .85 940 | .14 060 | .09 140 | .23 200 | 7 |
| 54 | .76 817 | .90 851 | .85 967 | .14 033 | .09 149 | .23 183 | 6 |
| 55 | 9.76 835 | 9.90 842 | 9.85 993 | 0.14 007 | 0.09 158 | 0.23 165 | 5 |
| 56 | .76 852 | .90 832 | .86 020 | .13 980 | .09 168 | .23 148 | 4 |
| 57 | .76 870 | .90 823 | .86 046 | .13 954 | .09 177 | .23 130 | 3 |
| 58 | .76 887 | .90 814 | .86 073 | .13 927 | .09 186 | .23 113 | 2 |
| 59 | .76 904 | .90 805 | .86 100 | .13 900 | .09 195 | .23 096 | 1 |
| 60 | 9.76 922 | 9.90 796 | 9.86 126 | 0.13 874 | 0.09 204 | 0.23 078 | 0 |
| | Cos | Sin | Cot | Tan | Csc | Sec | |

125° (305°)

(234°) 54°

36° (216°)

(323°) 143°

| ' | Sin | Cos | Tan | Cot | Sec | Csc | ' |
|-----------|----------|----------|----------|----------|----------|----------|-----------|
| 0 | 9.76 922 | 9.90 796 | 9.86 126 | 0.13 874 | 0.09 204 | 0.23 078 | 60 |
| 1 | .76 939 | .90 787 | .86 153 | .13 847 | .09 213 | .23 061 | 59 |
| 2 | .76 957 | .90 777 | .86 179 | .13 821 | .09 223 | .23 043 | 58 |
| 3 | .76 974 | .90 768 | .86 206 | .13 794 | .09 232 | .23 026 | 57 |
| 4 | .76 991 | .90 759 | .86 232 | .13 768 | .09 241 | .23 009 | 56 |
| 5 | 9.77 009 | 9.90 750 | 9.86 259 | 0.13 741 | 0.09 250 | 0.22 991 | 55 |
| 6 | .77 026 | .90 741 | .86 285 | .13 715 | .09 259 | .22 974 | 54 |
| 7 | .77 043 | .90 731 | .86 312 | .13 688 | .09 269 | .22 957 | 53 |
| 8 | .77 061 | .90 722 | .86 338 | .13 662 | .09 278 | .22 939 | 52 |
| 9 | .77 078 | .90 713 | .86 365 | .13 635 | .09 287 | .22 922 | 51 |
| 10 | 9.77 095 | 9.90 704 | 9.86 392 | 0.13 608 | 0.09 296 | 0.22 905 | 50 |
| 11 | .77 112 | .90 694 | .86 418 | .13 582 | .09 306 | .22 888 | 49 |
| 12 | .77 130 | .90 685 | .86 445 | .13 555 | .09 315 | .22 870 | 48 |
| 13 | .77 147 | .90 676 | .86 471 | .13 529 | .09 324 | .22 853 | 47 |
| 14 | .77 164 | .90 667 | .86 498 | .13 502 | .09 333 | .22 836 | 46 |
| 15 | 9.77 181 | 9.90 657 | 9.86 524 | 0.13 476 | 0.09 343 | 0.22 819 | 45 |
| 16 | .77 199 | .90 648 | .86 551 | .13 449 | .09 352 | .22 801 | 44 |
| 17 | .77 216 | .90 639 | .86 577 | .13 423 | .09 361 | .22 784 | 43 |
| 18 | .77 233 | .90 630 | .86 603 | .13 397 | .09 370 | .22 767 | 42 |
| 19 | .77 250 | .90 620 | .86 630 | .13 370 | .09 380 | .22 750 | 41 |
| 20 | 9.77 268 | 9.90 611 | 9.86 656 | 0.13 344 | 0.09 389 | 0.22 732 | 40 |
| 21 | .77 285 | .90 602 | .86 683 | .13 317 | .09 398 | .22 715 | 39 |
| 22 | .77 302 | .90 592 | .86 709 | .13 291 | .09 408 | .22 698 | 38 |
| 23 | .77 319 | .90 583 | .86 736 | .13 264 | .09 417 | .22 681 | 37 |
| 24 | .77 336 | .90 574 | .86 762 | .13 238 | .09 426 | .22 664 | 36 |
| 25 | 9.77 353 | 9.90 565 | 9.86 789 | 0.13 211 | 0.09 435 | 0.22 647 | 35 |
| 26 | .77 370 | .90 555 | .86 815 | .13 185 | .09 445 | .22 630 | 34 |
| 27 | .77 387 | .90 546 | .86 842 | .13 158 | .09 454 | .22 613 | 33 |
| 28 | .77 405 | .90 537 | .86 868 | .13 132 | .09 463 | .22 595 | 32 |
| 29 | .77 422 | .90 527 | .86 894 | .13 106 | .09 473 | .22 578 | 31 |
| 30 | 9.77 439 | 9.90 518 | 9.86 921 | 0.13 079 | 0.09 482 | 0.22 561 | 30 |
| 31 | .77 456 | .90 509 | .86 947 | .13 053 | .09 491 | .22 544 | 29 |
| 32 | .77 473 | .90 499 | .86 974 | .13 026 | .09 501 | .22 527 | 28 |
| 33 | .77 490 | .90 490 | .87 000 | .13 000 | .09 510 | .22 510 | 27 |
| 34 | .77 507 | .90 480 | .87 027 | .12 973 | .09 520 | .22 493 | 26 |
| 35 | 9.77 524 | 9.90 471 | 9.87 053 | 0.12 947 | 0.09 529 | 0.22 476 | 25 |
| 36 | .77 541 | .90 462 | .87 079 | .12 921 | .09 538 | .22 459 | 24 |
| 37 | .77 558 | .90 452 | .87 106 | .12 894 | .09 548 | .22 442 | 23 |
| 38 | .77 575 | .90 443 | .87 132 | .12 868 | .09 557 | .22 425 | 22 |
| 39 | .77 592 | .90 434 | .87 158 | .12 842 | .09 566 | .22 408 | 21 |
| 40 | 9.77 609 | 9.90 424 | 9.87 185 | 0.12 815 | 0.09 576 | 0.22 391 | 20 |
| 41 | .77 626 | .90 415 | .87 211 | .12 789 | .09 585 | .22 374 | 19 |
| 42 | .77 643 | .90 405 | .87 238 | .12 762 | .09 595 | .22 357 | 18 |
| 43 | .77 660 | .90 396 | .87 264 | .12 736 | .09 604 | .22 340 | 17 |
| 44 | .77 677 | .90 386 | .87 290 | .12 710 | .09 614 | .22 323 | 16 |
| 45 | 9.77 694 | 9.90 377 | 9.87 317 | 0.12 683 | 0.09 623 | 0.22 306 | 15 |
| 46 | .77 711 | .90 368 | .87 343 | .12 657 | .09 632 | .22 289 | 14 |
| 47 | .77 728 | .90 358 | .87 369 | .12 631 | .09 642 | .22 272 | 13 |
| 48 | .77 744 | .90 349 | .87 396 | .12 604 | .09 651 | .22 256 | 12 |
| 49 | .77 761 | .90 339 | .87 422 | .12 578 | .09 661 | .22 239 | 11 |
| 50 | 9.77 778 | 9.90 330 | 9.87 448 | 0.12 552 | 0.09 670 | 0.22 222 | 10 |
| 51 | .77 795 | .90 320 | .87 475 | .12 525 | .09 680 | .22 205 | 9 |
| 52 | .77 812 | .90 311 | .87 501 | .12 499 | .09 689 | .22 188 | 8 |
| 53 | .77 829 | .90 301 | .87 527 | .12 473 | .09 699 | .22 171 | 7 |
| 54 | .77 846 | .90 292 | .87 554 | .12 446 | .09 708 | .22 154 | 6 |
| 55 | 9.77 862 | 9.90 282 | 9.87 580 | 0.12 420 | 0.09 718 | 0.22 138 | 5 |
| 56 | .77 879 | .90 273 | .87 606 | .12 394 | .09 727 | .22 121 | 4 |
| 57 | .77 896 | .90 263 | .87 633 | .12 367 | .09 737 | .22 104 | 3 |
| 58 | .77 913 | .90 254 | .87 659 | .12 341 | .09 746 | .22 087 | 2 |
| 59 | .77 930 | .90 244 | .87 685 | .12 315 | .09 756 | .22 070 | 1 |
| 60 | 9.77 946 | 9.90 235 | 9.87 711 | 0.12 289 | 0.09 765 | 0.22 054 | 0 |
| | Cos | Sin | Cot | Tan | Csc | Sec | ' |

126° (306°)

(233°) 53°

37° (217°)

(322°) 142°

| | Sin | Cos | Tan | Cot | Sec | Csc | |
|----|----------|----------|----------|----------|----------|----------|-----------|
| 0 | 9.77 946 | 9.90 235 | 9.87 711 | 0.12 289 | 0.09 765 | 0.22 054 | 60 |
| 1 | .77 963 | .90 225 | .87 738 | .12 262 | .09 775 | .22 037 | 59 |
| 2 | .77 980 | .90 216 | .87 764 | .12 236 | .09 784 | .22 020 | 58 |
| 3 | .77 997 | .90 206 | .87 790 | .12 210 | .09 794 | .22 003 | 57 |
| 4 | .78 013 | .90 197 | .87 817 | .12 183 | .09 803 | .21 987 | 56 |
| 5 | 9.78 030 | 9.90 187 | 9.87 843 | 0.12 157 | 0.09 813 | 0.21 970 | 55 |
| 6 | .78 047 | .90 178 | .87 869 | .12 131 | .09 822 | .21 953 | 54 |
| 7 | .78 063 | .90 168 | .87 895 | .12 105 | .09 832 | .21 937 | 53 |
| 8 | .78 080 | .90 159 | .87 922 | .12 078 | .09 841 | .21 920 | 52 |
| 9 | .78 097 | .90 149 | .87 948 | .12 052 | .09 851 | .21 903 | 51 |
| 10 | 9.78 113 | 9.90 139 | 9.87 974 | 0.12 026 | 0.09 861 | 0.21 887 | 50 |
| 11 | .78 130 | .90 130 | .88 000 | .12 000 | .09 870 | .21 870 | 49 |
| 12 | .78 147 | .90 120 | .88 027 | .11 973 | .09 880 | .21 853 | 48 |
| 13 | .78 163 | .90 111 | .88 053 | .11 947 | .09 889 | .21 837 | 47 |
| 14 | .78 180 | .90 101 | .88 079 | .11 921 | .09 899 | .21 820 | 46 |
| 15 | 9.78 197 | 9.90 091 | 9.88 105 | 0.11 895 | 0.09 909 | 0.21 803 | 45 |
| 16 | .78 213 | .90 082 | .88 131 | .11 869 | .09 918 | .21 787 | 44 |
| 17 | .78 230 | .90 072 | .88 158 | .11 842 | .09 928 | .21 770 | 43 |
| 18 | .78 246 | .90 063 | .88 184 | .11 816 | .09 937 | .21 754 | 42 |
| 19 | .78 263 | .90 053 | .88 210 | .11 790 | .09 947 | .21 737 | 41 |
| 20 | 9.78 280 | 9.90 043 | 9.88 236 | 0.11 764 | 0.09 957 | 0.21 720 | 40 |
| 21 | .78 296 | .90 034 | .88 262 | .11 738 | .09 966 | .21 704 | 39 |
| 22 | .78 313 | .90 024 | .88 289 | .11 711 | .09 976 | .21 687 | 38 |
| 23 | .78 329 | .90 014 | .88 315 | .11 685 | .09 986 | .21 671 | 37 |
| 24 | .78 346 | .90 005 | .88 341 | .11 659 | .09 995 | .21 654 | 36 |
| 25 | 9.78 362 | 9.89 995 | 9.88 367 | 0.11 633 | 0.10 005 | 0.21 638 | 35 |
| 26 | .78 379 | .89 985 | .88 393 | .11 607 | .10 015 | .21 621 | 34 |
| 27 | .78 395 | .89 976 | .88 420 | .11 580 | .10 024 | .21 605 | 33 |
| 28 | .78 412 | .89 966 | .88 446 | .11 554 | .10 034 | .21 588 | 32 |
| 29 | .78 428 | .89 956 | .88 472 | .11 528 | .10 044 | .21 572 | 31 |
| 30 | 9.78 445 | 9.89 947 | 9.88 498 | 0.11 502 | 0.10 053 | 0.21 555 | 30 |
| 31 | .78 461 | .89 937 | .88 524 | .11 476 | .10 063 | .21 539 | 29 |
| 32 | .78 478 | .89 927 | .88 550 | .11 450 | .10 073 | .21 522 | 28 |
| 33 | .78 494 | .89 918 | .88 577 | .11 423 | .10 082 | .21 506 | 27 |
| 34 | .78 510 | .89 908 | .88 603 | .11 397 | .10 092 | .21 490 | 26 |
| 35 | 9.78 527 | 9.89 898 | 9.88 629 | 0.11 371 | 0.10 102 | 0.21 473 | 25 |
| 36 | .78 543 | .89 888 | .88 655 | .11 345 | .10 112 | .21 457 | 24 |
| 37 | .78 560 | .89 879 | .88 681 | .11 319 | .10 121 | .21 440 | 23 |
| 38 | .78 576 | .89 869 | .88 707 | .11 293 | .10 131 | .21 424 | 22 |
| 39 | .78 592 | .89 859 | .88 733 | .11 267 | .10 141 | .21 408 | 21 |
| 40 | 9.78 609 | 9.89 849 | 9.88 759 | 0.11 241 | 0.10 151 | 0.21 391 | 20 |
| 41 | .78 625 | .89 840 | .88 786 | .11 214 | .10 160 | .21 375 | 19 |
| 42 | .78 642 | .89 830 | .88 812 | .11 188 | .10 170 | .21 358 | 18 |
| 43 | .78 658 | .89 820 | .88 838 | .11 162 | .10 180 | .21 342 | 17 |
| 44 | .78 674 | .89 810 | .88 864 | .11 136 | .10 190 | .21 326 | 16 |
| 45 | 9.78 691 | 9.89 801 | 9.88 890 | 0.11 110 | 0.10 199 | 0.21 309 | 15 |
| 46 | .78 707 | .89 791 | .88 916 | .11 084 | .10 209 | .21 293 | 14 |
| 47 | .78 723 | .89 781 | .88 942 | .11 058 | .10 219 | .21 277 | 13 |
| 48 | .78 739 | .89 771 | .88 968 | .11 032 | .10 229 | .21 261 | 12 |
| 49 | .78 756 | .89 761 | .88 994 | .11 006 | .10 239 | .21 244 | 11 |
| 50 | 9.78 772 | 9.89 752 | 9.89 020 | 0.10 980 | 0.10 248 | 0.21 228 | 10 |
| 51 | .78 788 | .89 742 | .89 046 | .10 954 | .10 258 | .21 212 | 9 |
| 52 | .78 805 | .89 732 | .89 073 | .10 927 | .10 268 | .21 195 | 8 |
| 53 | .78 821 | .89 722 | .89 099 | .10 901 | .10 278 | .21 179 | 7 |
| 54 | .78 837 | .89 712 | .89 125 | .10 875 | .10 288 | .21 163 | 6 |
| 55 | 9.78 853 | 9.89 702 | 9.89 151 | 0.10 849 | 0.10 298 | 0.21 147 | 5 |
| 56 | .78 869 | .89 693 | .89 177 | .10 823 | .10 307 | .21 131 | 4 |
| 57 | .78 886 | .89 683 | .89 203 | .10 797 | .10 317 | .21 114 | 3 |
| 58 | .78 902 | .89 673 | .89 229 | .10 771 | .10 327 | .21 098 | 2 |
| 59 | .78 918 | .89 663 | .89 255 | .10 745 | .10 337 | .21 082 | 1 |
| 60 | 9.78 934 | 9.89 653 | 9.89 281 | 0.10 719 | 0.10 347 | 0.21 066 | 0 |

| | Cos | Sin | Cot | Tan | Csc | Sec | |
|--|-----|-----|-----|-----|-----|-----|--|
|--|-----|-----|-----|-----|-----|-----|--|

127° (307°)

(232°) 52°

| | Sin | Cos | Tan | Cot | Sec | Csc | |
|----|----------|----------|----------|----------|----------|----------|-----------|
| 0 | 9.78 934 | 9.89 653 | 9.89 281 | 0.10 719 | 0.10 347 | 0.21 066 | 60 |
| 1 | .78 950 | .89 643 | .89 307 | .10 693 | .10 357 | .21 050 | 59 |
| 2 | .78 967 | .89 633 | .89 333 | .10 667 | .10 367 | .21 033 | 58 |
| 3 | .78 983 | .89 624 | .89 359 | .10 641 | .10 376 | .21 017 | 57 |
| 4 | .78 999 | .89 614 | .89 385 | .10 615 | .10 386 | .21 001 | 56 |
| 5 | 9.79 015 | 9.89 604 | 9.89 411 | 0.10 589 | 0.10 396 | 0.20 985 | 55 |
| 6 | .79 031 | .89 594 | .89 437 | .10 563 | .10 406 | .20 969 | 54 |
| 7 | .79 047 | .89 584 | .89 463 | .10 537 | .10 416 | .20 953 | 53 |
| 8 | .79 063 | .89 574 | .89 489 | .10 511 | .10 426 | .20 937 | 52 |
| 9 | .79 079 | .89 564 | .89 515 | .10 485 | .10 436 | .20 921 | 51 |
| 10 | 9.79 095 | 9.89 554 | 9.89 541 | 0.10 459 | 0.10 446 | 0.20 905 | 50 |
| 11 | .79 111 | .89 544 | .89 567 | .10 433 | .10 456 | .20 889 | 49 |
| 12 | .79 128 | .89 534 | .89 593 | .10 407 | .10 466 | .20 872 | 48 |
| 13 | .79 144 | .89 524 | .89 619 | .10 381 | .10 476 | .20 856 | 47 |
| 14 | .79 160 | .89 514 | .89 645 | .10 355 | .10 486 | .20 840 | 46 |
| 15 | 9.79 176 | 9.89 504 | 9.89 671 | 0.10 329 | 0.10 496 | 0.20 824 | 45 |
| 16 | .79 192 | .89 495 | .89 697 | .10 303 | .10 505 | .20 808 | 44 |
| 17 | .79 208 | .89 485 | .89 723 | .10 277 | .10 515 | .20 792 | 43 |
| 18 | .79 224 | .89 475 | .89 749 | .10 251 | .10 525 | .20 776 | 42 |
| 19 | .79 240 | .89 465 | .89 775 | .10 225 | .10 535 | .20 760 | 41 |
| 20 | 9.79 256 | 9.89 455 | 9.89 801 | 0.10 199 | 0.10 545 | 0.20 744 | 40 |
| 21 | .79 272 | .89 445 | .89 827 | .10 173 | .10 555 | .20 728 | 39 |
| 22 | .79 288 | .89 435 | .89 853 | .10 147 | .10 565 | .20 712 | 38 |
| 23 | .79 304 | .89 425 | .89 879 | .10 121 | .10 575 | .20 696 | 37 |
| 24 | .79 319 | .89 415 | .89 905 | .10 095 | .10 585 | .20 681 | 36 |
| 25 | 9.79 335 | 9.89 405 | 9.89 931 | 0.10 069 | 0.10 595 | 0.20 665 | 35 |
| 26 | .79 351 | .89 395 | .89 957 | .10 043 | .10 605 | .20 649 | 34 |
| 27 | .79 367 | .89 385 | .89 983 | .10 017 | .10 615 | .20 633 | 33 |
| 28 | .79 383 | .89 375 | .90 009 | .09 991 | .10 625 | .20 617 | 32 |
| 29 | .79 399 | .89 364 | .90 035 | .09 965 | .10 636 | .20 601 | 31 |
| 30 | 9.79 415 | 9.89 354 | 9.90 061 | 0.09 939 | 0.10 646 | 0.20 585 | 30 |
| 31 | .79 431 | .89 344 | .90 086 | .09 914 | .10 656 | .20 569 | 29 |
| 32 | .79 447 | .89 334 | .90 112 | .09 888 | .10 666 | .20 553 | 28 |
| 33 | .79 463 | .89 324 | .90 138 | .09 862 | .10 676 | .20 537 | 27 |
| 34 | .79 478 | .89 314 | .90 164 | .09 836 | .10 686 | .20 522 | 26 |
| 35 | 9.79 494 | 9.89 304 | 9.90 190 | 0.09 810 | 0.10 696 | 0.20 506 | 25 |
| 36 | .79 510 | .89 294 | .90 216 | .09 784 | .10 706 | .20 490 | 24 |
| 37 | .79 526 | .89 284 | .90 242 | .09 758 | .10 716 | .20 474 | 23 |
| 38 | .79 542 | .89 274 | .90 268 | .09 732 | .10 726 | .20 458 | 22 |
| 39 | .79 558 | .89 264 | .90 294 | .09 706 | .10 736 | .20 442 | 21 |
| 40 | 9.79 573 | 9.89 254 | 9.90 320 | 0.09 680 | 0.10 746 | 0.20 427 | 20 |
| 41 | .79 589 | .89 244 | .90 346 | .09 654 | .10 756 | .20 411 | 19 |
| 42 | .79 605 | .89 233 | .90 371 | .09 629 | .10 767 | .20 395 | 18 |
| 43 | .79 621 | .89 223 | .90 397 | .09 603 | .10 777 | .20 379 | 17 |
| 44 | .79 636 | .89 213 | .90 423 | .09 577 | .10 787 | .20 364 | 16 |
| 45 | 9.79 652 | 9.89 203 | 9.90 449 | 0.09 551 | 0.10 797 | 0.20 348 | 15 |
| 46 | .79 668 | .89 193 | .90 475 | .09 525 | .10 807 | .20 332 | 14 |
| 47 | .79 684 | .89 183 | .90 501 | .09 499 | .10 817 | .20 316 | 13 |
| 48 | .79 699 | .89 173 | .90 527 | .09 473 | .10 827 | .20 301 | 12 |
| 49 | .79 715 | .89 162 | .90 553 | .09 447 | .10 838 | .20 285 | 11 |
| 50 | 9.79 731 | 9.89 152 | 9.90 578 | 0.09 422 | 0.10 848 | 0.20 269 | 10 |
| 51 | .79 746 | .89 142 | .90 604 | .09 396 | .10 858 | .20 254 | 9 |
| 52 | .79 762 | .89 132 | .90 630 | .09 370 | .10 868 | .20 238 | 8 |
| 53 | .79 778 | .89 122 | .90 656 | .09 344 | .10 878 | .20 222 | 7 |
| 54 | .79 793 | .89 112 | .90 682 | .09 318 | .10 888 | .20 207 | 6 |
| 55 | 9.79 809 | 9.89 101 | 9.90 708 | 0.09 292 | 0.10 899 | 0.20 191 | 5 |
| 56 | .79 825 | .89 091 | .90 734 | .09 266 | .10 909 | .20 175 | 4 |
| 57 | .79 840 | .89 081 | .90 759 | .09 241 | .10 919 | .20 160 | 3 |
| 58 | .79 856 | .89 071 | .90 785 | .09 215 | .10 929 | .20 144 | 2 |
| 59 | .79 872 | .89 060 | .90 811 | .09 189 | .10 940 | .20 128 | 1 |
| 60 | 9.79 887 | 9.89 050 | 9.90 837 | 0.09 163 | 0.10 950 | 0.20 113 | 0 |
| | Cos | Sin | Cot | Tan | Csc | Sec | ' |

Table 4. Trigonometric Logarithms

39° (219°)

(320°) 140°

| | Sin | Cos | Tan | Cot | Sec | Csc | |
|-----------|----------|----------|----------|----------|----------|----------|-----------|
| 0 | 9.79 887 | 9.89 050 | 9.90 837 | 0.09 163 | 0.10 950 | 0.20 113 | 60 |
| 1 | .79 903 | .89 040 | .90 863 | .09 137 | .10 960 | .20 097 | 59 |
| 2 | .79 918 | .89 030 | .90 889 | .09 111 | .10 970 | .20 082 | 58 |
| 3 | .79 934 | .89 020 | .90 914 | .09 086 | .10 980 | .20 066 | 57 |
| 4 | .79 950 | .89 009 | .90 940 | .09 060 | .10 991 | .20 050 | 56 |
| 5 | 9.79 965 | 9.88 999 | 9.90 966 | 0.09 034 | 0.11 001 | 0.20 035 | 55 |
| 6 | .79 981 | .88 989 | .90 992 | .09 008 | .11 011 | .20 019 | 54 |
| 7 | .79 996 | .88 978 | .91 018 | .08 982 | .11 022 | .20 004 | 53 |
| 8 | .80 012 | .88 968 | .91 043 | .08 957 | .11 032 | .19 988 | 52 |
| 9 | .80 027 | .88 958 | .91 069 | .08 931 | .11 042 | .19 973 | 51 |
| 10 | 9.80 043 | 9.88 948 | 9.91 095 | 0.08 905 | 0.11 052 | 0.19 957 | 50 |
| 11 | .80 058 | .88 937 | .91 121 | .08 879 | .11 063 | .19 942 | 49 |
| 12 | .80 074 | .88 927 | .91 147 | .08 853 | .11 073 | .19 926 | 48 |
| 13 | .80 089 | .88 917 | .91 172 | .08 828 | .11 083 | .19 911 | 47 |
| 14 | .80 105 | .88 906 | .91 198 | .08 802 | .11 094 | .19 895 | 46 |
| 15 | 9.80 120 | 9.88 896 | 9.91 224 | 0.08 776 | 0.11 104 | 0.19 880 | 45 |
| 16 | .80 136 | .88 886 | .91 250 | .08 750 | .11 114 | .19 864 | 44 |
| 17 | .80 151 | .88 875 | .91 276 | .08 724 | .11 125 | .19 849 | 43 |
| 18 | .80 166 | .88 865 | .91 301 | .08 699 | .11 135 | .19 834 | 42 |
| 19 | .80 182 | .88 855 | .91 327 | .08 673 | .11 145 | .19 818 | 41 |
| 20 | 9.80 197 | 9.88 844 | 9.91 353 | 0.08 647 | 0.11 156 | 0.19 803 | 40 |
| 21 | .80 213 | .88 834 | .91 379 | .08 621 | .11 166 | .19 787 | 39 |
| 22 | .80 228 | .88 824 | .91 404 | .08 596 | .11 176 | .19 772 | 38 |
| 23 | .80 244 | .88 813 | .91 430 | .08 570 | .11 187 | .19 756 | 37 |
| 24 | .80 259 | .88 803 | .91 456 | .08 544 | .11 197 | .19 741 | 36 |
| 25 | 9.80 274 | 9.88 793 | 9.91 482 | 0.08 518 | 0.11 207 | 0.19 726 | 35 |
| 26 | .80 290 | .88 782 | .91 507 | .08 493 | .11 218 | .19 710 | 34 |
| 27 | .80 305 | .88 772 | .91 533 | .08 467 | .11 228 | .19 695 | 33 |
| 28 | .80 320 | .88 761 | .91 559 | .08 441 | .11 239 | .19 680 | 32 |
| 29 | .80 336 | .88 751 | .91 585 | .08 415 | .11 249 | .19 664 | 31 |
| 30 | 9.80 351 | 9.88 741 | 9.91 610 | 0.08 390 | 0.11 259 | 0.19 649 | 30 |
| 31 | .80 366 | .88 730 | .91 636 | .08 364 | .11 270 | .19 634 | 29 |
| 32 | .80 382 | .88 720 | .91 662 | .08 338 | .11 280 | .19 618 | 28 |
| 33 | .80 397 | .88 709 | .91 688 | .08 312 | .11 291 | .19 603 | 27 |
| 34 | .80 412 | .88 699 | .91 713 | .08 287 | .11 301 | .19 588 | 26 |
| 35 | 9.80 428 | 9.88 688 | 9.91 739 | 0.08 261 | 0.11 312 | 0.19 572 | 25 |
| 36 | .80 443 | .88 678 | .91 765 | .08 235 | .11 322 | .19 557 | 24 |
| 37 | .80 458 | .88 668 | .91 791 | .08 209 | .11 332 | .19 542 | 23 |
| 38 | .80 473 | .88 657 | .91 816 | .08 184 | .11 343 | .19 527 | 22 |
| 39 | .80 489 | .88 647 | .91 842 | .08 158 | .11 353 | .19 511 | 21 |
| 40 | 9.80 504 | 9.88 636 | 9.91 868 | 0.08 132 | 0.11 364 | 0.19 496 | 20 |
| 41 | .80 519 | .88 626 | .91 893 | .08 107 | .11 374 | .19 481 | 19 |
| 42 | .80 534 | .88 615 | .91 919 | .08 081 | .11 385 | .19 466 | 18 |
| 43 | .80 550 | .88 605 | .91 945 | .08 055 | .11 395 | .19 450 | 17 |
| 44 | .80 565 | .88 594 | .91 971 | .08 029 | .11 406 | .19 435 | 16 |
| 45 | 9.80 580 | 9.88 584 | 9.91 996 | 0.08 004 | 0.11 416 | 0.19 420 | 15 |
| 46 | .80 595 | .88 573 | .92 022 | .07 978 | .11 427 | .19 405 | 14 |
| 47 | .80 610 | .88 563 | .92 048 | .07 952 | .11 437 | .19 390 | 13 |
| 48 | .80 625 | .88 552 | .92 073 | .07 927 | .11 448 | .19 375 | 12 |
| 49 | .80 641 | .88 542 | .92 099 | .07 901 | .11 458 | .19 359 | 11 |
| 50 | 9.80 656 | 9.88 531 | 9.92 125 | 0.07 875 | 0.11 469 | 0.19 344 | 10 |
| 51 | .80 671 | .88 521 | .92 150 | .07 850 | .11 479 | .19 329 | 9 |
| 52 | .80 686 | .88 510 | .92 176 | .07 824 | .11 490 | .19 314 | 8 |
| 53 | .80 701 | .88 499 | .92 202 | .07 798 | .11 501 | .19 299 | 7 |
| 54 | .80 716 | .88 489 | .92 227 | .07 773 | .11 511 | .19 284 | 6 |
| 55 | 9.80 731 | 9.88 478 | 9.92 253 | 0.07 747 | 0.11 522 | 0.19 269 | 5 |
| 56 | .80 746 | .88 468 | .92 279 | .07 721 | .11 532 | .19 254 | 4 |
| 57 | .80 762 | .88 457 | .92 304 | .07 696 | .11 543 | .19 238 | 3 |
| 58 | .80 777 | .88 447 | .92 330 | .07 670 | .11 553 | .19 223 | 2 |
| 59 | .80 792 | .88 436 | .92 356 | .07 644 | .11 564 | .19 208 | 1 |
| 60 | 9.80 807 | 9.88 425 | 9.92 381 | 0.07 619 | 0.11 575 | 0.19 193 | 0 |

129° (309°)

(230°) 50°

Cos Sin Cot Tan Csc Sec

40° (220°)

(319°) 139°

| | Sin | Cos | Tan | Cot | Sec | Csc | |
|----|----------|----------|----------|----------|----------|----------|-----------|
| 0 | 9.80 807 | 9.88 425 | 9.92 381 | 0.07 619 | 0.11 575 | 0.19 193 | 60 |
| 1 | .80 822 | .88 415 | .92 407 | .07 593 | .11 585 | .19 178 | 59 |
| 2 | .80 837 | .88 404 | .92 433 | .07 567 | .11 596 | .19 163 | 58 |
| 3 | .80 852 | .88 394 | .92 458 | .07 542 | .11 606 | .19 148 | 57 |
| 4 | .80 867 | .88 383 | .92 484 | .07 516 | .11 617 | .19 133 | 56 |
| 5 | 9.80 882 | 9.88 372 | 9.92 510 | 0.07 490 | 0.11 628 | 0.19 118 | 55 |
| 6 | .80 897 | .88 362 | .92 535 | .07 465 | .11 638 | .19 103 | 54 |
| 7 | .80 912 | .88 351 | .92 561 | .07 439 | .11 649 | .19 088 | 53 |
| 8 | .80 927 | .88 340 | .92 587 | .07 413 | .11 660 | .19 073 | 52 |
| 9 | .80 942 | .88 330 | .92 612 | .07 388 | .11 670 | .19 058 | 51 |
| 10 | 9.80 957 | 9.88 319 | 9.92 638 | 0.07 362 | 0.11 681 | 0.19 043 | 50 |
| 11 | .80 972 | .88 308 | .92 663 | .07 337 | .11 692 | .19 028 | 49 |
| 12 | .80 987 | .88 298 | .92 689 | .07 311 | .11 702 | .19 013 | 48 |
| 13 | .81 002 | .88 287 | .92 715 | .07 285 | .11 713 | .18 998 | 47 |
| 14 | .81 017 | .88 276 | .92 740 | .07 260 | .11 724 | .18 983 | 46 |
| 15 | 9.81 032 | 9.88 266 | 9.92 766 | 0.07 234 | 0.11 734 | 0.18 968 | 45 |
| 16 | .81 047 | .88 255 | .92 792 | .07 208 | .11 745 | .18 953 | 44 |
| 17 | .81 061 | .88 244 | .92 817 | .07 183 | .11 756 | .18 939 | 43 |
| 18 | .81 076 | .88 234 | .92 843 | .07 157 | .11 766 | .18 924 | 42 |
| 19 | .81 091 | .88 223 | .92 868 | .07 132 | .11 777 | .18 909 | 41 |
| 20 | 9.81 106 | 9.88 212 | 9.92 894 | 0.07 106 | 0.11 788 | 0.18 894 | 40 |
| 21 | .81 121 | .88 201 | .92 920 | .07 080 | .11 799 | .18 879 | 39 |
| 22 | .81 136 | .88 191 | .92 945 | .07 055 | .11 809 | .18 864 | 38 |
| 23 | .81 151 | .88 180 | .92 971 | .07 029 | .11 820 | .18 849 | 37 |
| 24 | .81 166 | .88 169 | .92 996 | .07 004 | .11 831 | .18 834 | 36 |
| 25 | 9.81 180 | 9.88 158 | 9.93 022 | 0.06 978 | 0.11 842 | 0.18 820 | 35 |
| 26 | .81 195 | .88 148 | .93 048 | .06 952 | .11 852 | .18 805 | 34 |
| 27 | .81 210 | .88 137 | .93 073 | .06 927 | .11 863 | .18 790 | 33 |
| 28 | .81 225 | .88 126 | .93 099 | .06 901 | .11 874 | .18 775 | 32 |
| 29 | .81 240 | .88 115 | .93 124 | .06 876 | .11 885 | .18 760 | 31 |
| 30 | 9.81 254 | 9.88 105 | 9.93 150 | 0.06 850 | 0.11 895 | 0.18 746 | 30 |
| 31 | .81 269 | .88 094 | .93 175 | .06 825 | .11 906 | .18 731 | 29 |
| 32 | .81 284 | .88 083 | .93 201 | .06 799 | .11 917 | .18 716 | 28 |
| 33 | .81 299 | .88 072 | .93 227 | .06 773 | .11 928 | .18 701 | 27 |
| 34 | .81 314 | .88 061 | .93 252 | .06 748 | .11 939 | .18 686 | 26 |
| 35 | 9.81 328 | 9.88 051 | 9.93 278 | 0.06 722 | 0.11 949 | 0.18 672 | 25 |
| 36 | .81 343 | .88 040 | .93 303 | .06 697 | .11 960 | .18 657 | 24 |
| 37 | .81 358 | .88 029 | .93 329 | .06 671 | .11 971 | .18 642 | 23 |
| 38 | .81 372 | .88 018 | .93 354 | .06 646 | .11 982 | .18 628 | 22 |
| 39 | .81 387 | .88 007 | .93 380 | .06 620 | .11 993 | .18 613 | 21 |
| 40 | 9.81 402 | 9.87 996 | 9.93 406 | 0.06 594 | 0.12 004 | 0.18 598 | 20 |
| 41 | .81 417 | .87 985 | .93 431 | .06 569 | .12 015 | .18 583 | 19 |
| 42 | .81 431 | .87 975 | .93 457 | .06 543 | .12 025 | .18 569 | 18 |
| 43 | .81 446 | .87 964 | .92 482 | .06 518 | .12 036 | .18 554 | 17 |
| 44 | .81 461 | .87 953 | .93 508 | .06 492 | .12 047 | .18 539 | 16 |
| 45 | 9.81 475 | 9.87 942 | 9.93 533 | 0.06 467 | 0.12 058 | 0.18 525 | 15 |
| 46 | .81 490 | .87 931 | .93 559 | .06 441 | .12 069 | .18 510 | 14 |
| 47 | .81 505 | .87 920 | .93 584 | .06 416 | .12 080 | .18 495 | 13 |
| 48 | .81 519 | .87 909 | .93 610 | .06 390 | .12 091 | .18 481 | 12 |
| 49 | .81 534 | .87 898 | .93 636 | .06 364 | .12 102 | .18 466 | 11 |
| 50 | 9.81 549 | 9.87 887 | 9.93 661 | 0.06 339 | 0.12 113 | 0.18 451 | 10 |
| 51 | .81 563 | .87 877 | .93 687 | .06 313 | .12 123 | .18 437 | 9 |
| 52 | .81 578 | .87 866 | .93 712 | .06 288 | .12 134 | .18 422 | 8 |
| 53 | .81 592 | .87 855 | .93 738 | .06 262 | .12 145 | .18 408 | 7 |
| 54 | .81 607 | .87 844 | .93 763 | .06 237 | .12 156 | .18 393 | 6 |
| 55 | 9.81 622 | 9.87 833 | 9.93 789 | 0.06 211 | 0.12 167 | 0.18 378 | 5 |
| 56 | .81 636 | .87 822 | .93 814 | .06 186 | .12 178 | .18 364 | 4 |
| 57 | .81 651 | .87 811 | .93 840 | .06 160 | .12 189 | .18 349 | 3 |
| 58 | .81 665 | .87 800 | .93 865 | .06 135 | .12 200 | .18 335 | 2 |
| 59 | .81 680 | .87 789 | .93 891 | .06 109 | .12 211 | .18 320 | 1 |
| 60 | 9.81 694 | 9.87 778 | 9.93 916 | 0.06 084 | 0.12 222 | .18 306 | 0 |
| | Cos | Sin | Cot | Tan | Csc | Sec | |

130° (310°)

(229°) 49°

Table 4. Trigonometric Logarithms

41° (221°)

(318°) 138°

| | Sin | Cos | Tan | Cot | Sec | Csc | |
|-----------|------------|------------|------------|------------|------------|------------|-----------|
| 0 | 9.81 694 | 9.87 778 | 9.93 916 | 0.06 084 | 0.12 222 | 0.18 306 | 60 |
| 1 | .81 709 | .87 767 | .93 942 | .06 058 | .12 233 | .18 291 | 59 |
| 2 | .81 723 | .87 756 | .93 967 | .06 033 | .12 244 | .18 277 | 58 |
| 3 | .81 738 | .87 745 | .93 993 | .06 007 | .12 255 | .18 262 | 57 |
| 4 | .81 752 | .87 734 | .94 018 | .05 982 | .12 266 | .18 248 | 56 |
| 5 | 9.81 767 | 9.87 723 | 9.94 044 | 0.05 956 | 0.12 277 | 0.18 233 | 55 |
| 6 | .81 781 | .87 712 | .94 069 | .05 931 | .12 288 | .18 219 | 54 |
| 7 | .81 796 | .87 701 | .94 095 | .05 905 | .12 299 | .18 204 | 53 |
| 8 | .81 810 | .87 690 | .94 120 | .05 880 | .12 310 | .18 190 | 52 |
| 9 | .81 825 | .87 679 | .94 146 | .05 854 | .12 321 | .18 175 | 51 |
| 10 | 9.81 839 | 9.87 668 | 9.94 171 | 0.05 829 | 0.12 332 | 0.18 161 | 50 |
| 11 | .81 854 | .87 657 | .94 197 | .05 803 | .12 343 | .18 146 | 49 |
| 12 | .81 868 | .87 646 | .94 222 | .05 778 | .12 354 | .18 132 | 48 |
| 13 | .81 882 | .87 635 | .94 248 | .05 752 | .12 365 | .18 118 | 47 |
| 14 | .81 897 | .87 624 | .94 273 | .05 727 | .12 376 | .18 103 | 46 |
| 15 | 9.81 911 | 9.87 613 | 9.94 299 | 0.05 701 | 0.12 387 | 0.18 089 | 45 |
| 16 | .81 926 | .87 601 | .94 324 | .05 676 | .12 399 | .18 074 | 44 |
| 17 | .81 940 | .87 590 | .94 350 | .05 650 | .12 410 | .18 060 | 43 |
| 18 | .81 955 | .87 579 | .94 375 | .05 625 | .12 421 | .18 045 | 42 |
| 19 | .81 969 | .87 568 | .94 401 | .05 599 | .12 432 | .18 031 | 41 |
| 20 | 9.81 983 | 9.87 557 | 9.94 426 | 0.05 574 | 0.12 443 | 0.18 017 | 40 |
| 21 | .81 998 | .87 546 | .94 452 | .05 548 | .12 454 | .18 002 | 39 |
| 22 | .82 012 | .87 535 | .94 477 | .05 523 | .12 465 | .17 988 | 38 |
| 23 | .82 026 | .87 524 | .94 503 | .05 497 | .12 476 | .17 974 | 37 |
| 24 | .82 041 | .87 513 | .94 528 | .05 472 | .12 487 | .17 959 | 36 |
| 25 | 9.82 055 | 9.87 501 | 9.94 554 | 0.05 446 | 0.12 499 | 0.17 945 | 35 |
| 26 | .82 069 | .87 490 | .94 579 | .05 421 | .12 510 | .17 931 | 34 |
| 27 | .82 084 | .87 479 | .94 604 | .05 396 | .12 521 | .17 916 | 33 |
| 28 | .82 098 | .87 468 | .94 630 | .05 370 | .12 532 | .17 902 | 32 |
| 29 | .82 112 | .87 457 | .94 655 | .05 345 | .12 543 | .17 888 | 31 |
| 30 | 9.82 126 | 9.87 446 | 9.94 681 | 0.05 319 | 0.12 554 | 0.17 874 | 30 |
| 31 | .82 141 | .87 434 | .94 706 | .05 294 | .12 566 | .17 859 | 29 |
| 32 | .82 155 | .87 423 | .94 732 | .05 268 | .12 577 | .17 845 | 28 |
| 33 | .82 169 | .87 412 | .94 757 | .05 243 | .12 588 | .17 831 | 27 |
| 34 | .82 184 | .87 401 | .94 783 | .05 217 | .12 599 | .17 816 | 26 |
| 35 | 9.82 198 | 9.87 390 | 9.94 808 | 0.05 192 | 0.12 610 | 0.17 802 | 25 |
| 36 | .82 212 | .87 378 | .94 834 | .05 166 | .12 622 | .17 788 | 24 |
| 37 | .82 226 | .87 367 | .94 859 | .05 141 | .12 633 | .17 774 | 23 |
| 38 | .82 240 | .87 356 | .94 884 | .05 116 | .12 644 | .17 760 | 22 |
| 39 | .82 255 | .87 345 | .94 910 | .05 090 | .12 655 | .17 745 | 21 |
| 40 | 9.82 269 | 9.87 334 | 9.94 935 | 0.05 065 | 0.12 666 | 0.17 731 | 20 |
| 41 | .82 283 | .87 322 | .94 961 | .05 039 | .12 678 | .17 717 | 19 |
| 42 | .82 297 | .87 311 | .94 986 | .05 014 | .12 689 | .17 703 | 18 |
| 43 | .82 311 | .87 300 | .95 012 | .04 988 | .12 700 | .17 689 | 17 |
| 44 | .82 326 | .87 288 | .95 037 | .04 963 | .12 712 | .17 674 | 16 |
| 45 | 9.82 340 | 9.87 277 | 9.95 062 | 0.04 938 | 0.12 723 | 0.17 660 | 15 |
| 46 | .82 354 | .87 266 | .95 088 | .04 912 | .12 734 | .17 646 | 14 |
| 47 | .82 368 | .87 255 | .95 113 | .04 887 | .12 745 | .17 632 | 13 |
| 48 | .82 382 | .87 243 | .95 139 | .04 861 | .12 757 | .17 618 | 12 |
| 49 | .82 396 | .87 232 | .95 164 | .04 836 | .12 768 | .17 604 | 11 |
| 50 | 9.82 410 | 9.87 221 | 9.95 190 | 0.04 810 | 0.12 779 | 0.17 590 | 10 |
| 51 | .82 424 | .87 209 | .95 215 | .04 785 | .12 791 | .17 576 | 9 |
| 52 | .82 439 | .87 198 | .95 240 | .04 760 | .12 802 | .17 561 | 8 |
| 53 | .82 453 | .87 187 | .95 266 | .04 734 | .12 813 | .17 547 | 7 |
| 54 | .82 467 | .87 175 | .95 291 | .04 709 | .12 825 | .17 533 | 6 |
| 55 | 9.82 481 | 9.87 164 | 9.95 317 | 0.04 683 | 0.12 836 | 0.17 519 | 5 |
| 56 | .82 495 | .87 153 | .95 342 | .04 658 | .12 847 | .17 505 | 4 |
| 57 | .82 509 | .87 141 | .95 368 | .04 632 | .12 859 | .17 491 | 3 |
| 58 | .82 523 | .87 130 | .95 393 | .04 607 | .12 870 | .17 477 | 2 |
| 59 | .82 537 | .87 119 | .95 418 | .04 582 | .12 881 | .17 463 | 1 |
| 60 | 9.82 551 | 9.87 107 | 9.95 444 | 0.04 556 | 0.12 893 | 0.17 449 | 0 |
| | Cos | Sin | Cot | Tan | Csc | Sec | ' |

131° (311°)

(228°) 48°

42° (222°)

(317°) 137°

| | Sin | Cos | Tan | Cot | Sec | Csc | |
|----|----------|----------|----------|----------|----------|----------|-----------|
| 0 | 9.82 551 | 9.87 107 | 9.95 444 | 0.04 556 | 0.12 893 | 0.17 449 | 60 |
| 1 | .82 565 | .87 096 | .95 469 | .04 531 | .12 904 | .17 435 | 59 |
| 2 | .82 579 | .87 085 | .95 495 | .04 505 | .12 915 | .17 421 | 58 |
| 3 | .82 593 | .87 073 | .95 520 | .04 480 | .12 927 | .17 407 | 57 |
| 4 | .82 607 | .87 062 | .95 545 | .04 455 | .12 938 | .17 393 | 56 |
| 5 | 9.82 621 | 9.87 050 | 9.95 571 | 0.04 429 | 0.12 950 | 0.17 379 | 55 |
| 6 | .82 635 | .87 039 | .95 596 | .04 404 | .12 961 | .17 365 | 54 |
| 7 | .82 649 | .87 028 | .95 622 | .04 378 | .12 972 | .17 351 | 53 |
| 8 | .82 663 | .87 016 | .95 647 | .04 353 | .12 984 | .17 337 | 52 |
| 9 | .82 677 | .87 005 | .95 672 | .04 328 | .12 995 | .17 323 | 51 |
| 10 | 9.82 691 | 9.86 993 | 9.95 698 | 0.04 302 | 0.13 007 | 0.17 309 | 50 |
| 11 | .82 705 | .86 982 | .95 723 | .04 277 | .13 018 | .17 295 | 49 |
| 12 | .82 719 | .86 970 | .95 748 | .04 252 | .13 030 | .17 281 | 48 |
| 13 | .82 733 | .86 959 | .95 774 | .04 226 | .13 041 | .17 267 | 47 |
| 14 | .82 747 | .86 947 | .95 799 | .04 201 | .13 053 | .17 253 | 46 |
| 15 | 9.82 761 | 9.86 936 | 9.95 825 | 0.04 175 | 0.13 064 | 0.17 239 | 45 |
| 16 | .82 775 | .86 924 | .95 850 | .04 150 | .13 076 | .17 225 | 44 |
| 17 | .82 788 | .86 913 | .95 875 | .04 125 | .13 087 | .17 212 | 43 |
| 18 | .82 802 | .86 902 | .95 901 | .04 099 | .13 098 | .17 198 | 42 |
| 19 | .82 816 | .86 890 | .95 926 | .04 074 | .13 110 | .17 184 | 41 |
| 20 | 9.82 830 | 9.86 879 | 9.95 952 | 0.04 048 | 0.13 121 | 0.17 170 | 40 |
| 21 | .82 844 | .86 867 | .95 977 | .04 023 | .13 133 | .17 156 | 39 |
| 22 | .82 858 | .86 855 | .96 002 | .03 998 | .13 145 | .17 142 | 38 |
| 23 | .82 872 | .86 844 | .96 028 | .03 972 | .13 156 | .17 128 | 37 |
| 24 | .82 885 | .86 832 | .96 053 | .03 947 | .13 168 | .17 115 | 36 |
| 25 | 9.82 899 | 9.86 821 | 9.96 078 | 0.03 922 | 0.13 179 | 0.17 101 | 35 |
| 26 | .82 913 | .86 809 | .96 104 | .03 896 | .13 191 | .17 087 | 34 |
| 27 | .82 927 | .86 798 | .96 129 | .03 871 | .13 202 | .17 073 | 33 |
| 28 | .82 941 | .86 786 | .96 155 | .03 845 | .13 214 | .17 059 | 32 |
| 29 | .82 955 | .86 775 | .96 180 | .03 820 | .13 225 | .17 045 | 31 |
| 30 | 9.82 968 | 9.86 763 | 9.96 205 | 0.03 795 | 0.13 237 | 0.17 032 | 30 |
| 31 | .82 982 | .86 752 | .96 231 | .03 769 | .13 248 | .17 018 | 29 |
| 32 | .82 996 | .86 740 | .96 256 | .03 744 | .13 260 | .17 004 | 28 |
| 33 | .83 010 | .86 728 | .96 281 | .03 719 | .13 272 | .16 990 | 27 |
| 34 | .83 023 | .86 717 | .96 307 | .03 693 | .13 283 | .16 977 | 26 |
| 35 | 9.83 037 | 9.86 705 | 9.96 332 | 0.03 668 | 0.13 295 | 0.16 963 | 25 |
| 36 | .83 051 | .86 694 | .96 357 | .03 643 | .13 306 | .16 949 | 24 |
| 37 | .83 065 | .86 682 | .96 383 | .03 617 | .13 318 | .16 935 | 23 |
| 38 | .83 078 | .86 670 | .96 408 | .03 592 | .13 330 | .16 922 | 22 |
| 39 | .83 092 | .86 659 | .96 433 | .03 567 | .13 341 | .16 908 | 21 |
| 40 | 9.83 106 | 9.86 647 | 9.96 459 | 0.03 541 | 0.13 353 | 0.16 894 | 20 |
| 41 | .83 120 | .86 635 | .96 484 | .03 516 | .13 365 | .16 880 | 19 |
| 42 | .83 133 | .86 624 | .96 510 | .03 490 | .13 376 | .16 867 | 18 |
| 43 | .83 147 | .86 612 | .96 535 | .03 465 | .13 388 | .16 853 | 17 |
| 44 | .83 161 | .86 600 | .96 560 | .03 440 | .13 400 | .16 839 | 16 |
| 45 | 9.83 174 | 9.86 589 | 9.96 586 | 0.03 414 | 0.13 411 | 0.16 826 | 15 |
| 46 | .83 188 | .86 577 | .96 611 | .03 389 | .13 423 | .16 812 | 14 |
| 47 | .83 202 | .86 565 | .96 636 | .03 364 | .13 435 | .16 798 | 13 |
| 48 | .83 215 | .86 554 | .96 662 | .03 338 | .13 446 | .16 785 | 12 |
| 49 | .83 229 | .86 542 | .96 687 | .03 313 | .13 458 | .16 771 | 11 |
| 50 | 9.83 242 | 9.86 530 | 9.96 712 | 0.03 288 | 0.13 470 | 0.16 758 | 10 |
| 51 | .83 256 | .86 518 | .96 738 | .03 262 | .13 482 | .16 744 | 9 |
| 52 | .83 270 | .86 507 | .96 763 | .03 237 | .13 493 | .16 730 | 8 |
| 53 | .83 283 | .86 495 | .96 788 | .03 212 | .13 505 | .16 717 | 7 |
| 54 | .83 297 | .86 483 | .96 814 | .03 186 | .13 517 | .16 703 | 6 |
| 55 | 9.83 310 | 9.86 472 | 9.96 839 | 0.03 161 | 0.13 528 | 0.16 690 | 5 |
| 56 | .83 324 | .86 460 | .96 864 | .03 136 | .13 540 | .16 676 | 4 |
| 57 | .83 338 | .86 448 | .96 890 | .03 110 | .13 552 | .16 662 | 3 |
| 58 | .83 351 | .86 436 | .96 915 | .03 085 | .13 564 | .16 649 | 2 |
| 59 | .83 365 | .86 425 | .96 940 | .03 060 | .13 575 | .16 635 | 1 |
| 60 | 9.83 378 | 9.86 413 | 9.96 966 | 0.03 034 | 0.13 587 | 0.16 622 | 0 |
| | Cos | Sin | Cot | Tan | Csc | Sec | |

132° (312°)

(227°) 47°

43° (223°)

(316°) 136°

| | Sin | Cos | Tan | Cot | Sec | Csc | |
|-----------|------------|------------|------------|------------|------------|------------|-----------|
| 0 | 9.83 378 | 9.86 413 | 9.96 966 | 0.03 034 | 0.13 587 | 0.16 622 | 60 |
| 1 | .83 392 | .86 401 | .96 991 | .03 009 | .13 599 | .16 608 | 59 |
| 2 | .83 405 | .86 389 | .97 016 | .02 984 | .13 611 | .16 595 | 58 |
| 3 | .83 419 | .86 377 | .97 042 | .02 958 | .13 623 | .16 581 | 57 |
| 4 | .83 432 | .86 366 | .97 067 | .02 933 | .13 634 | .16 568 | 56 |
| 5 | 9.83 446 | 9.86 354 | 9.97 092 | 0.02 908 | 0.13 646 | 0.16 554 | 55 |
| 6 | .83 459 | .86 342 | .97 118 | .02 882 | .13 658 | .16 541 | 54 |
| 7 | .83 473 | .86 330 | .97 143 | .02 857 | .13 670 | .16 527 | 53 |
| 8 | .83 486 | .86 318 | .97 168 | .02 832 | .13 682 | .16 514 | 52 |
| 9 | .83 500 | .86 306 | .97 193 | .02 807 | .13 694 | .16 500 | 51 |
| 10 | 9.83 513 | 9.86 295 | 9.97 219 | 0.02 781 | 0.13 705 | 0.16 487 | 50 |
| 11 | .83 527 | .86 283 | .97 244 | .02 756 | .13 717 | .16 473 | 49 |
| 12 | .83 540 | .86 271 | .97 269 | .02 731 | .13 729 | .16 460 | 48 |
| 13 | .83 554 | .86 259 | .97 295 | .02 705 | .13 741 | .16 446 | 47 |
| 14 | .83 567 | .86 247 | .97 320 | .02 680 | .13 753 | .16 433 | 46 |
| 15 | 9.83 581 | 9.86 235 | 9.97 345 | 0.02 655 | 0.13 765 | 0.16 419 | 45 |
| 16 | .83 594 | .86 223 | .97 371 | .02 629 | .13 777 | .16 406 | 44 |
| 17 | .83 608 | .86 211 | .97 396 | .02 604 | .13 789 | .16 392 | 43 |
| 18 | .83 621 | .86 200 | .97 421 | .02 579 | .13 800 | .16 379 | 42 |
| 19 | .83 634 | .86 188 | .97 447 | .02 553 | .13 812 | .16 366 | 41 |
| 20 | 9.83 648 | 9.86 176 | 9.97 472 | 0.02 528 | 0.13 824 | 0.16 352 | 40 |
| 21 | .83 661 | .86 164 | .97 497 | .02 503 | .13 836 | .16 339 | 39 |
| 22 | .83 674 | .86 152 | .97 523 | .02 477 | .13 848 | .16 326 | 38 |
| 23 | .83 688 | .86 140 | .97 548 | .02 452 | .13 860 | .16 312 | 37 |
| 24 | .83 701 | .86 128 | .97 573 | .02 427 | .13 872 | .16 299 | 36 |
| 25 | 9.83 715 | 9.86 116 | 9.97 598 | 0.02 402 | 0.13 884 | 0.16 285 | 35 |
| 26 | .83 728 | .86 104 | .97 624 | .02 376 | .13 896 | .16 272 | 34 |
| 27 | .83 741 | .86 092 | .97 649 | .02 351 | .13 908 | .16 259 | 33 |
| 28 | .83 755 | .86 080 | .97 674 | .02 326 | .13 920 | .16 245 | 32 |
| 29 | .83 768 | .86 068 | .97 700 | .02 300 | .13 932 | .16 232 | 31 |
| 30 | 9.83 781 | 9.86 056 | 9.97 725 | 0.02 275 | 0.13 944 | 0.16 219 | 30 |
| 31 | .83 795 | .86 044 | .97 750 | .02 250 | .13 956 | .16 205 | 29 |
| 32 | .83 808 | .86 032 | .97 776 | .02 224 | .13 968 | .16 192 | 28 |
| 33 | .83 821 | .86 020 | .97 801 | .02 199 | .13 980 | .16 179 | 27 |
| 34 | .83 834 | .86 008 | .97 826 | .02 174 | .13 992 | .16 166 | 26 |
| 35 | 9.83 848 | 9.85 996 | 9.97 851 | 0.02 149 | 0.14 004 | 0.16 152 | 25 |
| 36 | .83 861 | .85 984 | .97 877 | .02 123 | .14 016 | .16 139 | 24 |
| 37 | .83 874 | .85 972 | .97 902 | .02 098 | .14 028 | .16 126 | 23 |
| 38 | .83 887 | .85 960 | .97 927 | .02 073 | .14 040 | .16 113 | 22 |
| 39 | .83 901 | .85 948 | .97 953 | .02 047 | .14 052 | .16 099 | 21 |
| 40 | 9.83 914 | 9.85 936 | 9.97 978 | 0.02 022 | 0.14 064 | 0.16 086 | 20 |
| 41 | .83 927 | .85 924 | .98 003 | .01 997 | .14 076 | .16 073 | 19 |
| 42 | .83 940 | .85 912 | .98 029 | .01 971 | .14 088 | .16 060 | 18 |
| 43 | .83 954 | .85 900 | .98 054 | .01 946 | .14 100 | .16 046 | 17 |
| 44 | .83 967 | .85 888 | .98 079 | .01 921 | .14 112 | .16 033 | 16 |
| 45 | 9.83 980 | 9.85 876 | 9.98 104 | 0.01 896 | 0.14 124 | 0.16 020 | 15 |
| 46 | .83 993 | .85 864 | .98 130 | .01 870 | .14 136 | .16 007 | 14 |
| 47 | .84 006 | .85 851 | .98 155 | .01 845 | .14 149 | .15 994 | 13 |
| 48 | .84 020 | .85 839 | .98 180 | .01 820 | .14 161 | .15 980 | 12 |
| 49 | .84 033 | .85 827 | .98 206 | .01 794 | .14 173 | .15 967 | 11 |
| 50 | 9.84 046 | 9.85 815 | 9.98 231 | 0.01 769 | 0.14 185 | 0.15 954 | 10 |
| 51 | .84 059 | .85 803 | .98 256 | .01 744 | .14 197 | .15 941 | 9 |
| 52 | .84 072 | .85 791 | .98 281 | .01 719 | .14 209 | .15 928 | 8 |
| 53 | .84 085 | .85 779 | .98 307 | .01 693 | .14 221 | .15 915 | 7 |
| 54 | .84 098 | .85 766 | .98 332 | .01 668 | .14 234 | .15 902 | 6 |
| 55 | 9.84 112 | 9.85 754 | 9.98 357 | 0.01 643 | 0.14 246 | 0.15 888 | 5 |
| 56 | .84 125 | .85 742 | .98 383 | .01 617 | .14 258 | .15 875 | 4 |
| 57 | .84 138 | .85 730 | .98 408 | .01 592 | .14 270 | .15 862 | 3 |
| 58 | .84 151 | .85 718 | .98 433 | .01 567 | .14 282 | .15 849 | 2 |
| 59 | .84 164 | .85 706 | .98 458 | .01 542 | .14 294 | .15 836 | 1 |
| 60 | 9.84 177 | 9.85 693 | 9.98 484 | 0.01 516 | 0.14 307 | 0.15 823 | 0 |
| | Cos | Sin | Cot | Tan | Csc | Sec | |

133° (313°)

(226°) 46°

44° (224°)

(315°) 135°

| | Sin | Cos | Tan | Cot | Sec | Csc | |
|-----------|----------|----------|----------|----------|----------|----------|-----------|
| 0 | 9.84 177 | 9.85 693 | 9.98 484 | 0.01 516 | 0.14 307 | 0.15 823 | 60 |
| 1 | .84 190 | .85 681 | .98 509 | .01 491 | .14 319 | .15 810 | 59 |
| 2 | .84 203 | .85 669 | .98 534 | .01 466 | .14 331 | .15 797 | 58 |
| 3 | .84 216 | .85 657 | .98 560 | .01 440 | .14 343 | .15 784 | 57 |
| 4 | .84 229 | .85 645 | .98 585 | .01 415 | .14 355 | .15 771 | 56 |
| 5 | 9.84 242 | 9.85 632 | 9.98 610 | 0.01 390 | 0.14 368 | 0.15 758 | 55 |
| 6 | .84 255 | .85 620 | .98 635 | .01 365 | .14 380 | .15 745 | 54 |
| 7 | .84 269 | .85 608 | .98 661 | .01 339 | .14 392 | .15 731 | 53 |
| 8 | .84 282 | .85 596 | .98 686 | .01 314 | .14 404 | .15 718 | 52 |
| 9 | .84 295 | .85 583 | .98 711 | .01 289 | .14 417 | .15 705 | 51 |
| 10 | 9.84 308 | 9.85 571 | 9.98 737 | 0.01 263 | 0.14 429 | 0.15 692 | 50 |
| 11 | .84 321 | .85 559 | .98 762 | .01 238 | .14 441 | .15 679 | 49 |
| 12 | .84 334 | .85 547 | .98 787 | .01 213 | .14 453 | .15 666 | 48 |
| 13 | .84 347 | .85 534 | .98 812 | .01 188 | .14 466 | .15 653 | 47 |
| 14 | .84 360 | .85 522 | .98 838 | .01 162 | .14 478 | .15 640 | 46 |
| 15 | 9.84 373 | 9.85 510 | 9.98 863 | 0.01 137 | 0.14 490 | 0.15 627 | 45 |
| 16 | .84 385 | .85 497 | .98 888 | .01 112 | .14 503 | .15 615 | 44 |
| 17 | .84 398 | .85 485 | .98 913 | .01 087 | .14 515 | .15 602 | 43 |
| 18 | .84 411 | .85 473 | .98 939 | .01 061 | .14 527 | .15 589 | 42 |
| 19 | .84 424 | .85 460 | .98 964 | .01 036 | .14 540 | .15 576 | 41 |
| 20 | 9.84 437 | 9.85 448 | 9.98 989 | 0.01 011 | 0.14 552 | 0.15 563 | 40 |
| 21 | .84 450 | .85 436 | .99 015 | .00 985 | .14 564 | .15 550 | 39 |
| 22 | .84 463 | .85 423 | .99 040 | .00 960 | .14 577 | .15 537 | 38 |
| 23 | .84 476 | .85 411 | .99 065 | .00 935 | .14 589 | .15 524 | 37 |
| 24 | .84 489 | .85 399 | .99 090 | .00 910 | .14 601 | .15 511 | 36 |
| 25 | 9.84 502 | 9.85 386 | 9.99 116 | 0.00 884 | 0.14 614 | 0.15 498 | 35 |
| 26 | .84 515 | .85 374 | .99 141 | .00 859 | .14 626 | .15 485 | 34 |
| 27 | .84 528 | .85 361 | .99 166 | .00 834 | .14 639 | .15 472 | 33 |
| 28 | .84 540 | .85 349 | .99 191 | .00 809 | .14 651 | .15 460 | 32 |
| 29 | .84 553 | .85 337 | .99 217 | .00 783 | .14 663 | .15 447 | 31 |
| 30 | 9.84 566 | 9.85 324 | 9.99 242 | 0.00 758 | 0.14 676 | 0.15 434 | 30 |
| 31 | .84 579 | .85 312 | .99 267 | .00 733 | .14 688 | .15 421 | 29 |
| 32 | .84 592 | .85 299 | .99 293 | .00 707 | .14 701 | .15 408 | 28 |
| 33 | .84 605 | .85 287 | .99 318 | .00 682 | .14 713 | .15 395 | 27 |
| 34 | .84 618 | .85 274 | .99 343 | .00 657 | .14 726 | .15 382 | 26 |
| 35 | 9.84 630 | 9.85 262 | 9.99 368 | 0.00 632 | 0.14 738 | 0.15 370 | 25 |
| 36 | .84 643 | .85 250 | .99 394 | .00 606 | .14 750 | .15 357 | 24 |
| 37 | .84 656 | .85 237 | .99 419 | .00 581 | .14 763 | .15 344 | 23 |
| 38 | .84 669 | .85 225 | .99 444 | .00 556 | .14 775 | .15 331 | 22 |
| 39 | .84 682 | .85 212 | .99 469 | .00 531 | .14 788 | .15 318 | 21 |
| 40 | 9.84 694 | 9.85 200 | 9.99 495 | 0.00 505 | 0.14 800 | 0.15 306 | 20 |
| 41 | .84 707 | .85 187 | .99 520 | .00 480 | .14 813 | .15 293 | 19 |
| 42 | .84 720 | .85 175 | .99 545 | .00 455 | .14 825 | .15 280 | 18 |
| 43 | .84 733 | .85 162 | .99 570 | .00 430 | .14 838 | .15 267 | 17 |
| 44 | .84 745 | .85 150 | .99 596 | .00 404 | .14 850 | .15 255 | 16 |
| 45 | 9.84 758 | 9.85 137 | 9.99 621 | 0.00 379 | 0.14 863 | 0.15 242 | 15 |
| 46 | .84 771 | .85 125 | .99 646 | .00 354 | .14 875 | .15 229 | 14 |
| 47 | .84 784 | .85 112 | .99 672 | .00 328 | .14 888 | .15 216 | 13 |
| 48 | .84 796 | .85 100 | .99 697 | .00 303 | .14 900 | .15 204 | 12 |
| 49 | .84 809 | .85 087 | .99 722 | .00 278 | .14 913 | .15 191 | 11 |
| 50 | 9.84 822 | 9.85 074 | 9.99 747 | 0.00 253 | 0.14 926 | 0.15 178 | 10 |
| 51 | .84 835 | .85 062 | .99 773 | .00 227 | .14 938 | .15 165 | 9 |
| 52 | .84 847 | .85 049 | .99 798 | .00 202 | .14 951 | .15 153 | 8 |
| 53 | .84 860 | .85 037 | .99 823 | .00 177 | .14 963 | .15 140 | 7 |
| 54 | .84 873 | .85 024 | .99 848 | .00 152 | .14 976 | .15 127 | 6 |
| 55 | 9.84 885 | 9.85 012 | 9.99 874 | 0.00 126 | 0.14 988 | 0.15 115 | 5 |
| 56 | .84 898 | .84 999 | .99 899 | .00 101 | .15 001 | .15 102 | 4 |
| 57 | .84 911 | .84 986 | .99 924 | .00 076 | .15 014 | .15 089 | 3 |
| 58 | .84 923 | .84 974 | .99 949 | .00 051 | .15 026 | .15 077 | 2 |
| 59 | .84 936 | .84 961 | .99 975 | .00 025 | .15 039 | .15 064 | 1 |
| 60 | 9.84 949 | 9.84 949 | 0.00 000 | 0.00 000 | 0.15 051 | 0.15 051 | 0 |
| | Cos | Sin | Cot | Tan | Csc | Sec | ' |

134° (314°)

(225°) 45°

Table 5. Meridional Parts

| | 0° | 1° | 2° | 3° | 4° | 5° | 6° | 7° | 8° | 9° | |
|----|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|----|
| 0 | 0.0 | 59.6 | 119.2 | 178.9 | 238.6 | 298.3 | 358.2 | 418.2 | 478.3 | 538.6 | 0 |
| 1 | 1.0 | 60.6 | 20.2 | 79.9 | 39.6 | 99.3 | 59.2 | 19.2 | 79.3 | 39.6 | 1 |
| 2 | 2.0 | 61.6 | 21.2 | 80.8 | 40.6 | 300.3 | 60.2 | 20.2 | 80.3 | 40.6 | 2 |
| 3 | 3.0 | 62.6 | 22.2 | 81.8 | 41.6 | 01.3 | 61.2 | 21.2 | 81.3 | 41.6 | 3 |
| 4 | 4.0 | 63.6 | 23.2 | 82.8 | 42.5 | 02.3 | 62.2 | 22.2 | 82.3 | 42.6 | 4 |
| 5 | 5.0 | 64.6 | 24.2 | 83.8 | 43.5 | 303.3 | 63.2 | 23.2 | 83.3 | 43.6 | 5 |
| 6 | 6.0 | 65.6 | 25.2 | 84.8 | 44.5 | 04.3 | 64.2 | 24.2 | 84.3 | 44.6 | 6 |
| 7 | 7.0 | 66.5 | 26.2 | 85.8 | 45.5 | 05.3 | 65.2 | 25.2 | 85.3 | 45.6 | 7 |
| 8 | 7.9 | 67.5 | 27.2 | 86.8 | 46.5 | 06.3 | 66.2 | 26.2 | 86.3 | 46.6 | 8 |
| 9 | 8.9 | 68.5 | 28.2 | 87.8 | 47.5 | 07.3 | 67.2 | 27.2 | 87.3 | 47.6 | 9 |
| 10 | 9.9 | 69.5 | 29.1 | 88.8 | 48.5 | 308.3 | 68.2 | 28.2 | 88.3 | 48.6 | 10 |
| 11 | 10.9 | 70.5 | 30.1 | 89.8 | 49.5 | 09.3 | 69.2 | 29.2 | 89.3 | 49.6 | 11 |
| 12 | 11.9 | 71.5 | 31.1 | 90.8 | 50.5 | 10.3 | 70.2 | 30.2 | 90.4 | 50.6 | 12 |
| 13 | 12.9 | 72.5 | 32.1 | 91.8 | 51.5 | 11.3 | 71.2 | 31.2 | 91.4 | 51.7 | 13 |
| 14 | 13.9 | 73.5 | 33.1 | 92.8 | 52.5 | 12.3 | 72.2 | 32.2 | 92.4 | 52.7 | 14 |
| 15 | 14.9 | 74.5 | 34.1 | 93.8 | 53.5 | 313.3 | 73.2 | 33.2 | 93.4 | 53.7 | 15 |
| 16 | 15.9 | 75.5 | 35.1 | 94.8 | 54.5 | 14.3 | 74.2 | 34.2 | 94.4 | 54.7 | 16 |
| 17 | 16.9 | 76.5 | 36.1 | 95.8 | 55.5 | 15.3 | 75.2 | 35.2 | 95.4 | 55.7 | 17 |
| 18 | 17.9 | 77.5 | 37.1 | 96.8 | 56.5 | 16.3 | 76.2 | 36.2 | 96.4 | 56.7 | 18 |
| 19 | 18.9 | 78.5 | 38.1 | 97.8 | 57.5 | 17.3 | 77.2 | 37.2 | 97.4 | 57.7 | 19 |
| 20 | 19.9 | 79.5 | 39.1 | 98.8 | 58.5 | 318.3 | 78.2 | 38.2 | 98.4 | 58.7 | 20 |
| 21 | 20.9 | 80.5 | 40.1 | 99.7 | 59.5 | 19.3 | 79.2 | 39.2 | 99.4 | 59.7 | 21 |
| 22 | 21.9 | 81.5 | 41.1 | 200.7 | 60.5 | 20.3 | 80.2 | 40.2 | 500.4 | 60.7 | 22 |
| 23 | 22.8 | 82.4 | 42.1 | 01.7 | 61.5 | 21.3 | 81.2 | 41.2 | 01.4 | 61.7 | 23 |
| 24 | 23.8 | 83.4 | 43.1 | 02.7 | 62.5 | 22.3 | 82.2 | 42.2 | 02.4 | 62.7 | 24 |
| 25 | 24.8 | 84.4 | 44.1 | 203.7 | 263.5 | 323.3 | 383.2 | 443.2 | 503.4 | 563.7 | 25 |
| 26 | 25.8 | 85.4 | 45.1 | 04.7 | 64.5 | 24.3 | 84.2 | 44.2 | 04.4 | 64.7 | 26 |
| 27 | 26.8 | 86.4 | 46.0 | 05.7 | 65.5 | 25.3 | 85.2 | 45.2 | 05.4 | 65.7 | 27 |
| 28 | 27.8 | 87.4 | 47.0 | 06.7 | 66.5 | 26.3 | 86.2 | 46.2 | 06.4 | 66.8 | 28 |
| 29 | 28.8 | 88.4 | 48.0 | 07.7 | 67.4 | 27.3 | 87.2 | 47.2 | 07.4 | 67.8 | 29 |
| 30 | 29.8 | 89.4 | 49.0 | 208.7 | 268.4 | 328.3 | 388.2 | 448.2 | 508.4 | 568.8 | 30 |
| 31 | 30.8 | 90.4 | 50.0 | 09.7 | 69.4 | 29.3 | 89.2 | 49.2 | 09.4 | 69.8 | 31 |
| 32 | 31.8 | 91.4 | 51.0 | 10.7 | 70.4 | 30.3 | 90.2 | 50.2 | 10.4 | 70.8 | 32 |
| 33 | 32.8 | 92.4 | 52.0 | 11.7 | 71.4 | 31.3 | 91.2 | 51.2 | 11.4 | 71.8 | 33 |
| 34 | 33.8 | 93.4 | 53.0 | 12.7 | 72.4 | 32.3 | 92.2 | 52.2 | 12.4 | 72.8 | 34 |
| 35 | 34.8 | 94.4 | 54.0 | 213.7 | 273.4 | 333.3 | 393.2 | 453.2 | 513.4 | 573.8 | 35 |
| 36 | 35.8 | 95.4 | 55.0 | 14.7 | 74.4 | 34.3 | 94.2 | 54.2 | 14.5 | 74.8 | 36 |
| 37 | 36.7 | 96.4 | 56.0 | 15.7 | 75.4 | 35.3 | 95.2 | 55.2 | 15.5 | 75.8 | 37 |
| 38 | 37.7 | 97.3 | 57.0 | 16.7 | 76.4 | 36.2 | 96.2 | 56.2 | 16.5 | 76.8 | 38 |
| 39 | 38.7 | 98.3 | 58.0 | 17.7 | 77.4 | 37.2 | 97.2 | 57.2 | 17.5 | 77.8 | 39 |
| 40 | 39.7 | 99.3 | 59.0 | 218.7 | 278.4 | 338.2 | 398.2 | 458.2 | 518.4 | 578.8 | 40 |
| 41 | 40.7 | 100.3 | 60.0 | 19.7 | 79.4 | 39.2 | 99.2 | 59.2 | 19.5 | 79.9 | 41 |
| 42 | 41.7 | 01.3 | 61.0 | 20.6 | 80.4 | 40.2 | 400.2 | 60.3 | 20.5 | 80.9 | 42 |
| 43 | 42.7 | 02.3 | 62.0 | 21.6 | 81.4 | 41.2 | 01.2 | 61.3 | 21.5 | 81.9 | 43 |
| 44 | 43.7 | 03.3 | 63.0 | 22.6 | 82.4 | 42.2 | 02.2 | 62.3 | 22.5 | 82.9 | 44 |
| 45 | 44.7 | 104.3 | 64.0 | 223.6 | 283.4 | 343.2 | 403.2 | 463.2 | 523.4 | 583.9 | 45 |
| 46 | 45.7 | 05.3 | 65.0 | 24.6 | 84.4 | 44.2 | 04.2 | 64.3 | 24.5 | 84.9 | 46 |
| 47 | 46.7 | 06.3 | 66.0 | 25.6 | 85.4 | 45.2 | 05.2 | 65.3 | 25.5 | 85.9 | 47 |
| 48 | 47.7 | 07.3 | 67.0 | 26.6 | 86.4 | 46.2 | 06.2 | 66.3 | 26.5 | 86.9 | 48 |
| 49 | 48.7 | 08.3 | 68.0 | 27.6 | 87.4 | 47.2 | 07.2 | 67.3 | 27.5 | 87.9 | 49 |
| 50 | 49.7 | 109.3 | 69.0 | 228.6 | 288.4 | 348.2 | 408.2 | 468.2 | 528.4 | 588.9 | 50 |
| 51 | 50.7 | 10.3 | 69.9 | 29.6 | 89.4 | 49.2 | 09.2 | 69.3 | 29.5 | 89.9 | 51 |
| 52 | 51.6 | 11.3 | 70.9 | 30.6 | 90.4 | 50.2 | 10.2 | 70.3 | 30.5 | 90.9 | 52 |
| 53 | 52.6 | 12.3 | 71.9 | 31.6 | 91.4 | 51.2 | 11.2 | 71.3 | 31.5 | 91.9 | 53 |
| 54 | 53.6 | 13.2 | 72.9 | 32.6 | 92.4 | 52.2 | 12.2 | 72.3 | 32.5 | 93.0 | 54 |
| 55 | 54.6 | 114.2 | 73.9 | 233.6 | 293.4 | 353.2 | 413.2 | 473.2 | 533.4 | 594.0 | 55 |
| 56 | 55.6 | 15.2 | 74.9 | 34.6 | 94.4 | 54.2 | 14.2 | 74.3 | 34.6 | 95.0 | 56 |
| 57 | 56.6 | 16.2 | 75.9 | 35.6 | 95.4 | 55.2 | 15.2 | 75.3 | 35.6 | 96.0 | 57 |
| 58 | 57.6 | 17.2 | 76.9 | 36.6 | 96.3 | 56.2 | 16.2 | 76.3 | 36.6 | 97.0 | 58 |
| 59 | 58.6 | 18.2 | 77.9 | 37.6 | 97.3 | 57.2 | 17.2 | 77.3 | 37.6 | 98.0 | 59 |
| 60 | 59.6 | 119.2 | 78.9 | 238.6 | 298.3 | 358.2 | 418.2 | 478.3 | 538.6 | 599.0 | 60 |
| | 0° | 1° | 2° | 3° | 4° | 5° | 6° | 7° | 8° | 9° | |

Table 5. Meridional Parts

| | 10° | 11° | 12° | 13° | 14° | 15° | 16° | 17° | 18° | 19° | |
|-----------|-------|-------|-------|-------|-------|-------|--------|--------|--------|--------|-----------|
| 0 | 599.0 | 659.6 | 720.5 | 781.5 | 842.8 | 904.4 | 966.3 | 1028.5 | 1091.0 | 1153.9 | 0 |
| 1 | 600.0 | 60.6 | 21.5 | 82.5 | 43.9 | 05.4 | 67.3 | 29.5 | 92.0 | 54.9 | 1 |
| 2 | 01.0 | 61.7 | 22.5 | 83.6 | 44.9 | 06.5 | 68.3 | 30.5 | 93.1 | 56.0 | 2 |
| 3 | 02.0 | 62.7 | 23.5 | 84.6 | 45.9 | 07.5 | 69.4 | 31.6 | 94.1 | 57.0 | 3 |
| 4 | 03.0 | 63.7 | 24.5 | 85.6 | 46.9 | 08.5 | 70.4 | 32.6 | 95.2 | 58.1 | 4 |
| 5 | 604.1 | 664.7 | 725.5 | 786.6 | 847.9 | 909.6 | 971.4 | 1033.7 | 1096.2 | 1159.1 | 5 |
| 6 | 05.1 | 65.7 | 26.6 | 87.6 | 49.0 | 10.6 | 72.5 | 34.7 | 97.3 | 60.2 | 6 |
| 7 | 06.1 | 66.7 | 27.6 | 88.7 | 50.0 | 11.6 | 73.5 | 35.7 | 98.3 | 61.2 | 7 |
| 8 | 07.1 | 67.7 | 28.6 | 89.7 | 51.0 | 12.6 | 74.6 | 36.8 | 99.4 | 62.3 | 8 |
| 9 | 08.1 | 68.7 | 29.6 | 90.7 | 52.0 | 13.7 | 75.6 | 37.8 | 100.4 | 63.3 | 9 |
| 10 | 609.1 | 669.8 | 730.6 | 791.7 | 853.1 | 914.7 | 976.6 | 1038.9 | 1101.4 | 1164.4 | 10 |
| 11 | 10.1 | 70.8 | 31.6 | 92.7 | 54.1 | 15.7 | 77.7 | 39.9 | 02.5 | 65.4 | 11 |
| 12 | 11.1 | 71.8 | 32.7 | 93.8 | 55.1 | 16.8 | 78.7 | 40.9 | 03.5 | 66.5 | 12 |
| 13 | 12.1 | 72.8 | 33.7 | 94.8 | 56.1 | 17.8 | 79.7 | 42.0 | 04.6 | 67.5 | 13 |
| 14 | 13.1 | 73.8 | 34.7 | 95.8 | 57.2 | 18.8 | 80.8 | 43.0 | 05.6 | 68.6 | 14 |
| 15 | 614.1 | 674.8 | 735.7 | 796.8 | 858.2 | 919.8 | 981.8 | 1044.1 | 1106.7 | 1169.7 | 15 |
| 16 | 15.2 | 75.8 | 36.7 | 97.8 | 59.2 | 20.9 | 82.8 | 45.1 | 07.7 | 70.7 | 16 |
| 17 | 16.2 | 76.8 | 37.7 | 98.9 | 60.2 | 21.9 | 83.9 | 46.1 | 08.8 | 71.8 | 17 |
| 18 | 17.2 | 77.9 | 38.8 | 99.9 | 61.3 | 22.9 | 84.9 | 47.2 | 09.8 | 72.8 | 18 |
| 19 | 18.2 | 78.9 | 39.8 | 800.9 | 62.3 | 24.0 | 85.9 | 48.2 | 10.9 | 73.9 | 19 |
| 20 | 619.2 | 679.9 | 740.8 | 801.9 | 863.3 | 925.0 | 987.0 | 1049.3 | 1111.9 | 1174.9 | 20 |
| 21 | 20.2 | 80.9 | 41.8 | 02.9 | 64.3 | 26.0 | 88.0 | 50.3 | 13.0 | 76.0 | 21 |
| 22 | 21.2 | 81.9 | 42.8 | 04.0 | 65.4 | 27.1 | 89.0 | 51.3 | 14.0 | 77.0 | 22 |
| 23 | 22.2 | 82.9 | 43.8 | 05.0 | 66.4 | 28.1 | 90.1 | 52.4 | 15.0 | 78.1 | 23 |
| 24 | 23.2 | 83.9 | 44.9 | 06.0 | 67.4 | 29.1 | 91.1 | 53.4 | 16.1 | 79.1 | 24 |
| 25 | 624.2 | 684.9 | 745.9 | 807.0 | 868.5 | 930.1 | 992.1 | 1054.5 | 1117.1 | 1180.2 | 25 |
| 26 | 25.3 | 86.0 | 46.9 | 08.1 | 69.5 | 31.2 | 93.2 | 55.5 | 18.2 | 81.2 | 26 |
| 27 | 26.3 | 87.0 | 47.9 | 09.1 | 70.5 | 32.2 | 94.2 | 56.6 | 19.2 | 82.3 | 27 |
| 28 | 27.3 | 88.0 | 48.9 | 10.1 | 71.5 | 33.2 | 95.3 | 57.6 | 20.3 | 83.3 | 28 |
| 29 | 28.3 | 89.0 | 49.9 | 11.1 | 72.6 | 34.3 | 96.3 | 58.6 | 21.3 | 84.4 | 29 |
| 30 | 629.3 | 690.0 | 751.0 | 812.1 | 873.6 | 935.3 | 997.3 | 1059.7 | 1122.4 | 1185.5 | 30 |
| 31 | 30.3 | 91.0 | 52.0 | 13.2 | 74.6 | 36.3 | 98.4 | 60.7 | 23.4 | 86.5 | 31 |
| 32 | 31.3 | 92.0 | 53.0 | 14.2 | 75.6 | 37.4 | 99.4 | 61.8 | 24.5 | 87.6 | 32 |
| 33 | 32.3 | 93.1 | 54.0 | 15.2 | 76.7 | 38.4 | 100.4 | 62.8 | 25.5 | 88.6 | 33 |
| 34 | 33.3 | 94.1 | 55.0 | 16.2 | 77.7 | 39.4 | 01.5 | 63.9 | 26.6 | 89.7 | 34 |
| 35 | 634.3 | 695.1 | 756.0 | 817.3 | 878.7 | 940.5 | 1002.5 | 1064.9 | 1127.6 | 1190.7 | 35 |
| 36 | 35.4 | 96.1 | 57.1 | 18.3 | 79.7 | 41.5 | 03.6 | 65.9 | 28.7 | 91.8 | 36 |
| 37 | 36.4 | 97.1 | 58.1 | 19.3 | 80.8 | 42.5 | 04.6 | 67.0 | 29.7 | 92.8 | 37 |
| 38 | 37.4 | 98.1 | 59.1 | 20.3 | 81.8 | 43.6 | 05.6 | 68.0 | 30.8 | 93.9 | 38 |
| 39 | 38.4 | 99.1 | 60.1 | 21.3 | 82.8 | 44.6 | 06.7 | 69.1 | 31.8 | 95.0 | 39 |
| 40 | 639.4 | 700.2 | 761.1 | 822.4 | 883.8 | 945.6 | 1007.7 | 1070.1 | 1132.9 | 1196.0 | 40 |
| 41 | 40.4 | 01.2 | 62.2 | 23.4 | 84.9 | 46.7 | 08.7 | 71.2 | 33.9 | 97.1 | 41 |
| 42 | 41.4 | 02.2 | 63.2 | 24.4 | 85.9 | 47.7 | 09.8 | 72.2 | 35.0 | 98.1 | 42 |
| 43 | 42.4 | 03.2 | 64.2 | 25.4 | 86.9 | 48.7 | 10.8 | 73.2 | 36.0 | 99.2 | 43 |
| 44 | 43.4 | 04.2 | 65.2 | 26.5 | 88.0 | 49.7 | 11.8 | 74.3 | 37.1 | 1200.2 | 44 |
| 45 | 644.5 | 705.2 | 766.2 | 827.5 | 889.0 | 950.8 | 1012.9 | 1075.3 | 1138.1 | 1201.3 | 45 |
| 46 | 45.5 | 06.2 | 67.3 | 28.5 | 90.0 | 51.8 | 13.9 | 76.4 | 39.2 | 02.3 | 46 |
| 47 | 46.5 | 07.3 | 68.3 | 29.5 | 91.0 | 52.8 | 15.0 | 77.4 | 40.2 | 03.4 | 47 |
| 48 | 47.5 | 08.3 | 69.3 | 30.5 | 92.1 | 53.9 | 16.0 | 78.5 | 41.3 | 04.5 | 48 |
| 49 | 48.5 | 09.3 | 70.3 | 31.6 | 93.1 | 54.9 | 17.0 | 79.5 | 42.3 | 05.5 | 49 |
| 50 | 649.5 | 710.3 | 771.3 | 832.6 | 894.1 | 955.9 | 1018.1 | 1080.5 | 1143.4 | 1206.6 | 50 |
| 51 | 50.5 | 11.3 | 72.3 | 33.6 | 95.2 | 57.0 | 19.1 | 81.6 | 44.4 | 07.6 | 51 |
| 52 | 51.5 | 12.3 | 73.4 | 34.6 | 96.2 | 58.0 | 20.2 | 82.6 | 45.5 | 08.7 | 52 |
| 53 | 52.5 | 13.4 | 74.4 | 35.7 | 97.2 | 59.0 | 21.2 | 83.7 | 46.5 | 09.7 | 53 |
| 54 | 53.6 | 14.4 | 75.4 | 36.7 | 98.2 | 60.1 | 22.2 | 84.7 | 47.6 | 10.8 | 54 |
| 55 | 654.6 | 715.4 | 776.4 | 837.7 | 899.3 | 961.1 | 1023.3 | 1085.8 | 1148.6 | 1211.8 | 55 |
| 56 | 55.6 | 16.4 | 77.4 | 38.7 | 900.3 | 62.1 | 24.3 | 86.8 | 49.7 | 12.9 | 56 |
| 57 | 56.6 | 17.4 | 78.5 | 39.8 | 01.3 | 63.2 | 25.3 | 87.9 | 50.7 | 14.0 | 57 |
| 58 | 57.6 | 18.4 | 79.5 | 40.8 | 02.3 | 64.2 | 26.4 | 88.9 | 51.8 | 15.0 | 58 |
| 59 | 58.6 | 19.4 | 80.5 | 41.8 | 03.4 | 65.2 | 27.4 | 89.9 | 52.8 | 16.1 | 59 |
| 60 | 659.6 | 720.5 | 781.5 | 842.8 | 904.4 | 966.3 | 1028.5 | 1091.0 | 1153.9 | 1217.1 | 60 |
| | 10° | 11° | 12° | 13° | 14° | 15° | 16° | 17° | 18° | 19° | |

Table 5. Meridional Parts

| | 20° | 21° | 22° | 23° | 24° | 25° | 26° | 27° | 28° | 29° | |
|-----------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-----------|
| 0 | 1217.1 | 1280.8 | 1344.9 | 1409.5 | 1474.5 | 1540.1 | 1606.2 | 1672.9 | 1740.2 | 1808.1 | 0 |
| 1 | 18.2 | 81.9 | 46.0 | 10.6 | 75.6 | 41.2 | 07.3 | 74.0 | 41.3 | 09.2 | 1 |
| 2 | 19.3 | 82.9 | 47.1 | 11.6 | 76.7 | 42.3 | 08.4 | 75.1 | 42.4 | 10.4 | 2 |
| 3 | 20.3 | 84.0 | 48.1 | 12.7 | 77.8 | 43.4 | 09.5 | 76.2 | 43.6 | 11.5 | 3 |
| 4 | 21.4 | 85.1 | 49.2 | 13.8 | 78.9 | 44.5 | 10.6 | 77.4 | 44.7 | 12.6 | 4 |
| 5 | 1222.4 | 1286.1 | 1350.3 | 1414.9 | 1480.0 | 1545.6 | 1611.7 | 1678.5 | 1745.8 | 1813.8 | 5 |
| 6 | 23.5 | 87.2 | 51.4 | 16.0 | 81.1 | 46.7 | 12.9 | 79.6 | 46.9 | 14.9 | 6 |
| 7 | 24.5 | 88.3 | 52.4 | 17.1 | 82.2 | 47.8 | 14.0 | 80.7 | 48.1 | 16.1 | 7 |
| 8 | 25.6 | 89.3 | 53.5 | 18.1 | 83.3 | 48.9 | 15.1 | 81.8 | 49.2 | 17.2 | 8 |
| 9 | 26.7 | 90.4 | 54.6 | 19.2 | 84.3 | 50.0 | 16.2 | 82.9 | 50.3 | 18.3 | 9 |
| 10 | 1227.7 | 1291.5 | 1355.7 | 1420.3 | 1485.4 | 1551.1 | 1617.3 | 1684.1 | 1751.5 | 1819.5 | 10 |
| 11 | 28.8 | 92.5 | 56.7 | 21.4 | 86.5 | 52.2 | 18.4 | 85.2 | 52.6 | 20.6 | 11 |
| 12 | 29.8 | 93.6 | 57.8 | 22.5 | 87.6 | 53.3 | 19.5 | 86.3 | 53.7 | 21.8 | 12 |
| 13 | 30.9 | 94.7 | 58.9 | 23.5 | 88.7 | 54.4 | 20.6 | 87.4 | 54.8 | 22.9 | 13 |
| 14 | 32.0 | 95.7 | 59.9 | 24.6 | 89.8 | 55.5 | 21.7 | 88.5 | 56.0 | 24.0 | 14 |
| 15 | 1233.0 | 1296.8 | 1361.0 | 1425.7 | 1490.9 | 1556.6 | 1622.8 | 1689.7 | 1757.1 | 1825.2 | 15 |
| 16 | 34.1 | 97.9 | 62.1 | 26.8 | 92.0 | 57.7 | 23.9 | 90.8 | 58.2 | 26.3 | 16 |
| 17 | 35.1 | 98.9 | 63.2 | 27.9 | 93.1 | 58.8 | 25.0 | 91.9 | 59.4 | 27.5 | 17 |
| 18 | 36.2 | 1300.0 | 64.2 | 29.0 | 94.2 | 59.9 | 26.2 | 93.0 | 60.5 | 28.6 | 18 |
| 19 | 37.3 | 01.1 | 65.3 | 30.0 | 95.2 | 61.0 | 27.3 | 94.1 | 61.6 | 29.7 | 19 |
| 20 | 1238.3 | 1302.1 | 1366.4 | 1431.1 | 1496.3 | 1562.1 | 1628.4 | 1695.3 | 1762.7 | 1830.9 | 20 |
| 21 | 39.4 | 03.2 | 67.5 | 32.2 | 97.4 | 63.2 | 29.5 | 96.4 | 63.9 | 32.0 | 21 |
| 22 | 40.4 | 04.3 | 68.5 | 33.3 | 98.5 | 64.3 | 30.6 | 97.5 | 65.0 | 33.2 | 22 |
| 23 | 41.5 | 05.3 | 69.6 | 34.4 | 99.6 | 65.4 | 31.7 | 98.6 | 66.1 | 34.3 | 23 |
| 24 | 42.6 | 06.4 | 70.7 | 35.4 | 1500.7 | 66.5 | 32.8 | 99.7 | 67.3 | 35.4 | 24 |
| 25 | 1243.6 | 1307.5 | 1371.8 | 1436.5 | 1501.8 | 1567.6 | 1633.9 | 1700.9 | 1768.4 | 1836.6 | 25 |
| 26 | 44.7 | 08.5 | 72.8 | 37.6 | 02.9 | 68.7 | 35.0 | 02.0 | 69.5 | 37.7 | 26 |
| 27 | 45.7 | 09.6 | 73.9 | 38.7 | 04.0 | 69.8 | 36.1 | 03.1 | 70.7 | 38.9 | 27 |
| 28 | 46.8 | 10.7 | 75.0 | 39.8 | 05.1 | 70.9 | 37.3 | 04.2 | 71.8 | 40.0 | 28 |
| 29 | 47.9 | 11.7 | 76.1 | 40.9 | 06.2 | 72.0 | 38.4 | 05.3 | 72.9 | 41.2 | 29 |
| 30 | 1248.9 | 1312.8 | 1377.1 | 1442.0 | 1507.3 | 1573.1 | 1639.5 | 1706.5 | 1774.1 | 1842.3 | 30 |
| 31 | 50.0 | 13.9 | 78.2 | 43.0 | 08.4 | 74.2 | 40.6 | 07.6 | 75.2 | 43.4 | 31 |
| 32 | 51.0 | 14.9 | 79.3 | 44.1 | 09.4 | 75.3 | 41.7 | 08.7 | 76.3 | 44.6 | 32 |
| 33 | 52.1 | 16.0 | 80.4 | 45.2 | 10.5 | 76.4 | 42.8 | 09.8 | 77.4 | 45.7 | 33 |
| 34 | 53.2 | 17.1 | 81.5 | 46.3 | 11.6 | 77.5 | 43.9 | 10.9 | 78.6 | 46.9 | 34 |
| 35 | 1254.2 | 1318.2 | 1382.5 | 1447.4 | 1512.7 | 1578.6 | 1645.0 | 1712.1 | 1779.7 | 1848.0 | 35 |
| 36 | 55.3 | 19.2 | 83.6 | 48.5 | 13.8 | 79.7 | 46.2 | 13.2 | 80.8 | 49.2 | 36 |
| 37 | 56.4 | 20.3 | 84.7 | 49.5 | 14.9 | 80.8 | 47.3 | 14.3 | 82.0 | 50.3 | 37 |
| 38 | 57.4 | 21.4 | 85.8 | 50.6 | 16.0 | 81.9 | 48.4 | 15.4 | 83.1 | 51.4 | 38 |
| 39 | 58.5 | 22.4 | 86.8 | 51.7 | 17.1 | 83.0 | 49.5 | 16.6 | 84.2 | 52.6 | 39 |
| 40 | 1259.5 | 1323.5 | 1387.9 | 1452.8 | 1518.2 | 1584.1 | 1650.6 | 1717.7 | 1785.4 | 1853.7 | 40 |
| 41 | 60.6 | 24.6 | 89.0 | 53.9 | 19.3 | 85.2 | 51.7 | 18.8 | 86.5 | 54.9 | 41 |
| 42 | 61.7 | 25.6 | 90.1 | 55.0 | 20.4 | 86.3 | 52.8 | 19.9 | 87.6 | 56.0 | 42 |
| 43 | 62.7 | 26.7 | 91.1 | 56.1 | 21.5 | 87.4 | 53.9 | 21.1 | 88.8 | 57.2 | 43 |
| 44 | 63.8 | 27.8 | 92.2 | 57.1 | 22.6 | 88.5 | 55.1 | 22.2 | 89.9 | 58.3 | 44 |
| 45 | 1264.9 | 1328.9 | 1393.3 | 1458.2 | 1523.7 | 1589.6 | 1656.2 | 1723.3 | 1791.1 | 1859.5 | 45 |
| 46 | 65.9 | 29.9 | 94.4 | 59.3 | 24.8 | 90.7 | 57.3 | 24.4 | 92.2 | 60.6 | 46 |
| 47 | 67.0 | 31.0 | 95.5 | 60.4 | 25.9 | 91.8 | 58.4 | 25.5 | 93.3 | 61.8 | 47 |
| 48 | 68.0 | 32.1 | 96.5 | 61.5 | 27.0 | 92.9 | 59.5 | 26.7 | 94.5 | 62.9 | 48 |
| 49 | 69.1 | 33.1 | 97.6 | 62.6 | 28.0 | 94.1 | 60.6 | 27.8 | 95.6 | 64.0 | 49 |
| 50 | 1270.2 | 1334.2 | 1398.7 | 1463.7 | 1529.1 | 1595.2 | 1661.7 | 1728.9 | 1796.7 | 1865.2 | 50 |
| 51 | 71.2 | 35.3 | 99.8 | 64.8 | 30.2 | 96.3 | 62.9 | 30.0 | 97.9 | 66.3 | 51 |
| 52 | 72.3 | 36.3 | 1400.9 | 65.8 | 31.3 | 97.4 | 64.0 | 31.2 | 99.0 | 67.5 | 52 |
| 53 | 73.4 | 37.4 | 01.9 | 66.9 | 32.4 | 98.5 | 65.1 | 32.3 | 1800.1 | 68.6 | 53 |
| 54 | 74.4 | 38.5 | 03.0 | 68.0 | 33.5 | 99.6 | 66.2 | 33.4 | 01.3 | 69.8 | 54 |
| 55 | 1275.5 | 1339.6 | 1404.1 | 1469.1 | 1534.6 | 1600.7 | 1667.3 | 1734.5 | 1802.4 | 1870.9 | 55 |
| 56 | 76.6 | 40.6 | 05.2 | 70.2 | 35.7 | 01.8 | 68.4 | 35.7 | 03.5 | 72.1 | 56 |
| 57 | 77.6 | 41.7 | 06.2 | 71.3 | 36.8 | 02.9 | 69.5 | 36.8 | 04.7 | 73.2 | 57 |
| 58 | 78.7 | 42.8 | 07.3 | 72.4 | 37.9 | 04.0 | 70.7 | 37.9 | 05.8 | 74.4 | 58 |
| 59 | 79.7 | 43.8 | 08.4 | 73.5 | 39.0 | 05.1 | 71.8 | 39.1 | 07.0 | 75.5 | 59 |
| 60 | 1280.8 | 1344.9 | 1409.5 | 1474.5 | 1540.1 | 1606.2 | 1672.9 | 1740.2 | 1808.1 | 1876.7 | 60 |
| | 20° | 21° | 22° | 23° | 24° | 25° | 26° | 27° | 28° | 29° | |

Table 5. Meridional Parts

| | 30° | 31° | 32° | 33° | 34° | 35° | 36° | 37° | 38° | 39° | |
|-----------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-----------|
| 0 | 1876.7 | 1946.0 | 2016.0 | 2086.8 | 2158.4 | 2230.9 | 2304.2 | 2378.5 | 2453.8 | 2530.2 | 0 |
| 1 | 77.8 | 47.1 | 17.2 | 88.0 | 59.6 | 32.1 | 05.5 | 79.8 | 55.1 | 31.5 | 1 |
| 2 | 79.0 | 48.3 | 18.3 | 89.2 | 60.8 | 33.3 | 06.7 | 81.0 | 56.4 | 32.8 | 2 |
| 3 | 80.1 | 49.4 | 19.5 | 90.3 | 62.0 | 34.5 | 07.9 | 82.3 | 57.6 | 34.0 | 3 |
| 4 | 81.3 | 50.6 | 20.7 | 91.5 | 63.2 | 35.7 | 09.2 | 83.5 | 58.9 | 35.3 | 4 |
| 5 | 1882.4 | 1951.8 | 2021.9 | 2092.7 | 2164.4 | 2236.9 | 2310.4 | 2384.8 | 2460.2 | 2536.6 | 5 |
| 6 | 83.6 | 52.9 | 23.0 | 93.9 | 65.6 | 38.2 | 11.6 | 86.0 | 61.4 | 37.9 | 6 |
| 7 | 84.7 | 54.1 | 24.2 | 95.1 | 66.8 | 39.4 | 12.9 | 87.3 | 62.7 | 39.2 | 7 |
| 8 | 85.9 | 55.3 | 25.4 | 96.3 | 68.0 | 40.6 | 14.1 | 88.5 | 64.0 | 40.5 | 8 |
| 9 | 87.0 | 56.4 | 26.6 | 97.5 | 69.2 | 41.8 | 15.3 | 89.8 | 65.2 | 41.7 | 9 |
| 10 | 1888.2 | 1957.6 | 2027.7 | 2098.7 | 2170.4 | 2243.0 | 2316.5 | 2391.0 | 2466.5 | 2543.0 | 10 |
| 11 | 89.3 | 58.7 | 28.9 | 99.8 | 71.6 | 44.2 | 17.8 | 92.3 | 67.8 | 44.3 | 11 |
| 12 | 90.5 | 59.9 | 30.1 | 2101.0 | 72.8 | 45.5 | 19.0 | 93.5 | 69.0 | 45.6 | 12 |
| 13 | 91.6 | 61.1 | 31.3 | 02.2 | 74.0 | 46.7 | 20.3 | 94.8 | 70.3 | 46.9 | 13 |
| 14 | 92.8 | 62.2 | 32.4 | 03.4 | 75.2 | 47.9 | 21.5 | 96.0 | 71.6 | 48.2 | 14 |
| 15 | 1893.9 | 1963.4 | 2033.6 | 2104.6 | 2176.4 | 2249.1 | 2322.7 | 2397.3 | 2472.8 | 2549.5 | 15 |
| 16 | 95.1 | 64.6 | 34.8 | 05.8 | 77.6 | 50.3 | 24.0 | 98.5 | 74.1 | 50.7 | 16 |
| 17 | 96.2 | 65.7 | 36.0 | 07.0 | 78.8 | 51.6 | 25.2 | 99.8 | 75.4 | 52.0 | 17 |
| 18 | 97.4 | 66.9 | 37.1 | 08.2 | 80.0 | 52.8 | 26.4 | 2401.0 | 76.6 | 53.3 | 18 |
| 19 | 98.5 | 68.1 | 38.3 | 09.4 | 81.2 | 54.0 | 27.7 | 02.3 | 77.9 | 54.6 | 19 |
| 20 | 1899.7 | 1969.2 | 2039.5 | 2110.6 | 2182.5 | 2255.2 | 2328.9 | 2403.5 | 2479.2 | 2555.9 | 20 |
| 21 | 1900.8 | 70.4 | 40.7 | 11.8 | 83.7 | 56.4 | 30.1 | 04.8 | 80.4 | 57.2 | 21 |
| 22 | 02.0 | 71.5 | 41.8 | 12.9 | 84.9 | 57.7 | 31.4 | 06.0 | 81.7 | 58.5 | 22 |
| 23 | 03.1 | 72.7 | 43.0 | 14.1 | 86.1 | 58.9 | 32.6 | 07.3 | 83.0 | 59.8 | 23 |
| 24 | 04.3 | 73.9 | 44.2 | 15.3 | 87.3 | 60.1 | 33.8 | 08.5 | 84.3 | 61.0 | 24 |
| 25 | 1905.5 | 1975.0 | 2045.4 | 2116.5 | 2188.5 | 2261.3 | 2335.1 | 2409.8 | 2485.5 | 2562.3 | 25 |
| 26 | 06.6 | 76.2 | 46.6 | 17.7 | 89.7 | 62.5 | 36.3 | 11.1 | 86.8 | 63.6 | 26 |
| 27 | 07.8 | 77.4 | 47.7 | 18.9 | 90.9 | 63.8 | 37.6 | 12.3 | 88.1 | 64.9 | 27 |
| 28 | 08.9 | 78.5 | 48.9 | 20.1 | 92.1 | 65.0 | 38.8 | 13.6 | 89.3 | 66.2 | 28 |
| 29 | 10.1 | 79.7 | 50.1 | 21.3 | 93.3 | 66.2 | 40.0 | 14.8 | 90.6 | 67.5 | 29 |
| 30 | 1911.2 | 1980.9 | 2051.3 | 2122.5 | 2194.5 | 2267.4 | 2341.3 | 2416.1 | 2491.9 | 2568.8 | 30 |
| 31 | 12.4 | 82.0 | 52.5 | 23.7 | 95.7 | 68.7 | 42.5 | 17.3 | 93.2 | 70.1 | 31 |
| 32 | 13.5 | 83.2 | 53.6 | 24.9 | 96.9 | 69.9 | 43.7 | 18.6 | 94.4 | 71.4 | 32 |
| 33 | 14.7 | 84.4 | 54.8 | 26.1 | 98.1 | 71.1 | 45.0 | 19.8 | 95.7 | 72.7 | 33 |
| 34 | 15.8 | 85.5 | 56.0 | 27.3 | 99.4 | 72.3 | 46.2 | 21.1 | 97.0 | 73.9 | 34 |
| 35 | 1917.0 | 1986.7 | 2057.2 | 2128.5 | 2200.6 | 2273.5 | 2347.5 | 2422.3 | 2498.3 | 2575.2 | 35 |
| 36 | 18.2 | 87.9 | 58.4 | 29.6 | 01.8 | 74.8 | 48.7 | 23.6 | 99.5 | 76.5 | 36 |
| 37 | 19.3 | 89.1 | 59.5 | 30.8 | 03.0 | 76.0 | 49.9 | 24.9 | 2500.8 | 77.8 | 37 |
| 38 | 20.5 | 90.2 | 60.7 | 32.0 | 04.2 | 77.2 | 51.2 | 26.1 | 02.1 | 79.1 | 38 |
| 39 | 21.6 | 91.4 | 61.9 | 33.2 | 05.4 | 78.4 | 52.4 | 27.4 | 03.4 | 80.4 | 39 |
| 40 | 1922.8 | 1992.6 | 2063.1 | 2134.4 | 2206.6 | 2279.7 | 2353.7 | 2428.6 | 2504.6 | 2581.7 | 40 |
| 41 | 23.9 | 93.7 | 64.3 | 35.6 | 07.8 | 80.9 | 54.9 | 29.9 | 05.9 | 83.0 | 41 |
| 42 | 25.1 | 94.9 | 65.5 | 36.8 | 09.0 | 82.1 | 56.1 | 31.2 | 07.2 | 84.3 | 42 |
| 43 | 26.3 | 96.1 | 66.6 | 38.0 | 10.2 | 83.3 | 57.4 | 32.4 | 08.5 | 85.6 | 43 |
| 44 | 27.4 | 97.2 | 67.8 | 39.2 | 11.5 | 84.6 | 58.6 | 33.7 | 09.7 | 86.9 | 44 |
| 45 | 1928.6 | 1998.4 | 2069.0 | 2140.4 | 2212.7 | 2285.8 | 2359.9 | 2434.9 | 2511.0 | 2588.2 | 45 |
| 46 | 29.7 | 99.6 | 70.2 | 41.6 | 13.9 | 87.0 | 61.1 | 36.2 | 12.3 | 89.5 | 46 |
| 47 | 30.9 | 2000.7 | 71.4 | 42.8 | 15.1 | 88.3 | 62.4 | 37.4 | 13.6 | 90.8 | 47 |
| 48 | 32.0 | 01.9 | 72.6 | 44.0 | 16.3 | 89.5 | 63.6 | 38.7 | 14.8 | 92.1 | 48 |
| 49 | 33.2 | 03.1 | 73.7 | 45.2 | 17.5 | 90.7 | 64.8 | 40.0 | 16.1 | 93.4 | 49 |
| 50 | 1934.4 | 2004.3 | 2074.9 | 2146.4 | 2218.7 | 2291.9 | 2366.1 | 2441.2 | 2517.4 | 2594.7 | 50 |
| 51 | 35.5 | 05.4 | 76.1 | 47.6 | 19.9 | 93.2 | 67.3 | 42.5 | 18.7 | 96.0 | 51 |
| 52 | 36.7 | 06.6 | 77.3 | 48.8 | 21.1 | 94.4 | 68.6 | 43.7 | 20.0 | 97.3 | 52 |
| 53 | 37.8 | 07.8 | 78.5 | 50.0 | 22.4 | 95.6 | 69.8 | 45.0 | 21.2 | 98.5 | 53 |
| 54 | 39.0 | 08.9 | 79.7 | 51.2 | 23.6 | 96.9 | 71.1 | 46.3 | 22.5 | 99.8 | 54 |
| 55 | 1940.2 | 2010.1 | 2080.8 | 2152.4 | 2224.8 | 2298.1 | 2372.3 | 2447.5 | 2523.8 | 2601.1 | 55 |
| 56 | 41.3 | 11.3 | 82.0 | 53.6 | 26.0 | 99.3 | 73.6 | 48.8 | 25.1 | 02.4 | 56 |
| 57 | 42.5 | 12.5 | 83.2 | 54.8 | 27.2 | 2300.5 | 74.8 | 50.1 | 26.4 | 03.7 | 57 |
| 58 | 43.6 | 13.6 | 84.4 | 56.0 | 28.4 | 01.8 | 76.1 | 51.3 | 27.6 | 05.0 | 58 |
| 59 | 44.8 | 14.8 | 85.6 | 57.2 | 29.6 | 03.0 | 77.3 | 52.6 | 28.9 | 06.3 | 59 |
| 60 | 1946.0 | 2016.0 | 2086.8 | 2158.4 | 2230.9 | 2304.2 | 2378.5 | 2453.8 | 2530.2 | 2607.6 | 60 |
| | 30° | 31° | 32° | 33° | 34° | 35° | 36° | 37° | 38° | 39° | |

Table 5. Meridional Parts

| | 40° | 41° | 42° | 43° | 44° | 45° | 46° | 47° | 48° | 49° | |
|----|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|----|
| 0 | 2607.6 | 2686.2 | 2766.0 | 2847.1 | 2929.5 | 3013.4 | 3098.7 | 3185.6 | 3274.1 | 3364.4 | 0 |
| 1 | 08.9 | 87.6 | 67.4 | 48.5 | 30.9 | 14.8 | 3100.1 | 87.1 | 75.6 | 65.9 | 1 |
| 2 | 10.2 | 88.9 | 68.7 | 49.9 | 32.3 | 16.2 | 01.6 | 88.5 | 77.1 | 67.4 | 2 |
| 3 | 11.5 | 90.2 | 70.1 | 51.2 | 33.7 | 17.6 | 03.0 | 90.0 | 78.6 | 69.0 | 3 |
| 4 | 12.8 | 91.5 | 71.4 | 52.6 | 35.1 | 19.0 | 04.4 | 91.4 | 80.1 | 70.5 | 4 |
| 5 | 2614.1 | 2692.8 | 2772.8 | 2853.9 | 2936.5 | 3020.4 | 3105.9 | 3192.9 | 3281.6 | 3372.0 | 5 |
| 6 | 15.4 | 94.2 | 74.1 | 55.3 | 37.9 | 21.8 | 07.3 | 94.4 | 83.1 | 73.5 | 6 |
| 7 | 16.8 | 95.5 | 75.4 | 56.7 | 39.3 | 23.3 | 08.8 | 95.8 | 84.6 | 75.1 | 7 |
| 8 | 18.1 | 96.8 | 76.8 | 58.0 | 40.6 | 24.7 | 10.2 | 97.3 | 86.1 | 76.6 | 8 |
| 9 | 19.4 | 98.1 | 78.1 | 59.4 | 42.0 | 26.1 | 11.6 | 98.8 | 87.6 | 78.1 | 9 |
| 10 | 2620.7 | 2699.5 | 2779.5 | 2860.8 | 2943.4 | 3027.5 | 3113.1 | 3200.2 | 3289.0 | 3379.6 | 10 |
| 11 | 22.0 | 2700.8 | 80.8 | 62.1 | 44.8 | 28.9 | 14.5 | 01.7 | 90.5 | 81.2 | 11 |
| 12 | 23.3 | 02.1 | 82.2 | 63.5 | 46.2 | 30.3 | 16.0 | 03.2 | 92.0 | 82.7 | 12 |
| 13 | 24.6 | 03.4 | 83.5 | 64.9 | 47.6 | 31.7 | 17.4 | 04.6 | 93.5 | 84.2 | 13 |
| 14 | 25.9 | 04.8 | 84.8 | 66.2 | 49.0 | 33.2 | 18.8 | 06.1 | 95.0 | 85.7 | 14 |
| 15 | 2627.2 | 2706.1 | 2786.2 | 2867.6 | 2950.4 | 3034.6 | 3120.3 | 3207.6 | 3296.5 | 3387.3 | 15 |
| 16 | 28.5 | 07.4 | 87.5 | 69.0 | 51.8 | 36.0 | 21.7 | 09.0 | 98.0 | 88.8 | 16 |
| 17 | 29.8 | 08.7 | 88.9 | 70.3 | 53.2 | 37.4 | 23.2 | 10.5 | 99.5 | 90.3 | 17 |
| 18 | 31.1 | 10.1 | 90.2 | 71.7 | 54.5 | 38.8 | 24.6 | 12.0 | 3301.0 | 91.8 | 18 |
| 19 | 32.4 | 11.4 | 91.6 | 73.1 | 55.9 | 40.2 | 26.0 | 13.4 | 02.5 | 93.4 | 19 |
| 20 | 2633.7 | 2712.7 | 2792.9 | 2874.4 | 2957.3 | 3041.7 | 3127.5 | 3214.9 | 3304.0 | 3394.9 | 20 |
| 21 | 35.0 | 14.0 | 94.3 | 75.8 | 58.7 | 43.1 | 28.9 | 16.4 | 05.5 | 96.4 | 21 |
| 22 | 36.3 | 15.4 | 95.6 | 77.2 | 60.1 | 44.5 | 30.4 | 17.9 | 07.0 | 98.0 | 22 |
| 23 | 37.6 | 16.7 | 97.0 | 78.6 | 61.5 | 45.9 | 31.8 | 19.3 | 08.5 | 99.5 | 23 |
| 24 | 38.9 | 18.0 | 98.3 | 79.9 | 62.9 | 47.3 | 33.3 | 20.8 | 10.0 | 3401.0 | 24 |
| 25 | 2640.2 | 2719.3 | 2799.7 | 2881.3 | 2964.3 | 3048.7 | 3134.7 | 3222.3 | 3311.5 | 3402.6 | 25 |
| 26 | 41.6 | 20.7 | 2801.0 | 82.7 | 65.7 | 50.2 | 36.2 | 23.7 | 13.0 | 04.1 | 26 |
| 27 | 42.9 | 22.0 | 02.4 | 84.0 | 67.1 | 51.6 | 37.6 | 25.2 | 14.5 | 05.6 | 27 |
| 28 | 44.2 | 23.3 | 03.7 | 85.4 | 68.5 | 53.0 | 39.0 | 26.7 | 16.0 | 07.2 | 28 |
| 29 | 45.5 | 24.7 | 05.1 | 86.8 | 69.9 | 54.4 | 40.5 | 28.2 | 17.5 | 08.7 | 29 |
| 30 | 2646.8 | 2726.0 | 2806.4 | 2888.2 | 2971.3 | 3055.9 | 3141.9 | 3229.6 | 3319.0 | 3410.2 | 30 |
| 31 | 48.1 | 27.3 | 07.8 | 89.5 | 72.7 | 57.3 | 43.4 | 31.1 | 20.5 | 11.8 | 31 |
| 32 | 49.4 | 28.6 | 09.1 | 90.9 | 74.1 | 58.7 | 44.8 | 32.6 | 22.1 | 13.3 | 32 |
| 33 | 50.7 | 30.0 | 10.5 | 92.3 | 75.5 | 60.1 | 46.3 | 34.1 | 23.6 | 14.8 | 33 |
| 34 | 52.0 | 31.3 | 11.8 | 93.7 | 76.9 | 61.5 | 47.7 | 35.6 | 25.1 | 16.4 | 34 |
| 35 | 2653.3 | 2732.6 | 2813.2 | 2895.0 | 2978.3 | 3063.0 | 3149.2 | 3237.0 | 3326.6 | 3417.9 | 35 |
| 36 | 54.7 | 34.0 | 14.5 | 96.4 | 79.7 | 64.4 | 50.6 | 38.5 | 28.1 | 19.5 | 36 |
| 37 | 56.0 | 35.3 | 15.9 | 97.8 | 81.1 | 65.8 | 52.1 | 40.0 | 29.6 | 21.0 | 37 |
| 38 | 57.3 | 36.6 | 17.2 | 99.2 | 82.5 | 67.2 | 53.5 | 41.5 | 31.1 | 22.5 | 38 |
| 39 | 58.6 | 38.0 | 18.6 | 2900.5 | 83.9 | 68.7 | 55.0 | 42.9 | 32.6 | 24.1 | 39 |
| 40 | 2659.9 | 2739.3 | 2820.0 | 2901.9 | 2985.3 | 3070.1 | 3156.4 | 3244.4 | 3334.1 | 3425.6 | 40 |
| 41 | 61.2 | 40.6 | 21.3 | 03.3 | 86.7 | 71.5 | 57.9 | 45.9 | 35.6 | 27.2 | 41 |
| 42 | 62.5 | 42.0 | 22.7 | 04.7 | 88.1 | 72.9 | 59.4 | 47.4 | 37.1 | 28.7 | 42 |
| 43 | 63.9 | 43.3 | 24.0 | 06.1 | 89.5 | 74.4 | 60.8 | 48.9 | 38.6 | 30.2 | 43 |
| 44 | 65.2 | 44.6 | 25.4 | 07.4 | 90.9 | 75.8 | 62.3 | 50.3 | 40.2 | 31.8 | 44 |
| 45 | 2666.5 | 2746.0 | 2826.7 | 2908.8 | 2992.3 | 3077.2 | 3163.7 | 3251.8 | 3341.7 | 3433.3 | 45 |
| 46 | 67.8 | 47.3 | 28.1 | 10.2 | 93.7 | 78.7 | 65.2 | 53.3 | 43.2 | 34.9 | 46 |
| 47 | 69.1 | 48.6 | 29.4 | 11.6 | 95.1 | 80.1 | 66.6 | 54.8 | 44.7 | 36.4 | 47 |
| 48 | 70.4 | 50.0 | 30.8 | 13.0 | 96.5 | 81.5 | 68.1 | 56.3 | 46.2 | 38.0 | 48 |
| 49 | 71.7 | 51.3 | 32.2 | 14.3 | 97.9 | 82.9 | 69.5 | 57.8 | 47.7 | 39.5 | 49 |
| 50 | 2673.1 | 2752.7 | 2833.5 | 2915.7 | 2999.3 | 3084.4 | 3171.0 | 3259.3 | 3349.2 | 3441.0 | 50 |
| 51 | 74.4 | 54.0 | 34.9 | 17.1 | 3000.7 | 85.8 | 72.5 | 60.7 | 50.8 | 42.6 | 51 |
| 52 | 75.7 | 55.3 | 36.2 | 18.5 | 02.1 | 87.2 | 73.9 | 62.2 | 52.3 | 44.1 | 52 |
| 53 | 77.0 | 56.7 | 37.6 | 19.9 | 03.5 | 88.7 | 75.4 | 63.7 | 53.8 | 45.7 | 53 |
| 54 | 78.3 | 58.0 | 39.0 | 21.2 | 04.9 | 90.1 | 76.8 | 65.2 | 55.3 | 47.2 | 54 |
| 55 | 2679.6 | 2759.3 | 2840.3 | 2922.6 | 3006.3 | 3091.5 | 3178.3 | 3266.7 | 3356.8 | 3448.8 | 55 |
| 56 | 81.0 | 60.7 | 41.7 | 24.0 | 07.7 | 93.0 | 79.7 | 68.2 | 58.3 | 50.3 | 56 |
| 57 | 82.3 | 62.0 | 43.0 | 25.4 | 09.2 | 94.4 | 81.2 | 69.7 | 59.9 | 51.9 | 57 |
| 58 | 83.6 | 63.4 | 44.4 | 26.8 | 10.6 | 95.8 | 82.7 | 71.1 | 61.4 | 53.4 | 58 |
| 59 | 84.9 | 64.7 | 45.8 | 28.2 | 12.0 | 97.3 | 84.1 | 72.6 | 62.9 | 55.0 | 59 |
| 60 | 2686.2 | 2766.0 | 2847.1 | 2929.5 | 3013.4 | 3098.7 | 3185.6 | 3274.1 | 3364.4 | 3456.5 | 60 |
| | 40° | 41° | 42° | 43° | 44° | 45° | 46° | 47° | 48° | 49° | |

Table 5. Meridional Parts

| | 50° | 51° | 52° | 53° | 54° | 55° | 56° | 57° | 58° | 59° | |
|-----------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-----------|
| 0 | 3456.5 | 3550.6 | 3646.7 | 3745.1 | 3845.7 | 3948.8 | 4054.5 | 4163.0 | 4274.4 | 4389.1 | 0 |
| 1 | 58.1 | 52.2 | 48.4 | 46.7 | 47.4 | 50.5 | 56.3 | 64.8 | 76.3 | 91.0 | 1 |
| 2 | 59.6 | 53.8 | 50.0 | 48.4 | 49.1 | 52.3 | 58.1 | 66.6 | 78.2 | 92.9 | 2 |
| 3 | 61.2 | 55.4 | 51.6 | 50.0 | 50.8 | 54.0 | 59.8 | 68.5 | 80.1 | 94.9 | 3 |
| 4 | 62.7 | 56.9 | 53.2 | 51.7 | 52.5 | 55.7 | 61.6 | 70.3 | 82.0 | 96.8 | 4 |
| 5 | 3464.3 | 3558.5 | 3654.8 | 3753.4 | 3854.2 | 3957.5 | 4063.4 | 4172.1 | 4283.9 | 4398.8 | 5 |
| 6 | 65.9 | 60.1 | 56.5 | 55.0 | 55.9 | 59.2 | 65.2 | 74.0 | 85.7 | 4400.7 | 6 |
| 7 | 67.4 | 61.7 | 58.1 | 56.7 | 57.6 | 61.0 | 67.0 | 75.8 | 87.6 | 102.6 | 7 |
| 8 | 69.0 | 63.3 | 59.7 | 58.3 | 59.3 | 62.7 | 68.8 | 77.7 | 89.5 | 104.6 | 8 |
| 9 | 70.5 | 64.9 | 61.3 | 60.0 | 61.0 | 64.5 | 70.6 | 79.5 | 91.4 | 106.5 | 9 |
| 10 | 3472.1 | 3566.5 | 3663.0 | 3761.7 | 3862.7 | 3966.2 | 4072.4 | 4181.3 | 4293.3 | 4408.5 | 10 |
| 11 | 73.6 | 68.1 | 64.6 | 63.3 | 64.4 | 68.0 | 74.2 | 83.2 | 95.2 | 104.1 | 11 |
| 12 | 75.2 | 69.7 | 66.2 | 65.0 | 66.1 | 69.7 | 76.0 | 85.0 | 97.1 | 12.4 | 12 |
| 13 | 76.7 | 71.3 | 67.9 | 66.7 | 67.8 | 71.5 | 77.7 | 86.9 | 99.0 | 14.3 | 13 |
| 14 | 78.3 | 72.8 | 69.5 | 68.3 | 69.5 | 73.2 | 79.5 | 88.7 | 4300.9 | 16.3 | 14 |
| 15 | 3479.9 | 3574.4 | 3671.1 | 3770.0 | 3871.2 | 3975.0 | 4081.3 | 4190.6 | 4302.8 | 4418.2 | 15 |
| 16 | 81.4 | 76.0 | 72.7 | 71.7 | 72.9 | 76.7 | 83.1 | 92.4 | 104.7 | 20.2 | 16 |
| 17 | 83.0 | 77.6 | 74.4 | 73.3 | 74.6 | 78.5 | 84.9 | 94.2 | 106.6 | 22.1 | 17 |
| 18 | 84.5 | 79.2 | 76.0 | 75.0 | 76.3 | 80.2 | 86.7 | 96.1 | 108.5 | 24.1 | 18 |
| 19 | 86.1 | 80.8 | 77.6 | 76.7 | 78.1 | 82.0 | 88.5 | 97.9 | 104.4 | 26.1 | 19 |
| 20 | 3487.7 | 3582.4 | 3679.3 | 3778.3 | 3879.8 | 3983.7 | 4090.3 | 4199.8 | 4312.3 | 4428.0 | 20 |
| 21 | 89.2 | 84.0 | 80.9 | 80.0 | 81.5 | 85.5 | 92.1 | 4201.6 | 14.2 | 30.0 | 21 |
| 22 | 90.8 | 85.6 | 82.5 | 81.7 | 83.2 | 87.2 | 93.9 | 103.5 | 16.1 | 31.9 | 22 |
| 23 | 92.4 | 87.2 | 84.2 | 83.3 | 84.9 | 89.0 | 95.7 | 105.3 | 18.0 | 33.9 | 23 |
| 24 | 93.9 | 88.8 | 85.8 | 85.0 | 86.6 | 90.7 | 97.5 | 107.2 | 19.9 | 35.8 | 24 |
| 25 | 3495.5 | 3590.4 | 3687.4 | 3786.7 | 3888.3 | 3992.5 | 4099.3 | 4209.0 | 4321.8 | 4437.8 | 25 |
| 26 | 97.1 | 92.0 | 89.1 | 88.4 | 90.0 | 94.3 | 4101.1 | 10.9 | 23.7 | 39.8 | 26 |
| 27 | 98.6 | 93.6 | 90.7 | 90.0 | 91.8 | 96.0 | 102.9 | 12.8 | 25.6 | 41.7 | 27 |
| 28 | 3500.2 | 95.2 | 92.3 | 91.7 | 93.5 | 97.8 | 104.8 | 14.6 | 27.5 | 43.7 | 28 |
| 29 | 01.8 | 96.8 | 94.0 | 93.4 | 95.2 | 99.5 | 106.6 | 16.5 | 29.4 | 45.7 | 29 |
| 30 | 3503.3 | 3598.4 | 3695.6 | 3795.1 | 3896.9 | 4001.3 | 4108.4 | 4218.3 | 4331.3 | 4447.6 | 30 |
| 31 | 04.9 | 3600.0 | 97.3 | 96.8 | 98.6 | 103.1 | 10.2 | 20.2 | 33.2 | 49.6 | 31 |
| 32 | 06.5 | 01.6 | 98.9 | 98.4 | 3900.4 | 04.8 | 12.0 | 22.0 | 35.2 | 51.6 | 32 |
| 33 | 08.0 | 03.2 | 3700.5 | 3800.1 | 02.1 | 06.6 | 13.8 | 23.9 | 37.1 | 53.5 | 33 |
| 34 | 09.6 | 04.8 | 02.2 | 01.8 | 03.8 | 08.3 | 15.6 | 25.8 | 39.0 | 55.5 | 34 |
| 35 | 3511.2 | 3606.4 | 3703.8 | 3803.5 | 3905.5 | 4010.1 | 4117.4 | 4227.6 | 4340.9 | 4457.5 | 35 |
| 36 | 12.7 | 08.0 | 05.0 | 05.1 | 07.2 | 11.9 | 19.2 | 29.5 | 42.8 | 59.4 | 36 |
| 37 | 14.3 | 09.6 | 07.1 | 06.8 | 09.0 | 13.6 | 21.0 | 31.3 | 44.7 | 61.4 | 37 |
| 38 | 15.9 | 11.2 | 08.7 | 08.5 | 10.7 | 15.4 | 22.9 | 33.2 | 46.6 | 63.4 | 38 |
| 39 | 17.5 | 12.8 | 10.4 | 10.2 | 12.4 | 17.2 | 24.7 | 35.1 | 48.6 | 65.4 | 39 |
| 40 | 3519.0 | 3614.5 | 3712.0 | 3811.9 | 3914.1 | 4018.9 | 4126.5 | 4236.9 | 4350.5 | 4467.3 | 40 |
| 41 | 20.6 | 16.1 | 13.7 | 13.6 | 15.9 | 20.7 | 28.3 | 38.8 | 52.4 | 69.3 | 41 |
| 42 | 22.2 | 17.7 | 15.3 | 15.2 | 17.6 | 22.5 | 30.1 | 40.7 | 54.3 | 71.3 | 42 |
| 43 | 23.7 | 19.3 | 17.0 | 17.0 | 19.3 | 24.3 | 31.9 | 42.5 | 56.2 | 73.3 | 43 |
| 44 | 25.3 | 20.9 | 18.6 | 18.6 | 21.0 | 26.0 | 33.8 | 44.4 | 58.2 | 75.3 | 44 |
| 45 | 3526.9 | 3622.5 | 3720.3 | 3820.3 | 3922.8 | 4027.8 | 4135.6 | 4246.3 | 4360.1 | 4477.2 | 45 |
| 46 | 28.5 | 24.1 | 21.9 | 22.0 | 24.5 | 29.6 | 37.4 | 48.1 | 62.0 | 79.2 | 46 |
| 47 | 30.1 | 25.7 | 23.6 | 23.7 | 26.2 | 31.4 | 39.2 | 50.0 | 63.9 | 81.2 | 47 |
| 48 | 31.6 | 27.3 | 25.2 | 25.4 | 28.0 | 33.1 | 41.0 | 51.9 | 65.9 | 83.2 | 48 |
| 49 | 33.2 | 29.0 | 26.9 | 27.1 | 29.7 | 34.9 | 42.9 | 53.8 | 67.8 | 85.2 | 49 |
| 50 | 3534.8 | 3630.6 | 3728.5 | 3828.7 | 3931.4 | 4036.7 | 4144.7 | 4255.6 | 4369.7 | 4487.2 | 50 |
| 51 | 36.4 | 32.2 | 30.2 | 30.4 | 33.2 | 38.5 | 46.5 | 57.5 | 71.7 | 89.1 | 51 |
| 52 | 37.9 | 33.8 | 31.8 | 32.1 | 34.9 | 40.2 | 48.3 | 59.4 | 73.6 | 91.1 | 52 |
| 53 | 39.5 | 35.4 | 33.5 | 33.8 | 36.6 | 42.0 | 50.2 | 61.3 | 75.5 | 93.1 | 53 |
| 54 | 41.1 | 37.0 | 35.1 | 35.5 | 38.4 | 43.8 | 52.0 | 63.1 | 77.4 | 95.1 | 54 |
| 55 | 3542.7 | 3638.6 | 3736.8 | 3837.2 | 3940.1 | 4045.6 | 4153.8 | 4265.0 | 4379.4 | 4497.1 | 55 |
| 56 | 44.3 | 40.3 | 38.4 | 38.9 | 41.8 | 47.4 | 55.7 | 66.9 | 81.3 | 99.1 | 56 |
| 57 | 45.9 | 41.9 | 40.1 | 40.6 | 43.6 | 49.1 | 57.5 | 68.8 | 83.2 | 4501.1 | 57 |
| 58 | 47.4 | 43.5 | 41.7 | 42.3 | 45.3 | 50.9 | 59.3 | 70.7 | 85.2 | 103.1 | 58 |
| 59 | 49.0 | 45.1 | 43.4 | 45.0 | 47.0 | 52.7 | 61.1 | 72.5 | 87.1 | 105.1 | 59 |
| 60 | 3550.6 | 3646.7 | 3745.1 | 3845.7 | 3948.8 | 4054.5 | 4163.0 | 4274.4 | 4389.1 | 4507.1 | 60 |
| | 50° | 51° | 52° | 53° | 54° | 55° | 56° | 57° | 58° | 59° | |

Combined Correction for Observed
Sextant Altitudes

| OBSERVED ALTITUDE | CORRECTION | |
|----------------------|---|---|
| | For Sun (to be added to observed alti- tude) | For Star (to be subtracted from observed altitude) |
| 5° | 6' 14" | 9' 55" |
| 6 | 7 41 | 8 28 |
| 7 | 8 45 | 7 24 |
| 8 | 9 35 | 6 34 |
| 9 | 10 16 | 5 53 |
| 10 | 10 50 | 5 19 |
| 11 | 11 17 | 4 51 |
| 12 | 11 41 | 4 27 |
| 13 | 12 2 | 4 7 |
| 14 | 12 19 | 3 49 |
| 15 | 12 34 | 3 34 |
| 20 | 13 29 | 2 39 |
| 25 | 14 3 | 2 5 |
| 30 | 14 26 | 1 41 |
| 35 | 14 44 | 1 23 |
| 40 | 14 57 | 1 10 |
| 45 | 15 8 | 0 58 |
| 50 | 15 17 | 0 49 |
| 55 | 15 25 | 0 40 |
| 60 | 15 31 | 0 34 |
| 65 | 15 37 | 0 27 |
| 70 | 15 42 | 0 21 |
| 75 | 15 47 | 0 16 |
| 80 | 15 52 | 0 10 |
| 85 | 15 55 | 0 5 |

Small supplementary correction, for Sun
only.

Jan. to March } add 10".
and Oct. to Dec. }
April to Sept., subtract 10".

Correction for Dip of
Sea Horizon
(Sun or Star)

| HEIGHT OF OBSERVER'S EYE ABOVE SEA LEVEL (feet) | DIP CORRECTION (to be subtracted from observed altitude) |
|---|--|
| 4 | 1' 58" |
| 6 | 2 24 |
| 8 | 2 46 |
| 10 | 3 06 |
| 12 | 3 24 |
| 14 | 3 40 |
| 16 | 3 55 |
| 18 | 4 9 |
| 20 | 4 23 |
| 22 | 4 36 |
| 24 | 4 48 |
| 26 | 5 0 |
| 28 | 5 11 |
| 30 | 5 22 |
| 35 | 5 48 |
| 40 | 6 12 |
| 45 | 6 36 |
| 50 | 6 56 |
| 55 | 7 16 |
| 60 | 7 35 |
| 70 | 8 12 |
| 85 | 9 2 |
| 100 | 9 48 |

The dip correction is not
required when the artificial
horizon is used.

To Change Hours and Minutes into Decimals of a Day

HOURS EXPRESSED
AS DECIMAL PARTS
OF A DAY

MINUTES EXPRESSED AS DECIMAL PARTS
OF A DAY

| HOURS | DECIMAL |
|-------|---------|
| 1 | .0416 |
| 2 | .0833 |
| 3 | .1250 |
| 4 | .1666 |
| 5 | .2083 |
| 6 | .2500 |
| 7 | .2916 |
| 8 | .3333 |
| 9 | .3750 |
| 10 | .4166 |
| 11 | .4583 |
| 12 | .5000 |
| 13 | .5416 |
| 14 | .5833 |
| 15 | .6249 |
| 16 | .6666 |
| 17 | .7083 |
| 18 | .7500 |
| 19 | .7916 |
| 20 | .8333 |
| 21 | .8749 |
| 22 | .9166 |
| 23 | .9583 |
| 24 | 1.0000 |

| MINUTES | DECIMAL | MINUTES | DECIMAL |
|---------|---------|---------|---------|
| 1 | .0006 | 31 | .0215 |
| 2 | .0013 | 32 | .0222 |
| 3 | .0020 | 33 | .0229 |
| 4 | .0027 | 34 | .0236 |
| 5 | .0034 | 35 | .0243 |
| 6 | .0041 | 36 | .0250 |
| 7 | .0048 | 37 | .0256 |
| 8 | .0055 | 38 | .0263 |
| 9 | .0062 | 39 | .0270 |
| 10 | .0069 | 40 | .0277 |
| 11 | .0076 | 41 | .0284 |
| 12 | .0083 | 42 | .0291 |
| 13 | .0090 | 43 | .0298 |
| 14 | .0097 | 44 | .0305 |
| 15 | .0104 | 45 | .0312 |
| 16 | .0111 | 46 | .0319 |
| 17 | .0118 | 47 | .0326 |
| 18 | .0125 | 48 | .0333 |
| 19 | .0131 | 49 | .0340 |
| 20 | .0138 | 50 | .0347 |
| 21 | .0145 | 51 | .0354 |
| 22 | .0152 | 52 | .0361 |
| 23 | .0159 | 53 | .0368 |
| 24 | .0166 | 54 | .0375 |
| 25 | .0173 | 55 | .0381 |
| 26 | .0180 | 56 | .0388 |
| 27 | .0187 | 57 | .0395 |
| 28 | .0194 | 58 | .0402 |
| 29 | .0201 | 59 | .0409 |
| 30 | .0208 | 60 | .0416 |

To Interchange Degrees and Minutes of Longitude and Hours, Minutes, and Seconds of Time. Part 1

| | 0 ^h | 1 ^h | 2 ^h | 3 ^h | 4 ^h | 5 ^h | 6 ^h | 7 ^h | 8 ^h | 9 ^h | 10 ^h | 11 ^h |
|----------------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|-----------------|-----------------|
| 0^m | 0° | 15° | 30° | 45° | 60° | 75° | 90° | 105° | 120° | 135° | 150° | 165° |
| 4 | 1 | 16 | 31 | 46 | 61 | 76 | 91 | 106 | 121 | 136 | 151 | 166 |
| 8 | 2 | 17 | 32 | 47 | 62 | 77 | 92 | 107 | 122 | 137 | 152 | 167 |
| 12 | 3 | 18 | 33 | 48 | 63 | 78 | 93 | 108 | 123 | 138 | 153 | 168 |
| 16 | 4 | 19 | 34 | 49 | 64 | 79 | 94 | 109 | 124 | 139 | 154 | 169 |
| 20 | 5 | 20 | 35 | 50 | 65 | 80 | 95 | 110 | 125 | 140 | 155 | 170 |
| 24 | 6 | 21 | 36 | 51 | 66 | 81 | 96 | 111 | 126 | 141 | 156 | 171 |
| 28 | 7 | 22 | 37 | 52 | 67 | 82 | 97 | 112 | 127 | 142 | 157 | 172 |
| 32 | 8 | 23 | 38 | 53 | 68 | 83 | 98 | 113 | 128 | 143 | 158 | 173 |
| 36 | 9 | 24 | 39 | 54 | 69 | 84 | 99 | 114 | 129 | 144 | 159 | 174 |
| 40 | 10 | 25 | 40 | 55 | 70 | 85 | 100 | 115 | 130 | 145 | 160 | 175 |
| 44 | 11 | 26 | 41 | 56 | 71 | 86 | 101 | 116 | 131 | 146 | 161 | 176 |
| 48 | 12 | 27 | 42 | 57 | 72 | 87 | 102 | 117 | 132 | 147 | 162 | 177 |
| 52 | 13 | 28 | 43 | 58 | 73 | 88 | 103 | 118 | 133 | 148 | 163 | 178 |
| 56 | 14 | 29 | 44 | 59 | 74 | 89 | 104 | 119 | 134 | 149 | 164 | 179 |

| | 12 ^h | 13 ^h | 14 ^h | 15 ^h | 16 ^h | 17 ^h | 18 ^h | 19 ^h | 20 ^h | 21 ^h | 22 ^h | 23 ^h |
|----------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| 0^m | 180° | 195° | 210° | 225° | 240° | 255° | 270° | 285° | 300° | 315° | 330° | 345° |
| 4 | 181 | 196 | 211 | 226 | 241 | 256 | 271 | 286 | 301 | 316 | 331 | 346 |
| 8 | 182 | 197 | 212 | 227 | 242 | 257 | 272 | 287 | 302 | 317 | 332 | 347 |
| 12 | 183 | 198 | 213 | 228 | 243 | 258 | 273 | 288 | 303 | 318 | 333 | 348 |
| 16 | 184 | 199 | 214 | 229 | 244 | 259 | 274 | 289 | 304 | 319 | 334 | 349 |
| 20 | 185 | 200 | 215 | 230 | 245 | 260 | 275 | 290 | 305 | 320 | 335 | 350 |
| 24 | 186 | 201 | 216 | 231 | 246 | 261 | 276 | 291 | 306 | 321 | 336 | 351 |
| 28 | 187 | 202 | 217 | 232 | 247 | 262 | 277 | 292 | 307 | 322 | 337 | 352 |
| 32 | 188 | 203 | 218 | 233 | 248 | 263 | 278 | 293 | 308 | 323 | 338 | 353 |
| 36 | 189 | 204 | 219 | 234 | 249 | 264 | 279 | 294 | 309 | 324 | 339 | 354 |
| 40 | 190 | 205 | 220 | 235 | 250 | 265 | 280 | 295 | 310 | 325 | 340 | 355 |
| 44 | 191 | 206 | 221 | 236 | 251 | 266 | 281 | 296 | 311 | 326 | 341 | 356 |
| 48 | 192 | 207 | 222 | 237 | 252 | 267 | 282 | 297 | 312 | 327 | 342 | 357 |
| 52 | 193 | 208 | 223 | 238 | 253 | 268 | 283 | 298 | 313 | 328 | 343 | 358 |
| 56 | 194 | 209 | 224 | 239 | 254 | 269 | 284 | 299 | 314 | 329 | 344 | 359 |

Part 2

EXPLANATION OF TABLE 9

| | 0 ^m | 1 ^m | 2 ^m | 3 ^m |
|----------------------|----------------|----------------|----------------|----------------|
| 0^s | 0' | 15' | 30' | 45' |
| 4 | 1 | 16 | 31 | 46 |
| 8 | 2 | 17 | 32 | 47 |
| 12 | 3 | 18 | 33 | 48 |
| 16 | 4 | 19 | 34 | 49 |
| 20 | 5 | 20 | 35 | 50 |
| 24 | 6 | 21 | 36 | 51 |
| 28 | 7 | 22 | 37 | 52 |
| 32 | 8 | 23 | 38 | 53 |
| 36 | 9 | 24 | 39 | 54 |
| 40 | 10 | 25 | 40 | 55 |
| 44 | 11 | 26 | 41 | 56 |
| 48 | 12 | 27 | 42 | 57 |
| 52 | 13 | 28 | 43 | 58 |
| 56 | 14 | 29 | 44 | 59 |

1. To change degrees of longitude into hours and minutes of time: Find the number of degrees in Part 1. The required hours will then be found at the head of the column containing the degrees, and the required minutes at the left-hand end of the line containing the degrees.

Examples: $113^\circ = 7^h 32^m$; $294^\circ = 19^h 36^m$.

2. To change minutes of longitude into minutes and seconds of time: Find the minutes of longitude in Part 2. The required minutes and seconds of time will again be found at the head of the column and the left-hand end of the line.

Examples: $43' = 2^m 52^s$; $28' = 1^m 52^s$.

3. 1 and 2 can be combined by addition.
Examples: $113^\circ 43' = 7^h 34^m 52^s$.
 $294^\circ 28' = 19^h 37^m 52^s$.

4. To change hours and minutes of time into degrees and minutes of longitude: Find the number of hours at the head of one of the columns of Part 1; then run down the column until you reach a line having at its left-hand end a number of minutes equal to (or just smaller than) the given number of minutes of time. Where that line

and column meet you will find the required degrees of longitude.

Examples: $7^h 32^m = 113^\circ$; $19^h 36^m = 294^\circ$.

5. To change minutes and seconds of time into minutes of longitude: Find the number of minutes of time at the head of one of the columns of Part 2; then run down the column until you reach a line having at its left-hand end a number of seconds equal (or nearly equal) to the given number of seconds of time. Where that line and column meet you will find the minutes of longitude.

Examples: $2^m 52^s = 43'$; $1^m 52^s = 28'$.

6. 4 and 5 can be combined by addition:

Examples: $7^h 34^m 52^s = 113^\circ 43'$; $19^h 37^m 52^s = 294^\circ 28'$.

Table 10. Haversine Table

| s | ' | 0 ^h 0 ^m 0° | | 0 ^h 4 ^m 1° | | 0 ^h 8 ^m 2° | | 0 ^h 12 ^m 3° | |
|----|----|----------------------------------|---------|----------------------------------|---------|-----------------------------------|---------|-----------------------------------|---------|
| | | Hav. | No. | Hav. | No. | Hav. | No. | Hav. | No. |
| 0 | 0 | | 0.00000 | 5.88168 | 0.00008 | 6.48371 | 0.00030 | 6.83584 | 0.00069 |
| 4 | 1 | 2.32539 | .00000 | .89604 | .00008 | .49092 | .00031 | .84065 | .00069 |
| 8 | 2 | .92745 | .00000 | .91016 | .00008 | .49807 | .00031 | .84543 | .00070 |
| 12 | 3 | 3.27963 | .00000 | .92406 | .00008 | .50516 | .00032 | .85019 | .00071 |
| 16 | 4 | .52951 | .00000 | .93774 | .00009 | .51219 | .00033 | .85492 | .00072 |
| 20 | 5 | 3.72333 | 0.00000 | 5.95121 | 0.00009 | 6.51916 | 0.00033 | 6.85963 | 0.00072 |
| 24 | 6 | .88169 | .00000 | .96447 | .00009 | .52608 | .00034 | .86431 | .00073 |
| 28 | 7 | 4.01559 | .00000 | .97753 | .00010 | .53295 | .00034 | .86897 | .00074 |
| 32 | 8 | .13157 | .00000 | .99040 | .00010 | .53976 | .00035 | .87360 | .00075 |
| 36 | 9 | .23388 | .00000 | 6.00308 | .00010 | .54652 | .00035 | .87821 | .00076 |
| 40 | 10 | 4.32539 | 0.00000 | 6.01557 | 0.00010 | 6.55323 | 0.00036 | 6.88279 | 0.00076 |
| 44 | 11 | .40818 | .00000 | .02789 | .00011 | .55988 | .00036 | .88735 | .00077 |
| 48 | 12 | .48375 | .00000 | .04004 | .00011 | .56649 | .00037 | .89188 | .00078 |
| 52 | 13 | .55328 | .00000 | .05202 | .00011 | .57304 | .00037 | .89639 | .00079 |
| 56 | 14 | .61765 | .00000 | .06384 | .00012 | .57955 | .00038 | .90088 | .00080 |
| s | ' | 0 ^h 1 ^m 0° | | 0 ^h 5 ^m 1° | | 0 ^h 9 ^m 2° | | 0 ^h 13 ^m 3° | |
| 0 | 15 | 4.67757 | 0.00000 | 6.07550 | 0.00012 | 6.58600 | 0.00039 | 6.90535 | 0.00080 |
| 4 | 16 | .73363 | .00001 | .08700 | .00012 | .59241 | .00039 | .90979 | .00081 |
| 8 | 17 | .78629 | .00001 | .09836 | .00013 | .59878 | .00040 | .91421 | .00082 |
| 12 | 18 | .83594 | .00001 | .10956 | .00013 | .60509 | .00040 | .91860 | .00083 |
| 16 | 19 | .88290 | .00001 | .12063 | .00013 | .61136 | .00041 | .92298 | .00084 |
| 20 | 20 | 4.92745 | 0.00001 | 6.13155 | 0.00014 | 6.61759 | 0.00041 | 6.92733 | 0.00085 |
| 24 | 21 | .96983 | .00001 | .14234 | .00014 | .62377 | .00042 | .93166 | .00085 |
| 28 | 22 | 5.01024 | .00001 | .15300 | .00014 | .62991 | .00043 | .93597 | .00086 |
| 32 | 23 | .04885 | .00001 | .16353 | .00015 | .63600 | .00043 | .94026 | .00087 |
| 36 | 24 | .08581 | .00001 | .17393 | .00015 | .64205 | .00044 | .94453 | .00088 |
| 40 | 25 | 5.12127 | 0.00001 | 6.18421 | 0.00015 | 6.64806 | 0.00044 | 6.94877 | 0.00089 |
| 44 | 26 | .15534 | .00001 | .19437 | .00016 | .65403 | .00045 | .95300 | .00090 |
| 48 | 27 | .18812 | .00002 | .20441 | .00016 | .65996 | .00046 | .95720 | .00091 |
| 52 | 28 | .21971 | .00002 | .21433 | .00016 | .66585 | .00046 | .96139 | .00091 |
| 56 | 29 | .25019 | .00002 | .22415 | .00017 | .67170 | .00047 | .96555 | .00092 |
| s | ' | 0 ^h 2 ^m 0° | | 0 ^h 6 ^m 1° | | 0 ^h 10 ^m 2° | | 0 ^h 14 ^m 3° | |
| 0 | 30 | 5.27963 | 0.00002 | 6.23385 | 0.00017 | 6.67751 | 0.00048 | 6.96970 | 0.00093 |
| 4 | 31 | .30811 | .00002 | .23454 | .00018 | .68328 | .00048 | .97382 | .00094 |
| 8 | 32 | .33569 | .00002 | .25294 | .00018 | .68901 | .00049 | .97793 | .00095 |
| 12 | 33 | .36242 | .00002 | .26233 | .00018 | .69470 | .00050 | .98201 | .00096 |
| 16 | 34 | .38835 | .00002 | .27162 | .00019 | .70036 | .00050 | .98608 | .00097 |
| 20 | 35 | 5.41352 | 0.00003 | 6.28081 | 0.00019 | 6.70598 | 0.00051 | 6.99013 | 0.00098 |
| 24 | 36 | .43799 | .00003 | .28991 | .00019 | .71157 | .00051 | .99416 | .00099 |
| 28 | 37 | .46179 | .00003 | .29891 | .00020 | .71712 | .00052 | .99817 | .00100 |
| 32 | 38 | .48496 | .00003 | .30781 | .00020 | .72263 | .00053 | 7.00216 | .00101 |
| 36 | 39 | .50752 | .00003 | .31663 | .00021 | .72811 | .00053 | .00613 | .00101 |
| 40 | 40 | 5.52951 | 0.00003 | 6.32536 | 0.00021 | 6.73355 | 0.00054 | 7.01009 | 0.00102 |
| 44 | 41 | .55095 | .00004 | .33400 | .00022 | .73896 | .00055 | .01403 | .00103 |
| 48 | 42 | .57189 | .00004 | .34256 | .00022 | .74434 | .00056 | .01795 | .00104 |
| 52 | 43 | .59232 | .00004 | .35103 | .00022 | .74969 | .00056 | .02185 | .00105 |
| 56 | 44 | .61229 | .00004 | .35943 | .00023 | .75500 | .00057 | .02573 | .00106 |
| s | ' | 0 ^h 3 ^m 0° | | 0 ^h 7 ^m 1° | | 0 ^h 11 ^m 2° | | 0 ^h 15 ^m 3° | |
| 0 | 45 | 5.63181 | 0.00004 | 6.36774 | 0.00023 | 6.76028 | 0.00058 | 7.02960 | 0.00107 |
| 4 | 46 | .65090 | .00004 | .37597 | .00024 | .76552 | .00058 | .03345 | .00108 |
| 8 | 47 | .66958 | .00005 | .38412 | .00024 | .77074 | .00059 | .03729 | .00109 |
| 12 | 48 | .68787 | .00005 | .39220 | .00025 | .77592 | .00060 | .04110 | .00110 |
| 16 | 49 | .70578 | .00005 | .40021 | .00025 | .78108 | .00060 | .04490 | .00111 |
| 20 | 50 | 5.72332 | 0.00005 | 6.40814 | 0.00026 | 6.78620 | 0.00061 | 7.04869 | 0.00112 |
| 24 | 51 | .74052 | .00006 | .41600 | .00026 | .79129 | .00062 | .05245 | .00113 |
| 28 | 52 | .75739 | .00006 | .42379 | .00027 | .79630 | .00063 | .05620 | .00114 |
| 32 | 53 | .77394 | .00006 | .43151 | .00027 | .80139 | .00063 | .05994 | .00115 |
| 36 | 54 | .79017 | .00006 | .43916 | .00027 | .80640 | .00064 | .06366 | .00116 |
| 40 | 55 | 5.80611 | 0.00006 | 6.44675 | 0.00028 | 6.81137 | 0.00065 | 7.06736 | 0.00117 |
| 44 | 56 | .82176 | .00007 | .45427 | .00028 | .81632 | .00066 | .07105 | .00118 |
| 48 | 57 | .83713 | .00007 | .46172 | .00029 | .82124 | .00066 | .07472 | .00119 |
| 52 | 58 | .85224 | .00007 | .46911 | .00029 | .82614 | .00067 | .07837 | .00120 |
| 56 | 59 | .86709 | .00007 | .47644 | .00030 | .83100 | .00068 | .08201 | .00121 |
| 60 | 60 | 5.88168 | 0.00008 | 6.48371 | 0.00030 | 6.83584 | 0.00069 | 7.08564 | 0.00122 |

Table 10. Haversine Table

| s | ' | 0h 16 ^m 4° | | 0h 20 ^m 5° | | 0h 24 ^m 6° | | 0h 28 ^m 7° | |
|----|----|-----------------------|----------------|-----------------------|----------------|-----------------------|----------------|-----------------------|----------------|
| | | Hav. | No. | Hav. | No. | Hav. | No. | Hav. | No. |
| 0 | 0 | 7.08564 | 0.00122 | 7.27936 | 0.00190 | 7.43760 | 0.00274 | 7.57135 | 0.00373 |
| 4 | 1 | .08925 | .00123 | .28225 | .00192 | .44001 | .00275 | .57341 | .00374 |
| 8 | 2 | .09284 | .00124 | .28513 | .00193 | .44241 | .00277 | .57547 | .00376 |
| 12 | 3 | .09642 | .00125 | .28800 | .00194 | .44480 | .00278 | .57752 | .00378 |
| 16 | 4 | .09999 | .00126 | .29086 | .00195 | .44719 | .00280 | .57957 | .00380 |
| 20 | 5 | 7.10354 | 0.00127 | 7.29371 | 0.00197 | 7.44957 | 0.00282 | 7.58162 | 0.00382 |
| 24 | 6 | .10708 | .00128 | .29655 | .00198 | .45194 | .00283 | .58366 | .00383 |
| 28 | 7 | .11060 | .00129 | .29938 | .00199 | .45431 | .00285 | .58569 | .00385 |
| 32 | 8 | .11411 | .00130 | .30220 | .00201 | .45667 | .00286 | .58772 | .00387 |
| 36 | 9 | .11760 | .00131 | .30502 | .00202 | .45903 | .00288 | .58974 | .00389 |
| 40 | 10 | 7.12108 | 0.00132 | 7.30782 | 0.00203 | 7.46138 | 0.00289 | 7.59176 | 0.00391 |
| 44 | 11 | .12455 | .00133 | .31062 | .00204 | .46372 | .00291 | .59378 | .00392 |
| 48 | 12 | .12800 | .00134 | .31340 | .00206 | .46605 | .00292 | .59579 | .00394 |
| 52 | 13 | .13144 | .00135 | .31618 | .00207 | .46838 | .00294 | .59779 | .00396 |
| 56 | 14 | .13486 | .00136 | .31895 | .00208 | .47071 | .00296 | .59979 | .00398 |
| s | ' | 0h 17 ^m 4° | | 0h 21 ^m 5° | | 0h 25 ^m 6° | | 0h 29 ^m 7° | |
| 0 | 15 | 7.13827 | 0.00137 | 7.32171 | 0.00210 | 7.47302 | 0.00297 | 7.60179 | 0.00400 |
| 4 | 16 | .14167 | .00139 | .32446 | .00211 | .47533 | .00299 | .60378 | .00402 |
| 8 | 17 | .14506 | .00140 | .32720 | .00212 | .47764 | .00300 | .60577 | .00403 |
| 12 | 18 | .14843 | .00141 | .32994 | .00214 | .47994 | .00302 | .60775 | .00405 |
| 16 | 19 | .15179 | .00142 | .33266 | .00215 | .48223 | .00304 | .60973 | .00407 |
| 20 | 20 | 7.15513 | 0.00143 | 7.33538 | 0.00216 | 7.48452 | 0.00305 | 7.61170 | 0.00409 |
| 24 | 21 | .15846 | .00144 | .33809 | .00218 | .48680 | .00307 | .61367 | .00411 |
| 28 | 22 | .16178 | .00145 | .34079 | .00219 | .48907 | .00308 | .61564 | .00413 |
| 32 | 23 | .16509 | .00146 | .34348 | .00221 | .49134 | .00310 | .61760 | .00415 |
| 36 | 24 | .16839 | .00147 | .34616 | .00222 | .49360 | .00312 | .61955 | .00416 |
| 40 | 25 | 7.17167 | 0.00148 | 7.34884 | 0.00223 | 7.49586 | 0.00313 | 7.62151 | 0.00418 |
| 44 | 26 | .17494 | .00150 | .35150 | .00225 | .49811 | .00315 | .62345 | .00420 |
| 48 | 27 | .17820 | .00151 | .35416 | .00226 | .50036 | .00316 | .62540 | .00422 |
| 52 | 28 | .18144 | .00152 | .35681 | .00227 | .50259 | .00318 | .62733 | .00424 |
| 56 | 29 | .18468 | .00153 | .35945 | .00229 | .50483 | .00320 | .62927 | .00426 |
| s | ' | 0h 18 ^m 4° | | 0h 22 ^m 5° | | 0h 26 ^m 6° | | 0h 30 ^m 7° | |
| 0 | 30 | 7.18790 | 0.00154 | 7.36209 | 0.00230 | 7.50706 | 0.00321 | 7.63120 | 0.00428 |
| 4 | 31 | .19111 | .00155 | .36471 | .00232 | .50928 | .00323 | .63312 | .00430 |
| 8 | 32 | .19430 | .00156 | .36733 | .00233 | .51149 | .00325 | .63504 | .00432 |
| 12 | 33 | .19749 | .00158 | .36994 | .00234 | .51370 | .00326 | .63696 | .00433 |
| 16 | 34 | .20066 | .00159 | .37254 | .00236 | .51591 | .00328 | .63887 | .00435 |
| 20 | 35 | 7.20383 | 0.00160 | 7.37514 | 0.00237 | 7.51811 | 0.00330 | 7.64078 | 0.00437 |
| 24 | 36 | .20698 | .00161 | .37773 | .00239 | .52030 | .00331 | .64269 | .00439 |
| 28 | 37 | .21012 | .00162 | .38030 | .00240 | .52249 | .00333 | .64458 | .00441 |
| 32 | 38 | .21325 | .00163 | .38288 | .00241 | .52467 | .00335 | .64648 | .00443 |
| 36 | 39 | .21636 | .00165 | .38544 | .00243 | .52685 | .00336 | .64837 | .00445 |
| 40 | 40 | 7.21947 | 0.00166 | 7.38800 | 0.00244 | 7.52902 | 0.00338 | 7.65026 | 0.00447 |
| 44 | 41 | .22256 | .00167 | .39054 | .00246 | .53119 | .00340 | .65214 | .00449 |
| 48 | 42 | .22565 | .00168 | .39309 | .00247 | .53335 | .00341 | .65402 | .00451 |
| 52 | 43 | .22872 | .00169 | .39562 | .00249 | .53550 | .00343 | .65590 | .00453 |
| 56 | 44 | .23178 | .00171 | .39815 | .00250 | .53766 | .00345 | .65777 | .00455 |
| s | ' | 0h 19 ^m 4° | | 0h 23 ^m 5° | | 0h 27 ^m 6° | | 0h 31 ^m 7° | |
| 0 | 45 | 7.23483 | 0.00172 | 7.40067 | 0.00252 | 7.53980 | 0.00347 | 7.65964 | 0.00457 |
| 4 | 46 | .23787 | .00173 | .40318 | .00253 | .54194 | .00348 | .66150 | .00459 |
| 8 | 47 | .24090 | .00174 | .40568 | .00255 | .54407 | .00350 | .66336 | .00461 |
| 12 | 48 | .24392 | .00175 | .40818 | .00256 | .54620 | .00352 | .66521 | .00463 |
| 16 | 49 | .24693 | .00177 | .41067 | .00257 | .54833 | .00353 | .66706 | .00465 |
| 20 | 50 | 7.24993 | 0.00178 | 7.41315 | 0.00259 | 7.55045 | 0.00355 | 7.66891 | 0.00467 |
| 24 | 51 | .25292 | .00179 | .41563 | .00260 | .55256 | .00357 | .67075 | .00469 |
| 28 | 52 | .25590 | .00180 | .41810 | .00262 | .55467 | .00359 | .67259 | .00471 |
| 32 | 53 | .25886 | .00181 | .42056 | .00263 | .55677 | .00360 | .67443 | .00473 |
| 36 | 54 | .26182 | .00183 | .42301 | .00265 | .55887 | .00362 | .67626 | .00475 |
| 40 | 55 | 7.26477 | 0.00184 | 7.42546 | 0.00266 | 7.56096 | 0.00364 | 7.67809 | 0.00477 |
| 44 | 56 | .26771 | .00185 | .42790 | .00268 | .56305 | .00366 | .67991 | .00479 |
| 48 | 57 | .27064 | .00186 | .43034 | .00269 | .56513 | .00367 | .68173 | .00481 |
| 52 | 58 | .27355 | .00188 | .43277 | .00271 | .56721 | .00369 | .68355 | .00483 |
| 56 | 59 | .27646 | .00189 | .43519 | .00272 | .56928 | .00371 | .68536 | .00485 |
| 60 | 60 | 7.27936 | 0.00190 | 7.43760 | 0.00274 | 7.57135 | 0.00373 | 7.68717 | 0.00487 |

Table 10. Haversine Table

| s | 0h 32 ^m 8° | | 0h 36 ^m 9° | | 0h 40 ^m 10° | | 0h 44 ^m 11° | | |
|----|-----------------------|-----------------------|-----------------------|-----------------------|------------------------|------------------------|------------------------|------------------------|---------|
| | Hav. | No. | Hav. | No. | Hav. | No. | Hav. | No. | |
| 0 | 0 | 7.68717 | 0.00487 | 7.78929 | 0.00616 | 7.88059 | 0.00760 | 7.96315 | 0.00919 |
| 4 | 1 | .68897 | .00489 | .79089 | .00618 | .88203 | .00762 | .96446 | .00921 |
| 8 | 2 | .69077 | .00491 | .79249 | .00620 | .88348 | .00765 | .96577 | .00924 |
| 12 | 3 | .69257 | .00493 | .79409 | .00622 | .88491 | .00767 | .96707 | .00927 |
| 16 | 4 | .69437 | .00495 | .79568 | .00625 | .88635 | .00770 | .96838 | .00930 |
| 20 | 5 | 7.69616 | 0.00497 | 7.79728 | 0.00627 | 7.88778 | 0.00772 | 7.96968 | 0.00933 |
| 24 | 6 | .69794 | .00499 | .79886 | .00629 | .88921 | .00775 | .97098 | .00935 |
| 28 | 7 | .69972 | .00501 | .80045 | .00632 | .89064 | .00777 | .97228 | .00938 |
| 32 | 8 | .70150 | .00503 | .80203 | .00634 | .89207 | .00780 | .97358 | .00941 |
| 36 | 9 | .70328 | .00505 | .80361 | .00636 | .89349 | .00783 | .97478 | .00944 |
| 40 | 10 | 7.70505 | 0.00507 | 7.80519 | 0.00639 | 7.89491 | 0.00785 | 7.97617 | 0.00947 |
| 44 | 11 | .70682 | .00509 | .80677 | .00641 | .89633 | .00788 | .97746 | .00949 |
| 48 | 12 | .70858 | .00511 | .80834 | .00643 | .89775 | .00790 | .97875 | .00952 |
| 52 | 13 | .71034 | .00513 | .80991 | .00646 | .89916 | .00793 | .98003 | .00955 |
| 56 | 14 | .71210 | .00515 | .81147 | .00648 | .90057 | .00795 | .98132 | .00958 |
| s | | 0h 33 ^m 8° | | 0h 37 ^m 9° | | 0h 41 ^m 10° | | 0h 45 ^m 11° | |
| 0 | 15 | 7.71385 | 0.00517 | 7.81303 | 0.00650 | 7.90198 | 0.00798 | 7.98260 | 0.00961 |
| 4 | 16 | .71560 | .00520 | .81459 | .00653 | .90339 | .00801 | .98389 | .00964 |
| 8 | 17 | .71735 | .00522 | .81615 | .00655 | .90480 | .00803 | .98517 | .00966 |
| 12 | 18 | .71909 | .00524 | .81771 | .00657 | .90620 | .00806 | .98644 | .00969 |
| 16 | 19 | .72083 | .00526 | .81926 | .00660 | .90760 | .00808 | .98772 | .00972 |
| 20 | 20 | 7.72257 | 0.00528 | 7.82081 | 0.00662 | 7.90900 | 0.00811 | 7.98899 | 0.00975 |
| 24 | 21 | .72430 | .00530 | .82235 | .00664 | .91039 | .00814 | .99027 | .00978 |
| 28 | 22 | .72603 | .00532 | .82390 | .00667 | .91179 | .00816 | .99154 | .00981 |
| 32 | 23 | .72775 | .00534 | .82544 | .00669 | .91318 | .00819 | .99281 | .00984 |
| 36 | 24 | .72948 | .00536 | .82698 | .00671 | .91457 | .00821 | .99407 | .00986 |
| 40 | 25 | 7.73119 | 0.00539 | 7.82851 | 0.00674 | 7.91596 | 0.00824 | 7.99534 | 0.00989 |
| 44 | 26 | .73291 | .00541 | .83004 | .00676 | .91734 | .00827 | .99660 | .00992 |
| 48 | 27 | .73462 | .00543 | .83157 | .00679 | .91872 | .00829 | .99786 | .00995 |
| 52 | 28 | .73633 | .00545 | .83310 | .00681 | .92010 | .00832 | .99912 | .00998 |
| 56 | 29 | .73803 | .00547 | .83463 | .00683 | .92148 | .00835 | 8.00038 | .01001 |
| s | | 0h 34 ^m 8° | | 0h 38 ^m 9° | | 0h 42 ^m 10° | | 0h 46 ^m 11° | |
| 0 | 30 | 7.73974 | 0.00549 | 7.83615 | 0.00686 | 7.92286 | 0.00837 | 8.00163 | 0.01004 |
| 4 | 31 | .74143 | .00551 | .83767 | .00688 | .92423 | .00840 | .00289 | .01007 |
| 8 | 32 | .74313 | .00554 | .83918 | .00691 | .92560 | .00843 | .00414 | .01010 |
| 12 | 33 | .74482 | .00556 | .84070 | .00693 | .92697 | .00845 | .00539 | .01012 |
| 16 | 34 | .74651 | .00558 | .84221 | .00695 | .92834 | .00848 | .00664 | .01015 |
| 20 | 35 | 7.74819 | 0.00560 | 7.84372 | 0.00698 | 7.92970 | 0.00851 | 8.00788 | 0.01018 |
| 24 | 36 | .74988 | .00562 | .84522 | .00700 | .93107 | .00853 | .00913 | .01021 |
| 28 | 37 | .75155 | .00564 | .84672 | .00703 | .93243 | .00856 | .01037 | .01024 |
| 32 | 38 | .75323 | .00567 | .84822 | .00705 | .93379 | .00859 | .01161 | .01027 |
| 36 | 39 | .75490 | .00569 | .84972 | .00707 | .93514 | .00861 | .01285 | .01030 |
| 40 | 40 | 7.75657 | 0.00571 | 7.85122 | 0.00710 | 7.93650 | 0.00864 | 8.01409 | 0.01033 |
| 44 | 41 | .75824 | .00573 | .85271 | .00712 | .93785 | .00867 | .01532 | .01036 |
| 48 | 42 | .75990 | .00575 | .85420 | .00715 | .93920 | .00869 | .01656 | .01039 |
| 52 | 43 | .76156 | .00578 | .85569 | .00717 | .94055 | .00872 | .01779 | .01042 |
| 56 | 44 | .76321 | .00580 | .85717 | .00720 | .94189 | .00875 | .01902 | .01045 |
| s | | 0h 35 ^m 8° | | 0h 39 ^m 9° | | 0h 43 ^m 10° | | 0h 47 ^m 11° | |
| 0 | 45 | 7.76487 | 0.00582 | 7.85866 | 0.00722 | 7.94324 | 0.00877 | 8.02025 | 0.01048 |
| 4 | 46 | .76652 | .00584 | .86014 | .00725 | .94458 | .00880 | .02148 | .01051 |
| 8 | 47 | .76816 | .00586 | .86161 | .00727 | .94592 | .00883 | .02270 | .01054 |
| 12 | 48 | .76981 | .00589 | .86309 | .00730 | .94726 | .00886 | .02392 | .01057 |
| 16 | 49 | .77145 | .00591 | .86456 | .00732 | .94859 | .00888 | .02515 | .01060 |
| 20 | 50 | 7.77308 | 0.00593 | 7.86603 | 0.00735 | 7.94992 | 0.00891 | 8.02637 | 0.01063 |
| 24 | 51 | .77472 | .00595 | .86750 | .00737 | .95126 | .00894 | .02758 | .01066 |
| 28 | 52 | .77635 | .00598 | .86896 | .00740 | .95259 | .00897 | .02880 | .01069 |
| 32 | 53 | .77798 | .00600 | .87042 | .00742 | .95391 | .00899 | .03001 | .01072 |
| 36 | 54 | .77960 | .00602 | .87188 | .00745 | .95524 | .00902 | .03123 | .01075 |
| 40 | 55 | 7.78122 | 0.00604 | 7.87334 | 0.00747 | 7.95656 | 0.00905 | 8.03244 | 0.01078 |
| 44 | 56 | .78284 | .00607 | .87480 | .00750 | .95788 | .00908 | .03365 | .01081 |
| 48 | 57 | .78446 | .00609 | .87625 | .00752 | .95920 | .00910 | .03486 | .01084 |
| 52 | 58 | .78607 | .00611 | .87770 | .00755 | .96052 | .00913 | .03606 | .01087 |
| 56 | 59 | .78768 | .00613 | .87915 | .00757 | .96183 | .00916 | .03727 | .01090 |
| 60 | 60 | 7.78929 | 0.00616 | 7.88059 | 0.00760 | 7.96315 | 0.00919 | 8.03847 | 0.01093 |

Table 10. Haversine Table

| s | ' | 0h 48m 12° | | 0h 52m 13° | | 0h 56m 14° | | 1h 0m 15° | |
|----|----|------------|----------------|------------|----------------|------------|----------------|-----------|----------------|
| | | Hav. | No. | Hav. | No. | Hav. | No. | Hav. | No. |
| 0 | 0 | 8.03847 | 0.01093 | 8.10772 | 0.01282 | 8.17179 | 0.01485 | 8.23140 | 0.01704 |
| 4 | 1 | .03967 | .01096 | .10883 | .01285 | .17282 | .01489 | .23235 | .01707 |
| 8 | 2 | .04087 | .01099 | .10993 | .01288 | .17384 | .01492 | .23331 | .01711 |
| 12 | 3 | .04207 | .01102 | .11104 | .01291 | .17487 | .01496 | .23427 | .01715 |
| 16 | 4 | .04326 | .01105 | .11214 | .01295 | .17590 | .01499 | .23523 | .01719 |
| 20 | 5 | 8.04446 | 0.01108 | 8.11324 | 0.01298 | 8.17692 | 0.01503 | 8.23618 | 0.01723 |
| 24 | 6 | .04565 | .01111 | .11435 | .01301 | .17794 | .01506 | .23713 | .01726 |
| 28 | 7 | .04684 | .01114 | .11544 | .01305 | .17896 | .01510 | .23809 | .01730 |
| 32 | 8 | .04803 | .01117 | .11654 | .01308 | .17998 | .01513 | .23904 | .01734 |
| 36 | 9 | .04922 | .01120 | .11764 | .01311 | .18100 | .01517 | .23999 | .01738 |
| 40 | 10 | 8.05041 | 0.01123 | 8.11873 | 0.01314 | 8.18202 | 0.01521 | 8.24094 | 0.01742 |
| 44 | 11 | .05159 | .01126 | .11983 | .01317 | .18303 | .01524 | .24189 | .01745 |
| 48 | 12 | .05277 | .01129 | .12092 | .01321 | .18405 | .01528 | .24283 | .01749 |
| 52 | 13 | .05395 | .01132 | .12201 | .01324 | .18506 | .01531 | .24378 | .01753 |
| 56 | 14 | .05513 | .01135 | .12310 | .01328 | .18607 | .01535 | .24473 | .01757 |
| s | ' | 0h 49m 12° | | 0h 53m 13° | | 0h 57m 14° | | 1h 1m 15° | |
| 0 | 15 | 8.05631 | 0.01138 | 8.12419 | 0.01331 | 8.18709 | 0.01538 | 8.24567 | 0.01761 |
| 4 | 16 | .05749 | .01142 | .12528 | .01334 | .18810 | .01542 | .24661 | .01764 |
| 8 | 17 | .05866 | .01145 | .12636 | .01338 | .18910 | .01546 | .24755 | .01768 |
| 12 | 18 | .05984 | .01148 | .12745 | .01341 | .19011 | .01549 | .24850 | .01772 |
| 16 | 19 | .06101 | .01151 | .12853 | .01344 | .19112 | .01553 | .24944 | .01776 |
| 20 | 20 | 8.06218 | 0.01154 | 8.12961 | 0.01348 | 8.19212 | 0.01556 | 8.25037 | 0.01780 |
| 24 | 21 | .06335 | .01157 | .13069 | .01351 | .19313 | .01560 | .25131 | .01784 |
| 28 | 22 | .06451 | .01160 | .13177 | .01354 | .19413 | .01564 | .25225 | .01788 |
| 32 | 23 | .06568 | .01163 | .13285 | .01358 | .19513 | .01567 | .25319 | .01791 |
| 36 | 24 | .06684 | .01166 | .13392 | .01361 | .19613 | .01571 | .25412 | .01795 |
| 40 | 25 | 8.06800 | 0.01170 | 8.13500 | 0.01365 | 8.19713 | 0.01574 | 8.25505 | 0.01799 |
| 44 | 26 | .06917 | .01173 | .13607 | .01368 | .19813 | .01578 | .25599 | .01803 |
| 48 | 27 | .07032 | .01176 | .13714 | .01371 | .19913 | .01582 | .25692 | .01807 |
| 52 | 28 | .07148 | .01179 | .13822 | .01375 | .20012 | .01585 | .25785 | .01811 |
| 56 | 29 | .07264 | .01182 | .13928 | .01378 | .20112 | .01589 | .25878 | .01815 |
| s | ' | 0h 50m 12° | | 0h 54m 13° | | 0h 58m 14° | | 1h 2m 15° | |
| 0 | 30 | 8.07379 | 0.01185 | 8.14035 | 0.01382 | 8.20211 | 0.01593 | 8.25971 | 0.01818 |
| 4 | 31 | .07494 | .01188 | .14142 | .01385 | .20310 | .01596 | .26064 | .01822 |
| 8 | 32 | .07610 | .01192 | .14248 | .01388 | .20410 | .01600 | .26156 | .01826 |
| 12 | 33 | .07725 | .01195 | .14355 | .01392 | .20509 | .01604 | .26249 | .01830 |
| 16 | 34 | .07839 | .01198 | .14461 | .01395 | .20608 | .01607 | .26341 | .01834 |
| 20 | 35 | 8.07954 | 0.01201 | 8.14567 | 0.01399 | 8.20706 | 0.01611 | 8.26434 | 0.01838 |
| 24 | 36 | .08069 | .01204 | .14673 | .01402 | .20805 | .01615 | .26526 | .01842 |
| 28 | 37 | .08183 | .01207 | .14779 | .01405 | .20904 | .01618 | .26618 | .01846 |
| 32 | 38 | .08297 | .01211 | .14885 | .01409 | .21002 | .01622 | .26710 | .01850 |
| 36 | 39 | .08411 | .01214 | .14991 | .01412 | .21100 | .01626 | .26802 | .01854 |
| 40 | 40 | 8.08525 | 0.01217 | 8.15096 | 0.01416 | 8.21199 | 0.01629 | 8.26894 | 0.01858 |
| 44 | 41 | .08639 | .01220 | .15201 | .01419 | .21297 | .01633 | .26986 | .01861 |
| 48 | 42 | .08752 | .01223 | .15307 | .01423 | .21395 | .01637 | .27078 | .01865 |
| 52 | 43 | .08866 | .01226 | .15412 | .01426 | .21493 | .01640 | .27169 | .01869 |
| 56 | 44 | .08979 | .01230 | .15517 | .01429 | .21590 | .01644 | .27261 | .01873 |
| s | ' | 0h 51m 12° | | 0h 55m 13° | | 0h 59m 14° | | 1h 3m 15° | |
| 0 | 45 | 8.09092 | 0.01233 | 8.15622 | 0.01433 | 8.21688 | 0.01648 | 8.27352 | 0.01877 |
| 4 | 46 | .09205 | .01236 | .15726 | .01436 | .21785 | .01651 | .27443 | .01881 |
| 8 | 47 | .09318 | .01239 | .15831 | .01440 | .21883 | .01655 | .27534 | .01885 |
| 12 | 48 | .09431 | .01243 | .15935 | .01443 | .21980 | .01659 | .27626 | .01889 |
| 16 | 49 | .09543 | .01246 | .16040 | .01447 | .22077 | .01663 | .27717 | .01893 |
| 20 | 50 | 8.09656 | 0.01249 | 8.16144 | 0.01450 | 8.22175 | 0.01666 | 8.27807 | 0.01897 |
| 24 | 51 | .09768 | .01252 | .16248 | .01454 | .22272 | .01670 | .27898 | .01901 |
| 28 | 52 | .09880 | .01255 | .16352 | .01457 | .22368 | .01674 | .27989 | .01905 |
| 32 | 53 | .09992 | .01259 | .16456 | .01461 | .22465 | .01677 | .28080 | .01909 |
| 36 | 54 | .10104 | .01262 | .16559 | .01464 | .22562 | .01681 | .28170 | .01913 |
| 40 | 55 | 8.10216 | 0.01265 | 8.16663 | 0.01468 | 8.22658 | 0.01685 | 8.28260 | 0.01917 |
| 44 | 56 | .10327 | .01268 | .16766 | .01471 | .22755 | .01689 | .28351 | .01921 |
| 48 | 57 | .10439 | .01272 | .16870 | .01475 | .22851 | .01692 | .28441 | .01925 |
| 52 | 58 | .10550 | .01275 | .16973 | .01478 | .22947 | .01696 | .28531 | .01929 |
| 56 | 59 | .10661 | .01278 | .17076 | .01482 | .23044 | .01700 | .28621 | .01933 |
| 60 | 60 | 8.10772 | 0.01282 | 8.17179 | 0.01485 | 8.23140 | 0.01704 | 8.28711 | 0.01937 |

Table 10. Haversine Table

| s | ' | 1h 4 ^m 16° | | 1h 8 ^m 17° | | 1h 12 ^m 18° | | 1h 16 ^m 19° | |
|----|----|-----------------------|----------------|------------------------|----------------|------------------------|----------------|------------------------|----------------|
| | | Hav. | No. | Hav. | No. | Hav. | No. | Hav. | No. |
| 0 | 0 | 8.28711 | 0.01937 | 8.33940 | 0.02185 | 8.38867 | 0.02447 | 8.43522 | 0.02724 |
| 4 | 1 | .28801 | .01941 | .34025 | .02189 | .38946 | .02452 | .43597 | .02729 |
| 8 | 2 | .28891 | .01945 | .34109 | .02193 | .39026 | .02456 | .43673 | .02734 |
| 12 | 3 | .28980 | .01949 | .34194 | .02198 | .39105 | .02461 | .43748 | .02738 |
| 16 | 4 | .29070 | .01953 | .34278 | .02202 | .39185 | .02465 | .43823 | .02743 |
| 20 | 5 | 8.29159 | 0.01957 | 8.34362 | 0.02206 | 8.39264 | 0.02470 | 8.43899 | 0.02748 |
| 24 | 6 | .29249 | .01961 | .34446 | .02210 | .39344 | .02474 | .43974 | .02753 |
| 28 | 7 | .29338 | .01965 | .34530 | .02215 | .39423 | .02479 | .44049 | .02757 |
| 32 | 8 | .29427 | .01969 | .34614 | .02219 | .39502 | .02483 | .44124 | .02762 |
| 36 | 9 | .29516 | .01973 | .34698 | .02223 | .39581 | .02488 | .44199 | .02767 |
| 40 | 10 | 8.29605 | 0.01977 | 8.34782 | 0.02227 | 8.39660 | 0.02492 | 8.44273 | 0.02772 |
| 44 | 11 | .29694 | .01981 | .34865 | .02232 | .39739 | .02497 | .44348 | .02776 |
| 48 | 12 | .29783 | .01985 | .34949 | .02236 | .39818 | .02501 | .44423 | .02781 |
| 52 | 13 | .29872 | .01989 | .35032 | .02240 | .39897 | .02506 | .44498 | .02786 |
| 56 | 14 | .29960 | .01993 | .35116 | .02245 | .39976 | .02510 | .44572 | .02791 |
| s | ' | 1h 5 ^m 16° | | 1h 9 ^m 17° | | 1h 13 ^m 18° | | 1h 17 ^m 19° | |
| 0 | 15 | 8.30049 | 0.01998 | 8.35199 | 0.02249 | 8.40055 | 0.02515 | 8.44647 | 0.02796 |
| 4 | 16 | .30137 | .02002 | .35282 | .02253 | .40133 | .02520 | .44721 | .02800 |
| 8 | 17 | .30226 | .02006 | .35365 | .02258 | .40212 | .02524 | .44796 | .02805 |
| 12 | 18 | .30314 | .02010 | .35449 | .02262 | .40290 | .02529 | .44870 | .02810 |
| 16 | 19 | .30402 | .02014 | .35532 | .02266 | .40369 | .02533 | .44944 | .02815 |
| 20 | 20 | 8.30490 | 0.02018 | 8.35614 | 0.02271 | 8.40447 | 0.02538 | 8.45018 | 0.02820 |
| 24 | 21 | .30578 | .02022 | .35697 | .02275 | .40525 | .02542 | .45093 | .02824 |
| 28 | 22 | .30666 | .02026 | .35780 | .02279 | .40603 | .02547 | .45167 | .02829 |
| 32 | 23 | .30754 | .02030 | .35863 | .02284 | .40681 | .02552 | .45241 | .02834 |
| 36 | 24 | .30842 | .02034 | .35945 | .02288 | .40760 | .02556 | .45315 | .02839 |
| 40 | 25 | 8.30929 | 0.02038 | 8.36028 | 0.02292 | 8.40837 | 0.02561 | 8.45388 | 0.02844 |
| 44 | 26 | .31017 | .02043 | .36110 | .02297 | .40915 | .02565 | .45462 | .02849 |
| 48 | 27 | .31104 | .02047 | .36193 | .02301 | .40993 | .02570 | .45536 | .02853 |
| 52 | 28 | .31192 | .02051 | .36275 | .02305 | .41071 | .02575 | .45610 | .02858 |
| 56 | 29 | .31279 | .02055 | .36357 | .02310 | .41149 | .02579 | .45683 | .02863 |
| s | ' | 1h 6 ^m 16° | | 1h 10 ^m 17° | | 1h 14 ^m 18° | | 1h 18 ^m 19° | |
| 0 | 30 | 8.31366 | 0.02059 | 8.36439 | 0.02314 | 8.41226 | 0.02584 | 8.45757 | 0.02868 |
| 4 | 31 | .31453 | .02063 | .36521 | .02319 | .41304 | .02588 | .45830 | .02873 |
| 8 | 32 | .31540 | .02067 | .36603 | .02323 | .41381 | .02593 | .45904 | .02878 |
| 12 | 33 | .31627 | .02071 | .36685 | .02327 | .41459 | .02598 | .45977 | .02883 |
| 16 | 34 | .31714 | .02076 | .36767 | .02332 | .41536 | .02602 | .46050 | .02887 |
| 20 | 35 | 8.31800 | 0.02080 | 8.36849 | 0.02336 | 8.41613 | 0.02607 | 8.46124 | 0.02892 |
| 24 | 36 | .31887 | .02084 | .36930 | .02340 | .41690 | .02612 | .46197 | .02897 |
| 28 | 37 | .31974 | .02088 | .37012 | .02345 | .41767 | .02616 | .46270 | .02902 |
| 32 | 38 | .32060 | .02092 | .37093 | .02349 | .41845 | .02621 | .46343 | .02907 |
| 36 | 39 | .32147 | .02096 | .37175 | .02354 | .41921 | .02626 | .46416 | .02912 |
| 40 | 40 | 8.32233 | 0.02101 | 8.37256 | 0.02358 | 8.41998 | 0.02630 | 8.46489 | 0.02917 |
| 44 | 41 | .32319 | .02105 | .37337 | .02363 | .42075 | .02635 | .46562 | .02922 |
| 48 | 42 | .32405 | .02109 | .37419 | .02367 | .42152 | .02639 | .46634 | .02926 |
| 52 | 43 | .32491 | .02113 | .37500 | .02371 | .42229 | .02644 | .46707 | .02931 |
| 56 | 44 | .32577 | .02117 | .37581 | .02376 | .42305 | .02649 | .46780 | .02936 |
| s | ' | 1h 7 ^m 16° | | 1h 11 ^m 17° | | 1h 15 ^m 18° | | 1h 19 ^m 19° | |
| 0 | 45 | 8.32663 | 0.02121 | 8.37662 | 0.02380 | 8.42382 | 0.02653 | 8.46852 | 0.02941 |
| 4 | 46 | .32749 | .02126 | .37742 | .02385 | .42458 | .02658 | .46925 | .02946 |
| 8 | 47 | .32834 | .02130 | .37823 | .02389 | .42535 | .02663 | .46998 | .02951 |
| 12 | 48 | .32920 | .02134 | .37904 | .02394 | .42611 | .02668 | .47070 | .02956 |
| 16 | 49 | .33006 | .02138 | .37985 | .02398 | .42687 | .02672 | .47142 | .02961 |
| 20 | 50 | 8.33091 | 0.02142 | 8.38065 | 0.02402 | 8.42764 | 0.02677 | 8.47215 | 0.02966 |
| 24 | 51 | .33176 | .02147 | .38146 | .02407 | .42840 | .02682 | .47287 | .02971 |
| 28 | 52 | .33262 | .02151 | .38226 | .02411 | .42916 | .02686 | .47359 | .02976 |
| 32 | 53 | .33347 | .02155 | .38306 | .02416 | .42992 | .02691 | .47431 | .02981 |
| 36 | 54 | .33432 | .02159 | .38387 | .02420 | .43068 | .02696 | .47503 | .02986 |
| 40 | 55 | 8.33517 | 0.02164 | 8.38467 | 0.02425 | 8.43144 | 0.02700 | 8.47575 | 0.02991 |
| 44 | 56 | .33602 | .02168 | .38547 | .02429 | .43219 | .02705 | .47647 | .02996 |
| 48 | 57 | .33688 | .02172 | .38627 | .02434 | .43295 | .02710 | .47719 | .03000 |
| 52 | 58 | .33771 | .02176 | .38707 | .02438 | .43371 | .02715 | .47791 | .03005 |
| 56 | 59 | .33856 | .02181 | .38787 | .02443 | .43446 | .02719 | .47862 | .03010 |
| 60 | 60 | 8.33940 | 0.02185 | 8.38867 | 0.02447 | 8.43522 | 0.02724 | 8.47934 | 0.03015 |

Table 10. Haversine Table

| s | ' | 1h 20 ^m 20° | | 1h 24 ^m 21° | | 1h 28 ^m 22° | | 1h 32 ^m 23° | |
|----|----|------------------------|----------------|------------------------|----------------|------------------------|----------------|------------------------|----------------|
| | | Hav. | No. | Hav. | No. | Hav. | No. | Hav. | No. |
| 0 | 0 | 8.47934 | 0.03015 | 8.52127 | 0.03321 | 8.56120 | 0.03641 | 8.59931 | 0.03975 |
| 4 | 1 | .48006 | .03020 | .52195 | .03326 | .56185 | .03646 | .59993 | .03980 |
| 8 | 2 | .48077 | .03025 | .52263 | .03331 | .56250 | .03652 | .60055 | .03986 |
| 12 | 3 | .48149 | .03030 | .52331 | .03337 | .56315 | .03657 | .60117 | .03992 |
| 16 | 4 | .48220 | .03035 | .52399 | .03342 | .56379 | .03663 | .60179 | .03998 |
| 20 | 5 | 8.48292 | 0.03040 | 8.52467 | 0.03347 | 8.56444 | 0.03668 | 8.60241 | 0.04003 |
| 24 | 6 | .48363 | .03045 | .52535 | .03352 | .56509 | .03674 | .60303 | .04009 |
| 28 | 7 | .48434 | .03050 | .52602 | .03358 | .56574 | .03679 | .60365 | .04015 |
| 32 | 8 | .48505 | .03055 | .52670 | .03363 | .56638 | .03685 | .60426 | .04020 |
| 36 | 9 | .48576 | .03060 | .52738 | .03368 | .56703 | .03690 | .60488 | .04026 |
| 40 | 10 | 8.48648 | 0.03065 | 8.52806 | 0.03373 | 8.56767 | 0.03695 | 8.60550 | 0.04032 |
| 44 | 11 | .48719 | .03070 | .52873 | .03379 | .56832 | .03701 | .60611 | .04038 |
| 48 | 12 | .48789 | .03075 | .52941 | .03384 | .56896 | .03706 | .60673 | .04043 |
| 52 | 13 | .48860 | .03080 | .53008 | .03389 | .56960 | .03712 | .60734 | .04049 |
| 56 | 14 | .48931 | .03085 | .53076 | .03394 | .57025 | .03717 | .60796 | .04055 |
| s | ' | 1h 21 ^m 20° | | 1h 25 ^m 21° | | 1h 29 ^m 22° | | 1h 33 ^m 23° | |
| 0 | 15 | 8.49002 | 0.03090 | 8.53143 | 0.03400 | 8.57089 | 0.03723 | 8.60857 | 0.04060 |
| 4 | 16 | .49073 | .03095 | .53210 | .03405 | .57153 | .03728 | .60919 | .04066 |
| 8 | 17 | .49143 | .03101 | .53277 | .03410 | .57217 | .03734 | .60980 | .04072 |
| 12 | 18 | .49214 | .03106 | .53345 | .03415 | .57282 | .03740 | .61041 | .04078 |
| 16 | 19 | .49284 | .03111 | .53412 | .03421 | .57346 | .03745 | .61103 | .04083 |
| 20 | 20 | 8.49355 | 0.03116 | 8.53479 | 0.03426 | 8.57410 | 0.03751 | 8.61164 | 0.04089 |
| 24 | 21 | .49425 | .03121 | .53546 | .03431 | .57474 | .03756 | .61225 | .04095 |
| 28 | 22 | .49496 | .03126 | .53613 | .03437 | .57538 | .03762 | .61286 | .04101 |
| 32 | 23 | .49566 | .03131 | .53680 | .03442 | .57601 | .03767 | .61347 | .04106 |
| 36 | 24 | .49636 | .03136 | .53747 | .03447 | .57665 | .03773 | .61408 | .04112 |
| 40 | 25 | 8.49706 | 0.03141 | 8.53814 | 0.03453 | 8.57729 | 0.03778 | 8.61469 | 0.04118 |
| 44 | 26 | .49777 | .03146 | .53880 | .03458 | .57793 | .03784 | .61530 | .04124 |
| 48 | 27 | .49847 | .03151 | .53947 | .03463 | .57856 | .03789 | .61591 | .04130 |
| 52 | 28 | .49917 | .03156 | .54014 | .03468 | .57920 | .03795 | .61652 | .04135 |
| 56 | 29 | .49987 | .03161 | .54080 | .03474 | .57984 | .03800 | .61713 | .04141 |
| s | ' | 1h 22 ^m 20° | | 1h 26 ^m 21° | | 1h 30 ^m 22° | | 1h 34 ^m 23° | |
| 0 | 30 | 8.50056 | 0.03166 | 8.54147 | 0.03479 | 8.58047 | 0.03806 | 8.61773 | 0.04147 |
| 4 | 31 | .50126 | .03171 | .54214 | .03484 | .58111 | .03812 | .61834 | .04153 |
| 8 | 32 | .50196 | .03177 | .54280 | .03490 | .58174 | .03817 | .61895 | .04159 |
| 12 | 33 | .50266 | .03182 | .54346 | .03495 | .58238 | .03823 | .61955 | .04164 |
| 16 | 34 | .50335 | .03187 | .54413 | .03500 | .58301 | .03828 | .62016 | .04170 |
| 20 | 35 | 8.50405 | 0.03192 | 8.54479 | 0.03506 | 8.58364 | 0.03834 | 8.62077 | 0.04176 |
| 24 | 36 | .50475 | .03197 | .54545 | .03511 | .58427 | .03839 | .62137 | .04182 |
| 28 | 37 | .50544 | .03202 | .54612 | .03517 | .58491 | .03845 | .62197 | .04188 |
| 32 | 38 | .50614 | .03207 | .54678 | .03522 | .58554 | .03851 | .62258 | .04194 |
| 36 | 39 | .50683 | .03212 | .54744 | .03527 | .58617 | .03856 | .62318 | .04199 |
| 40 | 40 | 8.50752 | 0.03218 | 8.54810 | 0.03533 | 8.58680 | 0.03862 | 8.62379 | 0.04205 |
| 44 | 41 | .50821 | .03223 | .54876 | .03538 | .58743 | .03867 | .62439 | .04211 |
| 48 | 42 | .50891 | .03228 | .54942 | .03543 | .58806 | .03873 | .62499 | .04217 |
| 52 | 43 | .50960 | .03233 | .55008 | .03549 | .58869 | .03879 | .62559 | .04223 |
| 56 | 44 | .51029 | .03238 | .55073 | .03554 | .58932 | .03884 | .62619 | .04229 |
| s | ' | 1h 23 ^m 20° | | 1h 27 ^m 21° | | 1h 31 ^m 22° | | 1h 35 ^m 23° | |
| 0 | 45 | 8.51098 | 0.03243 | 8.55139 | 0.03560 | 8.58994 | 0.03890 | 8.62680 | 0.04234 |
| 4 | 46 | .51167 | .03248 | .55205 | .03565 | .59057 | .03896 | .62740 | .04240 |
| 8 | 47 | .51236 | .03254 | .55271 | .03570 | .59120 | .03901 | .62800 | .04246 |
| 12 | 48 | .51305 | .03259 | .55336 | .03576 | .59183 | .03907 | .62860 | .04252 |
| 16 | 49 | .51374 | .03264 | .55402 | .03581 | .59245 | .03912 | .62919 | .04258 |
| 20 | 50 | 8.51442 | 0.03269 | 8.55467 | 0.03587 | 8.59308 | 0.03918 | 8.62979 | 0.04264 |
| 24 | 51 | .51511 | .03274 | .55533 | .03592 | .59370 | .03924 | .63039 | .04270 |
| 28 | 52 | .51580 | .03279 | .55598 | .03597 | .59433 | .03929 | .63099 | .04276 |
| 32 | 53 | .51648 | .03285 | .55664 | .03603 | .59495 | .03935 | .63159 | .04281 |
| 36 | 54 | .51717 | .03290 | .55729 | .03608 | .59558 | .03941 | .63218 | .04287 |
| 40 | 55 | 8.51785 | 0.03295 | 8.55794 | 0.03614 | 8.59620 | 0.03946 | 8.63278 | 0.04293 |
| 44 | 56 | .51854 | .03300 | .55859 | .03619 | .59682 | .03952 | .63338 | .04299 |
| 48 | 57 | .51922 | .03305 | .55925 | .03624 | .59745 | .03958 | .63397 | .04305 |
| 52 | 58 | .51990 | .03311 | .55990 | .03630 | .59807 | .03963 | .63457 | .04311 |
| 56 | 59 | .52058 | .03316 | .56055 | .03635 | .59869 | .03969 | .63516 | .04317 |
| 60 | 60 | 8.52127 | 0.03321 | 8.56120 | 0.03641 | 8.59931 | 0.03975 | 8.63576 | 0.04323 |

Table 10. Haversine Table

| s | 1h 36m 24° | | 1h 40m 25° | | 1h 44m 26° | | 1h 48m 27° | | |
|----|------------|------------|----------------|------------|----------------|------------|----------------|------------|----------------|
| | Hav. | No. | Hav. | No. | Hav. | No. | Hav. | No. | |
| 0 | 0 | 8.63576 | 0.04323 | 8.67067 | 0.04685 | 8.70418 | 0.05060 | 8.73637 | 0.05450 |
| 4 | 1 | .63635 | .04329 | .67124 | .04691 | .70472 | .05067 | .73690 | .05456 |
| 8 | 2 | .63695 | .04335 | .67181 | .04697 | .70527 | .05073 | .73742 | .05463 |
| 12 | 3 | .63754 | .04340 | .67238 | .04703 | .70582 | .05079 | .73795 | .05470 |
| 16 | 4 | .63813 | .04346 | .67295 | .04709 | .70636 | .05086 | .73847 | .05476 |
| 20 | 5 | 8.63872 | 0.04352 | 8.67352 | 0.04715 | 8.70691 | 0.05092 | 8.73900 | 0.05483 |
| 24 | 6 | .63932 | .04358 | .67409 | .04722 | .70745 | .05099 | .73952 | .05489 |
| 28 | 7 | .63991 | .04364 | .67465 | .04728 | .70800 | .05105 | .74005 | .05496 |
| 32 | 8 | .64050 | .04370 | .67522 | .04734 | .70854 | .05111 | .74057 | .05503 |
| 36 | 9 | .64109 | .04376 | .67579 | .04740 | .70909 | .05118 | .74109 | .05509 |
| 40 | 10 | 8.64168 | 0.04382 | 8.67635 | 0.04746 | 8.70963 | 0.05124 | 8.74162 | 0.05516 |
| 44 | 11 | .64227 | .04388 | .67692 | .04752 | .71017 | .05131 | .74214 | .05523 |
| 48 | 12 | .64286 | .04394 | .67748 | .04759 | .71072 | .05137 | .74266 | .05529 |
| 52 | 13 | .64345 | .04400 | .67805 | .04765 | .71126 | .05144 | .74318 | .05536 |
| 56 | 14 | .64404 | .04405 | .67861 | .04771 | .71180 | .05150 | .74371 | .05542 |
| s | | 1h 37m 24° | | 1h 41m 25° | | 1h 45m 26° | | 1h 49m 27° | |
| 0 | 15 | 8.64463 | 0.04412 | 8.67918 | 0.04777 | 8.71234 | 0.05156 | 8.74423 | 0.05549 |
| 4 | 16 | .64521 | .04418 | .67974 | .04783 | .71289 | .05163 | .74475 | .05556 |
| 8 | 17 | .64580 | .04424 | .68030 | .04790 | .71343 | .05169 | .74527 | .05562 |
| 12 | 18 | .64639 | .04430 | .68087 | .04796 | .71397 | .05176 | .74579 | .05569 |
| 16 | 19 | .64697 | .04436 | .68143 | .04802 | .71451 | .05182 | .74631 | .05576 |
| 20 | 20 | 8.64756 | 0.04442 | 8.68199 | 0.04808 | 8.71505 | 0.05189 | 8.74683 | 0.05582 |
| 24 | 21 | .64815 | .04448 | .68256 | .04815 | .71559 | .05195 | .74735 | .05589 |
| 28 | 22 | .64873 | .04454 | .68312 | .04821 | .71613 | .05201 | .74787 | .05596 |
| 32 | 23 | .64932 | .04460 | .68368 | .04827 | .71667 | .05208 | .74839 | .05603 |
| 36 | 24 | .64990 | .04466 | .68424 | .04833 | .71721 | .05214 | .74890 | .05609 |
| 40 | 25 | 8.65049 | 0.04472 | 8.68480 | 0.04839 | 8.71774 | 0.05221 | 8.74942 | 0.05616 |
| 44 | 26 | .65107 | .04478 | .68536 | .04846 | .71828 | .05227 | .74994 | .05623 |
| 48 | 27 | .65165 | .04484 | .68592 | .04852 | .71882 | .05234 | .75046 | .05629 |
| 52 | 28 | .65224 | .04490 | .68648 | .04858 | .71936 | .05240 | .75097 | .05636 |
| 56 | 29 | .65282 | .04496 | .68704 | .04864 | .71989 | .05247 | .75149 | .05643 |
| s | | 1h 38m 24° | | 1h 42m 25° | | 1h 46m 26° | | 1h 50m 27° | |
| 0 | 30 | 8.65340 | 0.04502 | 8.68760 | 0.04871 | 8.72043 | 0.05253 | 8.75201 | 0.05649 |
| 4 | 31 | .65398 | .04508 | .68815 | .04877 | .72097 | .05260 | .75252 | .05656 |
| 8 | 32 | .65456 | .04514 | .68871 | .04883 | .72150 | .05266 | .75304 | .05663 |
| 12 | 33 | .65514 | .04520 | .68927 | .04890 | .72204 | .05273 | .75355 | .05670 |
| 16 | 34 | .65572 | .04526 | .68983 | .04896 | .72257 | .05279 | .75407 | .05676 |
| 20 | 35 | 8.65630 | 0.04532 | 8.69038 | 0.04902 | 8.72311 | 0.05286 | 8.75458 | 0.05683 |
| 24 | 36 | .65688 | .04538 | .69094 | .04908 | .72364 | .05292 | .75510 | .05690 |
| 28 | 37 | .65746 | .04544 | .69149 | .04915 | .72418 | .05299 | .75561 | .05697 |
| 32 | 38 | .65804 | .04550 | .69205 | .04921 | .72471 | .05305 | .75613 | .05703 |
| 36 | 39 | .65862 | .04556 | .69260 | .04927 | .72525 | .05312 | .75664 | .05710 |
| 40 | 40 | 8.65920 | 0.04562 | 8.69316 | 0.04934 | 8.72578 | 0.05318 | 8.75715 | 0.05717 |
| 44 | 41 | .65978 | .04569 | .69371 | .04940 | .72631 | .05325 | .75767 | .05724 |
| 48 | 42 | .66035 | .04575 | .69427 | .04946 | .72684 | .05331 | .75818 | .05730 |
| 52 | 43 | .66093 | .04581 | .69482 | .04952 | .72738 | .05338 | .75869 | .05737 |
| 56 | 44 | .66151 | .04587 | .69537 | .04959 | .72791 | .05345 | .75920 | .05744 |
| s | | 1h 39m 24° | | 1h 43m 25° | | 1h 47m 26° | | 1h 51m 27° | |
| 0 | 45 | 8.66208 | 0.04599 | 8.69593 | 0.04965 | 8.72844 | 0.05351 | 8.75972 | 0.05751 |
| 4 | 46 | .66266 | .04599 | .69648 | .04971 | .72897 | .05358 | .76023 | .05757 |
| 8 | 47 | .66323 | .04605 | .69703 | .04978 | .72950 | .05364 | .76074 | .05764 |
| 12 | 48 | .66381 | .04611 | .69758 | .04984 | .73003 | .05371 | .76125 | .05771 |
| 16 | 49 | .66438 | .04617 | .69814 | .04990 | .73056 | .05377 | .76176 | .05778 |
| 20 | 50 | 8.66496 | 0.04623 | 8.69869 | 0.04997 | 8.73109 | 0.05384 | 8.76227 | 0.05785 |
| 24 | 51 | .66553 | .04629 | .69924 | .05003 | .73162 | .05390 | .76278 | .05791 |
| 28 | 52 | .66610 | .04636 | .69979 | .05009 | .73215 | .05397 | .76329 | .05798 |
| 32 | 53 | .66668 | .04642 | .70034 | .05016 | .73268 | .05404 | .76380 | .05805 |
| 36 | 54 | .66725 | .04648 | .70089 | .05022 | .73321 | .05410 | .76431 | .05812 |
| 40 | 55 | 8.66782 | 0.04654 | 8.70144 | 0.05028 | 8.73374 | 0.05417 | 8.76481 | 0.05819 |
| 44 | 56 | .66839 | .04660 | .70198 | .05035 | .73426 | .05423 | .76532 | .05825 |
| 48 | 57 | .66896 | .04666 | .70253 | .05041 | .73479 | .05430 | .76583 | .05832 |
| 52 | 58 | .66953 | .04672 | .70308 | .05048 | .73532 | .05436 | .76634 | .05839 |
| 56 | 59 | .67010 | .04678 | .70363 | .05054 | .73584 | .05443 | .76684 | .05846 |
| 60 | 60 | 8.67067 | 0.04685 | 8.70418 | 0.05060 | 8.73637 | 0.05450 | 8.76735 | 0.05853 |

Table 10. Haversine Table

| s | ' | 1h 52 ^m 28° | | 1h 56 ^m 29° | | 2h 0 ^m 30° | | 2h 4 ^m 31° | |
|----|----|------------------------|----------------|------------------------|----------------|-----------------------|----------------|-----------------------|----------------|
| | | Hav. | No. | Hav. | No. | Hav. | No. | Hav. | No. |
| 0 | 0 | 8.76735 | 0.05853 | 8.79720 | 0.06269 | 8.82599 | 0.06699 | 8.85380 | 0.07142 |
| 4 | 1 | .76786 | .05859 | .79769 | .06276 | .82646 | .06706 | .85425 | .07149 |
| 8 | 2 | .76836 | .05866 | .79818 | .06283 | .82694 | .06713 | .85471 | .07157 |
| 12 | 3 | .76887 | .05873 | .79866 | .06290 | .82741 | .06721 | .85516 | .07164 |
| 16 | 4 | .76938 | .05880 | .79915 | .06297 | .82788 | .06728 | .85562 | .07172 |
| 20 | 5 | 8.76988 | 0.05887 | 8.79964 | 0.06304 | 8.82835 | 0.06735 | 8.85607 | 0.07179 |
| 24 | 6 | .77039 | .05894 | .80013 | .06311 | .82882 | .06742 | .85653 | .07187 |
| 28 | 7 | .77089 | .05901 | .80061 | .06318 | .82929 | .06750 | .85698 | .07194 |
| 32 | 8 | .77139 | .05907 | .80110 | .06326 | .82976 | .06757 | .85743 | .07202 |
| 36 | 9 | .77190 | .05914 | .80158 | .06333 | .83023 | .06764 | .85789 | .07209 |
| 40 | 10 | 8.77240 | 0.05921 | 8.80207 | 0.06340 | 8.83069 | 0.06772 | 8.85834 | 0.07217 |
| 44 | 11 | .77291 | .05928 | .80256 | .06347 | .83116 | .06779 | .85879 | .07224 |
| 48 | 12 | .77341 | .05935 | .80304 | .06354 | .83163 | .06786 | .85925 | .07232 |
| 52 | 13 | .77391 | .05942 | .80353 | .06361 | .83210 | .06794 | .85970 | .07239 |
| 56 | 14 | .77441 | .05949 | .80401 | .06368 | .83257 | .06801 | .86015 | .07247 |
| s | ' | 1h 53 ^m 28° | | 1h 57 ^m 29° | | 2h 1 ^m 30° | | 2h 5 ^m 31° | |
| 0 | 15 | 8.77492 | 0.05955 | 8.80449 | 0.06375 | 8.83303 | 0.06808 | 8.86060 | 0.07254 |
| 4 | 16 | .77542 | .05962 | .80498 | .06382 | .83350 | .06816 | .86105 | .07262 |
| 8 | 17 | .77592 | .05969 | .80546 | .06389 | .83397 | .06823 | .86151 | .07270 |
| 12 | 18 | .77642 | .05976 | .80595 | .06397 | .83444 | .06830 | .86196 | .07277 |
| 16 | 19 | .77692 | .05983 | .80643 | .06404 | .83490 | .06838 | .86241 | .07285 |
| 20 | 20 | 8.77742 | 0.05990 | 8.80691 | 0.06411 | 8.83537 | 0.06845 | 8.86286 | 0.07292 |
| 24 | 21 | .77792 | .05997 | .80739 | .06418 | .83583 | .06852 | .86331 | .07300 |
| 28 | 22 | .77842 | .06004 | .80788 | .06425 | .83630 | .06860 | .86376 | .07307 |
| 32 | 23 | .77892 | .06011 | .80836 | .06432 | .83676 | .06867 | .86421 | .07315 |
| 36 | 24 | .77942 | .06018 | .80884 | .06439 | .83723 | .06874 | .86466 | .07322 |
| 40 | 25 | 8.77992 | 0.06024 | 8.80932 | 0.06446 | 8.83769 | 0.06882 | 8.86511 | 0.07330 |
| 44 | 26 | .78042 | .06031 | .80980 | .06454 | .83816 | .06889 | .86556 | .07338 |
| 48 | 27 | .78092 | .06038 | .81028 | .06461 | .83862 | .06896 | .86600 | .07345 |
| 52 | 28 | .78142 | .06045 | .81076 | .06468 | .83909 | .06904 | .86645 | .07353 |
| 56 | 29 | .78191 | .06052 | .81124 | .06475 | .83955 | .06911 | .86690 | .07360 |
| s | ' | 1h 54 ^m 28° | | 1h 58 ^m 29° | | 2h 2 ^m 30° | | 2h 6 ^m 31° | |
| 0 | 30 | 8.78241 | 0.06059 | 8.81172 | 0.06482 | 8.84002 | 0.06919 | 8.86735 | 0.07368 |
| 4 | 31 | .78291 | .06066 | .81220 | .06489 | .84048 | .06926 | .86780 | .07376 |
| 8 | 32 | .78341 | .06073 | .81268 | .06497 | .84094 | .06933 | .86825 | .07383 |
| 12 | 33 | .78390 | .06080 | .81316 | .06504 | .84140 | .06941 | .86869 | .07391 |
| 16 | 34 | .78440 | .06087 | .81364 | .06511 | .84187 | .06948 | .86914 | .07398 |
| 20 | 35 | 8.78490 | 0.06094 | 8.81412 | 0.06518 | 8.84233 | 0.06956 | 8.86959 | 0.07406 |
| 24 | 36 | .78539 | .06101 | .81460 | .06525 | .84279 | .06963 | .87003 | .07414 |
| 28 | 37 | .78589 | .06108 | .81508 | .06532 | .84325 | .06970 | .87048 | .07421 |
| 32 | 38 | .78638 | .06115 | .81555 | .06540 | .84371 | .06978 | .87093 | .07429 |
| 36 | 39 | .78688 | .06122 | .81603 | .06547 | .84417 | .06985 | .87137 | .07437 |
| 40 | 40 | 8.78737 | 0.06129 | 8.81651 | 0.06554 | 8.84464 | 0.06993 | 8.87182 | 0.07444 |
| 44 | 41 | .78787 | .06136 | .81699 | .06561 | .84510 | .07000 | .87226 | .07452 |
| 48 | 42 | .78836 | .06143 | .81746 | .06568 | .84556 | .07007 | .87271 | .07459 |
| 52 | 43 | .78885 | .06150 | .81794 | .06576 | .84602 | .07015 | .87315 | .07467 |
| 56 | 44 | .78935 | .06157 | .81841 | .06583 | .84648 | .07022 | .87360 | .07475 |
| s | ' | 1h 55 ^m 28° | | 1h 59 ^m 29° | | 2h 3 ^m 30° | | 2h 7 ^m 31° | |
| 0 | 45 | 8.78984 | 0.06164 | 8.81889 | 0.06590 | 8.84694 | 0.07030 | 8.87404 | 0.07482 |
| 4 | 46 | .79033 | .06171 | .81937 | .06597 | .84740 | .07037 | .87448 | .07490 |
| 8 | 47 | .79082 | .06178 | .81984 | .06605 | .84785 | .07045 | .87493 | .07498 |
| 12 | 48 | .79132 | .06185 | .82032 | .06612 | .84831 | .07052 | .87537 | .07505 |
| 16 | 49 | .79181 | .06192 | .82079 | .06619 | .84877 | .07059 | .87582 | .07513 |
| 20 | 50 | 8.79230 | 0.06199 | 8.82126 | 0.06626 | 8.84923 | 0.07067 | 8.87626 | 0.07521 |
| 24 | 51 | .79279 | .06206 | .82174 | .06633 | .84969 | .07074 | .87670 | .07528 |
| 28 | 52 | .79328 | .06213 | .82221 | .06641 | .85015 | .07082 | .87714 | .07536 |
| 32 | 53 | .79377 | .06220 | .82269 | .06648 | .85060 | .07089 | .87759 | .07544 |
| 36 | 54 | .79426 | .06227 | .82316 | .06655 | .85106 | .07097 | .87803 | .07551 |
| 40 | 55 | 8.79475 | 0.06234 | 8.82363 | 0.06662 | 8.85152 | 0.07104 | 8.87847 | 0.07559 |
| 44 | 56 | .79524 | .06241 | .82410 | .06670 | .85197 | .07112 | .87891 | .07567 |
| 48 | 57 | .79573 | .06248 | .82458 | .06677 | .85243 | .07119 | .87935 | .07574 |
| 52 | 58 | .79622 | .06255 | .82505 | .06684 | .85289 | .07127 | .87980 | .07582 |
| 56 | 59 | .79671 | .06262 | .82552 | .06691 | .85334 | .07134 | .88024 | .07590 |
| 60 | 60 | 8.79720 | 0.06269 | 8.82599 | 0.06699 | 8.85380 | 0.07142 | 8.88068 | 0.07598 |

| s | ' | $2^h 8^m$ 32° | | $2^h 12^m$ 33° | | $2^h 16^m$ 34° | | $2^h 20^m$ 35° | |
|----|----|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| | | Hav. | No. | Hav. | No. | Hav. | No. | Hav. | No. |
| 0 | 0 | 8.88068 | 0.07598 | 8.90668 | 0.08066 | 8.93187 | 0.08548 | 8.95628 | 0.09042 |
| 4 | 1 | .88112 | .07605 | .90711 | .08074 | .93228 | .08556 | .95668 | .09051 |
| 8 | 2 | .88156 | .07613 | .90754 | .08082 | .93270 | .08564 | .95709 | .09059 |
| 12 | 3 | .88200 | .07621 | .90796 | .08090 | .93311 | .08573 | .95749 | .09067 |
| 16 | 4 | .88244 | .07628 | .90839 | .08098 | .93352 | .08581 | .95789 | .09076 |
| 20 | 5 | 8.88288 | 0.07636 | 8.90881 | 0.08106 | 8.93393 | 0.08589 | 8.95828 | 0.09084 |
| 24 | 6 | .88332 | .07644 | .90924 | .08114 | .93435 | .08597 | .95868 | .09093 |
| 28 | 7 | .88375 | .07652 | .90966 | .08122 | .93476 | .08605 | .95908 | .09101 |
| 32 | 8 | .88419 | .07659 | .91009 | .08130 | .93517 | .08613 | .95948 | .09109 |
| 36 | 9 | .88463 | .07667 | .91051 | .08138 | .93558 | .08621 | .95988 | .09118 |
| 40 | 10 | 8.88507 | 0.07675 | 8.91094 | 0.08146 | 8.93599 | 0.08630 | 8.96028 | 0.09126 |
| 44 | 11 | .88551 | .07683 | .91136 | .08154 | .93640 | .08638 | .96068 | .09134 |
| 48 | 12 | .88595 | .07690 | .91179 | .08162 | .93681 | .08646 | .96108 | .09143 |
| 52 | 13 | .88638 | .07698 | .91221 | .08170 | .93722 | .08654 | .96148 | .09151 |
| 56 | 14 | .88682 | .07706 | .91263 | .08178 | .93764 | .08662 | .96187 | .09160 |
| s | ' | $2^h 9^m$ 32° | | $2^h 13^m$ 33° | | $2^h 17^m$ 34° | | $2^h 21^m$ 35° | |
| 0 | 15 | 8.88726 | 0.07714 | 8.91306 | 0.08186 | 8.93805 | 0.08671 | 8.96227 | 0.09168 |
| 4 | 16 | .88769 | .07721 | .91348 | .08194 | .93846 | .08679 | .96267 | .09176 |
| 8 | 17 | .88813 | .07729 | .91390 | .08202 | .93886 | .08687 | .96307 | .09185 |
| 12 | 18 | .88857 | .07737 | .91432 | .08210 | .93927 | .08695 | .96346 | .09193 |
| 16 | 19 | .88900 | .07745 | .91475 | .08218 | .93968 | .08703 | .96386 | .09202 |
| 20 | 20 | 8.88944 | 0.07752 | 8.91517 | 0.08226 | 8.94009 | 0.08711 | 8.96426 | 0.09210 |
| 24 | 21 | .88988 | .07760 | .91559 | .08234 | .94050 | .08720 | .96465 | .09218 |
| 28 | 22 | .89031 | .07768 | .91601 | .08242 | .94091 | .08728 | .96505 | .09227 |
| 32 | 23 | .89075 | .07776 | .91643 | .08250 | .94132 | .08736 | .96545 | .09235 |
| 36 | 24 | .89118 | .07784 | .91685 | .08258 | .94173 | .08744 | .96584 | .09244 |
| 40 | 25 | 8.89162 | 0.07791 | 8.91728 | 0.08266 | 8.94213 | 0.08753 | 8.96624 | 0.09252 |
| 44 | 26 | .89205 | .07799 | .91770 | .08274 | .94254 | .08761 | .96663 | .09260 |
| 48 | 27 | .89248 | .07807 | .91812 | .08282 | .94295 | .08769 | .96703 | .09269 |
| 52 | 28 | .89292 | .07815 | .91854 | .08290 | .94336 | .08777 | .96742 | .09277 |
| 56 | 29 | .89335 | .07823 | .91896 | .08298 | .94376 | .08785 | .96782 | .09286 |
| s | ' | $2^h 10^m$ 32° | | $2^h 14^m$ 33° | | $2^h 18^m$ 34° | | $2^h 22^m$ 35° | |
| 0 | 30 | 8.89379 | 0.07830 | 8.91938 | 0.08306 | 8.94417 | 0.08794 | 8.96821 | 0.09294 |
| 4 | 31 | .89422 | .07838 | .91980 | .08314 | .94458 | .08802 | .96861 | .09303 |
| 8 | 32 | .89465 | .07846 | .92022 | .08322 | .94498 | .08810 | .96900 | .09311 |
| 12 | 33 | .89509 | .07854 | .92064 | .08330 | .94539 | .08818 | .96940 | .09320 |
| 16 | 34 | .89552 | .07862 | .92105 | .08338 | .94580 | .08827 | .96979 | .09328 |
| 20 | 35 | 8.89595 | 0.07870 | 8.92147 | 0.08346 | 8.94620 | 0.08835 | 8.97018 | 0.09337 |
| 24 | 36 | .89638 | .07877 | .92189 | .08354 | .94661 | .08843 | .97058 | .09345 |
| 28 | 37 | .89681 | .07885 | .92231 | .08362 | .94701 | .08851 | .97097 | .09353 |
| 32 | 38 | .89725 | .07893 | .92273 | .08370 | .94742 | .08860 | .97136 | .09362 |
| 36 | 39 | .89768 | .07901 | .92315 | .08378 | .94782 | .08868 | .97176 | .09370 |
| 40 | 40 | 8.89811 | 0.07909 | 8.92356 | 0.08386 | 8.94823 | 0.08876 | 8.97215 | 0.09379 |
| 44 | 41 | .89854 | .07917 | .92398 | .08394 | .94863 | .08885 | .97254 | .09387 |
| 48 | 42 | .89897 | .07924 | .92440 | .08402 | .94904 | .08893 | .97294 | .09396 |
| 52 | 43 | .89940 | .07932 | .92482 | .08410 | .94944 | .08901 | .97333 | .09404 |
| 56 | 44 | .89983 | .07940 | .92523 | .08418 | .94985 | .08909 | .97372 | .09413 |
| s | ' | $2^h 11^m$ 32° | | $2^h 15^m$ 33° | | $2^h 19^m$ 34° | | $2^h 23^m$ 35° | |
| 0 | 45 | 8.90026 | 0.07948 | 8.92565 | 0.08427 | 8.95025 | 0.08918 | 8.97411 | 0.09421 |
| 4 | 46 | .90069 | .07956 | .92607 | .08435 | .95065 | .08926 | .97450 | .09430 |
| 8 | 47 | .90112 | .07964 | .92648 | .08443 | .95106 | .08934 | .97489 | .09438 |
| 12 | 48 | .90155 | .07972 | .92690 | .08451 | .95146 | .08943 | .97529 | .09447 |
| 16 | 49 | .90198 | .07980 | .92731 | .08459 | .95186 | .08951 | .97568 | .09455 |
| 20 | 50 | 8.90241 | 0.07987 | 8.92773 | 0.08467 | 8.95227 | 0.08959 | 8.97607 | 0.09464 |
| 24 | 51 | .90284 | .07995 | .92814 | .08475 | .95267 | .08967 | .97646 | .09472 |
| 28 | 52 | .90326 | .08003 | .92856 | .08483 | .95307 | .08976 | .97685 | .09481 |
| 32 | 53 | .90369 | .08011 | .92897 | .08491 | .95347 | .08984 | .97724 | .09489 |
| 36 | 54 | .90412 | .08019 | .92939 | .08499 | .95388 | .08992 | .97763 | .09498 |
| 40 | 55 | 8.90455 | 0.08027 | 8.92980 | 0.08508 | 8.95428 | 0.09001 | 8.97802 | 0.09506 |
| 44 | 56 | .90498 | .08035 | .93022 | .08516 | .95468 | .09009 | .97841 | .09515 |
| 48 | 57 | .90540 | .08043 | .93063 | .08524 | .95508 | .09017 | .97880 | .09524 |
| 52 | 58 | .90583 | .08051 | .93104 | .08532 | .95548 | .09026 | .97919 | .09532 |
| 56 | 59 | .90626 | .08059 | .93146 | .08540 | .95588 | .09034 | .97958 | .09541 |
| 60 | 60 | 8.90668 | 0.08066 | 8.93187 | 0.08548 | 8.95628 | 0.09042 | 8.97997 | 0.09549 |

Table 10. Haversine Table

| s | 2h 24 ^m 36° | | 2h 28 ^m 37° | | 2h 32 ^m 38° | | 2h 36 ^m 39° | | |
|----|------------------------|------------------------|------------------------|------------------------|------------------------|---------|------------------------|---------|----------------|
| | Hav. | No. | Hav. | No. | Hav. | No. | Hav. | No. | |
| 0 | 0 | 8.97997 | 0.09549 | 9.00295 | 0.10068 | 9.02528 | 0.10599 | 9.04699 | 0.11143 |
| 4 | 1 | .98035 | .09558 | .00333 | .10077 | .02565 | .10608 | .04735 | .11152 |
| 8 | 2 | .98074 | .09566 | .00371 | .10086 | .02602 | .10617 | .04770 | .11161 |
| 12 | 3 | .98113 | .09575 | .00408 | .10095 | .02638 | .10626 | .04806 | .11170 |
| 16 | 4 | .98152 | .09583 | .00446 | .10103 | .02675 | .10635 | .04842 | .11179 |
| 20 | 5 | 8.98191 | 0.09592 | 9.00484 | 0.10112 | 9.02712 | 0.10644 | 9.04877 | 0.11189 |
| 24 | 6 | .98229 | .09601 | .00522 | .10121 | .02748 | .10653 | .04913 | .11198 |
| 28 | 7 | .98268 | .09609 | .00559 | .10130 | .02785 | .10662 | .04948 | .11207 |
| 32 | 8 | .98307 | .09618 | .00597 | .10138 | .02821 | .10671 | .04984 | .11216 |
| 36 | 9 | .98346 | .09626 | .00634 | .10147 | .02858 | .10680 | .05019 | .11225 |
| 40 | 10 | 8.98384 | 0.09635 | 9.00672 | 0.10156 | 9.02894 | 0.10689 | 9.05055 | 0.11234 |
| 44 | 11 | .98423 | .09643 | .00710 | .10165 | .02931 | .10698 | .05090 | .11244 |
| 48 | 12 | .98462 | .09652 | .00747 | .10174 | .02967 | .10707 | .05126 | .11253 |
| 52 | 13 | .98500 | .09661 | .00785 | .10182 | .03004 | .10716 | .05161 | .11262 |
| 56 | 14 | .98539 | .09669 | .00822 | .10191 | .03040 | .10725 | .05197 | .11271 |
| s | | 2h 25 ^m 36° | 2h 29 ^m 37° | 2h 33 ^m 38° | 2h 37 ^m 39° | | | | |
| 0 | 15 | 8.98578 | 0.09678 | 9.00860 | 0.10200 | 9.03077 | 0.10734 | 9.05232 | 0.11280 |
| 4 | 16 | .98616 | .09686 | .00897 | .10209 | .03113 | .10743 | .05268 | .11290 |
| 8 | 17 | .98655 | .09695 | .00935 | .10218 | .03150 | .10752 | .05303 | .11299 |
| 12 | 18 | .98693 | .09704 | .00972 | .10226 | .03186 | .10761 | .05339 | .11308 |
| 16 | 19 | .98732 | .09712 | .01009 | .10235 | .03222 | .10770 | .05374 | .11317 |
| 20 | 20 | 8.98770 | 0.09721 | 9.01047 | 0.10244 | 9.03259 | 0.10779 | 9.05409 | 0.11326 |
| 24 | 21 | .98809 | .09729 | .01084 | .10253 | .03295 | .10788 | .05445 | .11336 |
| 28 | 22 | .98847 | .09738 | .01122 | .10262 | .03331 | .10797 | .05480 | .11345 |
| 32 | 23 | .98886 | .09747 | .01159 | .10270 | .03368 | .10806 | .05515 | .11354 |
| 36 | 24 | .98924 | .09755 | .01196 | .10279 | .03404 | .10815 | .05551 | .11363 |
| 40 | 25 | 8.98963 | 0.09764 | 9.01234 | 0.10288 | 9.03440 | 0.10824 | 9.05586 | 0.11373 |
| 44 | 26 | .99001 | .09773 | .01271 | .10297 | .03476 | .10833 | .05621 | .11382 |
| 48 | 27 | .99039 | .09781 | .01308 | .10306 | .03513 | .10842 | .05656 | .11391 |
| 52 | 28 | .99078 | .09790 | .01345 | .10315 | .03549 | .10851 | .05692 | .11400 |
| 56 | 29 | .99116 | .09799 | .01383 | .10323 | .03585 | .10861 | .05727 | .11410 |
| s | | 2h 26 ^m 36° | 2h 30 ^m 37° | 2h 34 ^m 38° | 2h 38 ^m 39° | | | | |
| 0 | 30 | 8.99154 | 0.09807 | 9.01420 | 0.10332 | 9.03621 | 0.10870 | 9.05762 | 0.11419 |
| 4 | 31 | .99193 | .09816 | .01457 | .10341 | .03657 | .10879 | .05797 | .11428 |
| 8 | 32 | .99231 | .09824 | .01494 | .10350 | .03694 | .10888 | .05832 | .11437 |
| 12 | 33 | .99269 | .09833 | .01531 | .10359 | .03730 | .10897 | .05867 | .11447 |
| 16 | 34 | .99307 | .09842 | .01569 | .10368 | .03766 | .10906 | .05903 | .11456 |
| 20 | 35 | 8.99346 | 0.09850 | 9.01606 | 0.10377 | 9.03802 | 0.10915 | 9.05938 | 0.11465 |
| 24 | 36 | .99384 | .09859 | .01643 | .10386 | .03838 | .10924 | .05973 | .11474 |
| 28 | 37 | .99422 | .09868 | .01680 | .10394 | .03874 | .10933 | .06008 | .11484 |
| 32 | 38 | .99460 | .09876 | .01717 | .10403 | .03910 | .10942 | .06043 | .11493 |
| 36 | 39 | .99498 | .09885 | .01754 | .10412 | .03946 | .10951 | .06078 | .11502 |
| 40 | 40 | 8.99536 | 0.09894 | 9.01791 | 0.10421 | 9.03982 | 0.10960 | 9.06113 | 0.11511 |
| 44 | 41 | .99575 | .09903 | .01828 | .10430 | .04018 | .10969 | .06148 | .11521 |
| 48 | 42 | .99613 | .09911 | .01865 | .10439 | .04054 | .10978 | .06183 | .11530 |
| 52 | 43 | .99651 | .09920 | .01902 | .10448 | .04090 | .10988 | .06218 | .11539 |
| 56 | 44 | .99689 | .09929 | .01939 | .10457 | .04126 | .10997 | .06253 | .11549 |
| s | | 2h 27 ^m 36° | 2h 31 ^m 37° | 2h 35 ^m 38° | 2h 39 ^m 39° | | | | |
| 0 | 45 | 8.99727 | 0.09937 | 9.01976 | 0.10466 | 9.04162 | 0.11006 | 9.06288 | 0.11558 |
| 4 | 46 | .99765 | .09946 | .02013 | .10474 | .04198 | .11015 | .06323 | .11567 |
| 8 | 47 | .99803 | .09955 | .02050 | .10483 | .04234 | .11024 | .06358 | .11577 |
| 12 | 48 | .99841 | .09963 | .02087 | .10492 | .04270 | .11033 | .06393 | .11586 |
| 16 | 49 | .99879 | .09972 | .02124 | .10501 | .04306 | .11042 | .06428 | .11595 |
| 20 | 50 | 8.99917 | 0.09981 | 9.02161 | 0.10510 | 9.04341 | 0.11051 | 9.06462 | 0.11604 |
| 24 | 51 | .99955 | .09990 | .02197 | .10519 | .04377 | .11060 | .06497 | .11614 |
| 28 | 52 | .99993 | .09998 | .02234 | .10528 | .04413 | .11070 | .06532 | .11623 |
| 32 | 53 | 9.00031 | 1.00007 | .02271 | .10537 | .04449 | .11079 | .06567 | .11632 |
| 36 | 54 | .00068 | .10016 | .02308 | .10546 | .04485 | .11088 | .06602 | .11642 |
| 40 | 55 | 9.00106 | 0.10025 | 9.02345 | 0.10555 | 9.04520 | 0.11097 | 9.06637 | 0.11651 |
| 44 | 56 | .00144 | .10033 | .02381 | .10564 | .04556 | .11106 | .06671 | .11660 |
| 48 | 57 | .00182 | .10042 | .02418 | .10573 | .04592 | .11115 | .06706 | .11670 |
| 52 | 58 | .00220 | .10051 | .02455 | .10582 | .04628 | .11124 | .06741 | .11679 |
| 56 | 59 | .00258 | .10059 | .02492 | .10591 | .04663 | .11134 | .06776 | .11688 |
| 60 | 60 | 9.00295 | 0.10068 | 9.02528 | 0.10599 | 9.04699 | 0.11143 | 9.06810 | 0.11698 |

Table 10. Haversine Table

| s | ' | 2h 40m 40° | | 2h 44m 41° | | 2h 48m 42° | | 2h 52m 43° | |
|----|----|------------|----------------|------------|----------------|------------|----------------|------------|----------------|
| | | Hav. | No. | Hav. | No. | Hav. | No. | Hav. | No. |
| 0 | 0 | 9.06810 | 0.11698 | 9.08865 | 0.12265 | 9.10866 | 0.12843 | 9.12815 | 0.13432 |
| 4 | 1 | .06845 | .11707 | .08899 | .12274 | .10899 | .12852 | .12847 | .13442 |
| 8 | 2 | .06880 | .11716 | .08933 | .12284 | .10932 | .12862 | .12879 | .13452 |
| 12 | 3 | .06914 | .11726 | .08966 | .12293 | .10965 | .12872 | .12911 | .13462 |
| 16 | 4 | .06949 | .11735 | .09000 | .12303 | .10997 | .12882 | .12943 | .13472 |
| 20 | 5 | 9.06984 | 0.11745 | 9.09034 | 0.12312 | 9.11030 | 0.12891 | 9.12975 | 0.13482 |
| 24 | 6 | .07018 | .11754 | .09068 | .12322 | .11063 | .12901 | .13007 | .13492 |
| 28 | 7 | .07053 | .11763 | .09101 | .12331 | .11096 | .12911 | .13039 | .13502 |
| 32 | 8 | .07088 | .11773 | .09135 | .12341 | .11129 | .12921 | .13071 | .13512 |
| 36 | 9 | .07122 | .11782 | .09169 | .12351 | .11161 | .12930 | .13103 | .13522 |
| 40 | 10 | 3.07157 | 0.11791 | 9.09202 | 0.12360 | 9.11194 | 0.12940 | 9.13135 | 0.13532 |
| 44 | 11 | .07191 | .11801 | .09236 | .12370 | .11227 | .12950 | .13167 | .13542 |
| 48 | 12 | .07226 | .11810 | .09269 | .12379 | .11260 | .12960 | .13199 | .13552 |
| 52 | 13 | .07260 | .11820 | .09303 | .12389 | .11292 | .12970 | .13231 | .13562 |
| 56 | 14 | .07295 | .11829 | .09337 | .12398 | .11325 | .12979 | .13263 | .13571 |
| s | ' | 2h 41m 40° | | 2h 45m 41° | | 2h 49m 42° | | 2h 53m 43° | |
| 0 | 15 | 9.07329 | 0.11838 | 9.09370 | 0.12408 | 9.11358 | 0.12989 | 9.13295 | 0.13581 |
| 4 | 16 | .07364 | .11848 | .09404 | .12418 | .11391 | .12999 | .13326 | .13591 |
| 8 | 17 | .07398 | .11857 | .09437 | .12427 | .11423 | .13009 | .13358 | .13601 |
| 12 | 18 | .07433 | .11867 | .09471 | .12437 | .11456 | .13018 | .13390 | .13611 |
| 16 | 19 | .07467 | .11876 | .09504 | .12446 | .11489 | .13028 | .13422 | .13621 |
| 20 | 20 | 9.07501 | 0.11885 | 9.09538 | 0.12456 | 9.11521 | 0.13038 | 9.13454 | 0.13631 |
| 24 | 21 | .07536 | .11895 | .09571 | .12466 | .11554 | .13048 | .13486 | .13641 |
| 28 | 22 | .07570 | .11904 | .09605 | .12475 | .11586 | .13058 | .13517 | .13651 |
| 32 | 23 | .07605 | .11914 | .09638 | .12485 | .11619 | .13067 | .13549 | .13661 |
| 36 | 24 | .07639 | .11923 | .09672 | .12494 | .11652 | .13077 | .13581 | .13671 |
| 40 | 25 | 9.07673 | 0.11933 | 9.09705 | 0.12504 | 9.11684 | 0.13087 | 9.13613 | 0.13681 |
| 44 | 26 | .07708 | .11942 | .09739 | .12514 | .11717 | .13097 | .13644 | .13691 |
| 48 | 27 | .07742 | .11951 | .09772 | .12523 | .11749 | .13107 | .13676 | .13701 |
| 52 | 28 | .07776 | .11961 | .09805 | .12533 | .11782 | .13116 | .13708 | .13711 |
| 56 | 29 | .07810 | .11970 | .09839 | .12543 | .11814 | .13126 | .13739 | .13721 |
| s | ' | 2h 42m 40° | | 2h 46m 41° | | 2h 50m 42° | | 2h 54m 43° | |
| 0 | 30 | 9.07845 | 0.11980 | 9.09872 | 0.12552 | 9.11847 | 0.13136 | 9.13771 | 0.13731 |
| 4 | 31 | .07879 | .11989 | .09905 | .12562 | .11879 | .13146 | .13803 | .13741 |
| 8 | 32 | .07913 | .11999 | .09939 | .12572 | .11912 | .13156 | .13834 | .13751 |
| 12 | 33 | .07947 | .12008 | .09972 | .12581 | .11944 | .13166 | .13866 | .13761 |
| 16 | 34 | .07981 | .12018 | .10005 | .12591 | .11977 | .13175 | .13898 | .13771 |
| 20 | 35 | 9.08016 | 0.12027 | 9.10039 | 0.12600 | 9.12009 | 0.13185 | 9.13929 | 0.13781 |
| 24 | 36 | .08050 | .12036 | .10072 | .12610 | .12041 | .13195 | .13961 | .13791 |
| 28 | 37 | .08084 | .12046 | .10105 | .12620 | .12074 | .13205 | .13992 | .13801 |
| 32 | 38 | .08118 | .12055 | .10138 | .12629 | .12106 | .13215 | .14024 | .13811 |
| 36 | 39 | .08152 | .12065 | .10172 | .12639 | .12139 | .13225 | .14056 | .13822 |
| 40 | 40 | 9.08186 | 0.12074 | 9.10205 | 0.12649 | 9.12171 | 0.13235 | 9.14087 | 0.13832 |
| 44 | 41 | .08220 | .12084 | .10238 | .12658 | .12203 | .13244 | .14119 | .13842 |
| 48 | 42 | .08254 | .12093 | .10271 | .12668 | .12236 | .13254 | .14150 | .13852 |
| 52 | 43 | .08288 | .12103 | .10304 | .12678 | .12268 | .13264 | .14182 | .13862 |
| 56 | 44 | .08323 | .12112 | .10337 | .12687 | .12300 | .13274 | .14213 | .13872 |
| s | ' | 2h 43m 40° | | 2h 47m 41° | | 2h 51m 42° | | 2h 55m 43° | |
| 0 | 45 | 9.08357 | 0.12122 | 9.10371 | 0.12697 | 9.12332 | 0.13284 | 9.14245 | 0.13882 |
| 4 | 46 | .08391 | .12131 | .10404 | .12707 | .12365 | .13294 | .14276 | .13892 |
| 8 | 47 | .08425 | .12141 | .10437 | .12717 | .12397 | .13304 | .14307 | .13902 |
| 12 | 48 | .08459 | .12150 | .10470 | .12726 | .12429 | .13314 | .14339 | .13912 |
| 16 | 49 | .08492 | .12160 | .10503 | .12736 | .12461 | .13323 | .14370 | .13922 |
| 20 | 50 | 9.08526 | 0.12169 | 9.10536 | 0.12746 | 9.12494 | 0.13333 | 9.14402 | 0.13932 |
| 24 | 51 | .08560 | .12179 | .10569 | .12755 | .12526 | .13343 | .14433 | .13942 |
| 28 | 52 | .08594 | .12188 | .10602 | .12765 | .12558 | .13353 | .14465 | .13952 |
| 32 | 53 | .08628 | .12198 | .10635 | .12775 | .12590 | .13363 | .14496 | .13962 |
| 36 | 54 | .08662 | .12207 | .10668 | .12784 | .12622 | .13373 | .14527 | .13972 |
| 40 | 55 | 9.08696 | 0.12217 | 9.10701 | 0.12794 | 9.12655 | 0.13383 | 9.14559 | 0.13983 |
| 44 | 56 | .08730 | .12226 | .10734 | .12804 | .12687 | .13393 | .14590 | .13993 |
| 48 | 57 | .08764 | .12236 | .10767 | .12814 | .12719 | .13403 | .14621 | .14003 |
| 52 | 58 | .08797 | .12245 | .10800 | .12823 | .12751 | .13412 | .14653 | .14013 |
| 56 | 59 | .08831 | .12255 | .10833 | .12833 | .12783 | .13422 | .14684 | .14023 |
| 60 | 60 | 9.08865 | 0.12265 | 9.10866 | 0.12843 | 9.12815 | 0.13432 | 9.14715 | 0.14033 |

Table 10. Haversine Table

| s | ' | 2h 56m 44° | | 3h 0m 45° | | 3h 4m 46° | | 3h 8m 47° | |
|----|----|------------|----------------|-----------|----------------|-----------|----------------|------------|----------------|
| | | Hav. | No. | Hav. | No. | Hav. | No. | Hav. | No. |
| 0 | 0 | 9.14715 | 0.14033 | 9.16568 | 0.14645 | 9.18376 | 0.15267 | 9.20140 | 0.15900 |
| 4 | 1 | .14746 | .14043 | .16598 | .14655 | .18405 | .15278 | .20169 | .15911 |
| 8 | 2 | .14778 | .14053 | .16629 | .14665 | .18435 | .15288 | .20198 | .15921 |
| 12 | 3 | .14809 | .14063 | .16659 | .14676 | .18465 | .15298 | .20227 | .15932 |
| 16 | 4 | .14840 | .14073 | .16690 | .14686 | .18495 | .15309 | .20256 | .15943 |
| 20 | 5 | 9.14871 | 0.14084 | 9.16720 | 0.14696 | 9.18524 | 0.15319 | 9.20285 | 0.15953 |
| 24 | 6 | .14902 | .14094 | .16751 | .14706 | .18554 | .15330 | .20314 | .15964 |
| 28 | 7 | .14934 | .14104 | .16781 | .14717 | .18584 | .15340 | .20343 | .15975 |
| 32 | 8 | .14965 | .14114 | .16812 | .14727 | .18613 | .15351 | .20372 | .15985 |
| 36 | 9 | .14996 | .14124 | .16842 | .14737 | .18643 | .15361 | .20401 | .15996 |
| 40 | 10 | 9.15027 | 0.14134 | 9.16872 | 0.14748 | 9.18673 | 0.15372 | 9.20430 | 0.16007 |
| 44 | 11 | .15058 | .14144 | .16903 | .14758 | .18702 | .15382 | .20459 | .16017 |
| 48 | 12 | .15089 | .14154 | .16933 | .14768 | .18732 | .15393 | .20488 | .16028 |
| 52 | 13 | .15120 | .14165 | .16963 | .14779 | .18762 | .15403 | .20517 | .16039 |
| 56 | 14 | .15152 | .14175 | .16994 | .14789 | .18791 | .15414 | .20546 | .16049 |
| s | ' | 2h 57m 44° | | 3h 1m 45° | | 3h 5m 46° | | 3h 9m 47° | |
| 0 | 15 | 9.15183 | 0.14185 | 9.17024 | 0.14799 | 9.18821 | 0.15424 | 9.20574 | 0.16060 |
| 4 | 16 | .15214 | .14195 | .17054 | .14810 | .18850 | .15435 | .20603 | .16071 |
| 8 | 17 | .15245 | .14205 | .17085 | .14820 | .18880 | .15445 | .20632 | .16081 |
| 12 | 18 | .15276 | .14215 | .17115 | .14830 | .18909 | .15456 | .20661 | .16092 |
| 16 | 19 | .15307 | .14226 | .17145 | .14841 | .18939 | .15466 | .20690 | .16103 |
| 20 | 20 | 9.15338 | 0.14236 | 9.17175 | 0.14851 | 9.18968 | 0.15477 | 9.20719 | 0.16113 |
| 24 | 21 | .15369 | .14246 | .17206 | .14861 | .18998 | .15487 | .20748 | .16124 |
| 28 | 22 | .15400 | .14256 | .17236 | .14872 | .19027 | .15498 | .20777 | .16135 |
| 32 | 23 | .15431 | .14266 | .17266 | .14882 | .19057 | .15509 | .20805 | .16146 |
| 36 | 24 | .15462 | .14276 | .17296 | .14892 | .19086 | .15519 | .20834 | .16156 |
| 40 | 25 | 9.15493 | 0.14287 | 9.17327 | 0.14903 | 9.19116 | 0.15530 | 9.20863 | 0.16167 |
| 44 | 26 | .15524 | .14297 | .17357 | .14913 | .19145 | .15540 | .20891 | .16178 |
| 48 | 27 | .15555 | .14307 | .17387 | .14923 | .19175 | .15551 | .20920 | .16188 |
| 52 | 28 | .15585 | .14317 | .17417 | .14934 | .19204 | .15561 | .20949 | .16199 |
| 56 | 29 | .15616 | .14327 | .17447 | .14944 | .19234 | .15572 | .20978 | .16210 |
| s | ' | 2h 58m 44° | | 3h 2m 45° | | 3h 6m 46° | | 3h 10m 47° | |
| 0 | 30 | 9.15647 | 0.14337 | 9.17477 | 0.14955 | 9.19263 | 0.15582 | 9.21006 | 0.16220 |
| 4 | 31 | .15678 | .14348 | .17507 | .14965 | .19292 | .15593 | .21035 | .16231 |
| 8 | 32 | .15709 | .14358 | .17538 | .14975 | .19322 | .15603 | .21064 | .16242 |
| 12 | 33 | .15740 | .14368 | .17568 | .14986 | .19351 | .15614 | .21092 | .16253 |
| 16 | 34 | .15771 | .14378 | .17598 | .14996 | .19381 | .15625 | .21121 | .16263 |
| 20 | 35 | 9.15802 | 0.14388 | 9.17628 | 0.15006 | 9.19410 | 0.15635 | 9.21150 | 0.16274 |
| 24 | 36 | .15832 | .14399 | .17658 | .15017 | .19439 | .15646 | .21178 | .16285 |
| 28 | 37 | .15863 | .14409 | .17688 | .15027 | .19469 | .15656 | .21207 | .16296 |
| 32 | 38 | .15894 | .14419 | .17718 | .15038 | .19498 | .15667 | .21236 | .16306 |
| 36 | 39 | .15925 | .14429 | .17748 | .15048 | .19527 | .15677 | .21264 | .16317 |
| 40 | 40 | 9.15955 | 0.14440 | 9.17778 | 0.15058 | 9.19557 | 0.15688 | 9.21293 | 0.16328 |
| 44 | 41 | .15986 | .14450 | .17808 | .15069 | .19586 | .15699 | .21322 | .16339 |
| 48 | 42 | .16017 | .14460 | .17838 | .15079 | .19615 | .15709 | .21350 | .16349 |
| 52 | 43 | .16048 | .14470 | .17868 | .15090 | .19644 | .15720 | .21379 | .16360 |
| 56 | 44 | .16078 | .14480 | .17898 | .15100 | .19674 | .15730 | .21407 | .16371 |
| s | ' | 2h 59m 44° | | 3h 3m 45° | | 3h 7m 46° | | 3h 11m 47° | |
| 0 | 45 | 9.16109 | 0.14491 | 9.17928 | 0.15110 | 9.19703 | 0.15741 | 9.21436 | 0.16382 |
| 4 | 46 | .16140 | .14501 | .17958 | .15121 | .19732 | .15751 | .21464 | .16392 |
| 8 | 47 | .16170 | .14511 | .17988 | .15131 | .19761 | .15762 | .21493 | .16403 |
| 12 | 48 | .16201 | .14521 | .18018 | .15142 | .19790 | .15773 | .21521 | .16414 |
| 16 | 49 | .16232 | .14532 | .18048 | .15152 | .19820 | .15783 | .21550 | .16425 |
| 20 | 50 | 9.16262 | 0.14542 | 9.18077 | 0.15163 | 9.19849 | 0.15794 | 9.21578 | 0.16436 |
| 24 | 51 | .16293 | .14552 | .18107 | .15173 | .19878 | .15804 | .21607 | .16446 |
| 28 | 52 | .16324 | .14562 | .18137 | .15183 | .19907 | .15815 | .21635 | .16457 |
| 32 | 53 | .16354 | .14573 | .18167 | .15194 | .19936 | .15826 | .21664 | .16468 |
| 36 | 54 | .16385 | .14583 | .18197 | .15204 | .19965 | .15836 | .21692 | .16479 |
| 40 | 55 | 9.16415 | 0.14593 | 9.18227 | 0.15215 | 9.19995 | 0.15847 | 9.21721 | 0.16489 |
| 44 | 56 | .16446 | .14604 | .18256 | .15225 | .20024 | .15858 | .21749 | .16500 |
| 48 | 57 | .16476 | .14614 | .18286 | .15236 | .20053 | .15868 | .21778 | .16511 |
| 52 | 58 | .16507 | .14624 | .18316 | .15246 | .20082 | .15879 | .21806 | .16522 |
| 56 | 59 | .16537 | .14634 | .18346 | .15257 | .20111 | .15889 | .21834 | .16533 |
| 60 | 60 | 9.16568 | 0.14645 | 9.18376 | 0.15267 | 9.20140 | 0.15900 | 9.21863 | 0.16543 |

Table 10. Haversine Table

| s | ' | 3h 12m 48° | | 3h 16m 49° | | 3h 20m 50° | | 3h 24m 51° | |
|----|----|------------|----------------|------------|----------------|------------|----------------|------------|----------------|
| | | Hav. | No. | Hav. | No. | Hav. | No. | Hav. | No. |
| 0 | 0 | 9.21863 | 0.16543 | 9.23545 | 0.17197 | 9.25190 | 0.17861 | 9.26797 | 0.18534 |
| 4 | 1 | .21891 | .16554 | .23573 | .17208 | .25217 | .17872 | .26823 | .18545 |
| 8 | 2 | .21919 | .16565 | .23601 | .17219 | .25244 | .17883 | .26850 | .18557 |
| 12 | 3 | .21948 | .16576 | .23629 | .17230 | .25271 | .17894 | .26876 | .18568 |
| 16 | 4 | .21976 | .16587 | .23656 | .17241 | .25298 | .17905 | .26903 | .18579 |
| 20 | 5 | 9.22004 | 0.16598 | 9.23684 | 0.17252 | 9.25325 | 0.17916 | 9.26929 | 0.18591 |
| 24 | 6 | .22033 | .16608 | .23712 | .17263 | .25352 | .17928 | .26956 | .18602 |
| 28 | 7 | .22061 | .16619 | .23739 | .17274 | .25379 | .17939 | .26982 | .18613 |
| 32 | 8 | .22089 | .16630 | .23767 | .17285 | .25406 | .17950 | .27008 | .18624 |
| 36 | 9 | .22118 | .16641 | .23794 | .17296 | .25433 | .17961 | .27035 | .18636 |
| 40 | 10 | 9.22146 | 0.16652 | 9.23822 | 0.17307 | 9.25460 | 0.17972 | 9.27061 | 0.18647 |
| 44 | 11 | .22174 | .16663 | .23850 | .17318 | .25487 | .17983 | .27088 | .18658 |
| 48 | 12 | .22202 | .16673 | .23877 | .17329 | .25514 | .17995 | .27114 | .18670 |
| 52 | 13 | .22231 | .16684 | .23905 | .17340 | .25541 | .18006 | .27140 | .18681 |
| 56 | 14 | .22259 | .16695 | .23932 | .17351 | .25568 | .18017 | .27167 | .18692 |
| s | ' | 3h 13m 48° | | 3h 17m 49° | | 3h 21m 50° | | 3h 25m 51° | |
| 0 | 15 | 9.22287 | 0.16706 | 9.23960 | 0.17362 | 9.25595 | 0.18028 | 9.27193 | 0.18704 |
| 4 | 16 | .22315 | .16717 | .23988 | .17373 | .25622 | .18039 | .27219 | .18715 |
| 8 | 17 | .22343 | .16728 | .24015 | .17384 | .25649 | .18050 | .27246 | .18727 |
| 12 | 18 | .22372 | .16738 | .24043 | .17395 | .25676 | .18062 | .27272 | .18738 |
| 16 | 19 | .22400 | .16749 | .24070 | .17406 | .25703 | .18073 | .27298 | .18749 |
| 20 | 20 | 9.22428 | 0.16760 | 9.24098 | 0.17417 | 9.25729 | 0.18084 | 9.27325 | 0.18761 |
| 24 | 21 | .22456 | .16771 | .24125 | .17428 | .25756 | .18095 | .27351 | .18772 |
| 28 | 22 | .22484 | .16782 | .24153 | .17439 | .25783 | .18106 | .27377 | .18783 |
| 32 | 23 | .22512 | .16793 | .24180 | .17450 | .25810 | .18118 | .27403 | .18795 |
| 36 | 24 | .22540 | .16804 | .24208 | .17461 | .25837 | .18129 | .27430 | .18806 |
| 40 | 25 | 9.22569 | 0.16815 | 9.24235 | 0.17472 | 9.25864 | 0.18140 | 9.27456 | 0.18817 |
| 44 | 26 | .22597 | .16825 | .24263 | .17483 | .25891 | .18151 | .27482 | .18829 |
| 48 | 27 | .22625 | .16836 | .24290 | .17494 | .25917 | .18162 | .27508 | .18840 |
| 52 | 28 | .22653 | .16847 | .24317 | .17505 | .25944 | .18174 | .27535 | .18852 |
| 56 | 29 | .22681 | .16858 | .24345 | .17517 | .25971 | .18185 | .27561 | .18863 |
| s | ' | 3h 14m 48° | | 3h 18m 49° | | 3h 22m 50° | | 3h 26m 51° | |
| 0 | 30 | 9.22709 | 0.16869 | 9.24372 | 0.17528 | 9.25998 | 0.18196 | 9.27587 | 0.18874 |
| 4 | 31 | .22737 | .16880 | .24400 | .17539 | .26025 | .18207 | .27613 | .18886 |
| 8 | 32 | .22765 | .16891 | .24427 | .17550 | .26051 | .18219 | .27639 | .18897 |
| 12 | 33 | .22793 | .16902 | .24454 | .17561 | .26078 | .18230 | .27666 | .18908 |
| 16 | 34 | .22821 | .16913 | .24482 | .17572 | .26105 | .18241 | .27692 | .18920 |
| 20 | 35 | 9.22849 | 0.16924 | 9.24509 | 0.17583 | 9.26132 | 0.18252 | 9.27718 | 0.18931 |
| 24 | 36 | .22877 | .16934 | .24536 | .17594 | .26158 | .18263 | .27744 | .18943 |
| 28 | 37 | .22905 | .16945 | .24564 | .17605 | .26185 | .18275 | .27770 | .18954 |
| 32 | 38 | .22933 | .16956 | .24591 | .17616 | .26212 | .18286 | .27796 | .18965 |
| 36 | 39 | .22961 | .16967 | .24618 | .17627 | .26238 | .18297 | .27822 | .18977 |
| 40 | 40 | 9.22989 | 0.16978 | 9.24646 | 0.17638 | 9.26265 | 0.18308 | 9.27848 | 0.18988 |
| 44 | 41 | .23017 | .16989 | .24673 | .17649 | .26292 | .18320 | .27875 | .19000 |
| 48 | 42 | .23045 | .17000 | .24700 | .17661 | .26319 | .18331 | .27901 | .19011 |
| 52 | 43 | .23073 | .17011 | .24728 | .17672 | .26345 | .18342 | .27927 | .19022 |
| 56 | 44 | .23100 | .17022 | .24755 | .17683 | .26372 | .18353 | .27953 | .19034 |
| s | ' | 3h 15m 48° | | 3h 19m 49° | | 3h 23m 50° | | 3h 27m 51° | |
| 0 | 45 | 9.23128 | 0.17033 | 9.24782 | 0.17694 | 9.26398 | 0.18365 | 9.27979 | 0.19045 |
| 4 | 46 | .23156 | .17044 | .24809 | .17705 | .26425 | .18376 | .28005 | .19057 |
| 8 | 47 | .23184 | .17055 | .24837 | .17716 | .26452 | .18387 | .28031 | .19068 |
| 12 | 48 | .23212 | .17066 | .24864 | .17727 | .26478 | .18399 | .28057 | .19080 |
| 16 | 49 | .23240 | .17076 | .24891 | .17738 | .26505 | .18410 | .28083 | .19091 |
| 20 | 50 | 9.23268 | 0.17087 | 9.24918 | 0.17749 | 9.26532 | 0.18421 | 9.28109 | 0.19102 |
| 24 | 51 | .23295 | .17098 | .24945 | .17760 | .26558 | .18432 | .28135 | .19114 |
| 28 | 52 | .23323 | .17109 | .24973 | .17772 | .26585 | .18444 | .28161 | .19125 |
| 32 | 53 | .23351 | .17120 | .25000 | .17783 | .26611 | .18455 | .28187 | .19137 |
| 36 | 54 | .23379 | .17131 | .25027 | .17794 | .26638 | .18466 | .28213 | .19148 |
| 40 | 55 | 9.23407 | 0.17142 | 9.25054 | 0.17805 | 9.26664 | 0.18478 | 9.28239 | 0.19160 |
| 44 | 56 | .23434 | .17153 | .25081 | .17816 | .26691 | .18489 | .28265 | .19171 |
| 48 | 57 | .23462 | .17164 | .25108 | .17827 | .26717 | .18500 | .28291 | .19183 |
| 52 | 53 | .23490 | .17175 | .25135 | .17838 | .26744 | .18511 | .28317 | .19194 |
| 56 | 59 | .23518 | .17186 | .25163 | .17849 | .26770 | .18523 | .28342 | .19205 |
| 60 | 60 | 9.23545 | 0.17197 | 9.25190 | 0.17861 | 9.26797 | 0.18534 | 9.28368 | 0.19217 |

Table 10. Haversine Table

| s | ' | 3h 28 ^m 52° | | 3h 32 ^m 53° | | 3h 36 ^m 54° | | 3h 40 ^m 55° | |
|----|----|------------------------|----------------|------------------------|----------------|------------------------|----------------|------------------------|----------------|
| | | Hav. | No. | Hav. | No. | Hav. | No. | Hav. | No. |
| 0 | 0 | 9.28368 | 0.19217 | 9.29906 | 0.19909 | 9.31409 | 0.20611 | 9.32881 | 0.21321 |
| 4 | 1 | .28394 | .19228 | .29931 | .19921 | .31434 | .20623 | .32905 | .21333 |
| 8 | 2 | .28420 | .19240 | .29956 | .19932 | .31459 | .20634 | .32930 | .21345 |
| 12 | 3 | .28446 | .19251 | .29981 | .19944 | .31484 | .20646 | .32954 | .21357 |
| 16 | 4 | .28472 | .19263 | .30007 | .19956 | .31508 | .20658 | .32978 | .21369 |
| 20 | 5 | 9.28498 | 0.19274 | 9.30032 | 0.19967 | 9.31533 | 0.20670 | 9.33002 | 0.21381 |
| 24 | 6 | .28524 | .19286 | .30057 | .19979 | .31558 | .20681 | .33027 | .21393 |
| 28 | 7 | .28549 | .19297 | .30083 | .19991 | .31583 | .20693 | .33051 | .21405 |
| 32 | 8 | .28575 | .19309 | .30108 | .20002 | .31607 | .20705 | .33075 | .21417 |
| 36 | 9 | .28601 | .19320 | .30133 | .20014 | .31632 | .20717 | .33099 | .21429 |
| 40 | 10 | 9.28627 | 0.19332 | 9.30158 | 0.20026 | 9.31657 | 0.20729 | 9.33123 | 0.21440 |
| 44 | 11 | .28653 | .19343 | .30184 | .20037 | .31682 | .20740 | .33148 | .21452 |
| 48 | 12 | .28679 | .19355 | .30209 | .20049 | .31706 | .20752 | .33172 | .21464 |
| 52 | 13 | .28704 | .19366 | .30234 | .20060 | .31731 | .20764 | .33196 | .21476 |
| 56 | 14 | .28730 | .19378 | .30259 | .20072 | .31756 | .20776 | .33220 | .21488 |
| s | ' | 3h 29 ^m 52° | | 3h 33 ^m 53° | | 3h 37 ^m 54° | | 3h 41 ^m 55° | |
| 0 | 15 | 9.28756 | 0.19389 | 9.30285 | 0.20084 | 9.31780 | 0.20788 | 9.33244 | 0.21500 |
| 4 | 16 | .28782 | .19401 | .30310 | .20095 | .31805 | .20799 | .33268 | .21512 |
| 8 | 17 | .28807 | .19412 | .30335 | .20107 | .31830 | .20811 | .33292 | .21524 |
| 12 | 18 | .28833 | .19424 | .30360 | .20119 | .31854 | .20823 | .33317 | .21536 |
| 16 | 19 | .28859 | .19435 | .30385 | .20130 | .31879 | .20835 | .33341 | .21548 |
| 20 | 20 | 9.28885 | 0.19447 | 9.30410 | 0.20142 | 9.31903 | 0.20847 | 9.33365 | 0.21560 |
| 24 | 21 | .28910 | .19458 | .30436 | .20154 | .31928 | .20858 | .33389 | .21572 |
| 28 | 22 | .28936 | .19470 | .30461 | .20165 | .31953 | .20870 | .33413 | .21584 |
| 32 | 23 | .28962 | .19481 | .30486 | .20177 | .31977 | .20882 | .33437 | .21596 |
| 36 | 24 | .28987 | .19493 | .30511 | .20189 | .32002 | .20894 | .33461 | .21608 |
| 40 | 25 | 9.29013 | 0.19504 | 9.30536 | 0.20200 | 9.32026 | 0.20906 | 9.33485 | 0.21620 |
| 44 | 26 | .29039 | .19516 | .30561 | .20212 | .32051 | .20918 | .33509 | .21632 |
| 48 | 27 | .29064 | .19527 | .30586 | .20224 | .32076 | .20929 | .33533 | .21644 |
| 52 | 28 | .29090 | .19539 | .30611 | .20235 | .32100 | .20941 | .33557 | .21656 |
| 56 | 29 | .29116 | .19550 | .30636 | .20247 | .32125 | .20953 | .33581 | .21668 |
| s | ' | 3h 30 ^m 52° | | 3h 34 ^m 53° | | 3h 38 ^m 54° | | 3h 42 ^m 55° | |
| 0 | 30 | 9.29141 | 0.19562 | 9.30662 | 0.20259 | 9.32149 | 0.20965 | 9.33605 | 0.21680 |
| 4 | 31 | .29167 | .19573 | .30687 | .20271 | .32174 | .20977 | .33629 | .21692 |
| 8 | 32 | .29192 | .19585 | .30712 | .20282 | .32198 | .20989 | .33653 | .21704 |
| 12 | 33 | .29218 | .19597 | .30737 | .20294 | .32223 | .21000 | .33677 | .21716 |
| 16 | 34 | .29244 | .19608 | .30762 | .20306 | .32247 | .21012 | .33701 | .21728 |
| 20 | 35 | 9.29269 | 0.19620 | 9.30787 | 0.20317 | 9.32272 | 0.21024 | 9.33725 | 0.21740 |
| 24 | 36 | .29295 | .19631 | .30812 | .20329 | .32296 | .21036 | .33749 | .21752 |
| 28 | 37 | .29320 | .19643 | .30837 | .20341 | .32321 | .21048 | .33773 | .21764 |
| 32 | 38 | .29346 | .19654 | .30862 | .20352 | .32345 | .21060 | .33797 | .21776 |
| 36 | 39 | .29371 | .19666 | .30887 | .20364 | .32370 | .21072 | .33821 | .21788 |
| 40 | 40 | 9.29397 | 0.19677 | 9.30912 | 0.20376 | 9.32394 | 0.21083 | 9.33845 | 0.21800 |
| 44 | 41 | .29422 | .19689 | .30937 | .20388 | .32418 | .21095 | .33869 | .21812 |
| 48 | 42 | .29448 | .19701 | .30962 | .20399 | .32443 | .21107 | .33893 | .21824 |
| 52 | 43 | .29473 | .19712 | .30987 | .20411 | .32467 | .21119 | .33917 | .21836 |
| 56 | 44 | .29499 | .19724 | .31012 | .20423 | .32492 | .21131 | .33941 | .21848 |
| s | ' | 3h 31 ^m 52° | | 3h 35 ^m 53° | | 3h 39 ^m 54° | | 3h 43 ^m 55° | |
| 0 | 45 | 9.29524 | 0.19735 | 9.31036 | 0.20435 | 9.32516 | 0.21143 | 9.33965 | 0.21860 |
| 4 | 46 | .29550 | .19747 | .31061 | .20446 | .32541 | .21155 | .33988 | .21872 |
| 8 | 47 | .29575 | .19758 | .31086 | .20458 | .32565 | .21167 | .34012 | .21884 |
| 12 | 48 | .29601 | .19770 | .31111 | .20470 | .32589 | .21178 | .34036 | .21896 |
| 16 | 49 | .29626 | .19782 | .31136 | .20481 | .32614 | .21190 | .34060 | .21908 |
| 20 | 50 | 9.29652 | 0.19793 | 9.31161 | 0.20493 | 9.32638 | 0.21202 | 9.34084 | 0.21920 |
| 24 | 51 | .29677 | .19805 | .31186 | .20505 | .32662 | .21214 | .34108 | .21932 |
| 28 | 52 | .29703 | .19816 | .31211 | .20517 | .32687 | .21226 | .34132 | .21944 |
| 32 | 53 | .29728 | .19828 | .31236 | .20528 | .32711 | .21238 | .34155 | .21956 |
| 36 | 54 | .29753 | .19840 | .31260 | .20540 | .32735 | .21250 | .34179 | .21968 |
| 40 | 55 | 9.29779 | 0.19851 | 9.31285 | 0.20552 | 9.32760 | 0.21262 | 9.34203 | 0.21980 |
| 44 | 56 | .29804 | .19863 | .31310 | .20564 | .32784 | .21274 | .34227 | .21992 |
| 48 | 57 | .29829 | .19874 | .31335 | .20575 | .32808 | .21285 | .34251 | .22004 |
| 52 | 58 | .29855 | .19886 | .31360 | .20587 | .32833 | .21297 | .34274 | .22016 |
| 56 | 59 | .29880 | .19898 | .31385 | .20599 | .32857 | .21309 | .34298 | .22028 |
| 60 | 60 | 9.29906 | 0.19909 | 9.31409 | 0.20611 | 9.32881 | 0.21321 | 9.34322 | 0.22040 |

| s | ' | 3h 44 ^m 56° | | 3h 48 ^m 57° | | 3h 52 ^m 58° | | 3h 56 ^m 59° | |
|----|----|------------------------|----------------|------------------------|----------------|------------------------|----------------|------------------------|----------------|
| | | Hav. | No. | Hav. | No. | Hav. | No. | Hav. | No. |
| 0 | 0 | 9.34322 | 0.22040 | 9.35733 | 0.22768 | 9.37114 | 0.23504 | 9.38468 | 0.24248 |
| 4 | 1 | .34346 | .22052 | .35756 | .22780 | .37137 | .23516 | .38490 | .24261 |
| 8 | 2 | .34369 | .22064 | .35779 | .22792 | .37160 | .23529 | .38512 | .24273 |
| 12 | 3 | .34393 | .22077 | .35802 | .22805 | .37183 | .23541 | .38535 | .24286 |
| 16 | 4 | .34417 | .22089 | .35826 | .22817 | .37205 | .23553 | .38557 | .24298 |
| 20 | 5 | 9.34441 | 0.22101 | 9.35849 | 0.22829 | 9.37228 | 0.23566 | 9.38579 | 0.24310 |
| 24 | 6 | .34464 | .22113 | .35872 | .22841 | .37251 | .23578 | .38602 | .24323 |
| 28 | 7 | .34488 | .22125 | .35895 | .22853 | .37274 | .23590 | .38624 | .24335 |
| 32 | 8 | .34512 | .22137 | .35918 | .22866 | .37296 | .23603 | .38646 | .24348 |
| 36 | 9 | .34535 | .22149 | .35942 | .22878 | .37319 | .23615 | .38668 | .24360 |
| 40 | 10 | 9.34559 | 0.22161 | 9.35965 | 0.22890 | 9.37342 | 0.23627 | 9.38691 | 0.24373 |
| 44 | 11 | .34583 | .22173 | .35988 | .22902 | .37364 | .23640 | .38713 | .24385 |
| 48 | 12 | .34606 | .22185 | .36011 | .22915 | .37387 | .23652 | .38735 | .24398 |
| 52 | 13 | .34630 | .22197 | .36034 | .22927 | .37410 | .23665 | .38757 | .24410 |
| 56 | 14 | .34654 | .22209 | .36058 | .22939 | .37433 | .23677 | .38780 | .24423 |
| s | ' | 3h 45 ^m 56° | | 3h 49 ^m 57° | | 3h 53 ^m 58° | | 3h 57 ^m 59° | |
| 0 | 15 | 9.34677 | 0.22221 | 9.36081 | 0.22951 | 9.37455 | 0.23689 | 9.38802 | 0.24435 |
| 4 | 16 | .34701 | .22234 | .36104 | .22964 | .37478 | .23702 | .38824 | .24448 |
| 8 | 17 | .34725 | .22246 | .36127 | .22976 | .37501 | .23714 | .38846 | .24460 |
| 12 | 18 | .34748 | .22258 | .36150 | .22988 | .37523 | .23726 | .38868 | .24473 |
| 16 | 19 | .34772 | .22270 | .36173 | .23000 | .37546 | .23739 | .38891 | .24485 |
| 20 | 20 | 9.34795 | 0.22282 | 9.36196 | 0.23012 | 9.37569 | 0.23751 | 9.38913 | 0.24498 |
| 24 | 21 | .34819 | .22294 | .36219 | .23025 | .37591 | .23764 | .38935 | .24510 |
| 28 | 22 | .34843 | .22306 | .36243 | .23037 | .37614 | .23776 | .38957 | .24523 |
| 32 | 23 | .34866 | .22318 | .36266 | .23049 | .37636 | .23788 | .38979 | .24535 |
| 36 | 24 | .34890 | .22330 | .36289 | .23061 | .37659 | .23801 | .39002 | .24548 |
| 40 | 25 | 9.34913 | 0.22343 | 9.36312 | 0.23074 | 9.37682 | 0.23813 | 9.39024 | 0.24560 |
| 44 | 26 | .34937 | .22355 | .36335 | .23086 | .37704 | .23825 | .39046 | .24573 |
| 48 | 27 | .34960 | .22367 | .36358 | .23098 | .37727 | .23838 | .39068 | .24586 |
| 52 | 28 | .34984 | .22379 | .36381 | .23110 | .37749 | .23850 | .39090 | .24598 |
| 56 | 29 | .35007 | .22391 | .36404 | .23123 | .37772 | .23863 | .39112 | .24611 |
| s | ' | 3h 46 ^m 56° | | 3h 50 ^m 57° | | 3h 54 ^m 58° | | 3h 58 ^m 59° | |
| 0 | 30 | 9.35031 | 0.22403 | 9.36427 | 0.23135 | 9.37794 | 0.23875 | 9.39134 | 0.24623 |
| 4 | 31 | .35054 | .22415 | .36450 | .23147 | .37817 | .23887 | .39156 | .24636 |
| 8 | 32 | .35078 | .22427 | .36473 | .23160 | .37840 | .23900 | .39178 | .24648 |
| 12 | 33 | .35101 | .22440 | .36496 | .23172 | .37862 | .23912 | .39201 | .24661 |
| 16 | 34 | .35125 | .22452 | .36519 | .23184 | .37885 | .23925 | .39223 | .24673 |
| 20 | 35 | 9.35148 | 0.22464 | 9.36542 | 0.23196 | 9.37907 | 0.23937 | 9.39245 | 0.24686 |
| 24 | 36 | .35172 | .22476 | .36565 | .23209 | .37930 | .23950 | .39267 | .24698 |
| 28 | 37 | .35195 | .22488 | .36588 | .23221 | .37952 | .23962 | .39289 | .24711 |
| 32 | 38 | .35219 | .22500 | .36611 | .23233 | .37975 | .23974 | .39311 | .24723 |
| 36 | 39 | .35242 | .22512 | .36634 | .23246 | .37997 | .23987 | .39333 | .24736 |
| 40 | 40 | 9.35266 | 0.22525 | 9.36657 | 0.23258 | 9.38020 | 0.23999 | 9.39355 | 0.24749 |
| 44 | 41 | .35289 | .22537 | .36680 | .23270 | .38042 | .24012 | .39377 | .24761 |
| 48 | 42 | .35312 | .22549 | .36703 | .23282 | .38065 | .24024 | .39399 | .24774 |
| 52 | 43 | .35336 | .22561 | .36726 | .23295 | .38087 | .24036 | .39421 | .24786 |
| 56 | 44 | .35359 | .22573 | .36749 | .23307 | .38110 | .24049 | .39443 | .24799 |
| s | ' | 3h 47 ^m 56° | | 3h 51 ^m 57° | | 3h 55 ^m 58° | | 3h 59 ^m 59° | |
| 0 | 45 | 9.35383 | 0.22585 | 9.36772 | 0.23319 | 9.38132 | 0.24061 | 9.39465 | 0.24811 |
| 4 | 46 | .35406 | .22598 | .36794 | .23332 | .38154 | .24074 | .39487 | .24824 |
| 8 | 47 | .35429 | .22610 | .36817 | .23344 | .38177 | .24086 | .39509 | .24836 |
| 12 | 48 | .35453 | .22622 | .36840 | .23356 | .38199 | .24099 | .39531 | .24849 |
| 16 | 49 | .35476 | .22634 | .36863 | .23368 | .38222 | .24111 | .39553 | .24862 |
| 20 | 50 | 9.35500 | 0.22646 | 9.36886 | 0.23381 | 9.38244 | 0.24124 | 9.39575 | 0.24874 |
| 24 | 51 | .35523 | .22658 | .36909 | .23393 | .38267 | .24136 | .39597 | .24887 |
| 28 | 52 | .35546 | .22671 | .36932 | .23405 | .38289 | .24148 | .39619 | .24899 |
| 32 | 53 | .35570 | .22683 | .36955 | .23418 | .38311 | .24161 | .39641 | .24912 |
| 36 | 54 | .35593 | .22695 | .36977 | .23430 | .38334 | .24173 | .39663 | .24924 |
| 40 | 55 | 9.35616 | 0.22707 | 9.37000 | 0.23442 | 9.38356 | 0.24186 | 9.39685 | 0.24937 |
| 44 | 56 | .35639 | .22719 | .37023 | .23455 | .38378 | .24198 | .39706 | .24950 |
| 48 | 57 | .35663 | .22731 | .37046 | .23467 | .38401 | .24211 | .39728 | .24962 |
| 52 | 58 | .35686 | .22744 | .37069 | .23479 | .38423 | .24223 | .39750 | .24975 |
| 56 | 59 | .35709 | .22756 | .37091 | .23492 | .38445 | .24236 | .39772 | .24987 |
| 60 | 60 | 9.35733 | 0.22768 | 9.37114 | 0.23504 | 9.38468 | 0.24248 | 9.39794 | 0.25000 |

Table 10. Haversine Table

| s | ' | 4 ^h 0 ^m 60° | | 4 ^h 4 ^m 61° | | 4 ^h 8 ^m 62° | | 4 ^h 12 ^m 63° | |
|----|----|-----------------------------------|----------------|-----------------------------------|----------------|------------------------------------|----------------|------------------------------------|----------------|
| | | Hav. | No. | Hav. | No. | Hav. | No. | Hav. | No. |
| 0 | 0 | 9.39794 | 0.25000 | 9.41094 | 0.25760 | 9.42368 | 0.26526 | 9.43617 | 0.27300 |
| 4 | 1 | .39816 | .25013 | .41115 | .25772 | .42389 | .26539 | .43638 | .27313 |
| 8 | 2 | .39838 | .25025 | .41137 | .25785 | .42410 | .26552 | .43658 | .27326 |
| 12 | 3 | .39860 | .25038 | .41158 | .25798 | .42431 | .26565 | .43679 | .27339 |
| 16 | 4 | .39881 | .25050 | .41180 | .25810 | .42452 | .26578 | .43699 | .27352 |
| 20 | 5 | 9.39903 | 0.25063 | 9.41201 | 0.25823 | 9.42473 | 0.26591 | 9.43720 | 0.27365 |
| 24 | 6 | .39925 | .25076 | .41222 | .25836 | .42494 | .26604 | .43741 | .27378 |
| 28 | 7 | .39947 | .25088 | .41244 | .25849 | .42515 | .26616 | .43761 | .27391 |
| 32 | 8 | .39969 | .25101 | .41265 | .25861 | .42536 | .26629 | .43782 | .27404 |
| 36 | 9 | .39991 | .25113 | .41287 | .25874 | .42557 | .26642 | .43802 | .27417 |
| 40 | 10 | 9.40012 | 0.25126 | 9.41308 | 0.25887 | 9.42578 | 0.26655 | 9.43823 | 0.27430 |
| 44 | 11 | .40034 | .25139 | .41329 | .25900 | .42599 | .26668 | .43843 | .27443 |
| 48 | 12 | .40056 | .25151 | .41351 | .25912 | .42620 | .26681 | .43864 | .27456 |
| 52 | 13 | .40078 | .25164 | .41372 | .25925 | .42641 | .26694 | .43884 | .27469 |
| 56 | 14 | .40100 | .25177 | .41393 | .25938 | .42662 | .26706 | .43905 | .27482 |
| s | ' | 4 ^h 1 ^m 60° | | 4 ^h 5 ^m 61° | | 4 ^h 9 ^m 62° | | 4 ^h 13 ^m 63° | |
| 0 | 15 | 9.40121 | 0.25189 | 9.41415 | 0.25951 | 9.42682 | 0.26719 | 9.43926 | 0.27495 |
| 4 | 16 | .40143 | .25202 | .41436 | .25963 | .42703 | .26732 | .43946 | .27508 |
| 8 | 17 | .40165 | .25214 | .41457 | .25976 | .42724 | .26745 | .43967 | .27521 |
| 12 | 18 | .40187 | .25227 | .41479 | .25989 | .42745 | .26758 | .43987 | .27534 |
| 16 | 19 | .40208 | .25240 | .41500 | .26002 | .42766 | .26771 | .44008 | .27547 |
| 20 | 20 | 9.40230 | 0.25252 | 9.41521 | 0.26014 | 9.42787 | 0.26784 | 9.44028 | 0.27560 |
| 24 | 21 | .40252 | .25265 | .41543 | .26027 | .42808 | .26797 | .44048 | .27573 |
| 28 | 22 | .40274 | .25278 | .41564 | .26040 | .42829 | .26809 | .44069 | .27586 |
| 32 | 23 | .40295 | .25290 | .41585 | .26053 | .42850 | .26822 | .44089 | .27599 |
| 36 | 24 | .40317 | .25303 | .41606 | .26065 | .42870 | .26835 | .44110 | .27612 |
| 40 | 25 | 9.40339 | 0.25316 | 9.41628 | 0.26078 | 9.42891 | 0.26848 | 9.44130 | 0.27625 |
| 44 | 26 | .40360 | .25328 | .41649 | .26091 | .42912 | .26861 | .44151 | .27638 |
| 48 | 27 | .40382 | .25341 | .41670 | .26104 | .42933 | .26874 | .44171 | .27651 |
| 52 | 28 | .40404 | .25354 | .41692 | .26117 | .42954 | .26887 | .44192 | .27664 |
| 56 | 29 | .40425 | .25366 | .41713 | .26129 | .42975 | .26900 | .44212 | .27677 |
| s | ' | 4 ^h 2 ^m 60° | | 4 ^h 6 ^m 61° | | 4 ^h 10 ^m 62° | | 4 ^h 14 ^m 63° | |
| 0 | 30 | 9.40447 | 0.25379 | 9.41734 | 0.26142 | 9.42996 | 0.26913 | 9.44232 | 0.27690 |
| 4 | 31 | .40469 | .25391 | .41755 | .26155 | .43016 | .26925 | .44253 | .27703 |
| 8 | 32 | .40490 | .25404 | .41776 | .26168 | .43037 | .26938 | .44273 | .27716 |
| 12 | 33 | .40512 | .25417 | .41798 | .26180 | .43058 | .26951 | .44294 | .27729 |
| 16 | 34 | .40534 | .25429 | .41819 | .26193 | .43079 | .26964 | .44314 | .27742 |
| 20 | 35 | 9.40555 | 0.25442 | 9.41840 | 0.26206 | 9.43100 | 0.26977 | 9.44334 | 0.27755 |
| 24 | 36 | .40577 | .25455 | .41861 | .26219 | .43120 | .26990 | .44355 | .27768 |
| 28 | 37 | .40599 | .25467 | .41882 | .26232 | .43141 | .27003 | .44375 | .27781 |
| 32 | 38 | .40620 | .25480 | .41904 | .26244 | .43162 | .27016 | .44396 | .27794 |
| 36 | 39 | .40642 | .25493 | .41925 | .26257 | .43183 | .27029 | .44416 | .27807 |
| 40 | 40 | 9.40663 | 0.25506 | 9.41946 | 0.26270 | 9.43203 | 0.27042 | 9.44436 | 0.27820 |
| 44 | 41 | .40685 | .25518 | .41967 | .26283 | .43224 | .27055 | .44457 | .27833 |
| 48 | 42 | .40707 | .25531 | .41988 | .26296 | .43245 | .27068 | .44477 | .27846 |
| 52 | 43 | .40728 | .25544 | .42009 | .26308 | .43266 | .27080 | .44497 | .27859 |
| 56 | 44 | .40750 | .25556 | .42031 | .26321 | .43286 | .27093 | .44518 | .27873 |
| s | ' | 4 ^h 3 ^m 60° | | 4 ^h 7 ^m 61° | | 4 ^h 11 ^m 62° | | 4 ^h 15 ^m 63° | |
| 0 | 45 | 9.40771 | 0.25569 | 9.42052 | 0.26334 | 9.43307 | 0.27106 | 9.44538 | 0.27886 |
| 4 | 46 | .40793 | .25582 | .42073 | .26347 | .43328 | .27119 | .44558 | .27899 |
| 8 | 47 | .40814 | .25594 | .42094 | .26360 | .43348 | .27132 | .44579 | .27912 |
| 12 | 48 | .40836 | .25607 | .42115 | .26372 | .43369 | .27145 | .44599 | .27925 |
| 16 | 49 | .40858 | .25620 | .42136 | .26385 | .43390 | .27158 | .44619 | .27938 |
| 20 | 50 | 9.40879 | 0.25632 | 9.42157 | 0.26398 | 9.43411 | 0.27171 | 9.44639 | 0.27951 |
| 24 | 51 | .40900 | .25645 | .42178 | .26411 | .43431 | .27184 | .44660 | .27964 |
| 28 | 52 | .40922 | .25658 | .42199 | .26424 | .43452 | .27197 | .44680 | .27977 |
| 32 | 53 | .40943 | .25671 | .42221 | .26437 | .43473 | .27210 | .44700 | .27990 |
| 36 | 54 | .40965 | .25683 | .42242 | .26449 | .43493 | .27223 | .44721 | .28003 |
| 40 | 55 | 9.40986 | 0.25696 | 9.42263 | 0.26462 | 9.43514 | 0.27236 | 9.44741 | 0.28016 |
| 44 | 56 | .41008 | .25709 | .42284 | .26475 | .43535 | .27249 | .44761 | .28029 |
| 48 | 57 | .41029 | .25721 | .42305 | .26488 | .43555 | .27262 | .44781 | .28042 |
| 52 | 58 | .41051 | .25734 | .42326 | .26501 | .43576 | .27275 | .44801 | .28055 |
| 56 | 59 | .41072 | .25747 | .42347 | .26514 | .43596 | .27288 | .44822 | .28068 |
| 60 | 60 | 9.41094 | 0.25760 | 9.42368 | 0.26526 | 9.43617 | 0.27300 | 9.44842 | 0.28081 |

Table 10. Haversine Table

| s | ' | 4h 16m 64° | | 4h 20m 65° | | 4h 24m 66° | | 4h 28m 67° | |
|----|----|------------|----------------|------------|----------------|------------|----------------|------------|----------------|
| | | Hav. | No. | Hav. | No. | Hav. | No. | Hav. | No. |
| 0 | 0 | 9.44842 | 0.28081 | 9.46043 | 0.28869 | 9.47222 | 0.29663 | 9.48378 | 0.30463 |
| 4 | 1 | .44862 | .28095 | .46063 | .28882 | .47241 | .29676 | .48397 | .30477 |
| 8 | 2 | .44882 | .28108 | .46083 | .28895 | .47261 | .29690 | .48416 | .30490 |
| 12 | 3 | .44903 | .28121 | .46103 | .28909 | .47280 | .29703 | .48435 | .30504 |
| 16 | 4 | .44923 | .28134 | .46123 | .28922 | .47300 | .29716 | .48454 | .30517 |
| 20 | 5 | 9.44943 | 0.28147 | 9.46142 | 0.28935 | 9.47319 | 0.29730 | 9.48473 | 0.30530 |
| 24 | 6 | .44963 | .28160 | .46162 | .28948 | .47338 | .29743 | .48492 | .30544 |
| 28 | 7 | .44983 | .28173 | .46182 | .28961 | .47358 | .29756 | .48511 | .30557 |
| 32 | 8 | .45003 | .28186 | .46202 | .28975 | .47377 | .29770 | .48530 | .30571 |
| 36 | 9 | .45024 | .28199 | .46222 | .28988 | .47397 | .29783 | .48549 | .30584 |
| 40 | 10 | 9.45044 | 0.28212 | 9.46241 | 0.29001 | 9.47416 | 0.29796 | 9.48568 | 0.30597 |
| 44 | 11 | .45064 | .28225 | .46261 | .29014 | .47435 | .29809 | .48587 | .30611 |
| 48 | 12 | .45084 | .28238 | .46281 | .29027 | .47455 | .29823 | .48607 | .30624 |
| 52 | 13 | .45104 | .28252 | .46301 | .29041 | .47474 | .29836 | .48626 | .30638 |
| 56 | 14 | .45124 | .28265 | .46320 | .29054 | .47493 | .29849 | .48645 | .30651 |
| s | ' | 4h 17m 64° | | 4h 21m 65° | | 4h 25m 66° | | 4h 29m 67° | |
| 0 | 15 | 9.45144 | 0.28278 | 9.46340 | 0.29067 | 9.47513 | 0.29863 | 9.48664 | 0.30664 |
| 4 | 16 | .45165 | .28291 | .46360 | .29080 | .47532 | .29876 | .48683 | .30678 |
| 8 | 17 | .45185 | .28304 | .46380 | .29093 | .47552 | .29889 | .48702 | .30691 |
| 12 | 18 | .45205 | .28317 | .46399 | .29107 | .47571 | .29903 | .48720 | .30705 |
| 16 | 19 | .45225 | .28330 | .46419 | .29120 | .47590 | .29916 | .48739 | .30718 |
| 20 | 20 | 9.45245 | 0.28343 | 9.46439 | 0.29133 | 9.47610 | 0.29929 | 9.48758 | 0.30732 |
| 24 | 21 | .45265 | .28356 | .46458 | .29146 | .47629 | .29943 | .48777 | .30745 |
| 28 | 22 | .45285 | .28369 | .46478 | .29160 | .47648 | .29956 | .48796 | .30758 |
| 32 | 23 | .45305 | .28383 | .46498 | .29173 | .47668 | .29969 | .48815 | .30772 |
| 36 | 24 | .45325 | .28396 | .46517 | .29186 | .47687 | .29983 | .48834 | .30785 |
| 40 | 25 | 9.45345 | 0.28409 | 9.46537 | 0.29199 | 9.47706 | 0.29996 | 9.48853 | 0.30799 |
| 44 | 26 | .45365 | .28422 | .46557 | .29212 | .47725 | .30009 | .48872 | .30812 |
| 48 | 27 | .45385 | .28435 | .46576 | .29226 | .47745 | .30023 | .48891 | .30826 |
| 52 | 28 | .45405 | .28448 | .46596 | .29239 | .47764 | .30036 | .48910 | .30839 |
| 56 | 29 | .45426 | .28461 | .46616 | .29252 | .47783 | .30049 | .48929 | .30852 |
| s | ' | 4h 18m 64° | | 4h 22m 65° | | 4h 26m 66° | | 4h 30m 67° | |
| 0 | 30 | 9.45446 | 0.28474 | 9.46635 | 0.29265 | 9.47803 | 0.30063 | 9.48948 | 0.30866 |
| 4 | 31 | .45466 | .28488 | .46655 | .29279 | .47822 | .30076 | .48967 | .30879 |
| 8 | 32 | .45486 | .28501 | .46675 | .29292 | .47841 | .30089 | .48986 | .30893 |
| 12 | 33 | .45506 | .28514 | .46694 | .29305 | .47860 | .30103 | .49004 | .30906 |
| 16 | 34 | .45526 | .28527 | .46714 | .29318 | .47880 | .30116 | .49023 | .30920 |
| 20 | 35 | 9.45546 | 0.28540 | 9.46733 | 0.29332 | 9.47899 | 0.30129 | 9.49042 | 0.30933 |
| 24 | 36 | .45566 | .28553 | .46753 | .29345 | .47918 | .30143 | .49061 | .30946 |
| 28 | 37 | .45586 | .28566 | .46773 | .29358 | .47937 | .30156 | .49080 | .30960 |
| 32 | 38 | .45606 | .28580 | .46792 | .29371 | .47957 | .30169 | .49099 | .30973 |
| 36 | 39 | .45625 | .28593 | .46812 | .29385 | .47976 | .30183 | .49118 | .30987 |
| 40 | 40 | 9.45645 | 0.28606 | 9.46831 | 0.29398 | 9.47995 | 0.30196 | 9.49137 | 0.31000 |
| 44 | 41 | .45665 | .28619 | .46851 | .29411 | .48014 | .30209 | .49155 | .31014 |
| 48 | 42 | .45685 | .28632 | .46871 | .29424 | .48033 | .30223 | .49174 | .31027 |
| 52 | 43 | .45705 | .28645 | .46890 | .29438 | .48053 | .30236 | .49193 | .31041 |
| 56 | 44 | .45725 | .28658 | .46910 | .29451 | .48072 | .30249 | .49212 | .31054 |
| s | ' | 4h 19m 64° | | 4h 23m 65° | | 4h 27m 66° | | 4h 31m 67° | |
| 0 | 45 | 9.45745 | 0.28672 | 9.46929 | 0.29464 | 9.48091 | 0.30263 | 9.49231 | 0.31068 |
| 4 | 46 | .45765 | .28685 | .46949 | .29477 | .48110 | .30276 | .49250 | .31081 |
| 8 | 47 | .45785 | .28698 | .46968 | .29491 | .48129 | .30290 | .49268 | .31095 |
| 12 | 48 | .45805 | .28711 | .46988 | .29504 | .48148 | .30303 | .49287 | .31108 |
| 16 | 49 | .45825 | .28724 | .47007 | .29517 | .48168 | .30316 | .49306 | .31121 |
| 20 | 50 | 9.45845 | 0.28737 | 9.47027 | 0.29530 | 9.48187 | 0.30330 | 9.49325 | 0.31135 |
| 24 | 51 | .45865 | .28751 | .47046 | .29544 | .48206 | .30343 | .49344 | .31148 |
| 28 | 52 | .45884 | .28764 | .47066 | .29557 | .48225 | .30356 | .49362 | .31162 |
| 32 | 53 | .45904 | .28777 | .47085 | .29570 | .48244 | .30370 | .49481 | .31175 |
| 36 | 54 | .45924 | .28790 | .47105 | .29583 | .48263 | .30383 | .49400 | .31189 |
| 40 | 55 | 9.45944 | 0.28803 | 9.47124 | 0.29597 | 9.48282 | 0.30397 | 9.49419 | 0.31202 |
| 44 | 56 | .45964 | .28816 | .47144 | .29610 | .48302 | .30410 | .49437 | .31216 |
| 48 | 57 | .45984 | .28830 | .47163 | .29623 | .48321 | .30423 | .49456 | .31229 |
| 52 | 58 | .46004 | .28843 | .47183 | .29637 | .48340 | .30437 | .49475 | .31243 |
| 56 | 59 | .46023 | .28856 | .47202 | .29650 | .48359 | .30450 | .49494 | .31256 |
| 60 | 60 | 9.46043 | 0.28869 | 9.47222 | 0.29663 | 9.48378 | 0.30463 | 9.49512 | 0.31270 |

Table 10. Haversine Table

| s | ' | 4 ^h 32 ^m 68° | | 4 ^h 36 ^m 69° | | 4 ^h 40 ^m 70° | | 4 ^h 44 ^m 71° | |
|----|----|------------------------------------|----------------|------------------------------------|----------------|------------------------------------|----------------|------------------------------------|----------------|
| | | Hav. | No. | Hav. | No. | Hav. | No. | Hav. | No. |
| 0 | 0 | 9.49512 | 0.31270 | 9.50626 | 0.32082 | 9.51718 | 0.32899 | 9.52791 | 0.33722 |
| 4 | 1 | .49531 | .31283 | .50644 | .32095 | .51736 | .32913 | .52809 | .33735 |
| 8 | 2 | .49550 | .31297 | .50662 | .32109 | .51754 | .32926 | .52826 | .33749 |
| 12 | 3 | .49568 | .31310 | .50681 | .32122 | .51772 | .32940 | .52844 | .33763 |
| 16 | 4 | .49587 | .31324 | .50699 | .32136 | .51790 | .32954 | .52862 | .33777 |
| 20 | 5 | 9.49606 | 0.31337 | 9.50717 | 0.32150 | 9.51808 | 0.32967 | 9.52879 | 0.33790 |
| 24 | 6 | .49625 | .31351 | .50736 | .32163 | .51826 | .32981 | .52897 | .33804 |
| 28 | 7 | .49643 | .31364 | .50754 | .32177 | .51844 | .32995 | .52915 | .33818 |
| 32 | 8 | .49662 | .31378 | .50772 | .32190 | .51862 | .33008 | .52932 | .33832 |
| 36 | 9 | .49681 | .31391 | .50791 | .32204 | .51880 | .33022 | .52950 | .33845 |
| 40 | 10 | 9.49699 | 0.31405 | 9.50809 | 0.32217 | 9.51898 | 0.33036 | 9.52968 | 0.33859 |
| 44 | 11 | .49718 | .31418 | .50827 | .32231 | .51916 | .33049 | .52985 | .33873 |
| 48 | 12 | .49737 | .31432 | .50846 | .32245 | .51934 | .33063 | .53003 | .33887 |
| 52 | 13 | .49755 | .31445 | .50864 | .32258 | .51952 | .33077 | .53021 | .33900 |
| 56 | 14 | .49774 | .31459 | .50882 | .32272 | .51970 | .33090 | .53038 | .33914 |
| s | ' | 4 ^h 33 ^m 68° | | 4 ^h 37 ^m 69° | | 4 ^h 41 ^m 70° | | 4 ^h 45 ^m 71° | |
| 0 | 15 | 9.49793 | 0.31472 | 9.50901 | 0.32285 | 9.51988 | 0.33104 | 9.53056 | 0.33928 |
| 4 | 16 | .49811 | .31486 | .50919 | .32299 | .52006 | .33118 | .53073 | .33942 |
| 8 | 17 | .49830 | .31499 | .50937 | .32313 | .52024 | .33132 | .53091 | .33956 |
| 12 | 18 | .49849 | .31513 | .50956 | .32326 | .52042 | .33145 | .53109 | .33969 |
| 16 | 19 | .49867 | .31526 | .50974 | .32340 | .52060 | .33159 | .53126 | .33983 |
| 20 | 20 | 9.49886 | 0.31540 | 9.50992 | 0.32353 | 9.52078 | 0.33173 | 9.53144 | 0.33997 |
| 24 | 21 | .49904 | .31553 | .51010 | .32367 | .52096 | .33186 | .53162 | .34011 |
| 28 | 22 | .49923 | .31567 | .51029 | .32381 | .52114 | .33200 | .53179 | .34024 |
| 32 | 23 | .49942 | .31580 | .51047 | .32394 | .52132 | .33214 | .53197 | .34038 |
| 36 | 24 | .49960 | .31594 | .51065 | .32408 | .52150 | .33227 | .53214 | .34052 |
| 40 | 25 | 9.49979 | 0.31607 | 9.51083 | 0.32422 | 9.52168 | 0.33241 | 9.53232 | 0.34066 |
| 44 | 26 | .49997 | .31621 | .51102 | .32435 | .52185 | .33255 | .53249 | .34080 |
| 48 | 27 | .50016 | .31634 | .51120 | .32449 | .52203 | .33269 | .53267 | .34093 |
| 52 | 28 | .50034 | .31648 | .51138 | .32462 | .52221 | .33282 | .53285 | .34107 |
| 56 | 29 | .50053 | .31661 | .51156 | .32476 | .52239 | .33296 | .53302 | .34121 |
| s | ' | 4 ^h 34 ^m 68° | | 4 ^h 38 ^m 69° | | 4 ^h 42 ^m 70° | | 4 ^h 46 ^m 71° | |
| 0 | 30 | 9.50072 | 0.31675 | 9.51174 | 0.32490 | 9.52257 | 0.33310 | 9.53320 | 0.34135 |
| 4 | 31 | .50090 | .31688 | .51193 | .32503 | .52275 | .33323 | .53337 | .34149 |
| 8 | 32 | .50109 | .31702 | .51211 | .32517 | .52293 | .33337 | .53355 | .34162 |
| 12 | 33 | .50127 | .31716 | .51229 | .32531 | .52311 | .33351 | .53372 | .34176 |
| 16 | 34 | .50146 | .31729 | .51247 | .32544 | .52328 | .33365 | .53390 | .34190 |
| 20 | 35 | 9.50164 | 0.31742 | 9.51265 | 0.32558 | 9.52346 | 0.33378 | 9.53407 | 0.34204 |
| 24 | 36 | .50183 | .31756 | .51284 | .32571 | .52364 | .33392 | .53425 | .34218 |
| 28 | 37 | .50201 | .31770 | .51302 | .32585 | .52382 | .33406 | .53442 | .34231 |
| 32 | 38 | .50220 | .31783 | .51320 | .32599 | .52400 | .33419 | .53460 | .34245 |
| 36 | 39 | .50238 | .31797 | .51338 | .32612 | .52418 | .33433 | .53477 | .34259 |
| 40 | 40 | 9.50257 | 0.31810 | 9.51356 | 0.32626 | 9.52436 | 0.33447 | 9.53495 | 0.34273 |
| 44 | 41 | .50275 | .31824 | .51374 | .32640 | .52453 | .33461 | .53512 | .34287 |
| 48 | 42 | .50294 | .31837 | .51393 | .32653 | .52471 | .33474 | .53530 | .34300 |
| 52 | 43 | .50312 | .31851 | .51411 | .32667 | .52489 | .33488 | .53547 | .34314 |
| 56 | 44 | .50331 | .31865 | .51429 | .32681 | .52507 | .33502 | .53565 | .34328 |
| s | ' | 4 ^h 35 ^m 68° | | 4 ^h 39 ^m 69° | | 4 ^h 43 ^m 70° | | 4 ^h 47 ^m 71° | |
| 0 | 45 | 9.50349 | 0.31878 | 9.51447 | 0.32694 | 9.52525 | 0.33515 | 9.53582 | 0.34342 |
| 4 | 46 | .50368 | .31892 | .51465 | .32708 | .52542 | .33529 | .53600 | .34356 |
| 8 | 47 | .50386 | .31905 | .51483 | .32721 | .52560 | .33543 | .53617 | .34369 |
| 12 | 48 | .50405 | .31919 | .51501 | .32735 | .52578 | .33557 | .53635 | .34383 |
| 16 | 49 | .50423 | .31932 | .51519 | .32749 | .52596 | .33570 | .53652 | .34397 |
| 20 | 50 | 9.50442 | 0.31946 | 9.51538 | 0.32762 | 9.52613 | 0.33584 | 9.53670 | 0.34411 |
| 24 | 51 | .50460 | .31959 | .51556 | .32776 | .52631 | .33598 | .53687 | .34425 |
| 28 | 52 | .50478 | .31973 | .51574 | .32790 | .52649 | .33612 | .53704 | .34439 |
| 32 | 53 | .50497 | .31987 | .51592 | .32803 | .52667 | .33625 | .53722 | .34452 |
| 36 | 54 | .50515 | .32000 | .51610 | .32817 | .52684 | .33639 | .53739 | .34466 |
| 40 | 55 | 9.50534 | 0.32014 | 9.51628 | 0.32831 | 9.52702 | 0.33653 | 9.53757 | 0.34480 |
| 44 | 56 | .50552 | .32027 | .51646 | .32844 | .52720 | .33667 | .53774 | .34494 |
| 48 | 57 | .50570 | .32041 | .51664 | .32858 | .52738 | .33680 | .53792 | .34508 |
| 52 | 58 | .50589 | .32054 | .51682 | .32872 | .52755 | .33694 | .53809 | .34521 |
| 56 | 59 | .50607 | .32068 | .51700 | .32885 | .52773 | .33708 | .53826 | .34535 |
| 60 | 60 | 9.50626 | 0.32082 | 9.51718 | 0.32899 | 9.52791 | 0.33722 | 9.53844 | 0.34549 |

Table 10. Haversine Table

| s | ' | 4h 48 ^m 72° | | 4h 52 ^m 73° | | 4h 56 ^m 74° | | 5h 0 ^m 75° | |
|----|----|------------------------|----------------|------------------------|----------------|------------------------|----------------|-----------------------|----------------|
| | | Hav. | No. | Hav. | No. | Hav. | No. | Hav. | No. |
| 0 | 0 | 9.53844 | 0.34549 | 9.54878 | 0.35381 | 9.55893 | 0.36218 | 9.56889 | 0.37059 |
| 4 | 1 | .53861 | 34563 | .54895 | 35395 | .55909 | 36232 | .56906 | 37073 |
| 8 | 2 | .53879 | 34577 | .54912 | 35409 | .55926 | 36246 | .56922 | 37087 |
| 12 | 3 | .53896 | 34591 | .54929 | 35423 | .55943 | 36260 | .56939 | 37101 |
| 16 | 4 | .53913 | 34604 | .54946 | 35437 | .55960 | 36274 | .56955 | 37115 |
| 20 | 5 | 9.53931 | 0.34618 | 9.54963 | 0.35451 | 9.55976 | 0.36288 | 9.56972 | 0.37129 |
| 24 | 6 | .53948 | 34632 | .54980 | 35465 | .55993 | 36302 | .56988 | 37143 |
| 28 | 7 | .53966 | 34646 | .54997 | 35479 | .56010 | 36316 | .57005 | 37157 |
| 32 | 8 | .53983 | 34660 | .55014 | 35493 | .56027 | 36330 | .57021 | 37171 |
| 36 | 9 | .54000 | 34674 | .55031 | 35507 | .56043 | 36344 | .57037 | 37186 |
| 40 | 10 | 9.54017 | 0.34688 | 9.55048 | 0.35521 | 9.56060 | 0.36358 | 9.57054 | 0.37200 |
| 44 | 11 | .54035 | 34701 | .55065 | 35534 | .56077 | 36372 | .57070 | 37214 |
| 48 | 12 | .54052 | 34715 | .55082 | 35548 | .56093 | 36386 | .57087 | 37228 |
| 52 | 13 | .54069 | 34729 | .55099 | 35562 | .56110 | 36400 | .57103 | 37242 |
| 56 | 14 | .54087 | 34743 | .55116 | 35576 | .56127 | 36414 | .57119 | 37256 |
| s | ' | 4h 49 ^m 72° | | 4h 53 ^m 73° | | 4h 57 ^m 74° | | 5h 1 ^m 75° | |
| 0 | 15 | 9.54104 | 0.34757 | 9.55133 | 0.35590 | 9.56144 | 0.36428 | 9.57136 | 0.37270 |
| 4 | 16 | .54121 | 34771 | .55150 | 35604 | .56160 | 36442 | .57152 | 37284 |
| 8 | 17 | .54139 | 34784 | .55167 | 35618 | .56177 | 36456 | .57169 | 37298 |
| 12 | 18 | .54156 | 34798 | .55184 | 35632 | .56194 | 36470 | .57185 | 37312 |
| 16 | 19 | .54173 | 34812 | .55201 | 35646 | .56210 | 36484 | .57201 | 37326 |
| 20 | 20 | 9.54190 | 0.34826 | 9.55218 | 0.35660 | 9.56227 | 0.36498 | 9.57218 | 0.37340 |
| 24 | 21 | .54208 | 34840 | .55235 | 35674 | .56244 | 36512 | .57234 | 37354 |
| 28 | 22 | .54225 | 34854 | .55252 | 35688 | .56260 | 36526 | .57250 | 37368 |
| 32 | 23 | .54242 | 34868 | .55269 | 35702 | .56277 | 36540 | .57267 | 37382 |
| 36 | 24 | .54260 | 34882 | .55286 | 35716 | .56294 | 36554 | .57283 | 37397 |
| 40 | 25 | 9.54277 | 0.34895 | 9.55303 | 0.35730 | 9.56310 | 0.36568 | 9.57299 | 0.37411 |
| 44 | 26 | .54294 | 34909 | .55320 | 35743 | .56327 | 36582 | .57316 | 37425 |
| 48 | 27 | .54311 | 34923 | .55337 | 35757 | .56343 | 36596 | .57332 | 37439 |
| 52 | 28 | .54329 | 34937 | .55354 | 35771 | .56360 | 36610 | .57348 | 37453 |
| 56 | 29 | .54346 | 34951 | .55370 | 35785 | .56377 | 36624 | .57365 | 37467 |
| s | ' | 4h 50 ^m 72° | | 4h 54 ^m 73° | | 4h 58 ^m 74° | | 5h 2 ^m 75° | |
| 0 | 30 | 9.54363 | 0.34965 | 9.55387 | 0.35799 | 9.56393 | 0.36638 | 9.57381 | 0.37481 |
| 4 | 31 | .54380 | 34979 | .55404 | 35813 | .56410 | 36652 | .57397 | 37495 |
| 8 | 32 | .54397 | 34992 | .55421 | 35827 | .56426 | 36666 | .57414 | 37509 |
| 12 | 33 | .54415 | 35006 | .55438 | 35841 | .56443 | 36680 | .57430 | 37523 |
| 16 | 34 | .54432 | 35020 | .55455 | 35855 | .56460 | 36694 | .57446 | 37537 |
| 20 | 35 | 9.54449 | 0.35034 | 9.55472 | 0.35869 | 9.56476 | 0.36708 | 9.57463 | 0.37551 |
| 24 | 36 | .54466 | 35048 | .55489 | 35883 | .56493 | 36722 | .57479 | 37566 |
| 28 | 37 | .54483 | 35062 | .55506 | 35897 | .56509 | 36736 | .57495 | 37580 |
| 32 | 38 | .54501 | 35076 | .55523 | 35911 | .56526 | 36750 | .57511 | 37594 |
| 36 | 39 | .54518 | 35090 | .55539 | 35925 | .56543 | 36764 | .57528 | 37608 |
| 40 | 40 | 9.54535 | 0.35103 | 9.55556 | 0.35939 | 9.56559 | 0.36778 | 9.57544 | 0.37622 |
| 44 | 41 | .54552 | 35117 | .55573 | 35953 | .56576 | 36792 | .57560 | 37636 |
| 48 | 42 | .54569 | 35131 | .55590 | 35967 | .56592 | 36806 | .57577 | 37650 |
| 52 | 43 | .54587 | 35145 | .55607 | 35981 | .56609 | 36820 | .57593 | 37664 |
| 56 | 44 | .54604 | 35159 | .55624 | 35995 | .56625 | 36834 | .57609 | 37678 |
| s | ' | 4h 51 ^m 72° | | 4h 55 ^m 73° | | 4h 59 ^m 74° | | 5h 3 ^m 75° | |
| 0 | 45 | 9.54621 | 0.35173 | 9.55641 | 0.36009 | 9.56642 | 0.36848 | 9.57625 | 0.37692 |
| 4 | 46 | .54638 | 35187 | .55657 | 36023 | .56658 | 36862 | .57642 | 37706 |
| 8 | 47 | .54655 | 35201 | .55674 | 36036 | .56675 | 36877 | .57658 | 37721 |
| 12 | 48 | .54672 | 35215 | .55691 | 36050 | .56692 | 36891 | .57674 | 37735 |
| 16 | 49 | .54689 | 35228 | .55708 | 36064 | .56708 | 36905 | .57690 | 37749 |
| 20 | 50 | 9.54707 | 0.35242 | 9.55725 | 0.36078 | 9.56725 | 0.36919 | 9.57706 | 0.37763 |
| 24 | 51 | .54724 | 35256 | .55742 | 36092 | .56741 | 36933 | .57723 | 37777 |
| 28 | 52 | .54741 | 35270 | .55758 | 36106 | .56758 | 36947 | .57739 | 37791 |
| 32 | 53 | .54758 | 35284 | .55775 | 36120 | .56774 | 36961 | .57755 | 37805 |
| 36 | 54 | .54775 | 35298 | .55792 | 36134 | .56791 | 36975 | .57771 | 37819 |
| 40 | 55 | 9.54792 | 0.35312 | 9.55809 | 0.36148 | 9.56807 | 0.36989 | 9.57787 | 0.37833 |
| 44 | 56 | .54809 | 35326 | .55826 | 36162 | .56824 | 37003 | .57804 | 37847 |
| 48 | 57 | .54826 | 35340 | .55842 | 36176 | .56840 | 37017 | .57820 | 37862 |
| 52 | 58 | .54843 | 35354 | .55859 | 36190 | .56856 | 37031 | .57836 | 37876 |
| 56 | 59 | .54860 | 35368 | .55876 | 36204 | .56873 | 37045 | .57852 | 37890 |
| 60 | 60 | 9.54878 | 0.35381 | 9.55893 | 0.36218 | 9.56889 | 0.37059 | 9.57868 | 0.37904 |

Table 10. Haversine Table

| s | ' | 5 ^h 4 ^m 76° | | 5 ^h 8 ^m 77° | | 5 ^h 12 ^m 78° | | 5 ^h 16 ^m 79° | |
|----|----|-----------------------------------|----------------|------------------------------------|----------------|------------------------------------|----------------|------------------------------------|----------------|
| | | Hav. | No. | Hav. | No. | Hav. | No. | Hav. | No. |
| 0 | 0 | 9.57868 | 0.37904 | 9.58830 | 0.38752 | 9.59774 | 0.39604 | 9.60702 | 0.40460 |
| 4 | 1 | .57885 | .37918 | .58846 | .38767 | .59790 | .39619 | .60717 | .40474 |
| 8 | 2 | .57901 | .37932 | .58862 | .38781 | .59806 | .39633 | .60733 | .40488 |
| 12 | 3 | .57917 | .37946 | .58878 | .38795 | .59821 | .39647 | .60748 | .40502 |
| 16 | 4 | .57933 | .37960 | .58893 | .38809 | .59837 | .39661 | .60763 | .40517 |
| 20 | 5 | 9.57949 | 0.37974 | 9.58909 | 0.38823 | 9.59852 | 0.39676 | 9.60779 | 0.40531 |
| 24 | 6 | .57965 | .37989 | .58925 | .38837 | .59868 | .39690 | .60794 | .40545 |
| 28 | 7 | .57981 | .38003 | .58941 | .38852 | .59883 | .39704 | .60809 | .40560 |
| 32 | 8 | .57998 | .38017 | .58957 | .38866 | .59899 | .39718 | .60825 | .40574 |
| 36 | 9 | .58014 | .38031 | .58973 | .38880 | .59915 | .39732 | .60840 | .40588 |
| 40 | 10 | 9.58030 | 0.38045 | 9.58989 | 0.38894 | 9.59930 | 0.39746 | 9.60855 | 0.40602 |
| 44 | 11 | .58046 | .38059 | .59004 | .38908 | .59946 | .39761 | .60870 | .40617 |
| 48 | 12 | .58062 | .38073 | .59020 | .38923 | .59961 | .39775 | .60886 | .40631 |
| 52 | 13 | .58078 | .38087 | .59036 | .38937 | .59977 | .39789 | .60901 | .40645 |
| 56 | 14 | .58094 | .38102 | .59052 | .38951 | .59992 | .39803 | .60916 | .40660 |
| s | ' | 5 ^h 5 ^m 76° | | 5 ^h 9 ^m 77° | | 5 ^h 13 ^m 78° | | 5 ^h 17 ^m 79° | |
| 0 | 15 | 9.58110 | 0.38116 | 9.59068 | 0.38965 | 9.60008 | 0.39818 | 9.60931 | 0.40674 |
| 4 | 16 | .58126 | .38130 | .59083 | .38979 | .60023 | .39832 | .60947 | .40688 |
| 8 | 17 | .58143 | .38144 | .59099 | .38994 | .60039 | .39846 | .60962 | .40702 |
| 12 | 18 | .58159 | .38158 | .59115 | .39008 | .60054 | .39861 | .60977 | .40717 |
| 16 | 19 | .58175 | .38172 | .59131 | .39022 | .60070 | .39875 | .60992 | .40731 |
| 20 | 20 | 9.58191 | 0.38186 | 9.59147 | 0.39036 | 9.60085 | 0.39889 | 9.61008 | 0.40745 |
| 24 | 21 | .58207 | .38200 | .59162 | .39050 | .60101 | .39903 | .61023 | .40760 |
| 28 | 22 | .58223 | .38215 | .59178 | .39064 | .60116 | .39918 | .61038 | .40774 |
| 32 | 23 | .58239 | .38229 | .59194 | .39079 | .60132 | .39932 | .61053 | .40788 |
| 36 | 24 | .58255 | .38243 | .59210 | .39093 | .60147 | .39946 | .61069 | .40802 |
| 40 | 25 | 9.58271 | 0.38257 | 9.59225 | 0.39107 | 9.60163 | 0.39960 | 9.61084 | 0.40817 |
| 44 | 26 | .58287 | .38271 | .59241 | .39121 | .60178 | .39975 | .61099 | .40831 |
| 48 | 27 | .58303 | .38285 | .59257 | .39135 | .60194 | .39989 | .61114 | .40845 |
| 52 | 28 | .58319 | .38299 | .59273 | .39150 | .60209 | .40003 | .61129 | .40860 |
| 56 | 29 | .58335 | .38314 | .59289 | .39164 | .60225 | .40017 | .61145 | .40874 |
| s | ' | 5 ^h 6 ^m 76° | | 5 ^h 10 ^m 77° | | 5 ^h 14 ^m 78° | | 5 ^h 18 ^m 79° | |
| 0 | 30 | 9.58351 | 0.38328 | 9.59304 | 0.39178 | 9.60240 | 0.40032 | 9.61160 | 0.40888 |
| 4 | 31 | .58367 | .38342 | .59320 | .39192 | .60256 | .40046 | .61175 | .40903 |
| 8 | 32 | .58383 | .38356 | .59336 | .39206 | .60271 | .40060 | .61190 | .40917 |
| 12 | 33 | .58399 | .38370 | .59351 | .39221 | .60287 | .40074 | .61205 | .40931 |
| 16 | 34 | .58415 | .38384 | .59367 | .39235 | .60302 | .40089 | .61221 | .40945 |
| 20 | 35 | 9.58431 | 0.38398 | 9.59383 | 0.39249 | 9.60318 | 0.40103 | 9.61236 | 0.40960 |
| 24 | 36 | .58447 | .38413 | .59399 | .39263 | .60333 | .40117 | .61251 | .40974 |
| 28 | 37 | .58463 | .38427 | .59414 | .39277 | .60348 | .40131 | .61266 | .40988 |
| 32 | 38 | .58479 | .38441 | .59430 | .39292 | .60364 | .40146 | .61281 | .41003 |
| 36 | 39 | .58495 | .38455 | .59446 | .39306 | .60379 | .40160 | .61296 | .41017 |
| 40 | 40 | 9.58511 | 0.38469 | 9.59461 | 0.39320 | 9.60395 | 0.40174 | 9.61312 | 0.41031 |
| 44 | 41 | .58527 | .38483 | .59477 | .39334 | .60410 | .40188 | .61327 | .41046 |
| 48 | 42 | .58543 | .38498 | .59493 | .39348 | .60426 | .40203 | .61342 | .41060 |
| 52 | 43 | .58559 | .38512 | .59508 | .39363 | .60441 | .40217 | .61357 | .41074 |
| 56 | 44 | .58575 | .38526 | .59524 | .39377 | .60456 | .40231 | .61372 | .41089 |
| s | ' | 5 ^h 7 ^m 76° | | 5 ^h 11 ^m 77° | | 5 ^h 15 ^m 78° | | 5 ^h 19 ^m 79° | |
| 0 | 45 | 9.58591 | 0.38540 | 9.59540 | 0.39391 | 9.60472 | 0.40245 | 9.61387 | 0.41103 |
| 4 | 46 | .58607 | .38554 | .59556 | .39405 | .60487 | .40260 | .61402 | .41117 |
| 8 | 47 | .58623 | .38568 | .59571 | .39420 | .60502 | .40274 | .61417 | .41131 |
| 12 | 48 | .58639 | .38582 | .59587 | .39434 | .60518 | .40288 | .61433 | .41146 |
| 16 | 49 | .58655 | .38597 | .59602 | .39448 | .60533 | .40303 | .61448 | .41160 |
| 20 | 50 | 9.58671 | 0.38611 | 9.59618 | 0.39462 | 9.60549 | 0.40317 | 9.61463 | 0.41174 |
| 24 | 51 | .58687 | .38625 | .59634 | .39476 | .60564 | .40331 | .61478 | .41189 |
| 28 | 52 | .58703 | .38639 | .59649 | .39491 | .60579 | .40345 | .61493 | .41203 |
| 32 | 53 | .58719 | .38653 | .59665 | .39505 | .60595 | .40360 | .61508 | .41217 |
| 36 | 54 | .58735 | .38667 | .59681 | .39519 | .60610 | .40374 | .61523 | .41232 |
| 40 | 55 | 9.58750 | 0.38682 | 9.59696 | 0.39533 | 9.60625 | 0.40388 | 9.61538 | 0.41246 |
| 44 | 56 | .58766 | .38696 | .59712 | .39548 | .60641 | .40402 | .61553 | .41260 |
| 48 | 57 | .58782 | .38710 | .59728 | .39562 | .60656 | .40417 | .61568 | .41275 |
| 52 | 58 | .58798 | .38724 | .59743 | .39576 | .60671 | .40431 | .61583 | .41289 |
| 56 | 59 | .58814 | .38738 | .59759 | .39590 | .60687 | .40445 | .61598 | .41303 |
| 60 | 60 | 9.58830 | 0.38752 | 9.59774 | 0.39604 | 9.60702 | 0.40460 | 9.61614 | 0.41318 |

Table 10. Haversine Table

| s | ' | 5h 20 ^m 80° | | 5h 24 ^m 81° | | 5h 28 ^m 82° | | 5h 32 ^m 83° | |
|----|----|------------------------|----------------|------------------------|----------------|------------------------|----------------|------------------------|----------------|
| | | Hav. | No. | Hav. | No. | Hav. | No. | Hav. | No. |
| 0 | 0 | 9.61614 | 0.41318 | 9.62509 | 0.42178 | 9.63389 | 0.43041 | 9.64253 | 0.43907 |
| 4 | 1 | .61629 | .41332 | .62524 | .42193 | .63403 | .43056 | .64267 | .43921 |
| 8 | 2 | .61644 | .41346 | .62538 | .42207 | .63418 | .43070 | .64281 | .43935 |
| 12 | 3 | .61659 | .41361 | .62553 | .42221 | .63432 | .43085 | .64296 | .43950 |
| 16 | 4 | .61674 | .41375 | .62568 | .42236 | .63447 | .43099 | .64310 | .43964 |
| 20 | 5 | 9.61689 | 0.41389 | 9.62583 | 0.42250 | 9.63461 | 0.43113 | 0.64324 | 0.43979 |
| 24 | 6 | .61704 | .41404 | .62598 | .42264 | .63476 | .43128 | .64339 | .43993 |
| 28 | 7 | .61719 | .41418 | .62612 | .42279 | .63490 | .43142 | .64353 | .44008 |
| 32 | 8 | .61734 | .41432 | .62627 | .42293 | .63505 | .43157 | .64367 | .44022 |
| 36 | 9 | .61749 | .41447 | .62642 | .42308 | .63519 | .43171 | .64381 | .44036 |
| 40 | 10 | 9.61764 | 0.41461 | 9.62657 | 0.42322 | 9.63534 | 0.43185 | 9.64396 | 0.44051 |
| 44 | 11 | .61779 | .41475 | .62671 | .42336 | .63548 | .43200 | .64410 | .44065 |
| 48 | 12 | .61794 | .41490 | .62686 | .42351 | .63563 | .43214 | .64424 | .44080 |
| 52 | 13 | .61809 | .41504 | .62701 | .42365 | .63577 | .43229 | .64438 | .44094 |
| 56 | 14 | .61824 | .41518 | .62716 | .42379 | .63592 | .43243 | .64452 | .44109 |
| s | ' | 5h 21 ^m 80° | | 5h 25 ^m 81° | | 5h 29 ^m 82° | | 5h 33 ^m 83° | |
| 0 | 15 | 9.61839 | 0.41533 | 9.62730 | 0.42394 | 9.63606 | 0.43257 | 9.64467 | 0.44123 |
| 4 | 16 | .61854 | .41547 | .62745 | .42408 | .63621 | .43272 | .64481 | .44138 |
| 8 | 17 | .61869 | .41561 | .62760 | .42423 | .63635 | .43286 | .64495 | .44152 |
| 12 | 18 | .61884 | .41576 | .62774 | .42437 | .63649 | .43301 | .64509 | .44166 |
| 16 | 19 | .61899 | .41590 | .62789 | .42451 | .63664 | .43315 | .64523 | .44181 |
| 20 | 20 | 9.61914 | 0.41604 | 9.62804 | 0.42466 | 9.63678 | 0.43330 | 9.64538 | 0.44195 |
| 24 | 21 | .61929 | .41619 | .62819 | .42480 | .63693 | .43344 | .64552 | .44210 |
| 28 | 22 | .61944 | .41633 | .62833 | .42494 | .63707 | .43358 | .64566 | .44224 |
| 32 | 23 | .61959 | .41647 | .62848 | .42509 | .63722 | .43373 | .64580 | .44239 |
| 36 | 24 | .61974 | .41662 | .62863 | .42523 | .63736 | .43387 | .64594 | .44253 |
| 40 | 25 | 9.61989 | 0.41676 | 9.62877 | 0.42538 | 9.63751 | 0.43402 | 9.64609 | 0.44268 |
| 44 | 26 | .62003 | .41690 | .62892 | .42552 | .63765 | .43416 | .64623 | .44282 |
| 48 | 27 | .62018 | .41705 | .62907 | .42566 | .63779 | .43430 | .64637 | .44296 |
| 52 | 28 | .62033 | .41719 | .62921 | .42581 | .63794 | .43445 | .64651 | .44311 |
| 56 | 29 | .62048 | .41733 | .62936 | .42595 | .63808 | .43459 | .64665 | .44325 |
| s | ' | 5h 22 ^m 80° | | 5h 26 ^m 81° | | 5h 30 ^m 82° | | 5h 34 ^m 83° | |
| 0 | 30 | 9.62063 | 0.41748 | 9.62951 | 0.42610 | 9.63823 | 0.43474 | 9.64679 | 0.44340 |
| 4 | 31 | .62078 | .41762 | .62965 | .42624 | .63837 | .43488 | .64694 | .44354 |
| 8 | 32 | .62093 | .41776 | .62980 | .42638 | .63851 | .43503 | .64708 | .44369 |
| 12 | 33 | .62108 | .41791 | .62995 | .42653 | .63866 | .43517 | .64722 | .44383 |
| 16 | 34 | .62123 | .41805 | .63009 | .42667 | .63880 | .43531 | .64736 | .44398 |
| 20 | 35 | 9.62138 | 0.41819 | 9.63024 | 0.42681 | 9.63895 | 0.43546 | 9.64750 | 0.44412 |
| 24 | 36 | .62153 | .41834 | .63039 | .42696 | .63909 | .43560 | .64764 | .44427 |
| 28 | 37 | .62168 | .41848 | .63063 | .42710 | .63923 | .43575 | .64778 | .44441 |
| 32 | 38 | .62182 | .41862 | .63068 | .42725 | .63938 | .43589 | .64793 | .44455 |
| 36 | 39 | .62197 | .41877 | .63082 | .42739 | .63952 | .43603 | .64807 | .44470 |
| 40 | 40 | 9.62212 | 0.41891 | 9.63097 | 0.42753 | 9.63966 | 0.43618 | 9.64821 | 0.44484 |
| 44 | 41 | .62227 | .41905 | .63112 | .42768 | .63981 | .43632 | .64835 | .44499 |
| 48 | 42 | .62242 | .41920 | .63126 | .42782 | .63995 | .43647 | .64849 | .44513 |
| 52 | 43 | .62257 | .41934 | .63141 | .42797 | .64010 | .43661 | .64863 | .44528 |
| 56 | 44 | .62272 | .41949 | .63156 | .42811 | .64024 | .43676 | .64877 | .44542 |
| s | ' | 5h 23 ^m 80° | | 5h 27 ^m 81° | | 5h 31 ^m 82° | | 5h 35 ^m 83° | |
| 0 | 45 | 9.62287 | 0.41963 | 9.63170 | 0.42825 | 9.64038 | 0.43690 | 9.64891 | 0.44557 |
| 4 | 46 | .62301 | .41977 | .63185 | .42840 | .64053 | .43704 | .64905 | .44571 |
| 8 | 47 | .62316 | .41992 | .63199 | .42854 | .64067 | .43719 | .64919 | .44586 |
| 12 | 48 | .62331 | .42006 | .63214 | .42869 | .64081 | .43733 | .64934 | .44600 |
| 16 | 49 | .62346 | .42020 | .63228 | .42883 | .64096 | .43748 | .64948 | .44614 |
| 20 | 50 | 9.62361 | 0.42035 | 9.63243 | 0.42897 | 9.64110 | 0.43762 | 9.64962 | 0.44629 |
| 24 | 51 | .62376 | .42049 | .63258 | .42912 | .64124 | .43777 | .64976 | .44643 |
| 28 | 52 | .62390 | .42063 | .63272 | .42926 | .64139 | .43791 | .64990 | .44658 |
| 32 | 53 | .62405 | .42078 | .63287 | .42941 | .64153 | .43805 | .65004 | .44672 |
| 36 | 54 | .62420 | .42092 | .63301 | .42955 | .64167 | .43820 | .65018 | .44687 |
| 40 | 55 | 9.62435 | 0.42106 | 9.63316 | 0.42969 | 9.64181 | 0.43834 | 9.65032 | 0.44701 |
| 44 | 56 | .62450 | .42121 | .63330 | .42984 | .64196 | .43849 | .65046 | .44716 |
| 48 | 57 | .62464 | .42135 | .63345 | .42998 | .64210 | .43863 | .65060 | .44730 |
| 52 | 58 | .62479 | .42150 | .63360 | .43013 | .64224 | .43878 | .65074 | .44745 |
| 56 | 59 | .62494 | .42164 | .63374 | .43027 | .64239 | .43892 | .65088 | .44759 |
| 60 | 60 | 9.62509 | 0.42178 | 9.63389 | 0.43041 | 9.64253 | 0.43907 | 9.65102 | 0.44774 |

Table 10. Haversine Table

| s | ' | 5h 36m 84° | | 5h 40m 85° | | 5h 44m 86° | | 5h 48m 87° | |
|----|----|------------|----------------|------------|----------------|------------|----------------|------------|----------------|
| | | Hav. | No. | Hav. | No. | Hav. | No. | Hav. | No. |
| 0 | 0 | 9.65102 | 0.44774 | 9.65937 | 0.45642 | 9.66757 | 0.46512 | 9.67562 | 0.47383 |
| 4 | 1 | .65116 | .44788 | .65950 | .45657 | .66770 | .46527 | .67576 | .47398 |
| 8 | 2 | .65130 | .44803 | .65964 | .45671 | .66784 | .46541 | .67589 | .47412 |
| 12 | 3 | .65144 | .44817 | .65978 | .45686 | .66797 | .46556 | .67602 | .47427 |
| 16 | 4 | .65158 | .44831 | .65992 | .45700 | .66811 | .46570 | .67616 | .47441 |
| 20 | 5 | 9.65172 | 0.44846 | 9.66006 | 0.45715 | 9.66824 | 0.46585 | 9.67629 | 0.47456 |
| 24 | 6 | .65186 | .44860 | .66019 | .45729 | .66838 | .46599 | .67642 | .47470 |
| 28 | 7 | .65200 | .44875 | .66033 | .45744 | .66851 | .46614 | .67656 | .47485 |
| 32 | 8 | .65214 | .44889 | .66047 | .45758 | .66865 | .46628 | .67669 | .47499 |
| 36 | 9 | .65228 | .44904 | .66061 | .45773 | .66878 | .46643 | .67682 | .47514 |
| 40 | 10 | 9.65242 | 0.44918 | 9.66074 | 0.45787 | 9.66892 | 0.46657 | 9.67695 | 0.47528 |
| 44 | 11 | .65256 | .44933 | .66088 | .45802 | .66905 | .46672 | .67709 | .47543 |
| 48 | 12 | .65270 | .44947 | .66102 | .45816 | .66919 | .46686 | .67722 | .47558 |
| 52 | 13 | .65284 | .44962 | .66116 | .45831 | .66932 | .46701 | .67735 | .47572 |
| 56 | 14 | .65298 | .44976 | .66129 | .45845 | .66946 | .46715 | .67748 | .47587 |
| s | ' | 5h 37m 84° | | 5h 41m 85° | | 5h 45m 86° | | 5h 49m 87° | |
| 0 | 15 | 9.65312 | 0.44991 | 9.66143 | 0.45860 | 9.66959 | 0.46730 | 9.67762 | 0.47601 |
| 4 | 16 | .65326 | .45005 | .66157 | .45874 | .66973 | .46744 | .67775 | .47616 |
| 8 | 17 | .65340 | .45020 | .66170 | .45889 | .66986 | .46759 | .67788 | .47630 |
| 12 | 18 | .65354 | .45034 | .66184 | .45903 | .67000 | .46773 | .67801 | .47645 |
| 16 | 19 | .65368 | .45048 | .66198 | .45918 | .67013 | .46788 | .67815 | .47659 |
| 20 | 20 | 9.65382 | 0.45063 | 9.66212 | 0.45932 | 9.67027 | 0.46802 | 9.67828 | 0.47674 |
| 24 | 21 | .65396 | .45077 | .66225 | .45947 | .67040 | .46817 | .67841 | .47688 |
| 28 | 22 | .65410 | .45092 | .66239 | .45961 | .67054 | .46831 | .67854 | .47703 |
| 32 | 23 | .65424 | .45106 | .66253 | .45976 | .67067 | .46846 | .67868 | .47717 |
| 36 | 24 | .65438 | .45121 | .66266 | .45990 | .67081 | .46860 | .67881 | .47732 |
| 40 | 25 | 9.65452 | 0.45135 | 9.66280 | 0.46005 | 9.67094 | 0.46875 | 9.67894 | 0.47746 |
| 44 | 26 | .65466 | .45150 | .66294 | .46019 | .67108 | .46890 | .67907 | .47761 |
| 48 | 27 | .65480 | .45164 | .66307 | .46034 | .67121 | .46904 | .67920 | .47775 |
| 52 | 28 | .65493 | .45179 | .66321 | .46048 | .67134 | .46919 | .67934 | .47790 |
| 56 | 29 | .65507 | .45193 | .66335 | .46063 | .67148 | .46933 | .67947 | .47805 |
| s | ' | 5h 38m 84° | | 5h 42m 85° | | 5h 46m 86° | | 5h 50m 87° | |
| 0 | 30 | 9.65521 | 0.45208 | 9.66348 | 0.46077 | 9.67161 | 0.46948 | 9.67960 | 0.47819 |
| 4 | 31 | .65535 | .45222 | .66362 | .46092 | .67175 | .46962 | .67973 | .47834 |
| 8 | 32 | .65549 | .45237 | .66376 | .46106 | .67188 | .46977 | .67986 | .47848 |
| 12 | 33 | .65563 | .45251 | .66389 | .46121 | .67202 | .46991 | .68000 | .47863 |
| 16 | 34 | .65577 | .45266 | .66403 | .46135 | .67215 | .47006 | .68013 | .47877 |
| 20 | 35 | 9.65591 | 0.45280 | 9.66417 | 0.46150 | 9.67228 | 0.47020 | 9.68026 | 0.47892 |
| 24 | 36 | .65605 | .45295 | .66430 | .46164 | .67242 | .47035 | .68039 | .47906 |
| 28 | 37 | .65619 | .45309 | .66444 | .46179 | .67255 | .47049 | .68052 | .47921 |
| 32 | 38 | .65632 | .45324 | .66458 | .46193 | .67269 | .47064 | .68066 | .47935 |
| 36 | 39 | .65646 | .45338 | .66471 | .46208 | .67282 | .47078 | .68079 | .47950 |
| 40 | 40 | 9.65660 | 0.45353 | 9.66485 | 0.46222 | 9.67295 | 0.47093 | 9.68092 | 0.47964 |
| 44 | 41 | .65674 | .45367 | .66499 | .46237 | .67309 | .47107 | .68105 | .47979 |
| 48 | 42 | .65688 | .45381 | .66512 | .46251 | .67322 | .47122 | .68118 | .47993 |
| 52 | 43 | .65702 | .45396 | .66526 | .46266 | .67336 | .47136 | .68131 | .48008 |
| 56 | 44 | .65716 | .45410 | .66539 | .46280 | .67349 | .47151 | .68144 | .48022 |
| s | ' | 5h 39m 84° | | 5h 43m 85° | | 5h 47m 86° | | 5h 51m 87° | |
| 0 | 45 | 9.65729 | 0.45425 | 9.66553 | 0.46295 | 9.67362 | 0.47165 | 9.68158 | 0.48037 |
| 4 | 46 | .65743 | .45439 | .66567 | .46309 | .67376 | .47180 | .68171 | .48052 |
| 8 | 47 | .65757 | .45454 | .66580 | .46324 | .67389 | .47194 | .68184 | .48066 |
| 12 | 48 | .65771 | .45468 | .66594 | .46338 | .67402 | .47209 | .68197 | .48081 |
| 16 | 49 | .65785 | .45483 | .66607 | .46353 | .67416 | .47223 | .68210 | .48095 |
| 20 | 50 | 9.65799 | 0.45497 | 9.66621 | 0.46367 | 9.67429 | 0.47238 | 9.68223 | 0.48110 |
| 24 | 51 | .65812 | .45512 | .66635 | .46382 | .67443 | .47252 | .68236 | .48124 |
| 28 | 52 | .65826 | .45526 | .66648 | .46396 | .67456 | .47267 | .68249 | .48139 |
| 32 | 53 | .65840 | .45541 | .66662 | .46411 | .67469 | .47282 | .68263 | .48153 |
| 36 | 54 | .65854 | .45555 | .66675 | .46425 | .67483 | .47296 | .68276 | .48168 |
| 40 | 55 | 9.65868 | 0.45570 | 9.66689 | 0.46440 | 9.67496 | 0.47311 | 9.68289 | 0.48182 |
| 44 | 56 | .65881 | .45584 | .66702 | .46454 | .67509 | .47325 | .68302 | .48197 |
| 48 | 57 | .65895 | .45599 | .66716 | .46469 | .67522 | .47340 | .68315 | .48211 |
| 52 | 58 | .65909 | .45613 | .66730 | .46483 | .67536 | .47354 | .68328 | .48226 |
| 56 | 59 | .65923 | .45628 | .66743 | .46498 | .67549 | .47369 | .68341 | .48241 |
| 60 | 60 | 9.65937 | 0.45642 | 9.66757 | 0.46512 | 9.67562 | 0.47383 | 9.68354 | 0.48255 |

| s | | 5h 52m 88° | | 5h 56m 89° | | s | | 6h 0m 6h 4m | |
|----|----|------------|---------|------------|---------|----|---------|-------------|------|
| | | Hav. | No. | Hav. | No. | | | Hav. | Hav. |
| 0 | 0 | 9.68354 | 0.48255 | 9.69132 | 0.49127 | 0 | 9.69897 | 9.70648 | |
| 4 | 1 | .68367 | .48269 | .69145 | .49142 | 4 | .69910 | .70661 | |
| 8 | 2 | .68380 | .48284 | .69158 | .49156 | 8 | .69922 | .70673 | |
| 12 | 3 | .68393 | .48299 | .69171 | .49171 | 12 | .69935 | .70686 | |
| 16 | 4 | .68407 | .48313 | .69184 | .49186 | 16 | .69948 | .70698 | |
| 20 | 5 | 9.68420 | 0.48328 | 9.69197 | 0.49200 | 20 | 9.69960 | 9.70710 | |
| 24 | 6 | .68433 | .48342 | .69209 | .49215 | 24 | .69973 | .70723 | |
| 28 | 7 | .68446 | .48357 | .69222 | .49229 | 28 | .69985 | .70735 | |
| 32 | 8 | .68459 | .48371 | .69235 | .49244 | 32 | .69998 | .70748 | |
| 36 | 9 | .68472 | .48386 | .69248 | .49258 | 36 | .70011 | .70760 | |
| 40 | 10 | 9.68485 | 0.48400 | 9.69261 | 0.49273 | 40 | 9.70023 | 9.70772 | |
| 44 | 11 | .68498 | .48415 | .69274 | .49287 | 44 | .70036 | .70785 | |
| 48 | 12 | .68511 | .48429 | .69286 | .49302 | 48 | .70048 | .70797 | |
| 52 | 13 | .68524 | .48444 | .69299 | .49316 | 52 | .70061 | .70809 | |
| 56 | 14 | .68537 | .48459 | .69312 | .49331 | 56 | .70074 | .70822 | |
| s | | 5h 53m 88° | | 5h 57m 89° | | s | | 6h 1m 6h 5m | |
| | | Hav. | No. | Hav. | No. | | | Hav. | Hav. |
| 0 | 15 | 9.68550 | 0.48473 | 9.69325 | 0.49346 | 0 | 9.70086 | 9.70834 | |
| 4 | 16 | .68563 | .48488 | .69338 | .49360 | 4 | .70099 | .70847 | |
| 8 | 17 | .68576 | .48502 | .69350 | .49375 | 8 | .70111 | .70859 | |
| 12 | 18 | .68589 | .48517 | .69363 | .49389 | 12 | .70124 | .70871 | |
| 16 | 19 | .68602 | .48531 | .69376 | .49404 | 16 | .70136 | .70884 | |
| 20 | 20 | 9.68615 | 0.48546 | 9.69389 | 0.49418 | 20 | 9.70149 | 9.70896 | |
| 24 | 21 | .68628 | .48560 | .69402 | .49433 | 24 | .70161 | .70908 | |
| 28 | 22 | .68641 | .48575 | .69414 | .49447 | 28 | .70174 | .70921 | |
| 32 | 23 | .68654 | .48589 | .69427 | .49462 | 32 | .70187 | .70933 | |
| 36 | 24 | .68667 | .48604 | .69440 | .49476 | 36 | .70199 | .70945 | |
| 40 | 25 | 9.68680 | 0.48618 | 9.69453 | 0.49491 | 40 | 9.70212 | 9.70958 | |
| 44 | 26 | .68693 | .48633 | .69465 | .49506 | 44 | .70224 | .70970 | |
| 48 | 27 | .68706 | .48648 | .69478 | .49520 | 48 | .70237 | .70982 | |
| 52 | 28 | .68719 | .48662 | .69491 | .49535 | 52 | .70249 | .70995 | |
| 56 | 29 | .68732 | .48677 | .69504 | .49549 | 56 | .70262 | .71007 | |
| s | | 5h 54m 88° | | 5h 58m 89° | | s | | 6h 2m 6h 6m | |
| | | Hav. | No. | Hav. | No. | | | Hav. | Hav. |
| 0 | 30 | 9.68745 | 0.48691 | 9.69516 | 0.49564 | 0 | 9.70274 | 9.71019 | |
| 4 | 31 | .68758 | .48706 | .69529 | .49578 | 4 | .70287 | .71032 | |
| 8 | 32 | .68771 | .48720 | .69542 | .49593 | 8 | .70299 | .71044 | |
| 12 | 33 | .68784 | .48735 | .69555 | .49607 | 12 | .70312 | .71056 | |
| 16 | 34 | .68797 | .48749 | .69567 | .49622 | 16 | .70324 | .71068 | |
| 20 | 35 | 9.68810 | 0.48764 | 9.69580 | 0.49636 | 20 | 9.70337 | 9.71081 | |
| 24 | 36 | .68823 | .48778 | .69593 | .49651 | 24 | .70349 | .71093 | |
| 28 | 37 | .68836 | .48793 | .69605 | .49665 | 28 | .70362 | .71105 | |
| 32 | 38 | .68849 | .48807 | .69618 | .49680 | 32 | .70374 | .71118 | |
| 36 | 39 | .68862 | .48822 | .69631 | .49695 | 36 | .70387 | .71130 | |
| 40 | 40 | 9.68875 | 0.48837 | 9.69644 | 0.49709 | 40 | 9.70399 | 9.71142 | |
| 44 | 41 | .68887 | .48851 | .69656 | .49724 | 44 | .70412 | .71154 | |
| 48 | 42 | .68900 | .48866 | .69669 | .49738 | 48 | .70424 | .71167 | |
| 52 | 43 | .68913 | .48880 | .69682 | .49753 | 52 | .70437 | .71179 | |
| 56 | 44 | .68926 | .48895 | .69694 | .49767 | 56 | .70449 | .71191 | |
| s | | 5h 55m 88° | | 5h 59m 89° | | s | | 6h 3m 6h 7m | |
| | | Hav. | No. | Hav. | No. | | | Hav. | Hav. |
| 0 | 45 | 9.68939 | 0.48909 | 9.69707 | 0.49782 | 0 | 9.70462 | 9.71203 | |
| 4 | 46 | .68952 | .48924 | .69720 | .49796 | 4 | .70474 | .71216 | |
| 8 | 47 | .68965 | .48938 | .69732 | .49811 | 8 | .70487 | .71228 | |
| 12 | 48 | .68978 | .48953 | .69745 | .49825 | 12 | .70499 | .71240 | |
| 16 | 49 | .68991 | .48967 | .69758 | .49840 | 16 | .70512 | .71252 | |
| 20 | 50 | 9.69004 | 0.48982 | 9.69770 | 0.49855 | 20 | 9.70524 | 9.71265 | |
| 24 | 51 | .69017 | .48997 | .69783 | .49869 | 24 | .70537 | .71277 | |
| 28 | 52 | .69029 | .49011 | .69796 | .49884 | 28 | .70549 | .71289 | |
| 32 | 53 | .69042 | .49026 | .69808 | .49898 | 32 | .70561 | .71301 | |
| 36 | 54 | .69055 | .49040 | .69821 | .49913 | 36 | .70574 | .71314 | |
| 40 | 55 | 9.69068 | 0.49055 | 9.69834 | 0.49927 | 40 | 9.70586 | 9.71326 | |
| 44 | 56 | .69081 | .49069 | .69846 | .49942 | 44 | .70599 | .71338 | |
| 48 | 57 | .69094 | .49084 | .69859 | .49956 | 48 | .70611 | .71350 | |
| 52 | 58 | .69107 | .49098 | .69872 | .49971 | 52 | .70624 | .71362 | |
| 56 | 59 | .69120 | .49113 | .69884 | .49985 | 56 | .70636 | .71375 | |
| 60 | 60 | 9.69132 | 0.49127 | 9.69897 | 0.50000 | 60 | 9.70648 | 9.71387 | |

Note. — The No. column is omitted in the rest of this table, as the No. haversines are not needed beyond 6h or 90°.

Table 10. Haversine Table

| s | 6h 8 ^m 6h 12 ^m | | 6h 16 ^m 6h 20 ^m | | 6h 24 ^m 6h 28 ^m | | 6h 32 ^m 6h 36 ^m | |
|----|---------------------------------------|---------|---------------------------------------|---------|---------------------------------------|---------|---------------------------------------|---------|
| | Hav. | Hav. | Hav. | Hav. | Hav. | Hav. | Hav. | Hav. |
| 0 | 9.71387 | 9.72112 | 9.72825 | 9.73526 | 9.74215 | 9.74891 | 9.75556 | 9.76209 |
| 4 | .71399 | .72124 | .72837 | .73538 | .74226 | .74902 | .75567 | .76220 |
| 8 | .71411 | .72136 | .72849 | .73549 | .74237 | .74914 | .75578 | .76231 |
| 12 | .71423 | .72148 | .72861 | .73561 | .74249 | .74925 | .75589 | .76241 |
| 16 | .71436 | .72160 | .72873 | .73572 | .74260 | .74936 | .75600 | .76252 |
| 20 | 9.71448 | 9.72172 | 9.72884 | 9.73584 | 9.74272 | 9.74947 | 9.75611 | 9.76263 |
| 24 | .71460 | .72184 | .72896 | .73596 | .74283 | .74958 | .75622 | .76274 |
| 28 | .71472 | .72196 | .72908 | .73607 | .74294 | .74969 | .75633 | .76285 |
| 32 | .71484 | .72208 | .72920 | .73619 | .74306 | .74981 | .75644 | .76296 |
| 36 | .71496 | .72220 | .72931 | .73630 | .74317 | .74992 | .75655 | .76306 |
| 40 | 9.71509 | 9.72232 | 9.72943 | 9.73642 | 9.74328 | 9.75003 | 9.75666 | 9.76317 |
| 44 | .71521 | .72244 | .72955 | .73653 | .74340 | .75014 | .75677 | .76328 |
| 48 | .71533 | .72256 | .72967 | .73665 | .74351 | .75025 | .75688 | .76338 |
| 52 | .71545 | .72268 | .72978 | .73676 | .74362 | .75036 | .75698 | .76349 |
| 56 | .71557 | .72280 | .72990 | .73688 | .74374 | .75047 | .75709 | .76360 |
| s | 6h 9 ^m 6h 13 ^m | | 6h 17 ^m 6h 21 ^m | | 6h 25 ^m 6h 29 ^m | | 6h 33 ^m 6h 37 ^m | |
| 0 | 9.71569 | 9.72292 | 9.73002 | 9.73699 | 9.74385 | 9.75059 | 9.75720 | 9.76371 |
| 4 | .71582 | .72304 | .73014 | .73711 | .74396 | .75070 | .75731 | .76381 |
| 8 | .71594 | .72316 | .73025 | .73722 | .74408 | .75081 | .75742 | .76392 |
| 12 | .71606 | .72328 | .73037 | .73734 | .74419 | .75092 | .75753 | .76403 |
| 16 | .71618 | .72340 | .73049 | .73746 | .74430 | .75103 | .75764 | .76414 |
| 20 | 9.71630 | 9.72352 | 9.73060 | 9.73757 | 9.74442 | 9.75114 | 9.75775 | 9.76424 |
| 24 | .71642 | .72363 | .73072 | .73769 | .74453 | .75125 | .75786 | .76435 |
| 28 | .71654 | .72375 | .73084 | .73780 | .74464 | .75136 | .75797 | .76446 |
| 32 | .71666 | .72387 | .73096 | .73792 | .74475 | .75147 | .75808 | .76456 |
| 36 | .71679 | .72399 | .73107 | .73803 | .74487 | .75159 | .75819 | .76467 |
| 40 | 9.71691 | 9.72411 | 9.73119 | 9.73815 | 9.74498 | 9.75170 | 9.75830 | 9.76478 |
| 44 | .71703 | .72423 | .73131 | .73826 | .74509 | .75181 | .75840 | .76489 |
| 48 | .71715 | .72435 | .73142 | .73838 | .74521 | .75192 | .75851 | .76499 |
| 52 | .71727 | .72447 | .73154 | .73849 | .74532 | .75203 | .75862 | .76510 |
| 56 | .71739 | .72459 | .73166 | .73860 | .74543 | .75214 | .75873 | .76521 |
| s | 6h 10 ^m 6h 14 ^m | | 6h 18 ^m 6h 22 ^m | | 6h 26 ^m 6h 30 ^m | | 6h 34 ^m 6h 38 ^m | |
| 0 | 9.71751 | 9.72471 | 9.73177 | 9.73872 | 9.74554 | 9.75225 | 9.75884 | 9.76531 |
| 4 | .71763 | .72482 | .73189 | .73883 | .74566 | .75236 | .75895 | .76542 |
| 8 | .71775 | .72494 | .73201 | .73895 | .74577 | .75247 | .75906 | .76553 |
| 12 | .71787 | .72506 | .73212 | .73906 | .74588 | .75258 | .75917 | .76563 |
| 16 | .71800 | .72518 | .73224 | .73918 | .74600 | .75269 | .75927 | .76574 |
| 20 | 9.71812 | 9.72530 | 9.73236 | 9.73929 | 9.74611 | 9.75280 | 9.75938 | 9.76585 |
| 24 | .71824 | .72542 | .73247 | .73941 | .74622 | .75291 | .75949 | .76595 |
| 28 | .71836 | .72554 | .73259 | .73952 | .74633 | .75303 | .75960 | .76606 |
| 32 | .71848 | .72565 | .73271 | .73964 | .74645 | .75314 | .75971 | .76617 |
| 36 | .71860 | .72577 | .73282 | .73975 | .74656 | .75325 | .75982 | .76627 |
| 40 | 9.71872 | 9.72589 | 9.73294 | 9.73987 | 9.74667 | 9.75336 | 9.75993 | 9.76638 |
| 44 | .71884 | .72601 | .73306 | .73998 | .74678 | .75347 | .76004 | .76649 |
| 48 | .71896 | .72613 | .73317 | .74009 | .74690 | .75358 | .76014 | .76659 |
| 52 | .71908 | .72625 | .73329 | .74021 | .74701 | .75369 | .76025 | .76670 |
| 56 | .71920 | .72637 | .73341 | .74032 | .74712 | .75380 | .76036 | .76681 |
| s | 6h 11 ^m 6h 15 ^m | | 6h 19 ^m 6h 23 ^m | | 6h 27 ^m 6h 31 ^m | | 6h 35 ^m 6h 39 ^m | |
| 0 | 9.71932 | 9.72648 | 9.73352 | 9.74044 | 9.74723 | 9.75391 | 9.76047 | 9.76691 |
| 4 | .71944 | .72660 | .73364 | .74055 | .74734 | .75402 | .76058 | .76702 |
| 8 | .71956 | .72672 | .73375 | .74067 | .74746 | .75413 | .76069 | .76713 |
| 12 | .71968 | .72684 | .73387 | .74078 | .74757 | .75424 | .76079 | .76723 |
| 16 | .71980 | .72696 | .73399 | .74089 | .74768 | .75435 | .76090 | .76734 |
| 20 | 9.71992 | 9.72708 | 9.73410 | 9.74101 | 9.74779 | 9.75446 | 9.76101 | 9.76745 |
| 24 | .72004 | .72719 | .73422 | .74112 | .74791 | .75457 | .76112 | .76755 |
| 28 | .72016 | .72731 | .73433 | .74124 | .74802 | .75468 | .76123 | .76766 |
| 32 | .72028 | .72743 | .73445 | .74135 | .74813 | .75479 | .76134 | .76777 |
| 36 | .72040 | .72755 | .73457 | .74146 | .74824 | .75490 | .76144 | .76787 |
| 40 | 9.72052 | 9.72767 | 9.73468 | 9.74158 | 9.74835 | 9.75501 | 9.76155 | 9.76798 |
| 44 | .72064 | .72778 | .73480 | .74169 | .74846 | .75512 | .76166 | .76808 |
| 48 | .72076 | .72790 | .73491 | .74181 | .74858 | .75523 | .76177 | .76819 |
| 52 | .72088 | .72802 | .73503 | .74192 | .74869 | .75534 | .76188 | .76830 |
| 56 | .72100 | .72814 | .73515 | .74203 | .74880 | .75545 | .76198 | .76840 |
| 60 | 9.72112 | 9.72825 | 9.73526 | 9.74215 | 9.74891 | 9.75556 | 9.76209 | 9.76851 |

Table 10. Haversine Table

| s | 6h 40 ^m | 6h 44 ^m | 6h 48 ^m | 6h 52 ^m | 6h 56 ^m | 7h 0 ^m | 7h 4 ^m | 7h 8 ^m |
|----|--------------------|--------------------|--------------------|--------------------|--------------------|-------------------|-------------------|--------------------|
| | Hav. | Hav. | Hav. | Hav. | Hav. | Hav. | Hav. | Hav. |
| 0 | 9.76851 | 9.77481 | 9.78101 | 9.78709 | 9.79306 | 9.79893 | 9.80470 | 9.81036 |
| 4 | .76861 | .77492 | .78111 | .78719 | .79316 | .79903 | .80479 | .81045 |
| 8 | .76872 | .77502 | .78121 | .78729 | .79326 | .79913 | .80489 | .81054 |
| 12 | .76883 | .77512 | .78131 | .78739 | .79336 | .79922 | .80498 | .81064 |
| 16 | .76893 | .77523 | .78141 | .78749 | .79346 | .79932 | .80508 | .81073 |
| 20 | 9.76904 | 9.77533 | 9.78152 | 9.78759 | 9.79356 | 9.79942 | 9.80517 | 9.81082 |
| 24 | .76914 | .77544 | .78162 | .78769 | .79366 | .79951 | .80527 | .81092 |
| 28 | .76925 | .77554 | .78172 | .78779 | .79376 | .79961 | .80536 | .81101 |
| 32 | .76936 | .77564 | .78182 | .78789 | .79385 | .79971 | .80546 | .81110 |
| 36 | .76946 | .77575 | .78192 | .78799 | .79395 | .79980 | .80555 | .81120 |
| 40 | 9.76957 | 9.77585 | 9.78203 | 9.78809 | 9.79405 | 9.79990 | 9.80565 | 9.81129 |
| 44 | .76967 | .77596 | .78213 | .78819 | .79415 | .80000 | .80574 | .81138 |
| 48 | .76978 | .77606 | .78223 | .78829 | .79425 | .80009 | .80584 | .81148 |
| 52 | .76988 | .77616 | .78233 | .78839 | .79434 | .80019 | .80593 | .81157 |
| 56 | .76999 | .77627 | .78243 | .78849 | .79444 | .80029 | .80603 | .81166 |
| s | 6h 41 ^m | 6h 45 ^m | 6h 49 ^m | 6h 53 ^m | 6h 57 ^m | 7h 1 ^m | 7h 5 ^m | 7h 9 ^m |
| 0 | 9.77009 | 9.77637 | 9.78254 | 9.78859 | 9.79454 | 9.80038 | 9.80612 | 9.81176 |
| 4 | .77020 | .77647 | .78264 | .78869 | .79464 | .80048 | .80622 | .81185 |
| 8 | .77031 | .77658 | .78274 | .78879 | .79474 | .80058 | .80631 | .81194 |
| 12 | .77041 | .77668 | .78284 | .78889 | .79484 | .80067 | .80641 | .81204 |
| 16 | .77052 | .77679 | .78294 | .78899 | .79493 | .80077 | .80650 | .81213 |
| 20 | 9.77062 | 9.77689 | 9.78305 | 9.78909 | 9.79503 | 9.80087 | 9.80660 | 9.81222 |
| 24 | .77073 | .77699 | .78315 | .78919 | .79513 | .80096 | .80669 | .81231 |
| 28 | .77083 | .77710 | .78325 | .78929 | .79523 | .80106 | .80678 | .81241 |
| 32 | .77094 | .77720 | .78335 | .78939 | .79533 | .80116 | .80688 | .81250 |
| 36 | .77104 | .77730 | .78345 | .78949 | .79542 | .80125 | .80697 | .81259 |
| 40 | 9.77115 | 9.77741 | 9.78355 | 9.78959 | 9.79552 | 9.80135 | 9.80707 | 9.81269 |
| 44 | .77125 | .77751 | .78365 | .78969 | .79562 | .80144 | .80716 | .81278 |
| 48 | .77136 | .77761 | .78376 | .78979 | .79572 | .80154 | .80726 | .81287 |
| 52 | .77146 | .77772 | .78386 | .78989 | .79582 | .80164 | .80735 | .81296 |
| 56 | .77157 | .77782 | .78396 | .78999 | .79591 | .80173 | .80745 | .81306 |
| s | 6h 42 ^m | 6h 46 ^m | 6h 50 ^m | 6h 54 ^m | 6h 58 ^m | 7h 2 ^m | 7h 6 ^m | 7h 10 ^m |
| 0 | 9.77167 | 9.77792 | 9.78406 | 9.79009 | 9.79601 | 9.80183 | 9.80754 | 9.81315 |
| 4 | .77178 | .77803 | .78416 | .79019 | .79611 | .80192 | .80763 | .81324 |
| 8 | .77188 | .77813 | .78426 | .79029 | .79621 | .80202 | .80773 | .81333 |
| 12 | .77199 | .77823 | .78436 | .79039 | .79631 | .80212 | .80782 | .81343 |
| 16 | .77209 | .77834 | .78447 | .79049 | .79640 | .80221 | .80792 | .81352 |
| 20 | 9.77220 | 9.77844 | 9.78457 | 9.79059 | 9.79650 | 9.80231 | 9.80801 | 9.81361 |
| 24 | .77230 | .77854 | .78467 | .79069 | .79660 | .80240 | .80811 | .81370 |
| 28 | .77241 | .77864 | .78477 | .79079 | .79670 | .80250 | .80820 | .81380 |
| 32 | .77251 | .77875 | .78487 | .79089 | .79679 | .80260 | .80829 | .81389 |
| 36 | .77262 | .77885 | .78497 | .79099 | .79689 | .80269 | .80839 | .81398 |
| 40 | 9.77272 | 9.77895 | 9.78507 | 9.79108 | 9.79699 | 9.80279 | 9.80848 | 9.81407 |
| 44 | .77283 | .77906 | .78517 | .79118 | .79709 | .80288 | .80858 | .81417 |
| 48 | .77293 | .77916 | .78528 | .79128 | .79718 | .80298 | .80867 | .81426 |
| 52 | .77304 | .77926 | .78538 | .79138 | .79728 | .80307 | .80876 | .81435 |
| 56 | .77314 | .77936 | .78548 | .79148 | .79738 | .80317 | .80886 | .81444 |
| s | 6h 43 ^m | 6h 47 ^m | 6h 51 ^m | 6h 55 ^m | 6h 59 ^m | 7h 3 ^m | 7h 7 ^m | 7h 11 ^m |
| 0 | 9.77325 | 9.77947 | 9.78558 | 9.79158 | 9.79748 | 9.80327 | 9.80895 | 9.81454 |
| 4 | .77335 | .77957 | .78568 | .79168 | .79757 | .80336 | .80905 | .81463 |
| 8 | .77346 | .77967 | .78578 | .79178 | .79767 | .80346 | .80914 | .81472 |
| 12 | .77356 | .77978 | .78588 | .79188 | .79777 | .80355 | .80923 | .81481 |
| 16 | .77366 | .77988 | .78598 | .79198 | .79787 | .80365 | .80933 | .81490 |
| 20 | 9.77377 | 9.77998 | 9.78608 | 9.79208 | 9.79796 | 9.80374 | 9.80942 | 9.81500 |
| 24 | .77387 | .78008 | .78618 | .79217 | .79806 | .80384 | .80952 | .81509 |
| 28 | .77398 | .78019 | .78628 | .79227 | .79816 | .80393 | .80961 | .81518 |
| 32 | .77408 | .78029 | .78638 | .79237 | .79825 | .80403 | .80970 | .81527 |
| 36 | .77419 | .78039 | .78649 | .79247 | .79835 | .80413 | .80980 | .81536 |
| 40 | 9.77429 | 9.78049 | 9.78659 | 9.79257 | 9.79845 | 9.80422 | 9.80989 | 9.81546 |
| 44 | .77440 | .78060 | .78669 | .79267 | .79855 | .80432 | .80998 | .81555 |
| 48 | .77450 | .78070 | .78679 | .79277 | .79864 | .80441 | .81008 | .81564 |
| 52 | .77460 | .78080 | .78689 | .79287 | .79874 | .80451 | .81017 | .81573 |
| 56 | .77471 | .78090 | .78699 | .79297 | .79884 | .80460 | .81026 | .81582 |
| 60 | 9.77481 | 9.78101 | 9.78709 | 9.79306 | 9.79893 | 9.80470 | 9.81036 | 9.81592 |

Table 10. Haversine Table

| s | 7h 12m | 7h 16m | 7h 20m | 7h 24m | 7h 28m | 7h 32m | 7h 36m | 7h 40m |
|----|---------|---------|---------|---------|---------|---------|---------|---------|
| | Hav. | Hav. | Hav. | Hav. | Hav. | Hav. | Hav. | Hav. |
| 0 | 9.81592 | 9.82137 | 9.82673 | 9.83199 | 9.83715 | 9.84221 | 9.84718 | 9.85206 |
| 4 | .81601 | .82146 | .82682 | .83207 | .83723 | .84230 | .84726 | .85214 |
| 8 | .81610 | .82155 | .82691 | .83216 | .83732 | .84238 | .84735 | .85222 |
| 12 | .81619 | .82164 | .82699 | .83225 | .83740 | .84246 | .84743 | .85230 |
| 16 | .81628 | .82173 | .82708 | .83233 | .83749 | .84255 | .84751 | .85238 |
| 20 | 9.81637 | 9.82182 | 9.82717 | 9.83242 | 9.83757 | 9.84263 | 9.84759 | 9.85246 |
| 24 | .81647 | .82191 | .82726 | .83251 | .83766 | .84271 | .84767 | .85254 |
| 28 | .81656 | .82200 | .82735 | .83259 | .83774 | .84280 | .84776 | .85262 |
| 32 | .81665 | .82209 | .82744 | .83268 | .83783 | .84288 | .84784 | .85270 |
| 36 | .81674 | .82218 | .82752 | .83277 | .83791 | .84296 | .84792 | .85278 |
| 40 | 9.81683 | 9.82227 | 9.82761 | 9.83285 | 9.83800 | 9.84305 | 9.84800 | 9.85286 |
| 44 | .81692 | .82236 | .82770 | .83294 | .83808 | .84313 | .84808 | .85294 |
| 48 | .81701 | .82245 | .82779 | .83303 | .83817 | .84321 | .84817 | .85302 |
| 52 | .81711 | .82254 | .82788 | .83311 | .83825 | .84330 | .84825 | .85310 |
| 56 | .81720 | .82263 | .82796 | .83320 | .83834 | .84338 | .84833 | .85318 |
| s | 7h 13m | 7h 17m | 7h 21m | 7h 25m | 7h 29m | 7h 33m | 7h 37m | 7h 41m |
| 0 | 9.81729 | 9.82272 | 9.82805 | 9.83329 | 9.83842 | 9.84346 | 9.84841 | 9.85326 |
| 4 | .81738 | .82281 | .82814 | .83337 | .83851 | .84355 | .84849 | .85334 |
| 8 | .81747 | .82290 | .82823 | .83346 | .83859 | .84363 | .84857 | .85342 |
| 12 | .81756 | .82299 | .82832 | .83355 | .83868 | .84371 | .84866 | .85350 |
| 16 | .81765 | .82308 | .82840 | .83363 | .83876 | .84380 | .84874 | .85358 |
| 20 | 9.81775 | 9.82317 | 9.82849 | 9.83372 | 9.83885 | 9.84388 | 9.84882 | 9.85366 |
| 24 | .81784 | .82326 | .82858 | .83380 | .83893 | .84396 | .84890 | .85374 |
| 28 | .81793 | .82335 | .82867 | .83389 | .83902 | .84405 | .84898 | .85382 |
| 32 | .81802 | .82344 | .82876 | .83398 | .83910 | .84413 | .84906 | .85390 |
| 36 | .81811 | .82353 | .82884 | .83406 | .83919 | .84421 | .84914 | .85398 |
| 40 | 9.81820 | 9.82362 | 9.82893 | 9.83415 | 9.83927 | 9.84430 | 9.84923 | 9.85406 |
| 44 | .81829 | .82371 | .82902 | .83424 | .83935 | .84438 | .84931 | .85414 |
| 48 | .81838 | .82380 | .82911 | .83432 | .83944 | .84446 | .84939 | .85422 |
| 52 | .81847 | .82388 | .82920 | .83441 | .83952 | .84454 | .84947 | .85430 |
| 56 | .81857 | .82397 | .82928 | .83449 | .83961 | .84463 | .84955 | .85438 |
| s | 7h 14m | 7h 18m | 7h 22m | 7h 26m | 7h 30m | 7h 34m | 7h 38m | 7h 42m |
| 0 | 9.81866 | 9.82406 | 9.82937 | 9.83458 | 9.83969 | 9.84471 | 9.84963 | 9.85446 |
| 4 | .81875 | .82415 | .82946 | .83467 | .83978 | .84479 | .84971 | .85454 |
| 8 | .81884 | .82424 | .82955 | .83475 | .83986 | .84488 | .84979 | .85462 |
| 12 | .81893 | .82433 | .82963 | .83484 | .83995 | .84496 | .84988 | .85470 |
| 16 | .81902 | .82442 | .82972 | .83492 | .84003 | .84504 | .84996 | .85478 |
| 20 | 9.81911 | 9.82451 | 9.82981 | 9.83501 | 9.84011 | 9.84512 | 9.85004 | 9.85486 |
| 24 | .81920 | .82460 | .82990 | .83510 | .84020 | .84521 | .85012 | .85494 |
| 28 | .81929 | .82469 | .82998 | .83518 | .84028 | .84529 | .85020 | .85502 |
| 32 | .81938 | .82478 | .83007 | .83527 | .84037 | .84537 | .85028 | .85510 |
| 36 | .81947 | .82487 | .83016 | .83535 | .84045 | .84545 | .85036 | .85518 |
| 40 | 9.81956 | 9.82495 | 9.83025 | 9.83544 | 9.84054 | 9.84554 | 9.85044 | 9.85526 |
| 44 | .81965 | .82504 | .83033 | .83552 | .84062 | .84562 | .85052 | .85534 |
| 48 | .81975 | .82513 | .83042 | .83561 | .84070 | .84570 | .85061 | .85542 |
| 52 | .81984 | .82522 | .83051 | .83570 | .84079 | .84578 | .85069 | .85550 |
| 56 | .81993 | .82531 | .83059 | .83578 | .84087 | .84587 | .85077 | .85557 |
| s | 7h 15m | 7h 19m | 7h 23m | 7h 27m | 7h 31m | 7h 35m | 7h 39m | 7h 43m |
| 0 | 9.82002 | 9.82540 | 9.83067 | 9.83587 | 9.84096 | 9.84595 | 9.85085 | 9.85565 |
| 4 | .82011 | .82549 | .83078 | .83595 | .84104 | .84603 | .85093 | .85573 |
| 8 | .82020 | .82558 | .83086 | .83604 | .84112 | .84611 | .85101 | .85581 |
| 12 | .82029 | .82567 | .83094 | .83612 | .84121 | .84620 | .85109 | .85589 |
| 16 | .82038 | .82575 | .83103 | .83621 | .84129 | .84628 | .85117 | .85597 |
| 20 | 9.82047 | 9.82584 | 9.83112 | 9.83630 | 9.84138 | 9.84636 | 9.85125 | 9.85605 |
| 24 | .82056 | .82593 | .83120 | .83638 | .84146 | .84644 | .85133 | .85613 |
| 28 | .82065 | .82602 | .83129 | .83647 | .84154 | .84653 | .85141 | .85621 |
| 32 | .82074 | .82611 | .83138 | .83655 | .84163 | .84661 | .85149 | .85629 |
| 36 | .82083 | .82620 | .83147 | .83664 | .84171 | .84669 | .85158 | .85637 |
| 40 | 9.82092 | 9.82629 | 9.83155 | 9.83672 | 9.84179 | 9.84677 | 9.85166 | 9.85645 |
| 44 | .82101 | .82638 | .83164 | .83681 | .84188 | .84685 | .85174 | .85653 |
| 48 | .82110 | .82646 | .83173 | .83689 | .84196 | .84694 | .85182 | .85660 |
| 52 | .82119 | .82655 | .83181 | .83698 | .84205 | .84702 | .85190 | .85668 |
| 56 | .82128 | .82664 | .83190 | .83706 | .84213 | .84710 | .85198 | .85676 |
| 60 | 9.82137 | 9.82673 | 9.83199 | 9.83715 | 9.84221 | 9.84718 | 9.85206 | 9.85684 |

Table 10. Haversine Table

| s | 7h 44 ^m | 7h 48 ^m | 7h 52 ^m | 7h 56 ^m | 8h 0 ^m | 8h 4 ^m | 8h 8 ^m | 8h 12 ^m |
|----|--------------------|--------------------|--------------------|--------------------|-------------------|-------------------|--------------------|--------------------|
| | Hav. | Hav. | Hav. | Hav. | Hav. | Hav. | Hav. | Hav. |
| 0 | 9.85684 | 9.86153 | 9.86613 | 9.87064 | 9.87506 | 9.87939 | 9.88364 | 9.88780 |
| 4 | .85692 | .86161 | .86621 | .87072 | .87513 | .87947 | .88371 | .88787 |
| 8 | .85700 | .86169 | .86628 | .87079 | .87521 | .87954 | .88378 | .88793 |
| 12 | .85708 | .86176 | .86636 | .87086 | .87528 | .87961 | .88385 | .88800 |
| 16 | .85716 | .86184 | .86643 | .87094 | .87535 | .87968 | .88392 | .88807 |
| 20 | 9.85724 | 9.86192 | 9.86651 | 9.87101 | 9.87543 | 9.87975 | 9.88399 | 9.88814 |
| 24 | .85731 | .86200 | .86659 | .87109 | .87550 | .87982 | .88406 | .88821 |
| 28 | .85739 | .86207 | .86666 | .87116 | .87557 | .87989 | .88413 | .88828 |
| 32 | .85747 | .86215 | .86674 | .87124 | .87564 | .87996 | .88420 | .88835 |
| 36 | .85755 | .86223 | .86681 | .87131 | .87572 | .88004 | .88427 | .88841 |
| 40 | 9.85763 | 9.86230 | 9.86689 | 9.87138 | 9.87579 | 9.88011 | 9.88434 | 9.88848 |
| 44 | .85771 | .86238 | .86696 | .87146 | .87586 | .88018 | .88441 | .88855 |
| 48 | .85779 | .86246 | .86704 | .87153 | .87593 | .88025 | .88448 | .88862 |
| 52 | .85787 | .86254 | .86712 | .87161 | .87601 | .88032 | .88455 | .88869 |
| 56 | .85794 | .86261 | .86719 | .87168 | .87608 | .88039 | .88462 | .88876 |
| s | 7h 45 ^m | 7h 49 ^m | 7h 53 ^m | 7h 57 ^m | 8h 1 ^m | 8h 5 ^m | 8h 9 ^m | 8h 13 ^m |
| 0 | 9.85802 | 9.86269 | 9.86727 | 9.87175 | 9.87615 | 9.88046 | 9.88469 | 9.88882 |
| 4 | .85810 | .86277 | .86734 | .87183 | .87623 | .88053 | .88476 | .88889 |
| 8 | .85818 | .86284 | .86742 | .87190 | .87630 | .88061 | .88483 | .88896 |
| 12 | .85826 | .86292 | .86749 | .87198 | .87637 | .88068 | .88490 | .88903 |
| 16 | .85834 | .86300 | .86757 | .87205 | .87644 | .88075 | .88496 | .88910 |
| 20 | 9.85841 | 9.86307 | 9.86764 | 9.87212 | 9.87652 | 9.88082 | 9.88503 | 9.88916 |
| 24 | .85849 | .86315 | .86772 | .87220 | .87659 | .88089 | .88510 | .88923 |
| 28 | .85857 | .86323 | .86780 | .87227 | .87666 | .88096 | .88517 | .88930 |
| 32 | .85865 | .86331 | .86787 | .87235 | .87673 | .88103 | .88524 | .88937 |
| 36 | .85873 | .86338 | .86795 | .87242 | .87680 | .88110 | .88531 | .88944 |
| 40 | 9.85881 | 9.86346 | 9.86802 | 9.87249 | 9.87688 | 9.88117 | 9.88528 | 9.88950 |
| 44 | .85888 | .86354 | .86810 | .87257 | .87695 | .88124 | .88545 | .88957 |
| 48 | .85896 | .86361 | .86817 | .87264 | .87702 | .88131 | .88552 | .88964 |
| 52 | .85904 | .86369 | .86825 | .87271 | .87709 | .88139 | .88559 | .88971 |
| 56 | .85912 | .86377 | .86832 | .87279 | .87717 | .88146 | .88566 | .88978 |
| s | 7h 46 ^m | 7h 50 ^m | 7h 54 ^m | 7h 58 ^m | 8h 2 ^m | 8h 6 ^m | 8h 10 ^m | 8h 14 ^m |
| 0 | 9.85920 | 9.86384 | 9.86840 | 9.87286 | 9.87724 | 9.88153 | 9.88573 | 9.88984 |
| 4 | .85928 | .86392 | .86847 | .87294 | .87731 | .88160 | .88580 | .88991 |
| 8 | .85935 | .86400 | .86855 | .87301 | .87738 | .88167 | .88587 | .88998 |
| 12 | .85943 | .86407 | .86862 | .87308 | .87745 | .88174 | .88594 | .89005 |
| 16 | .85951 | .86415 | .86870 | .87316 | .87753 | .88181 | .88600 | .89012 |
| 20 | 9.85959 | 9.86423 | 9.86877 | 9.87323 | 9.87760 | 9.88188 | 9.88607 | 9.89018 |
| 24 | .85967 | .86430 | .86885 | .87330 | .87767 | .88195 | .88614 | .89025 |
| 28 | .85974 | .86438 | .86892 | .87338 | .87774 | .88202 | .88621 | .89032 |
| 32 | .85982 | .86446 | .86900 | .87345 | .87782 | .88209 | .88628 | .89039 |
| 36 | .85990 | .86453 | .86907 | .87352 | .87789 | .88216 | .88635 | .89045 |
| 40 | 9.85998 | 9.86461 | 9.86915 | 9.87360 | 9.87796 | 9.88223 | 9.88642 | 9.89052 |
| 44 | .86006 | .86468 | .86922 | .87367 | .87803 | .88230 | .88649 | .89059 |
| 48 | .86013 | .86476 | .86930 | .87374 | .87810 | .88237 | .88656 | .89066 |
| 52 | .86021 | .86484 | .86937 | .87382 | .87818 | .88244 | .88663 | .89072 |
| 56 | .86029 | .86491 | .86945 | .87389 | .87825 | .88252 | .88670 | .89079 |
| s | 7h 47 ^m | 7h 51 ^m | 7h 55 ^m | 7h 59 ^m | 8h 3 ^m | 8h 7 ^m | 8h 11 ^m | 8h 15 ^m |
| 0 | 9.86037 | 9.86499 | 9.86952 | 9.87396 | 9.87832 | 9.88259 | 9.88677 | 9.89086 |
| 4 | .86045 | .86507 | .86960 | .87404 | .87839 | .88266 | .88683 | .89093 |
| 8 | .86052 | .86514 | .86967 | .87411 | .87846 | .88273 | .88690 | .89099 |
| 12 | .86060 | .86522 | .86975 | .87418 | .87853 | .88280 | .88697 | .89106 |
| 16 | .86068 | .86529 | .86982 | .87426 | .87861 | .88287 | .88704 | .89113 |
| 20 | 9.86076 | 9.86537 | 9.86990 | 9.87433 | 9.87868 | 9.88294 | 9.88711 | 9.89120 |
| 24 | .86083 | .86545 | .86997 | .87440 | .87875 | .88301 | .88718 | .89126 |
| 28 | .86091 | .86552 | .87004 | .87448 | .87882 | .88308 | .88725 | .89133 |
| 32 | .86099 | .86560 | .87012 | .87455 | .87889 | .88315 | .88732 | .89140 |
| 36 | .86107 | .86568 | .87019 | .87462 | .87896 | .88322 | .88739 | .89147 |
| 40 | 9.86114 | 9.86575 | 9.87027 | 9.87470 | 9.87904 | 9.88329 | 9.88745 | 9.89153 |
| 44 | .86122 | .86583 | .87034 | .87477 | .87911 | .88336 | .88752 | .89160 |
| 48 | .86130 | .86590 | .87042 | .87484 | .87918 | .88343 | .88759 | .89167 |
| 52 | .86138 | .86598 | .87049 | .87492 | .87925 | .88350 | .88766 | .89174 |
| 56 | .86145 | .86606 | .87057 | .87499 | .87932 | .88357 | .88773 | .89180 |
| 60 | 9.86153 | 9.86613 | 9.87064 | 9.87506 | 9.87939 | 9.88364 | 9.88780 | 9.89187 |

Table 10. Haversine Table

| s | 8 ^h 16 ^m | 8 ^h 20 ^m | 8 ^h 24 ^m | 8 ^h 28 ^m | 8 ^h 32 ^m | 8 ^h 36 ^m | 8 ^h 40 ^m | 8 ^h 44 ^m |
|----|--------------------------------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|
| | Hav. | Hav. | Hav. | Hav. | Hav. | Hav. | Hav. | Hav. |
| 0 | 9.89187 | 9.89586 | 9.89976 | 9.90358 | 9.90732 | 9.91098 | 9.91455 | 9.91805 |
| 4 | .89194 | .89592 | .89983 | .90365 | .90738 | .91104 | .91461 | .91810 |
| 8 | .89200 | .89599 | .89989 | .90371 | .90744 | .91110 | .91467 | .91816 |
| 12 | .89207 | .89606 | .89995 | .90377 | .90751 | .91116 | .91473 | .91822 |
| 16 | .89214 | .89612 | .90002 | .90383 | .90757 | .91122 | .91479 | .91828 |
| 20 | 9.89221 | 9.89619 | 9.90008 | 9.90390 | 9.90763 | 9.91128 | 9.91485 | 9.91833 |
| 24 | .89227 | .89625 | .90015 | .90396 | .90769 | .91134 | .91490 | .91839 |
| 28 | .89234 | .89632 | .90021 | .90402 | .90775 | .91140 | .91496 | .91845 |
| 32 | .89241 | .89638 | .90028 | .90409 | .90781 | .91146 | .91502 | .91851 |
| 36 | .89247 | .89645 | .90034 | .90415 | .90787 | .91152 | .91508 | .91856 |
| 40 | 9.89254 | 9.89651 | 9.90040 | 9.90421 | 9.90794 | 9.91158 | 9.91514 | 9.91862 |
| 44 | .89261 | .89658 | .90047 | .90428 | .90800 | .91164 | .91520 | .91868 |
| 48 | .89267 | .89665 | .90053 | .90434 | .90806 | .91170 | .91526 | .91874 |
| 52 | .89274 | .89671 | .90060 | .90440 | .90812 | .91176 | .91532 | .91879 |
| 56 | .89281 | .89678 | .90066 | .90446 | .90818 | .91182 | .91537 | .91885 |
| s | 8 ^h 17 ^m | 8 ^h 21 ^m | 8 ^h 25 ^m | 8 ^h 29 ^m | 8 ^h 33 ^m | 8 ^h 37 ^m | 8 ^h 41 ^m | 8 ^h 45 ^m |
| 0 | 9.89287 | 9.89684 | 9.90072 | 9.90452 | 9.90824 | 9.91188 | 9.91543 | 9.91891 |
| 4 | .89294 | .89691 | .90079 | .90459 | .90830 | .91194 | .91549 | .91896 |
| 8 | .89301 | .89697 | .90085 | .90465 | .90836 | .91200 | .91555 | .91902 |
| 12 | .89308 | .89704 | .90092 | .90471 | .90843 | .91206 | .91561 | .91908 |
| 16 | .89314 | .89710 | .90098 | .90478 | .90849 | .91212 | .91567 | .91914 |
| 20 | 9.89321 | 9.89717 | 9.90104 | 9.90484 | 9.90855 | 9.91218 | 9.91573 | 9.91919 |
| 24 | .89328 | .89723 | .90111 | .90490 | .90861 | .91224 | .91578 | .91925 |
| 28 | .89334 | .89730 | .90117 | .90496 | .90867 | .91230 | .91584 | .91931 |
| 32 | .89341 | .89736 | .90124 | .90503 | .90873 | .91236 | .91590 | .91936 |
| 36 | .89348 | .89743 | .90130 | .90509 | .90879 | .91242 | .91596 | .91942 |
| 40 | 9.89354 | 9.89749 | 9.90136 | 9.90515 | 9.90885 | 9.91248 | 9.91602 | 9.91948 |
| 44 | .89361 | .89756 | .90143 | .90521 | .90892 | .91254 | .91608 | .91954 |
| 48 | .89368 | .89763 | .90149 | .90527 | .90898 | .91260 | .91613 | .91959 |
| 52 | .89374 | .89769 | .90156 | .90534 | .90904 | .91265 | .91619 | .91965 |
| 56 | .89381 | .89776 | .90162 | .90540 | .90910 | .91271 | .91625 | .91971 |
| s | 8 ^h 18 ^m | 8 ^h 22 ^m | 8 ^h 26 ^m | 8 ^h 30 ^m | 8 ^h 34 ^m | 8 ^h 38 ^m | 8 ^h 42 ^m | 8 ^h 46 ^m |
| 0 | 9.89387 | 9.89782 | 9.90168 | 9.90546 | 9.90916 | 9.91277 | 9.91631 | 9.91976 |
| 4 | .89394 | .89789 | .90175 | .90552 | .90922 | .91283 | .91637 | .91982 |
| 8 | .89400 | .89795 | .90181 | .90559 | .90928 | .91289 | .91643 | .91988 |
| 12 | .89407 | .89802 | .90187 | .90565 | .90934 | .91295 | .91648 | .91993 |
| 16 | .89414 | .89808 | .90194 | .90571 | .90940 | .91301 | .91654 | .91999 |
| 20 | 9.89421 | 9.89815 | 9.90200 | 9.90577 | 9.90946 | 9.91307 | 9.91660 | 9.92005 |
| 24 | .89427 | .89821 | .90206 | .90584 | .90952 | .91313 | .91666 | .92010 |
| 28 | .89434 | .89828 | .90213 | .90590 | .90958 | .91319 | .91672 | .92016 |
| 32 | .89441 | .89834 | .90219 | .90596 | .90965 | .91325 | .91677 | .92022 |
| 36 | .89447 | .89840 | .90225 | .90602 | .90971 | .91331 | .91683 | .92027 |
| 40 | 9.89454 | 9.89847 | 9.90232 | 9.90608 | 9.90977 | 9.91337 | 9.91689 | 9.92033 |
| 44 | .89460 | .89853 | .90238 | .90615 | .90983 | .91343 | .91695 | .92039 |
| 48 | .89467 | .89860 | .90244 | .90621 | .90989 | .91349 | .91701 | .92044 |
| 52 | .89474 | .89866 | .90251 | .90627 | .90995 | .91355 | .91706 | .92050 |
| 56 | .89480 | .89873 | .90257 | .90633 | .91001 | .91361 | .91712 | .92056 |
| s | 8 ^h 19 ^m | 8 ^h 23 ^m | 8 ^h 27 ^m | 8 ^h 31 ^m | 8 ^h 35 ^m | 8 ^h 39 ^m | 8 ^h 43 ^m | 8 ^h 47 ^m |
| 0 | 9.89487 | 9.89879 | 9.90264 | 9.90639 | 9.91007 | 9.91367 | 9.91718 | 9.92061 |
| 4 | .89493 | .89886 | .90270 | .90646 | .91013 | .91372 | .91724 | .92067 |
| 8 | .89500 | .89892 | .90276 | .90652 | .91019 | .91378 | .91730 | .92073 |
| 12 | .89507 | .89899 | .90282 | .90658 | .91025 | .91384 | .91735 | .92078 |
| 16 | .89513 | .89905 | .90289 | .90664 | .91031 | .91390 | .91741 | .92084 |
| 20 | 9.89520 | 9.89912 | 9.90295 | 9.90670 | 9.91037 | 9.91396 | 9.91747 | 9.92090 |
| 24 | .89527 | .89918 | .90301 | .90676 | .91043 | .91402 | .91753 | .92095 |
| 28 | .89533 | .89925 | .90308 | .90683 | .91049 | .91408 | .91758 | .92101 |
| 32 | .89540 | .89931 | .90314 | .90689 | .91055 | .91414 | .91764 | .92107 |
| 36 | .89546 | .89938 | .90320 | .90695 | .91061 | .91420 | .91770 | .92112 |
| 40 | 9.89553 | 9.89944 | 9.90327 | 9.90701 | 9.91067 | 9.91426 | 9.91776 | 9.92118 |
| 44 | .89559 | .89950 | .90333 | .90707 | .91074 | .91432 | .91782 | .92124 |
| 48 | .89566 | .89957 | .90339 | .90714 | .91080 | .91437 | .91787 | .92129 |
| 52 | .89573 | .89963 | .90346 | .90720 | .91086 | .91443 | .91793 | .92135 |
| 56 | .89579 | .89970 | .90352 | .90726 | .91092 | .91449 | .91799 | .92140 |
| 60 | 9.89586 | 9.89976 | 9.90358 | 9.90732 | 9.91098 | 9.91455 | 9.91805 | 9.92146 |

Table 10. Haversine Table

| s | 8h 48m | 8h 52m | 8h 56m | 9h 0m | 9h 4m | 9h 8m | 9h 12m | 9h 16m |
|----|---------|---------|---------|---------|---------|---------|---------|---------|
| | Hav. | Hav. | Hav. | Hav. | Hav. | Hav. | Hav. | Hav. |
| 0 | 9.92146 | 9.92480 | 9.92805 | 9.93123 | 9.93433 | 9.93736 | 9.94030 | 9.94318 |
| 4 | .92152 | .92485 | .92811 | .93128 | .93438 | .93741 | .94035 | .94322 |
| 8 | .92157 | .92491 | .92816 | .93134 | .93443 | .93746 | .94040 | .94327 |
| 12 | .92163 | .92496 | .92821 | .93139 | .93448 | .93751 | .94045 | .94332 |
| 16 | .92169 | .92502 | .92827 | .93144 | .93454 | .93755 | .94050 | .94336 |
| 20 | 9.92174 | 9.92507 | 9.92832 | 9.93149 | 9.93459 | 9.93760 | 9.94055 | 9.94341 |
| 24 | .92180 | .92512 | .92837 | .93154 | .93464 | .93765 | .94059 | .94346 |
| 28 | .92185 | .92518 | .92843 | .93160 | .93469 | .93770 | .94064 | .94351 |
| 32 | .92191 | .92523 | .92848 | .93165 | .93474 | .93775 | .94069 | .94355 |
| 36 | .92197 | .92529 | .92853 | .93170 | .93479 | .93780 | .94074 | .94360 |
| 40 | 9.92202 | 9.92534 | 9.92859 | 9.93175 | 9.93484 | 9.93785 | 9.94079 | 9.94365 |
| 44 | .92208 | .92540 | .92864 | .93181 | .93489 | .93790 | .94084 | .94369 |
| 48 | .92213 | .92545 | .92869 | .93186 | .93494 | .93795 | .94088 | .94374 |
| 52 | .92219 | .92551 | .92875 | .93191 | .93499 | .93800 | .94093 | .94379 |
| 56 | .92225 | .92556 | .92880 | .93196 | .93504 | .93805 | .94098 | .94383 |
| s | 8h 49m | 8h 53m | 8h 57m | 9h 1m | 9h 5m | 9h 9m | 9h 13m | 9h 17m |
| 0 | 9.92230 | 9.92562 | 9.92885 | 9.93201 | 9.93509 | 9.93810 | 9.94103 | 9.94388 |
| 4 | .92236 | .92567 | .92891 | .93207 | .93515 | .93815 | .94108 | .94393 |
| 8 | .92241 | .92573 | .92896 | .93212 | .93520 | .93820 | .94112 | .94398 |
| 12 | .92247 | .92578 | .92901 | .93217 | .93525 | .93825 | .94117 | .94402 |
| 16 | .92253 | .92584 | .92907 | .93222 | .93530 | .93830 | .94122 | .94407 |
| 20 | 9.92258 | 9.92589 | 9.92912 | 9.93227 | 9.93535 | 9.93835 | 9.94127 | 9.94412 |
| 24 | .92264 | .92594 | .92917 | .93232 | .93540 | .93840 | .94132 | .94416 |
| 28 | .92269 | .92600 | .92923 | .93238 | .93545 | .93845 | .94137 | .94421 |
| 32 | .92275 | .92605 | .92928 | .93243 | .93550 | .93849 | .94141 | .94426 |
| 36 | .92280 | .92611 | .92933 | .93248 | .93555 | .93854 | .94146 | .94430 |
| 40 | 9.92286 | 9.92616 | 9.92939 | 9.93253 | 9.93560 | 9.93859 | 9.94151 | 9.94435 |
| 44 | .92292 | .92622 | .92944 | .93258 | .93565 | .93864 | .94156 | .94440 |
| 48 | .92297 | .92627 | .92949 | .93264 | .93570 | .93869 | .94161 | .94444 |
| 52 | .92303 | .92633 | .92955 | .93269 | .93575 | .93874 | .94165 | .94449 |
| 56 | .92308 | .92638 | .92960 | .93274 | .93580 | .93879 | .94170 | .94454 |
| s | 8h 50m | 8h 54m | 8h 58m | 9h 2m | 9h 6m | 9h 10m | 9h 14m | 9h 18m |
| 0 | 9.92314 | 9.92643 | 9.92965 | 9.93279 | 9.93585 | 9.93884 | 9.94175 | 9.94458 |
| 4 | .92319 | .92649 | .92970 | .93284 | .93590 | .93889 | .94180 | .94463 |
| 8 | .92325 | .92654 | .92975 | .93289 | .93595 | .93894 | .94184 | .94468 |
| 12 | .92330 | .92660 | .92981 | .93295 | .93600 | .93899 | .94189 | .94472 |
| 16 | .92336 | .92665 | .92986 | .93300 | .93605 | .93904 | .94194 | .94477 |
| 20 | 9.92342 | 9.92670 | 9.92992 | 9.93305 | 9.93611 | 9.93908 | 9.94199 | 9.94482 |
| 24 | .92347 | .92676 | .92997 | .93310 | .93616 | .93913 | .94204 | .94486 |
| 28 | .92353 | .92681 | .93002 | .93315 | .93621 | .93918 | .94208 | .94491 |
| 32 | .92358 | .92687 | .93007 | .93320 | .93626 | .93923 | .94213 | .94496 |
| 36 | .92364 | .92692 | .93013 | .93326 | .93631 | .93928 | .94218 | .94500 |
| 40 | 9.92369 | 9.92698 | 9.93018 | 9.93331 | 9.93636 | 9.93933 | 9.94223 | 9.94505 |
| 44 | .92375 | .92703 | .93023 | .93336 | .93641 | .93938 | .94227 | .94509 |
| 48 | .92380 | .92708 | .93029 | .93341 | .93646 | .93943 | .94232 | .94514 |
| 52 | .92386 | .92714 | .93034 | .93346 | .93651 | .93948 | .94237 | .94519 |
| 56 | .92391 | .92719 | .93039 | .93351 | .93656 | .93952 | .94242 | .94523 |
| s | 8h 51m | 8h 55m | 8h 59m | 9h 3m | 9h 7m | 9h 11m | 9h 15m | 9h 19m |
| 0 | 9.92397 | 9.92725 | 9.93044 | 9.93356 | 9.93661 | 9.93957 | 9.94246 | 9.94528 |
| 4 | .92402 | .92730 | .93050 | .93362 | .93666 | .93962 | .94251 | .94533 |
| 8 | .92408 | .92735 | .93055 | .93367 | .93671 | .93967 | .94256 | .94537 |
| 12 | .92413 | .92741 | .93060 | .93372 | .93676 | .93972 | .94261 | .94542 |
| 16 | .92419 | .92746 | .93065 | .93377 | .93681 | .93977 | .94265 | .94546 |
| 20 | 9.92425 | 9.92751 | 9.93071 | 9.93382 | 9.93686 | 9.93982 | 9.94270 | 9.94551 |
| 24 | .92430 | .92757 | .93076 | .93387 | .93691 | .93987 | .94275 | .94556 |
| 28 | .92436 | .92762 | .93081 | .93392 | .93696 | .93991 | .94280 | .94560 |
| 32 | .92441 | .92768 | .93086 | .93397 | .93701 | .93996 | .94284 | .94565 |
| 36 | .92447 | .92773 | .93092 | .93403 | .93706 | .94001 | .94289 | .94570 |
| 40 | 9.92452 | 9.92778 | 9.93097 | 9.93408 | 9.93711 | 9.94006 | 9.94294 | 9.94574 |
| 44 | .92458 | .92784 | .93102 | .93413 | .93716 | .94011 | .94299 | .94579 |
| 48 | .92463 | .92789 | .93107 | .93418 | .93721 | .94016 | .94303 | .94583 |
| 52 | .92469 | .92794 | .93113 | .93423 | .93726 | .94021 | .94308 | .94588 |
| 56 | .92474 | .92800 | .93118 | .93428 | .93731 | .94026 | .94313 | .94593 |
| 60 | 9.92480 | 9.92805 | 9.93123 | 9.93433 | 9.93736 | 9.94030 | 9.94318 | 9.94597 |

Table 10. Haversine Table

| s | 9h 20 ^m | 9h 24 ^m | 9h 28 ^m | 9h 32 ^m | 9h 36 ^m | 9h 40 ^m | 9h 44 ^m | 9h 48 ^m |
|----|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
| | Hav. | Hav. | Hav. | Hav. | Hav. | Hav. | Hav. | Hav. |
| 0 | 9.94597 | 9.94869 | 9.95134 | 9.95391 | 9.95641 | 9.95884 | 9.96119 | 9.96347 |
| 4 | .94602 | .94874 | .95138 | .95396 | .95645 | .95888 | .96123 | .96351 |
| 8 | .94606 | .94878 | .95143 | .95400 | .95649 | .95892 | .96127 | .96355 |
| 12 | .94611 | .94883 | .95147 | .95404 | .95654 | .95896 | .96131 | .96359 |
| 16 | .94616 | .94887 | .95151 | .95408 | .95658 | .95900 | .96135 | .96362 |
| 20 | 9.94620 | 9.94892 | 9.95156 | 9.95412 | 9.95662 | 9.95904 | 9.96139 | 9.96366 |
| 24 | .94625 | .94896 | .95160 | .95417 | .95666 | .95908 | .96142 | .96370 |
| 28 | .94629 | .94901 | .95164 | .95421 | .95670 | .95912 | .96146 | .96374 |
| 32 | .94634 | .94905 | .95169 | .95425 | .95674 | .95916 | .96150 | .96377 |
| 36 | .94638 | .94909 | .95173 | .95429 | .95678 | .95920 | .96154 | .96381 |
| 40 | 9.94643 | 9.94914 | 9.95177 | 9.95433 | 9.95682 | 9.95924 | 9.96158 | 9.96385 |
| 44 | .94648 | .94918 | .95182 | .95438 | .95686 | .95928 | .96162 | .96388 |
| 48 | .94652 | .94923 | .95186 | .95442 | .95690 | .95932 | .96165 | .96392 |
| 52 | .94657 | .94927 | .95190 | .95446 | .95694 | .95936 | .96169 | .96396 |
| 56 | .94661 | .94932 | .95195 | .95450 | .95699 | .95939 | .96173 | .96400 |
| s | 9h 21 ^m | 9h 25 ^m | 9h 29 ^m | 9h 33 ^m | 9h 37 ^m | 9h 41 ^m | 9h 45 ^m | 9h 49 ^m |
| 0 | 9.94666 | 9.94936 | 9.95199 | 9.95454 | 9.95703 | 9.95943 | 9.96177 | 9.96403 |
| 4 | .94670 | .94941 | .95203 | .95459 | .95707 | .95947 | .96181 | .96407 |
| 8 | .94675 | .94945 | .95208 | .95463 | .95711 | .95951 | .96185 | .96411 |
| 12 | .94680 | .94950 | .95212 | .95467 | .95715 | .95955 | .96188 | .96412 |
| 16 | .94684 | .94954 | .95216 | .95471 | .95719 | .95959 | .96192 | .96418 |
| 20 | 9.94689 | 9.94958 | 9.95221 | 9.95475 | 9.95723 | 9.95963 | 9.96196 | 9.96422 |
| 24 | .94693 | .94963 | .95225 | .95480 | .95727 | .95967 | .96200 | .96426 |
| 28 | .94698 | .94967 | .95229 | .95484 | .95731 | .95971 | .96204 | .96429 |
| 32 | .94702 | .94972 | .95234 | .95488 | .95735 | .95975 | .96208 | .96433 |
| 36 | .94707 | .94976 | .95238 | .95492 | .95739 | .95979 | .96211 | .96437 |
| 40 | 9.94711 | 9.94981 | 9.95242 | 9.95496 | 9.95743 | 9.95983 | 9.96215 | 9.96440 |
| 44 | .94716 | .94985 | .95246 | .95501 | .95747 | .95987 | .96219 | .96444 |
| 48 | .94721 | .94989 | .95251 | .95505 | .95751 | .95991 | .96223 | .96448 |
| 52 | .94725 | .94994 | .95255 | .95509 | .95755 | .95995 | .96227 | .96451 |
| 56 | .94730 | .94998 | .95259 | .95513 | .95759 | .95999 | .96230 | .96455 |
| s | 9h 22 ^m | 9h 26 ^m | 9h 30 ^m | 9h 34 ^m | 9h 38 ^m | 9h 42 ^m | 9h 46 ^m | 9h 50 ^m |
| 0 | 9.94734 | 9.95003 | 9.95264 | 9.95517 | 9.95763 | 9.96002 | 9.96234 | 9.96459 |
| 4 | .94739 | .95007 | .95268 | .95521 | .95768 | .96006 | .96238 | .96462 |
| 8 | .94743 | .95011 | .95272 | .95526 | .95772 | .96010 | .96242 | .96466 |
| 12 | .94748 | .95016 | .95276 | .95530 | .95776 | .96014 | .96246 | .96470 |
| 16 | .94752 | .95020 | .95281 | .95534 | .95780 | .96018 | .96249 | .96473 |
| 20 | 9.94757 | 9.95025 | 9.95285 | 9.95538 | 9.95784 | 9.96022 | 9.96253 | 9.96477 |
| 24 | .94761 | .95029 | .95289 | .95542 | .95788 | .96026 | .96257 | .96481 |
| 28 | .94766 | .95033 | .95294 | .95546 | .95792 | .96030 | .96261 | .96484 |
| 32 | .94770 | .95038 | .95298 | .95550 | .95796 | .96034 | .96265 | .96488 |
| 36 | .94774 | .95042 | .95302 | .95555 | .95800 | .96038 | .96268 | .96492 |
| 40 | 9.94779 | 9.95047 | 9.95306 | 9.95559 | 9.95804 | 9.96042 | 9.96272 | 9.96495 |
| 44 | .94784 | .95051 | .95311 | .95563 | .95808 | .96046 | .96276 | .96499 |
| 48 | .94788 | .95055 | .95315 | .95567 | .95812 | .96049 | .96280 | .96503 |
| 52 | .94793 | .95060 | .95319 | .95571 | .95816 | .96053 | .96283 | .96506 |
| 56 | .94797 | .95064 | .95323 | .95575 | .95820 | .96057 | .96287 | .96510 |
| s | 9h 23 ^m | 9h 27 ^m | 9h 31 ^m | 9h 35 ^m | 9h 39 ^m | 9h 43 ^m | 9h 47 ^m | 9h 51 ^m |
| 0 | 9.94802 | 9.95069 | 9.95328 | 9.95579 | 9.95824 | 9.96061 | 9.96291 | 9.96514 |
| 4 | .94806 | .95073 | .95332 | .95584 | .95828 | .96065 | .96295 | .96517 |
| 8 | .94811 | .95077 | .95336 | .95588 | .95832 | .96069 | .96299 | .96521 |
| 12 | .94815 | .95082 | .95340 | .95592 | .95836 | .96073 | .96302 | .96525 |
| 16 | .94820 | .95086 | .95345 | .95596 | .95840 | .96077 | .96306 | .96528 |
| 20 | 9.94824 | 9.95090 | 9.95349 | 9.95600 | 9.95844 | 9.96081 | 9.96310 | 9.96532 |
| 24 | .94829 | .95095 | .95353 | .95604 | .95848 | .96084 | .96314 | .96536 |
| 28 | .94833 | .95099 | .95357 | .95608 | .95852 | .96088 | .96317 | .96539 |
| 32 | .94838 | .95104 | .95362 | .95613 | .95856 | .96092 | .96321 | .96543 |
| 36 | .94842 | .95108 | .95366 | .95617 | .95860 | .96096 | .96325 | .96547 |
| 40 | 9.94847 | 9.95112 | 9.95370 | 9.95621 | 9.95864 | 9.96100 | 9.96329 | 9.96550 |
| 44 | .94851 | .95117 | .95374 | .95625 | .95868 | .96104 | .96332 | .96554 |
| 48 | .94856 | .95121 | .95379 | .95629 | .95872 | .96108 | .96336 | .96557 |
| 52 | .94860 | .95125 | .95383 | .95633 | .95876 | .96112 | .96340 | .96561 |
| 56 | .94865 | .95130 | .95387 | .95637 | .95880 | .96115 | .96344 | .96565 |
| 60 | 9.94869 | 9.95134 | 9.95391 | 9.95641 | 9.95884 | 9.96119 | 9.96347 | 9.96568 |

Table 10. Haversine Table

| s | 9h 52m | 9h 56m | 10h 0m | 10h 4m | 10h 8m | 10h 12m | 10h 16m | 10h 20m |
|----|---------|---------|---------|---------|---------|---------|---------|---------|
| | Hav. | Hav. | Hav. | Hav. | Hav. | Hav. | Hav. | Hav. |
| 0 | 9.96568 | 9.96782 | 9.96989 | 9.97188 | 9.97381 | 9.97566 | 9.97745 | 9.97916 |
| 4 | .96572 | .96786 | .96992 | .97192 | .97384 | .97569 | .97748 | .97919 |
| 8 | .96576 | .96789 | .96996 | .97195 | .97387 | .97572 | .97751 | .97922 |
| 12 | .96579 | .96793 | .96999 | .97198 | .97390 | .97575 | .97754 | .97925 |
| 16 | .96583 | .96796 | .97002 | .97201 | .97393 | .97578 | .97756 | .97927 |
| 20 | 9.96586 | 9.96800 | 9.97006 | 9.97205 | 9.97397 | 9.97581 | 9.97759 | 9.97930 |
| 24 | .96590 | .96803 | .97009 | .97208 | .97400 | .97584 | .97762 | .97933 |
| 28 | .96594 | .96807 | .97012 | .97211 | .97403 | .97587 | .97765 | .97936 |
| 32 | .96597 | .96810 | .97016 | .97214 | .97406 | .97591 | .97768 | .97939 |
| 36 | .96601 | .96814 | .97019 | .97218 | .97409 | .97594 | .97771 | .97941 |
| 40 | 9.96604 | 9.96817 | 9.97022 | 9.97221 | 9.97412 | 9.97597 | 9.97774 | 9.97944 |
| 44 | .96608 | .96821 | .97026 | .97224 | .97415 | .97600 | .97777 | .97947 |
| 48 | .96612 | .96824 | .97029 | .97227 | .97418 | .97603 | .97780 | .97950 |
| 52 | .96615 | .96827 | .97033 | .97231 | .97422 | .97606 | .97783 | .97953 |
| 56 | .96619 | .96831 | .97036 | .97234 | .97425 | .97609 | .97785 | .97955 |
| s | 9h 53m | 9h 57m | 10h 1m | 10h 5m | 10h 9m | 10h 13m | 10h 17m | 10h 21m |
| 0 | 9.96622 | 9.96834 | 9.97039 | 9.97237 | 9.97428 | 9.97612 | 9.97788 | 9.97958 |
| 4 | .96626 | .96837 | .97043 | .97240 | .97431 | .97615 | .97791 | .97961 |
| 8 | .96630 | .96841 | .97046 | .97244 | .97434 | .97618 | .97794 | .97964 |
| 12 | .96633 | .96845 | .97049 | .97247 | .97437 | .97621 | .97797 | .97966 |
| 16 | .96637 | .96848 | .97052 | .97250 | .97440 | .97624 | .97800 | .97969 |
| 20 | 9.96640 | 9.96852 | 9.97056 | 9.97253 | 9.97443 | 9.97627 | 9.97803 | 9.97972 |
| 24 | .96644 | .96855 | .97059 | .97257 | .97447 | .97630 | .97806 | .97975 |
| 28 | .96648 | .96859 | .97063 | .97260 | .97450 | .97633 | .97808 | .97977 |
| 32 | .96651 | .96862 | .97066 | .97263 | .97453 | .97636 | .97811 | .97980 |
| 36 | .96655 | .96866 | .97069 | .97266 | .97456 | .97639 | .97814 | .97983 |
| 40 | 9.96658 | 9.96869 | 9.97073 | 9.97269 | 9.97459 | 9.97642 | 9.97817 | 9.97986 |
| 44 | .96662 | .96873 | .97076 | .97273 | .97462 | .97645 | .97820 | .97988 |
| 48 | .96665 | .96876 | .97079 | .97276 | .97465 | .97647 | .97823 | .97991 |
| 52 | .96669 | .96879 | .97083 | .97279 | .97468 | .97650 | .97826 | .97994 |
| 56 | .96673 | .96883 | .97086 | .97282 | .97471 | .97653 | .97829 | .97997 |
| s | 9h 54m | 9h 58m | 10h 2m | 10h 6m | 10h 10m | 10h 14m | 10h 18m | 10h 22m |
| 0 | 9.96676 | 9.96886 | 9.97089 | 9.97285 | 9.97474 | 9.97656 | 9.97831 | 9.97999 |
| 4 | .96680 | .96890 | .97093 | .97289 | .97478 | .97659 | .97834 | .98002 |
| 8 | .96683 | .96894 | .97096 | .97292 | .97481 | .97662 | .97837 | .98005 |
| 12 | .96687 | .96897 | .97099 | .97295 | .97484 | .97665 | .97840 | .98008 |
| 16 | .96690 | .96900 | .97103 | .97298 | .97487 | .97668 | .97843 | .98010 |
| 20 | 9.96694 | 9.96904 | 9.97106 | 9.97301 | 9.97490 | 9.97671 | 9.97846 | 9.98013 |
| 24 | .96697 | .96907 | .97109 | .97305 | .97493 | .97674 | .97849 | .98016 |
| 28 | .96701 | .96910 | .97113 | .97308 | .97496 | .97677 | .97851 | .98019 |
| 32 | .96705 | .96914 | .97116 | .97311 | .97499 | .97680 | .97854 | .98021 |
| 36 | .96708 | .96917 | .97119 | .97314 | .97502 | .97683 | .97857 | .98024 |
| 40 | 9.96712 | 9.96921 | 9.97123 | 9.97317 | 9.97505 | 9.97686 | 9.97860 | 9.98027 |
| 44 | .96715 | .96924 | .97126 | .97321 | .97508 | .97689 | .97863 | .98030 |
| 48 | .96719 | .96928 | .97129 | .97324 | .97511 | .97692 | .97866 | .98032 |
| 52 | .96722 | .96931 | .97132 | .97327 | .97514 | .97695 | .97868 | .98035 |
| 56 | .96726 | .96934 | .97136 | .97330 | .97518 | .97698 | .97871 | .98038 |
| s | 9h 55m | 9h 59m | 10h 3m | 10h 7m | 10h 11m | 10h 15m | 10h 19m | 10h 23m |
| 0 | 9.96729 | 9.96938 | 9.97139 | 9.97333 | 9.97521 | 9.97701 | 9.97874 | 9.98040 |
| 4 | .96733 | .96941 | .97142 | .97337 | .97524 | .97704 | .97877 | .98043 |
| 8 | .96736 | .96945 | .97146 | .97340 | .97527 | .97707 | .97880 | .98046 |
| 12 | .96740 | .96948 | .97149 | .97343 | .97530 | .97710 | .97883 | .98049 |
| 16 | .96743 | .96951 | .97152 | .97346 | .97533 | .97713 | .97885 | .98051 |
| 20 | 9.96747 | 9.96955 | 9.97156 | 9.97349 | 9.97536 | 9.97716 | 9.97888 | 9.98054 |
| 24 | .96750 | .96958 | .97159 | .97352 | .97539 | .97718 | .97891 | .98057 |
| 28 | .96754 | .96962 | .97162 | .97356 | .97542 | .97721 | .97894 | .98059 |
| 32 | .96758 | .96965 | .97165 | .97359 | .97545 | .97724 | .97897 | .98062 |
| 36 | .96761 | .96968 | .97169 | .97362 | .97548 | .97727 | .97899 | .98065 |
| 40 | 9.96765 | 9.96972 | 9.97172 | 9.97365 | 9.97551 | 9.97730 | 9.97902 | 9.98067 |
| 44 | .96768 | .96975 | .97175 | .97368 | .97554 | .97733 | .97905 | .98070 |
| 48 | .96772 | .96979 | .97179 | .97371 | .97557 | .97736 | .97908 | .98073 |
| 52 | .96775 | .96982 | .97182 | .97375 | .97560 | .97739 | .97911 | .98076 |
| 56 | .96779 | .96985 | .97185 | .97378 | .97563 | .97742 | .97914 | .98078 |
| 60 | 9.96782 | 9.96989 | 9.97188 | 9.97381 | 9.97566 | 9.97745 | 9.97916 | 9.98081 |

Table 10. Haversine Table

| s | 10 ^h 24 ^m | 10 ^h 28 ^m | 10 ^h 32 ^m | 10 ^h 36 ^m | 10 ^h 40 ^m | 10 ^h 44 ^m | 10 ^h 48 ^m | 10 ^h 52 ^m |
|----|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| | Hav. | Hav. | Hav. | Hav. | Hav. | Hav. | Hav. | Hav. |
| 0 | 9.98081 | 9.98239 | 9.98389 | 9.98533 | 9.98670 | 9.98801 | 9.98924 | 9.99041 |
| 4 | .98084 | .98241 | .98392 | .98536 | .98673 | .98803 | .98926 | .99043 |
| 8 | .98086 | .98244 | .98394 | .98538 | .98675 | .98805 | .98928 | .99044 |
| 12 | .98089 | .98246 | .98397 | .98540 | .98677 | .98807 | .98930 | .99046 |
| 16 | .98092 | .98249 | .98399 | .98543 | .98679 | .98809 | .98932 | .99048 |
| 20 | 9.98094 | 9.98251 | 9.98402 | 9.98545 | 9.98681 | 9.98811 | 9.98934 | 9.99050 |
| 24 | .98097 | .98254 | .98404 | .98547 | .98684 | .98813 | .98936 | .99052 |
| 28 | .98100 | .98256 | .98406 | .98550 | .98686 | .98815 | .98938 | .99054 |
| 32 | .98102 | .98259 | .98409 | .98552 | .98688 | .98817 | .98940 | .99056 |
| 36 | .98105 | .98262 | .98411 | .98554 | .98690 | .98819 | .98942 | .99058 |
| 40 | 9.98108 | 9.98264 | 9.98414 | 9.98557 | 9.98692 | 9.98822 | 9.98944 | 9.99059 |
| 44 | .98110 | .98267 | .98416 | .98559 | .98695 | .98824 | .98946 | .99061 |
| 48 | .98113 | .98269 | .98419 | .98561 | .98697 | .98826 | .98948 | .99063 |
| 52 | .98116 | .98272 | .98421 | .98564 | .98699 | .98828 | .98950 | .99065 |
| 56 | .98118 | .98274 | .98424 | .98566 | .98701 | .98830 | .98952 | .99067 |
| s | 10 ^h 25 ^m | 10 ^h 29 ^m | 10 ^h 33 ^m | 10 ^h 37 ^m | 10 ^h 41 ^m | 10 ^h 45 ^m | 10 ^h 49 ^m | 10 ^h 53 ^m |
| 0 | 9.98121 | 9.98277 | 9.98426 | 9.98568 | 9.98703 | 9.98832 | 9.98954 | 9.99069 |
| 4 | .98124 | .98279 | .98428 | .98570 | .98706 | .98834 | .98956 | .99071 |
| 8 | .98126 | .98282 | .98431 | .98573 | .98708 | .98836 | .98958 | .99072 |
| 12 | .98129 | .98285 | .98433 | .98575 | .98710 | .98838 | .98960 | .99074 |
| 16 | .98132 | .98287 | .98436 | .98577 | .98712 | .98840 | .98962 | .99076 |
| 20 | 9.98134 | 9.98290 | 9.98438 | 9.98580 | 9.98714 | 9.98842 | 9.98964 | 9.99078 |
| 24 | .98137 | .98292 | .98440 | .98582 | .98717 | .98845 | .98966 | .99080 |
| 28 | .98139 | .98295 | .98443 | .98584 | .98719 | .98847 | .98968 | .99082 |
| 32 | .98142 | .98297 | .98445 | .98587 | .98721 | .98849 | .98970 | .99084 |
| 36 | .98145 | .98300 | .98448 | .98589 | .98723 | .98851 | .98971 | .99085 |
| 40 | 9.98147 | 9.98302 | 9.98450 | 9.98591 | 9.98725 | 9.98853 | 9.98973 | 9.99087 |
| 44 | .98150 | .98305 | .98453 | .98593 | .98728 | .98855 | .98975 | .99089 |
| 48 | .98153 | .98307 | .98455 | .98596 | .98730 | .98857 | .98977 | .99091 |
| 52 | .98155 | .98310 | .98457 | .98598 | .98732 | .98859 | .98979 | .99093 |
| 56 | .98158 | .98312 | .98460 | .98600 | .98734 | .98861 | .98981 | .99095 |
| s | 10 ^h 26 ^m | 10 ^h 30 ^m | 10 ^h 34 ^m | 10 ^h 38 ^m | 10 ^h 42 ^m | 10 ^h 46 ^m | 10 ^h 50 ^m | 10 ^h 54 ^m |
| 0 | 9.98161 | 9.98315 | 9.98462 | 9.98603 | 9.98736 | 9.98863 | 9.98983 | 9.99096 |
| 4 | .98163 | .98317 | .98465 | .98605 | .98738 | .98865 | .98985 | .99098 |
| 8 | .98166 | .98320 | .98467 | .98607 | .98741 | .98867 | .98987 | .99100 |
| 12 | .98168 | .98322 | .98469 | .98609 | .98743 | .98869 | .98989 | .99102 |
| 16 | .98171 | .98325 | .98472 | .98612 | .98745 | .98871 | .98991 | .99104 |
| 20 | 9.98174 | 9.98327 | 9.98474 | 9.98614 | 9.98747 | 9.98873 | 9.98993 | 9.99106 |
| 24 | .98176 | .98330 | .98476 | .98616 | .98749 | .98875 | .98995 | .99107 |
| 28 | .98179 | .98332 | .98479 | .98619 | .98751 | .98877 | .98997 | .99109 |
| 32 | .98182 | .98335 | .98481 | .98621 | .98754 | .98880 | .98999 | .99111 |
| 36 | .98184 | .98337 | .98484 | .98623 | .98756 | .98882 | .99001 | .99113 |
| 40 | 9.98187 | 9.98340 | 9.98486 | 9.98625 | 9.98758 | 9.98884 | 9.99003 | 9.99115 |
| 44 | .98189 | .98342 | .98488 | .98628 | .98760 | .98886 | .99004 | .99116 |
| 48 | .98192 | .98345 | .98491 | .98630 | .98762 | .98888 | .99006 | .99118 |
| 52 | .98195 | .98347 | .98493 | .98632 | .98764 | .98890 | .99008 | .99120 |
| 56 | .98197 | .98350 | .98496 | .98634 | .98766 | .98892 | .99010 | .99122 |
| s | 10 ^h 27 ^m | 10 ^h 31 ^m | 10 ^h 35 ^m | 10 ^h 39 ^m | 10 ^h 43 ^m | 10 ^h 47 ^m | 10 ^h 51 ^m | 10 ^h 55 ^m |
| 0 | 9.98200 | 9.98352 | 9.98498 | 9.98637 | 9.98769 | 9.98894 | 9.99012 | 9.99124 |
| 4 | .98202 | .98355 | .98500 | .98639 | .98771 | .98896 | .99014 | .99126 |
| 8 | .98205 | .98357 | .98503 | .98641 | .98773 | .98898 | .99016 | .99127 |
| 12 | .98208 | .98360 | .98505 | .98643 | .98775 | .98900 | .99018 | .99129 |
| 16 | .98210 | .98362 | .98507 | .98646 | .98777 | .98902 | .99020 | .99131 |
| 20 | 9.98213 | 9.98365 | 9.98510 | 9.98648 | 9.98779 | 9.98904 | 9.99022 | 9.99133 |
| 24 | .98215 | .98367 | .98512 | .98650 | .98781 | .98906 | .99024 | .99135 |
| 28 | .98218 | .98370 | .98514 | .98652 | .98784 | .98908 | .99026 | .99136 |
| 32 | .98221 | .98372 | .98517 | .98655 | .98786 | .98910 | .99027 | .99138 |
| 36 | .98223 | .98375 | .98519 | .98657 | .98788 | .98912 | .99029 | .99140 |
| 40 | 9.98226 | 9.98377 | 9.98521 | 9.98659 | 9.98790 | 9.98914 | 9.99031 | 9.99142 |
| 44 | .98228 | .98379 | .98524 | .98661 | .98792 | .98916 | .99033 | .99143 |
| 48 | .98231 | .98382 | .98526 | .98664 | .98794 | .98918 | .99035 | .99145 |
| 52 | .98233 | .98384 | .98529 | .98666 | .98796 | .98920 | .99037 | .99147 |
| 56 | .98236 | .98387 | .98531 | .98668 | .98798 | .98922 | .99039 | .99149 |
| 60 | 9.98239 | 9.98389 | 9.98533 | 9.98670 | 9.98801 | 9.98924 | 9.99041 | 9.99151 |

Table 10. Haversine Table

| s | 10h 56m | | 11h 0m | | 11h 4m | | 11h 8m | | 11h 12m | | 11h 16m | | 11h 20m | | 11h 24m | |
|----|---------|---------|---------|---------|---------|---------|---------|---------|---------|------|---------|------|---------|------|---------|------|
| | Hav. | Hav. | Hav. | Hav. | Hav. | Hav. | Hav. | Hav. | Hav. | Hav. | Hav. | Hav. | Hav. | Hav. | Hav. | Hav. |
| 0 | 9.99151 | 9.99254 | 9.99350 | 9.99440 | 9.99523 | 9.99599 | 9.99669 | 9.99732 | | | | | | | | |
| 4 | .99152 | .99255 | .99352 | .99441 | .99524 | .99600 | .99670 | .99733 | | | | | | | | |
| 8 | .99154 | .99257 | .99353 | .99443 | .99526 | .99602 | .99671 | .99734 | | | | | | | | |
| 12 | .99156 | .99259 | .99355 | .99444 | .99527 | .99603 | .99672 | .99735 | | | | | | | | |
| 16 | .99158 | .99260 | .99356 | .99446 | .99528 | .99604 | .99673 | .99736 | | | | | | | | |
| 20 | 9.99159 | 9.99262 | 9.99358 | 9.99447 | 9.99529 | 9.99605 | 9.99674 | 9.99737 | | | | | | | | |
| 24 | .99161 | .99264 | .99359 | .99448 | .99531 | .99606 | .99675 | .99738 | | | | | | | | |
| 28 | .99163 | .99265 | .99361 | .99450 | .99532 | .99608 | .99677 | .99739 | | | | | | | | |
| 32 | .99165 | .99267 | .99362 | .99451 | .99533 | .99609 | .99678 | .99740 | | | | | | | | |
| 36 | .99166 | .99269 | .99364 | .99453 | .99535 | .99610 | .99679 | .99741 | | | | | | | | |
| 40 | 9.99168 | 9.99270 | 9.99366 | 9.99454 | 9.99536 | 9.99611 | 9.99680 | 9.99742 | | | | | | | | |
| 44 | .99170 | .99272 | .99367 | .99456 | .99537 | .99612 | .99681 | .99743 | | | | | | | | |
| 48 | .99172 | .99274 | .99369 | .99457 | .99539 | .99614 | .99682 | .99744 | | | | | | | | |
| 52 | .99173 | .99275 | .99370 | .99458 | .99540 | .99615 | .99683 | .99745 | | | | | | | | |
| 56 | .99175 | .99277 | .99372 | .99460 | .99541 | .99616 | .99684 | .99746 | | | | | | | | |
| s | 10h 57m | | 11h 1m | | 11h 5m | | 11h 9m | | 11h 13m | | 11h 17m | | 11h 21m | | 11h 25m | |
| 0 | 9.99177 | 9.99278 | 9.99373 | 9.99461 | 9.99543 | 9.99617 | 9.99685 | 9.99747 | | | | | | | | |
| 4 | .99179 | .99280 | .99375 | .99463 | .99544 | .99618 | .99686 | .99748 | | | | | | | | |
| 8 | .99180 | .99282 | .99376 | .99464 | .99545 | .99620 | .99687 | .99748 | | | | | | | | |
| 12 | .99182 | .99283 | .99378 | .99465 | .99546 | .99621 | .99688 | .99749 | | | | | | | | |
| 16 | .99184 | .99285 | .99379 | .99467 | .99548 | .99622 | .99690 | .99750 | | | | | | | | |
| 20 | 9.99186 | 9.99287 | 9.99381 | 9.99468 | 9.99549 | 9.99623 | 9.99691 | 9.99751 | | | | | | | | |
| 24 | .99187 | .99288 | .99382 | .99470 | .99550 | .99624 | .99692 | .99752 | | | | | | | | |
| 28 | .99189 | .99290 | .99384 | .99471 | .99552 | .99626 | .99693 | .99753 | | | | | | | | |
| 32 | .99191 | .99291 | .99385 | .99472 | .99553 | .99627 | .99694 | .99754 | | | | | | | | |
| 36 | .99193 | .99293 | .99387 | .99474 | .99554 | .99628 | .99695 | .99755 | | | | | | | | |
| 40 | 9.99194 | 9.99295 | 9.99388 | 9.99475 | 9.99555 | 9.99629 | 9.99696 | 9.99756 | | | | | | | | |
| 44 | .99196 | .99296 | .99390 | .99477 | .99557 | .99630 | .99697 | .99757 | | | | | | | | |
| 48 | .99198 | .99298 | .99391 | .99478 | .99558 | .99631 | .99698 | .99758 | | | | | | | | |
| 52 | .99200 | .99300 | .99393 | .99479 | .99559 | .99633 | .99699 | .99759 | | | | | | | | |
| 56 | .99201 | .99301 | .99394 | .99481 | .99561 | .99634 | .99700 | .99760 | | | | | | | | |
| s | 10h 58m | | 11h 2m | | 11h 6m | | 11h 10m | | 11h 14m | | 11h 18m | | 11h 22m | | 11h 26m | |
| 0 | 9.99203 | 9.99303 | 9.99396 | 9.99482 | 9.99562 | 9.99635 | 9.99701 | 9.99761 | | | | | | | | |
| 4 | .99205 | .99304 | .99397 | .99484 | .99563 | .99636 | .99702 | .99762 | | | | | | | | |
| 8 | .99206 | .99306 | .99399 | .99485 | .99564 | .99637 | .99703 | .99763 | | | | | | | | |
| 12 | .99208 | .99308 | .99400 | .99486 | .99566 | .99638 | .99704 | .99764 | | | | | | | | |
| 16 | .99210 | .99309 | .99402 | .99488 | .99567 | .99639 | .99705 | .99765 | | | | | | | | |
| 20 | 9.99212 | 9.99311 | 9.99403 | 9.99489 | 9.99568 | 9.99641 | 9.99706 | 9.99766 | | | | | | | | |
| 24 | .99213 | .99312 | .99405 | .99490 | .99569 | .99642 | .99707 | .99766 | | | | | | | | |
| 28 | .99215 | .99314 | .99406 | .99492 | .99571 | .99643 | .99708 | .99767 | | | | | | | | |
| 32 | .99217 | .99316 | .99408 | .99493 | .99572 | .99644 | .99710 | .99768 | | | | | | | | |
| 36 | .99218 | .99317 | .99409 | .99495 | .99573 | .99645 | .99711 | .99769 | | | | | | | | |
| 40 | 9.99220 | 9.99319 | 9.99411 | 9.99496 | 9.99575 | 9.99646 | 9.99712 | 9.99770 | | | | | | | | |
| 44 | .99222 | .99320 | .99412 | .99497 | .99576 | .99648 | .99713 | .99771 | | | | | | | | |
| 48 | .99223 | .99322 | .99414 | .99499 | .99577 | .99649 | .99714 | .99772 | | | | | | | | |
| 52 | .99225 | .99324 | .99415 | .99500 | .99578 | .99650 | .99715 | .99773 | | | | | | | | |
| 56 | .99227 | .99325 | .99417 | .99501 | .99580 | .99651 | .99716 | .99774 | | | | | | | | |
| s | 10h 59m | | 11h 3m | | 11h 7m | | 11h 11m | | 11h 15m | | 11h 19m | | 11h 23m | | 11h 27m | |
| 0 | 9.99229 | 9.99327 | 9.99418 | 9.99503 | 9.99581 | 9.99652 | 9.99717 | 9.99774 | | | | | | | | |
| 4 | .99230 | .99328 | .99420 | .99504 | .99582 | .99653 | .99718 | .99775 | | | | | | | | |
| 8 | .99232 | .99330 | .99421 | .99505 | .99583 | .99654 | .99719 | .99776 | | | | | | | | |
| 12 | .99234 | .99331 | .99422 | .99507 | .99584 | .99655 | .99720 | .99777 | | | | | | | | |
| 16 | .99235 | .99333 | .99424 | .99508 | .99586 | .99657 | .99721 | .99778 | | | | | | | | |
| 20 | 9.99237 | 9.99335 | 9.99425 | 9.99510 | 9.99587 | 9.99658 | 9.99722 | 9.99779 | | | | | | | | |
| 24 | .99239 | .99336 | .99427 | .99511 | .99588 | .99659 | .99723 | .99780 | | | | | | | | |
| 28 | .99240 | .99338 | .99429 | .99512 | .99589 | .99660 | .99724 | .99781 | | | | | | | | |
| 32 | .99242 | .99339 | .99430 | .99514 | .99591 | .99661 | .99725 | .99782 | | | | | | | | |
| 36 | .99244 | .99341 | .99431 | .99515 | .99592 | .99662 | .99726 | .99783 | | | | | | | | |
| 40 | 9.99245 | 9.99342 | 9.99433 | 9.99516 | 9.99593 | 9.99663 | 9.99727 | 9.99784 | | | | | | | | |
| 44 | .99247 | .99344 | .99434 | .99518 | .99594 | .99664 | .99728 | .99785 | | | | | | | | |
| 48 | .99249 | .99345 | .99436 | .99519 | .99596 | .99666 | .99729 | .99786 | | | | | | | | |
| 52 | .99250 | .99347 | .99437 | .99520 | .99597 | .99667 | .99730 | .99786 | | | | | | | | |
| 56 | .99252 | .99349 | .99438 | .99522 | .99598 | .99668 | .99731 | .99787 | | | | | | | | |
| 60 | 9.99254 | 9.99350 | 9.99440 | 9.99523 | 9.99599 | 9.99669 | 9.99732 | 9.99788 | | | | | | | | |

Table 10. Haversine Table

| s | 11h 28 ^m | 11h 32 ^m | 11h 36 ^m | 11h 40 ^m | 11h 44 ^m | 11h 48 ^m | 11h 52 ^m | 11h 56 ^m |
|----|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
| | Hav. | Hav. | Hav. | Hav. | Hav. | Hav. | Hav. | Hav. |
| 0 | 9.99788 | 9.99838 | 9.99881 | 9.99917 | 9.99947 | 9.99970 | 9.99987 | 9.99997 |
| 4 | .99789 | .99839 | .99882 | .99918 | .99948 | .99971 | .99987 | .99997 |
| 8 | .99790 | .99839 | .99882 | .99918 | .99948 | .99971 | .99987 | .99997 |
| 12 | .99791 | .99840 | .99883 | .99919 | .99948 | .99971 | .99987 | .99997 |
| 16 | .99792 | .99841 | .99884 | .99919 | .99949 | .99972 | .99988 | .99997 |
| 20 | 9.99793 | 9.99842 | 9.99884 | 9.99920 | 9.99949 | 9.99972 | 9.99988 | 9.99997 |
| 24 | .99793 | .99842 | .99885 | .99921 | .99950 | .99972 | .99988 | .99997 |
| 28 | .99794 | .99843 | .99885 | .99921 | .99950 | .99973 | .99988 | .99997 |
| 32 | .99795 | .99844 | .99886 | .99922 | .99951 | .99973 | .99988 | .99998 |
| 36 | .99796 | .99845 | .99887 | .99922 | .99951 | .99973 | .99989 | .99998 |
| 40 | 9.99797 | 9.99845 | 9.99887 | 9.99923 | 9.99951 | 9.99973 | 9.99989 | 9.99998 |
| 44 | .99798 | .99846 | .99888 | .99923 | .99952 | .99974 | .99989 | .99998 |
| 48 | .99799 | .99847 | .99889 | .99924 | .99952 | .99974 | .99989 | .99998 |
| 52 | .99800 | .99848 | .99889 | .99924 | .99953 | .99974 | .99989 | .99998 |
| 56 | .99800 | .99848 | .99890 | .99925 | .99953 | .99975 | .99990 | .99998 |
| s | 11h 29 ^m | 11h 33 ^m | 11h 37 ^m | 11h 41 ^m | 11h 45 ^m | 11h 49 ^m | 11h 53 ^m | 11h 57 ^m |
| 0 | 9.99801 | 9.99849 | 9.99891 | 9.99925 | 9.99953 | 9.99975 | 9.99990 | 9.99998 |
| 4 | .99802 | .99850 | .99891 | .99926 | .99954 | .99975 | .99990 | .99998 |
| 8 | .99803 | .99851 | .99892 | .99926 | .99954 | .99976 | .99990 | .99998 |
| 12 | .99804 | .99851 | .99893 | .99927 | .99954 | .99976 | .99990 | .99998 |
| 16 | .99805 | .99852 | .99893 | .99927 | .99955 | .99976 | .99991 | .99998 |
| 20 | 9.99805 | 9.99853 | 9.99894 | 9.99928 | 9.99955 | 9.99976 | 9.99991 | 9.99999 |
| 24 | .99806 | .99854 | .99894 | .99928 | .99956 | .99977 | .99991 | .99999 |
| 28 | .99807 | .99854 | .99895 | .99929 | .99956 | .99977 | .99991 | .99999 |
| 32 | .99808 | .99855 | .99896 | .99929 | .99957 | .99977 | .99991 | .99999 |
| 36 | .99809 | .99856 | .99896 | .99930 | .99957 | .99978 | .99992 | .99999 |
| 40 | 9.99810 | 9.99857 | 9.99897 | 9.99931 | 9.99958 | 9.99978 | 9.99992 | 9.99999 |
| 44 | .99811 | .99857 | .99897 | .99931 | .99958 | .99978 | .99992 | .99999 |
| 48 | .99811 | .99858 | .99898 | .99932 | .99958 | .99978 | .99992 | .99999 |
| 52 | .99812 | .99859 | .99899 | .99932 | .99959 | .99979 | .99992 | .99999 |
| 56 | .99813 | .99859 | .99899 | .99933 | .99959 | .99979 | .99992 | .99999 |
| s | 11h 30 ^m | 11h 34 ^m | 11h 38 ^m | 11h 42 ^m | 11h 46 ^m | 11h 50 ^m | 11h 54 ^m | 11h 58 ^m |
| 0 | 9.99814 | 9.99860 | 9.99900 | 9.99933 | 9.99959 | 9.99979 | 9.99993 | 9.99999 |
| 4 | .99815 | .99861 | .99901 | .99934 | .99960 | .99980 | .99993 | .99999 |
| 8 | .99815 | .99862 | .99901 | .99934 | .99960 | .99980 | .99993 | .99999 |
| 12 | .99816 | .99862 | .99902 | .99935 | .99961 | .99980 | .99993 | .99999 |
| 16 | .99817 | .99863 | .99902 | .99935 | .99961 | .99980 | .99993 | .99999 |
| 20 | 9.99818 | 9.99864 | 9.99903 | 9.99935 | 9.99961 | 9.99981 | 9.99993 | 9.99999 |
| 24 | .99819 | .99864 | .99904 | .99936 | .99962 | .99981 | .99994 | .99999 |
| 28 | .99820 | .99865 | .99904 | .99936 | .99962 | .99981 | .99994 | .00000 |
| 32 | .99820 | .99866 | .99905 | .99937 | .99963 | .99981 | .99994 | .00000 |
| 36 | .99821 | .99867 | .99905 | .99937 | .99963 | .99982 | .99994 | .00000 |
| 40 | 9.99822 | 9.99867 | 9.99906 | 9.99938 | 9.99963 | 9.99982 | 9.99994 | 0.00000 |
| 44 | .99823 | .99868 | .99906 | .99938 | .99964 | .99982 | .99994 | .00000 |
| 48 | .99824 | .99869 | .99907 | .99939 | .99964 | .99983 | .99994 | .00000 |
| 52 | .99824 | .99869 | .99908 | .99939 | .99964 | .99983 | .99995 | .00000 |
| 56 | .99825 | .99870 | .99908 | .99940 | .99965 | .99983 | .99995 | .00000 |
| s | 11h 31 ^m | 11h 35 ^m | 11h 39 ^m | 11h 43 ^m | 11h 47 ^m | 11h 51 ^m | 11h 55 ^m | 11h 59 ^m |
| 0 | 9.99826 | 9.99871 | 9.99909 | 9.99940 | 9.99965 | 9.99983 | 9.99995 | 0.00000 |
| 4 | .99827 | .99871 | .99909 | .99941 | .99965 | .99983 | .99995 | .00000 |
| 8 | .99828 | .99872 | .99910 | .99941 | .99966 | .99984 | .99995 | .00000 |
| 12 | .99828 | .99873 | .99911 | .99942 | .99966 | .99984 | .99995 | .00000 |
| 16 | .99829 | .99874 | .99911 | .99942 | .99966 | .99984 | .99995 | .00000 |
| 20 | 9.99830 | 9.99874 | 9.99912 | 9.99943 | 9.99967 | 9.99984 | 9.99996 | 0.00000 |
| 24 | .99831 | .99875 | .99912 | .99943 | .99967 | .99985 | .99996 | .00000 |
| 28 | .99832 | .99876 | .99913 | .99943 | .99968 | .99985 | .99996 | .00000 |
| 32 | .99832 | .99876 | .99913 | .99944 | .99968 | .99985 | .99996 | .00000 |
| 36 | .99833 | .99877 | .99914 | .99944 | .99968 | .99985 | .99996 | .00000 |
| 40 | 9.99834 | 9.99878 | 9.99915 | 9.99945 | 9.99969 | 9.99986 | 9.99996 | 0.00000 |
| 44 | .99835 | .99878 | .99915 | .99945 | .99969 | .99986 | .99996 | .00000 |
| 48 | .99836 | .99879 | .99916 | .99946 | .99969 | .99986 | .99996 | .00000 |
| 52 | .99836 | .99880 | .99916 | .99946 | .99970 | .99986 | .99996 | .00000 |
| 56 | .99837 | .99880 | .99917 | .99947 | .99970 | .99987 | .99997 | .00000 |
| 60 | 9.99838 | 9.99881 | 9.99917 | 9.99947 | 9.99970 | 9.99987 | 9.99997 | 0.00000 |

Table 11. Azimuth

| | | T, THE SHIP'S APPARENT TIME FOR A SUN OBSERVATION, OR THE HOUR-ANGLE FOR A STAR OBSERVATION | | | | | | | | |
|---------------------------|--------------------------------|--|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------|----|
| USE THESE IN FORE-NOON → | 12 ^h 0 ^m | 12 ^h 8 ^m | 12 ^h 16 ^m | 12 ^h 24 ^m | 12 ^h 32 ^m | 12 ^h 40 ^m | 12 ^h 48 ^m | 12 ^h 56 ^m | ← USE THESE IN FORE-NOON | |
| USE THESE IN AFTER-NOON → | 0 ^h 0 ^m | 0 ^h 8 ^m | 0 ^h 16 ^m | 0 ^h 24 ^m | 0 ^h 32 ^m | 0 ^h 40 ^m | 0 ^h 48 ^m | 0 ^h 56 ^m | ← USE THESE IN AFTER-NOON | |
| | 12 0 | 11 52 | 11 44 | 11 36 | 11 28 | 11 20 | 11 12 | 11 4 | | |
| DECLINATIONS | 0° | 0 | 349 | 698 | 1045 | 1392 | 1737 | 2079 | 2419 | 0° |
| | 2 | 0 | 349 | 697 | 1045 | 1391 | 1736 | 2078 | 2417 | 2 |
| | 4 | 0 | 348 | 696 | 1042 | 1389 | 1732 | 2074 | 2413 | 4 |
| | 6 | 0 | 347 | 694 | 1040 | 1384 | 1726 | 2067 | 2406 | 6 |
| | 8 | 0 | 346 | 691 | 1035 | 1378 | 1720 | 2059 | 2395 | 8 |
| | 10 | 0 | 344 | 687 | 1029 | 1371 | 1710 | 2047 | 2382 | 10 |
| | 12 | 0 | 341 | 682 | 1022 | 1361 | 1698 | 2033 | 2367 | 12 |
| | 14 | 0 | 339 | 677 | 1015 | 1351 | 1685 | 2018 | 2347 | 14 |
| | 16 | 0 | 336 | 671 | 1005 | 1338 | 1669 | 1998 | 2326 | 16 |
| | 18 | 0 | 332 | 663 | 994 | 1323 | 1651 | 1977 | 2301 | 18 |
| | 20 | 0 | 328 | 656 | 982 | 1308 | 1632 | 1954 | 2274 | 20 |
| | 22 | 0 | 324 | 647 | 969 | 1290 | 1610 | 1928 | 2244 | 22 |
| | 24 | 0 | 319 | 637 | 955 | 1272 | 1586 | 1900 | 2210 | 24 |
| | 26 | 0 | 314 | 627 | 940 | 1251 | 1561 | 1868 | 2174 | 26 |
| | 28 | 0 | 308 | 616 | 923 | 1228 | 1533 | 1835 | 2136 | 28 |
| | 30 | 0 | 302 | 604 | 905 | 1205 | 1504 | 1801 | 2095 | 30 |
| | 32 | 0 | 296 | 592 | 886 | 1180 | 1472 | 1763 | 2051 | 32 |
| | 34 | 0 | 289 | 578 | 867 | 1153 | 1440 | 1724 | 2005 | 34 |
| | 36 | 0 | 282 | 564 | 846 | 1126 | 1405 | 1682 | 1957 | 36 |
| | 38 | 0 | 275 | 550 | 824 | 1096 | 1369 | 1639 | 1906 | 38 |
| 40 | 0 | 267 | 534 | 801 | 1066 | 1330 | 1592 | 1853 | 40 | |
| 42 | 0 | 259 | 518 | 777 | 1034 | 1290 | 1545 | 1798 | 42 | |
| 44 | 0 | 251 | 502 | 752 | 1001 | 1249 | 1496 | 1740 | 44 | |
| 46 | 0 | 242 | 485 | 726 | 967 | 1206 | 1444 | 1681 | 46 | |
| 48 | 0 | 234 | 467 | 699 | 931 | 1162 | 1391 | 1619 | 48 | |
| 50 | 0 | 224 | 448 | 672 | 895 | 1116 | 1337 | 1555 | 50 | |
| 52 | 0 | 215 | 429 | 644 | 857 | 1069 | 1280 | 1489 | 52 | |
| 54 | 0 | 205 | 411 | 615 | 818 | 1021 | 1222 | 1422 | 54 | |
| 56 | 0 | 195 | 390 | 585 | 778 | 971 | 1162 | 1353 | 56 | |
| 58 | 0 | 185 | 370 | 554 | 738 | 920 | 1102 | 1282 | 58 | |
| 60 | 0 | 175 | 349 | 523 | 696 | 868 | 1040 | 1210 | 60 | |
| 62 | 0 | 164 | 328 | 490 | 653 | 815 | 976 | 1136 | 62 | |
| 64 | 0 | 153 | 306 | 458 | 610 | 761 | 911 | 1060 | 64 | |
| 66 | 0 | 142 | 284 | 425 | 566 | 706 | 846 | 984 | 66 | |
| 68 | 0 | 131 | 261 | 392 | 521 | 651 | 779 | 906 | 68 | |
| 70 | 0 | 119 | 239 | 358 | 476 | 594 | 711 | 827 | 70 | |
| 72 | 0 | 108 | 216 | 323 | 430 | 537 | 643 | 748 | 72 | |
| 74 | 0 | 96 | 192 | 288 | 384 | 479 | 573 | 667 | 74 | |
| 76 | 0 | 84 | 169 | 253 | 337 | 420 | 503 | 585 | 76 | |
| 78 | 0 | 73 | 145 | 217 | 289 | 361 | 432 | 503 | 78 | |
| 80 | 0 | 61 | 121 | 182 | 242 | 302 | 361 | 420 | 80 | |
| 82 | 0 | 49 | 97 | 146 | 194 | 242 | 289 | 337 | 82 | |
| 84 | 0 | 36 | 73 | 109 | 146 | 182 | 217 | 253 | 84 | |
| 86 | 0 | 24 | 49 | 73 | 97 | 121 | 145 | 169 | 86 | |
| 88 | 0 | 12 | 24 | 36 | 49 | 61 | 73 | 84 | 88 | |
| USE THESE IN FORE-NOON → | 0° | 2° | 4° | 6° | 8° | 10° | 12° | 14° | ← USE THESE IN FORE-NOON | |
| USE THESE IN AFTER-NOON → | 180° | 178° | 184° | 186° | 188° | 190° | 192° | 194° | ← USE THESE IN AFTER-NOON | |
| | 360 | 358 | 356 | 354 | 352 | 350 | 348 | 346 | | |

TRUE BEARING OR AZIMUTH

Table 11. Azimuth

| | | T, THE SHIP'S APPARENT TIME FOR A SUN OBSERVATION, OR THE HOUR-ANGLE FOR A STAR OBSERVATION | | | | | | | | |
|---------------------------|------|--|--|--|--|--|--|---|---------------------------|--|
| USE THESE IN FORE-NOON → | | 13 ^h 4 ^m 22 56 | 13 ^h 12 ^m 22 48 | 13 ^h 20 ^m 22 40 | 13 ^h 28 ^m 22 32 | 13 ^h 36 ^m 22 24 | 13 ^h 44 ^m 22 16 | 13 ^h 52 ^m 22 8 | ← USE THESE IN FORE-NOON | |
| USE THESE IN AFTER-NOON → | | 1 ^h 4 ^m 10 56 | 1 ^h 12 ^m 10 48 | 1 ^h 20 ^m 10 40 | 1 ^h 28 ^m 10 32 | 1 ^h 36 ^m 10 24 | 1 ^h 44 ^m 10 16 | 1 ^h 52 ^m 10 8 | ← USE THESE IN AFTER-NOON | |
| DECLINATIONS | 0° | 2756 | 3090 | 3421 | 3746 | 4067 | 4383 | 4695 | 0° | |
| | 2 | 2755 | 3088 | 3418 | 3744 | 4065 | 4381 | 4692 | 2 | |
| | 4 | 2750 | 3082 | 3412 | 3737 | 4058 | 4373 | 4684 | 4 | |
| | 6 | 2742 | 3073 | 3402 | 3726 | 4044 | 4360 | 4669 | 6 | |
| | 8 | 2730 | 3060 | 3387 | 3710 | 4028 | 4341 | 4649 | 8 | |
| | 10 | 2714 | 3043 | 3368 | 3689 | 4005 | 4317 | 4624 | 10 | |
| | 12 | 2696 | 3023 | 3346 | 3664 | 3978 | 4287 | 4592 | 12 | |
| | 14 | 2674 | 2998 | 3319 | 3635 | 3947 | 4253 | 4555 | 14 | |
| | 16 | 2650 | 2970 | 3288 | 3600 | 3910 | 4214 | 4513 | 16 | |
| | 18 | 2622 | 2939 | 3253 | 3563 | 3868 | 4170 | 4465 | 18 | |
| | 20 | 2590 | 2903 | 3214 | 3521 | 3821 | 4119 | 4412 | 20 | |
| | 22 | 2556 | 2865 | 3171 | 3473 | 3771 | 4064 | 4353 | 22 | |
| | 24 | 2519 | 2823 | 3125 | 3422 | 3715 | 4005 | 4288 | 24 | |
| | 26 | 2477 | 2777 | 3074 | 3367 | 3656 | 3941 | 4220 | 26 | |
| | 28 | 2434 | 2729 | 3020 | 3308 | 3591 | 3871 | 4145 | 28 | |
| | 30 | 2387 | 2676 | 2962 | 3244 | 3522 | 3796 | 4065 | 30 | |
| | 32 | 2337 | 2620 | 2900 | 3177 | 3449 | 3718 | 3981 | 32 | |
| | 34 | 2285 | 2563 | 2835 | 3106 | 3372 | 3634 | 3892 | 34 | |
| | 36 | 2230 | 2500 | 2767 | 3031 | 3291 | 3546 | 3798 | 36 | |
| | 38 | 2172 | 2435 | 2696 | 2952 | 3205 | 3454 | 3699 | 38 | |
| 40 | 2112 | 2367 | 2620 | 2869 | 3116 | 3358 | 3596 | 40 | | |
| 42 | 2048 | 2297 | 2542 | 2784 | 3023 | 3258 | 3489 | 42 | | |
| 44 | 1983 | 2223 | 2460 | 2695 | 2925 | 3154 | 3377 | 44 | | |
| 46 | 1914 | 2147 | 2375 | 2602 | 2826 | 3045 | 3261 | 46 | | |
| 48 | 1845 | 2067 | 2289 | 2507 | 2721 | 2934 | 3142 | 48 | | |
| 50 | 1772 | 1986 | 2199 | 2408 | 2614 | 2818 | 3018 | 50 | | |
| 52 | 1697 | 1902 | 2106 | 2306 | 2504 | 2699 | 2891 | 52 | | |
| 54 | 1620 | 1818 | 2010 | 2202 | 2391 | 2577 | 2759 | 54 | | |
| 56 | 1541 | 1728 | 1913 | 2094 | 2275 | 2451 | 2625 | 56 | | |
| 58 | 1461 | 1638 | 1812 | 1986 | 2155 | 2324 | 2488 | 58 | | |
| 60 | 1378 | 1545 | 1710 | 1874 | 2033 | 2192 | 2347 | 60 | | |
| 62 | 1294 | 1451 | 1606 | 1759 | 1909 | 2058 | 2204 | 62 | | |
| 64 | 1209 | 1355 | 1499 | 1643 | 1783 | 1922 | 2058 | 64 | | |
| 66 | 1121 | 1257 | 1391 | 1524 | 1654 | 1783 | 1909 | 66 | | |
| 68 | 1032 | 1158 | 1281 | 1404 | 1524 | 1643 | 1759 | 68 | | |
| 70 | 943 | 1057 | 1169 | 1281 | 1391 | 1499 | 1606 | 70 | | |
| 72 | 852 | 955 | 1057 | 1158 | 1257 | 1355 | 1451 | 72 | | |
| 74 | 760 | 852 | 943 | 1032 | 1121 | 1209 | 1294 | 74 | | |
| 76 | 667 | 748 | 827 | 906 | 984 | 1060 | 1136 | 76 | | |
| 78 | 573 | 643 | 711 | 779 | 846 | 911 | 976 | 78 | | |
| 80 | 479 | 537 | 594 | 651 | 706 | 761 | 815 | 80 | | |
| 82 | 384 | 430 | 476 | 521 | 566 | 610 | 653 | 82 | | |
| 84 | 288 | 323 | 358 | 392 | 425 | 458 | 491 | 84 | | |
| 86 | 192 | 216 | 239 | 261 | 290 | 306 | 328 | 86 | | |
| 88 | 96 | 108 | 119 | 131 | 142 | 153 | 164 | 88 | | |
| USE THESE IN FORE-NOON → | 16° | 18° | 20° | 22° | 24° | 26° | 28° | ← USE THESE IN FORE-NOON | | |
| | 164 | 162 | 160 | 158 | 156 | 154 | 152 | | | |
| USE THESE IN AFTER-NOON → | 196° | 198° | 200° | 202° | 204° | 206° | 208° | ← USE THESE IN AFTER-NOON | | |
| | 344 | 342 | 340 | 338 | 336 | 334 | 332 | | | |

TRUE BEARING OR AZIMUTH

Table 11. Azimuth

| | | T, THE SHIP'S APPARENT TIME FOR A SUN OBSERVATION, OR THE HOUR-ANGLE FOR A STAR OBSERVATION | | | | | | | | | |
|---------------------------|------|--|--------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------|--|
| USE THESE IN FORE-NOON → | | 14 ^h 0 ^m | 14 ^h 8 ^m | 14 ^h 16 ^m | 14 ^h 24 ^m | 14 ^h 32 ^m | 14 ^h 40 ^m | 14 ^h 48 ^m | 14 ^h 56 ^m | ← USE THESE IN FORE-NOON | |
| USE THESE IN AFTER-NOON → | | 2 ^h 0 ^m | 2 ^h 8 ^m | 2 ^h 16 ^m | 2 ^h 24 ^m | 2 ^h 32 ^m | 2 ^h 40 ^m | 2 ^h 48 ^m | 2 ^h 56 ^m | ← USE THESE IN AFTER-NOON | |
| | | 10 0 | 9 52 | 9 44 | 9 36 | 9 28 | 9 20 | 9 12 | 9 4 | | |
| DECLINATIONS | 0° | 5000 | 5299 | 5593 | 5878 | 6156 | 6428 | 6691 | 6947 | 0° | |
| | 2 | 4997 | 5297 | 5589 | 5875 | 6153 | 6424 | 6688 | 6942 | 2 | |
| | 4 | 4987 | 5286 | 5578 | 5864 | 6142 | 6412 | 6676 | 6929 | 4 | |
| | 6 | 4973 | 5270 | 5562 | 5845 | 6124 | 6393 | 6655 | 6908 | 6 | |
| | 8 | 4951 | 5248 | 5538 | 5821 | 6096 | 6365 | 6627 | 6879 | 8 | |
| | 10 | 4923 | 5219 | 5507 | 5789 | 6063 | 6330 | 6591 | 6841 | 10 | |
| | 12 | 4891 | 5183 | 5470 | 5749 | 6022 | 6288 | 6545 | 6795 | 12 | |
| | 14 | 4852 | 5141 | 5426 | 5703 | 5973 | 6237 | 6492 | 6741 | 14 | |
| | 16 | 4806 | 5094 | 5375 | 5650 | 5919 | 6179 | 6433 | 6677 | 16 | |
| | 18 | 4755 | 5040 | 5319 | 5590 | 5856 | 6113 | 6363 | 6607 | 18 | |
| | 20 | 4699 | 4979 | 5255 | 5524 | 5785 | 6040 | 6288 | 6528 | 20 | |
| | 22 | 4635 | 4914 | 5184 | 5450 | 5709 | 5960 | 6204 | 6440 | 22 | |
| | 24 | 4567 | 4841 | 5109 | 5370 | 5624 | 5872 | 6112 | 6346 | 24 | |
| | 26 | 4493 | 4763 | 5025 | 5283 | 5534 | 5777 | 6015 | 6243 | 26 | |
| | 28 | 4415 | 4678 | 4938 | 5190 | 5437 | 5675 | 5907 | 6134 | 28 | |
| | 30 | 4330 | 4588 | 4843 | 5091 | 5332 | 5567 | 5794 | 6016 | 30 | |
| | 32 | 4240 | 4493 | 4742 | 4984 | 5222 | 5451 | 5674 | 5891 | 32 | |
| | 34' | 4145 | 4393 | 4635 | 4873 | 5104 | 5328 | 5547 | 5758 | 34 | |
| | 36 | 4044 | 4287 | 4524 | 4755 | 4980 | 5200 | 5414 | 5619 | 36 | |
| | 38 | 3941 | 4176 | 4407 | 4633 | 4852 | 5065 | 5272 | 5474 | 38 | |
| 40 | 3830 | 4060 | 4284 | 4503 | 4717 | 4923 | 5126 | 5321 | 40 | | |
| 42 | 3715 | 3939 | 4156 | 4368 | 4575 | 4776 | 4973 | 5162 | 42 | | |
| 44 | 3596 | 3812 | 4023 | 4229 | 4429 | 4624 | 4812 | 4997 | 44 | | |
| 46 | 3473 | 3681 | 3885 | 4083 | 4277 | 4465 | 4648 | 4825 | 46 | | |
| 48 | 3346 | 3546 | 3742 | 3932 | 4120 | 4301 | 4477 | 4648 | 48 | | |
| 50 | 3214 | 3406 | 3594 | 3779 | 3958 | 4131 | 4301 | 4465 | 50 | | |
| 52 | 3078 | 3263 | 3443 | 3619 | 3790 | 3958 | 4120 | 4277 | 52 | | |
| 54 | 2939 | 3115 | 3287 | 3454 | 3619 | 3779 | 3932 | 4083 | 54 | | |
| 56 | 2796 | 2963 | 3127 | 3287 | 3443 | 3594 | 3742 | 3885 | 56 | | |
| 58 | 2650 | 2808 | 2963 | 3115 | 3263 | 3406 | 3546 | 3681 | 58 | | |
| 60 | 2500 | 2650 | 2796 | 2939 | 3078 | 3214 | 3346 | 3473 | 60 | | |
| 62 | 2347 | 2488 | 2625 | 2760 | 2891 | 3018 | 3142 | 3261 | 62 | | |
| 64 | 2192 | 2324 | 2451 | 2577 | 2699 | 2818 | 2934 | 3045 | 64 | | |
| 66 | 2033 | 2155 | 2275 | 2391 | 2504 | 2614 | 2721 | 2826 | 66 | | |
| 68 | 1874 | 1986 | 2094 | 2202 | 2306 | 2408 | 2507 | 2602 | 68 | | |
| 70 | 1710 | 1812 | 1913 | 2010 | 2106 | 2199 | 2289 | 2375 | 70 | | |
| 72 | 1545 | 1638 | 1728 | 1817 | 1902 | 1986 | 2067 | 2147 | 72 | | |
| 74 | 1378 | 1461 | 1541 | 1620 | 1697 | 1770 | 1845 | 1914 | 74 | | |
| 76 | 1210 | 1282 | 1353 | 1422 | 1489 | 1555 | 1619 | 1681 | 76 | | |
| 78 | 1040 | 1102 | 1162 | 1222 | 1280 | 1337 | 1391 | 1444 | 78 | | |
| 80 | 868 | 920 | 971 | 1021 | 1069 | 1116 | 1162 | 1206 | 80 | | |
| 82 | 696 | 738 | 778 | 818 | 857 | 895 | 931 | 967 | 82 | | |
| 84 | 523 | 554 | 585 | 615 | 644 | 672 | 699 | 726 | 84 | | |
| 86 | 349 | 370 | 390 | 411 | 429 | 448 | 467 | 485 | 86 | | |
| 88 | 175 | 185 | 195 | 205 | 215 | 224 | 234 | 242 | 88 | | |
| USE THESE IN FORE-NOON → | | 30° | 32° | 34° | 36° | 38° | 40° | 42° | 44° | ← USE THESE IN FORE-NOON | |
| | | 150 | 148 | 146 | 144 | 142 | 140 | 138 | 136 | | |
| USE THESE IN AFTER-NOON → | | 210° | 212° | 214° | 216° | 218° | 220° | 222° | 224° | ← USE THESE IN AFTER-NOON | |
| | | 330 | 328 | 326 | 324 | 322 | 320 | 318 | 316 | | |
| TRUE BEARING OR AZIMUTH | | | | | | | | | | | |

| | | T, THE SHIP'S APPARENT TIME FOR A SUN OBSERVATION, OR THE HOUR-ANGLE FOR A STAR OBSERVATION | | | | | | | | |
|---------------------------|------|--|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------|--|
| USE THESE IN FORE-NOON → | | 15 ^h 4 ^m | 15 ^h 12 ^m | 15 ^h 20 ^m | 15 ^h 28 ^m | 15 ^h 36 ^m | 15 ^h 44 ^m | 15 ^h 52 ^m | ← USE THESE IN FORE-NOON | |
| | | 20 56 | 20 48 | 20 40 | 20 32 | 20 24 | 20 16 | 20 8 | | |
| USE THESE IN AFTER-NOON → | | 3 ^h 4 ^m | 3 ^h 12 ^m | 3 ^h 20 ^m | 3 ^h 28 ^m | 3 ^h 36 ^m | 3 ^h 44 ^m | 3 ^h 52 ^m | ← USE THESE IN AFTER-NOON | |
| | | 8 56 | 8 48 | 8 40 | 8 32 | 8 24 | 8 16 | 8 8 | | |
| DECLINATIONS | 0° | 7193 | 7432 | 7661 | 7879 | 8091 | 8290 | 8480 | 0° | |
| | 2 | 7190 | 7427 | 7656 | 7875 | 8085 | 8285 | 8476 | 2 | |
| | 4 | 7176 | 7413 | 7642 | 7861 | 8071 | 8269 | 8461 | 4 | |
| | 6 | 7153 | 7391 | 7619 | 7836 | 8046 | 8245 | 8433 | 6 | |
| | 8 | 7124 | 7358 | 7586 | 7803 | 8011 | 8210 | 8399 | 8 | |
| | 10 | 7084 | 7318 | 7544 | 7761 | 7968 | 8164 | 8352 | 10 | |
| | 12 | 7036 | 7269 | 7494 | 7707 | 7914 | 8110 | 8284 | 12 | |
| | 14 | 6979 | 7211 | 7433 | 7645 | 7850 | 8044 | 8228 | 14 | |
| | 16 | 6915 | 7144 | 7364 | 7575 | 7776 | 7969 | 8153 | 16 | |
| | 18 | 6841 | 7068 | 7286 | 7494 | 7695 | 7884 | 8065 | 18 | |
| | 20 | 6759 | 6984 | 7197 | 7404 | 7603 | 7791 | 7969 | 20 | |
| | 22 | 6670 | 6890 | 7103 | 7307 | 7501 | 7686 | 7863 | 22 | |
| | 24 | 6572 | 6789 | 6998 | 7199 | 7391 | 7573 | 7749 | 24 | |
| | 26 | 6466 | 6679 | 6885 | 7082 | 7271 | 7450 | 7623 | 26 | |
| | 28 | 6352 | 6561 | 6764 | 6958 | 7144 | 7319 | 7489 | 28 | |
| | 30 | 6230 | 6436 | 6634 | 6825 | 7006 | 7180 | 7345 | 30 | |
| | 32 | 6101 | 6302 | 6497 | 6683 | 6861 | 7031 | 7191 | 32 | |
| | 34 | 5964 | 6160 | 6351 | 6533 | 6707 | 6873 | 7031 | 34 | |
| | 36 | 5820 | 6012 | 6197 | 6375 | 6545 | 6707 | 6861 | 36 | |
| | 38 | 5669 | 5856 | 6037 | 6210 | 6375 | 6533 | 6683 | 38 | |
| 40 | 5511 | 5693 | 5868 | 6037 | 6197 | 6351 | 6497 | 40 | | |
| 42 | 5346 | 5522 | 5693 | 5856 | 6012 | 6160 | 6302 | 42 | | |
| 44 | 5175 | 5346 | 5511 | 5669 | 5820 | 5964 | 6101 | 44 | | |
| 46 | 4997 | 5162 | 5321 | 5474 | 5619 | 5758 | 5891 | 46 | | |
| 48 | 4812 | 4973 | 5126 | 5272 | 5414 | 5547 | 5674 | 48 | | |
| 50 | 4624 | 4776 | 4923 | 5065 | 5200 | 5328 | 5451 | 50 | | |
| 52 | 4429 | 4575 | 4717 | 4852 | 4980 | 5104 | 5222 | 52 | | |
| 54 | 4229 | 4368 | 4503 | 4633 | 4755 | 4873 | 4984 | 54 | | |
| 56 | 4023 | 4156 | 4284 | 4407 | 4524 | 4635 | 4742 | 56 | | |
| 58 | 3812 | 3939 | 4060 | 4176 | 4287 | 4393 | 4493 | 58 | | |
| 60 | 3596 | 3715 | 3830 | 3941 | 4044 | 4145 | 4240 | 60 | | |
| 62 | 3378 | 3489 | 3596 | 3700 | 3798 | 3892 | 3981 | 62 | | |
| 64 | 3154 | 3258 | 3358 | 3454 | 3546 | 3634 | 3718 | 64 | | |
| 66 | 2925 | 3023 | 3116 | 3205 | 3291 | 3372 | 3449 | 66 | | |
| 68 | 2695 | 2784 | 2869 | 2952 | 3031 | 3106 | 3177 | 68 | | |
| 70 | 2460 | 2542 | 2620 | 2696 | 2767 | 2835 | 2900 | 70 | | |
| 72 | 2223 | 2297 | 2367 | 2435 | 2500 | 2563 | 2620 | 72 | | |
| 74 | 1983 | 2048 | 2112 | 2172 | 2230 | 2285 | 2337 | 74 | | |
| 76 | 1740 | 1798 | 1853 | 1906 | 1957 | 2005 | 2051 | 76 | | |
| 78 | 1496 | 1545 | 1592 | 1639 | 1682 | 1724 | 1763 | 78 | | |
| 80 | 1249 | 1290 | 1330 | 1369 | 1405 | 1440 | 1472 | 80 | | |
| 82 | 1001 | 1034 | 1066 | 1096 | 1126 | 1153 | 1180 | 82 | | |
| 84 | 752 | 777 | 801 | 824 | 846 | 867 | 886 | 84 | | |
| 86 | 502 | 518 | 534 | 550 | 564 | 578 | 592 | 86 | | |
| 88 | 251 | 259 | 267 | 275 | 282 | 289 | 296 | 88 | | |
| USE THESE IN FORE-NOON → | | 46° | 48° | 50° | 52° | 54° | 56° | 58° | ← USE THESE IN FORE-NOON | |
| | | 134 | 132 | 130 | 128 | 126 | 124 | 122 | | |
| USE THESE IN AFTER-NOON → | | 226° | 228° | 230° | 232° | 234° | 236° | 238° | ← USE THESE IN AFTER-NOON | |
| | | 314 | 312 | 310 | 308 | 306 | 304 | 302 | | |

TRUE BEARING OR AZIMUTH

Table 11. Azimuth

| T, THE SHIP'S APPARENT TIME FOR A SUN OBSERVATION, OR THE HOUR-ANGLE FOR A STAR OBSERVATION | | | | | | | | | |
|--|--------|--------|---------|---------|---------|---------|---------|---------|---------------------------|
| USE THESE IN FORE-NOON → | 16h 0m | 16h 8m | 16h 16m | 16h 24m | 16h 32m | 16h 40m | 16h 48m | 16h 56m | ← USE THESE IN FORE-NOON |
| USE THESE IN AFTER-NOON → | 4h 0m | 4h 8m | 4h 16m | 4h 24m | 4h 32m | 4h 40m | 4h 48m | 4h 56m | ← USE THESE IN AFTER-NOON |
| | 20 0 | 19 52 | 19 44 | 19 36 | 19 28 | 19 20 | 19 12 | 19 4 | |
| | 8 0 | 7 52 | 7 44 | 7 36 | 7 28 | 7 20 | 7 12 | 7 4 | |
| 0° | 8660 | 8828 | 8989 | 9135 | 9272 | 9397 | 9510 | 9612 | 0° |
| 2 | 8656 | 8824 | 8982 | 9131 | 9266 | 9391 | 9506 | 9607 | 2 |
| 4 | 8640 | 8808 | 8966 | 9114 | 9249 | 9374 | 9486 | 9590 | 4 |
| 6 | 8612 | 8780 | 8939 | 9084 | 9221 | 9346 | 9458 | 9561 | 6 |
| 8 | 8576 | 8744 | 8900 | 9046 | 9181 | 9305 | 9419 | 9519 | 8 |
| 10 | 8529 | 8696 | 8851 | 8997 | 9131 | 9253 | 9367 | 9466 | 10 |
| 12 | 8470 | 8636 | 8792 | 8935 | 9069 | 9191 | 9303 | 9401 | 12 |
| 14 | 8403 | 8567 | 8722 | 8863 | 8997 | 9118 | 9228 | 9326 | 14 |
| 16 | 8326 | 8487 | 8640 | 8782 | 8913 | 9033 | 9143 | 9241 | 16 |
| 18 | 8235 | 8397 | 8549 | 8688 | 8818 | 8937 | 9044 | 9143 | 18 |
| 20 | 8137 | 8296 | 8447 | 8584 | 8714 | 8831 | 8937 | 9033 | 20 |
| 22 | 8030 | 8187 | 8333 | 8470 | 8596 | 8714 | 8818 | 8913 | 22 |
| 24 | 7912 | 8067 | 8212 | 8347 | 8470 | 8584 | 8688 | 8782 | 24 |
| 26 | 7784 | 7936 | 8078 | 8212 | 8333 | 8447 | 8549 | 8640 | 26 |
| 28 | 7647 | 7796 | 7936 | 8067 | 8187 | 8296 | 8397 | 8487 | 28 |
| 30 | 7501 | 7647 | 7784 | 7912 | 8030 | 8137 | 8235 | 8326 | 30 |
| 32 | 7345 | 7489 | 7623 | 7749 | 7863 | 7969 | 8065 | 8153 | 32 |
| 34 | 7180 | 7319 | 7450 | 7573 | 7686 | 7791 | 7884 | 7969 | 34 |
| 36 | 7006 | 7144 | 7271 | 7391 | 7501 | 7603 | 7695 | 7776 | 36 |
| 38 | 6825 | 6958 | 7082 | 7199 | 7307 | 7404 | 7494 | 7575 | 38 |
| 40 | 6634 | 6764 | 6885 | 6998 | 7103 | 7197 | 7286 | 7364 | 40 |
| 42 | 6436 | 6561 | 6679 | 6789 | 6890 | 6984 | 7068 | 7144 | 42 |
| 44 | 6230 | 6352 | 6466 | 6572 | 6670 | 6759 | 6841 | 6915 | 44 |
| 46 | 6016 | 6134 | 6243 | 6346 | 6440 | 6528 | 6607 | 6677 | 46 |
| 48 | 5794 | 5907 | 6015 | 6212 | 6204 | 6288 | 6363 | 6433 | 48 |
| 50 | 5567 | 5675 | 5777 | 5872 | 5960 | 6040 | 6113 | 6179 | 50 |
| 52 | 5332 | 5437 | 5534 | 5624 | 5709 | 5785 | 5856 | 5919 | 52 |
| 54 | 5091 | 5190 | 5283 | 5370 | 5450 | 5524 | 5590 | 5650 | 54 |
| 56 | 4843 | 4938 | 5025 | 5109 | 5184 | 5255 | 5319 | 5375 | 56 |
| 58 | 4588 | 4678 | 4763 | 4841 | 4914 | 4979 | 5040 | 5094 | 58 |
| 60 | 4330 | 4415 | 4493 | 4567 | 4635 | 4699 | 4755 | 4806 | 60 |
| 62 | 4065 | 4145 | 4220 | 4288 | 4353 | 4412 | 4465 | 4513 | 62 |
| 64 | 3796 | 3871 | 3941 | 4005 | 4064 | 4119 | 4170 | 4214 | 64 |
| 66 | 3522 | 3591 | 3656 | 3715 | 3771 | 3821 | 3868 | 3910 | 66 |
| 68 | 3244 | 3308 | 3367 | 3422 | 3473 | 3521 | 3563 | 3600 | 68 |
| 70 | 2962 | 3020 | 3074 | 3125 | 3171 | 3214 | 3253 | 3288 | 70 |
| 72 | 2676 | 2729 | 2777 | 2823 | 2865 | 2903 | 2939 | 2970 | 72 |
| 74 | 2387 | 2434 | 2477 | 2519 | 2556 | 2590 | 2622 | 2650 | 74 |
| 76 | 2095 | 2136 | 2174 | 2210 | 2244 | 2274 | 2301 | 2326 | 76 |
| 78 | 1801 | 1835 | 1868 | 1900 | 1928 | 1954 | 1977 | 1998 | 78 |
| 80 | 1504 | 1533 | 1561 | 1586 | 1610 | 1632 | 1651 | 1669 | 80 |
| 82 | 1205 | 1228 | 1251 | 1272 | 1290 | 1308 | 1323 | 1338 | 82 |
| 84 | 905 | 923 | 940 | 955 | 969 | 982 | 994 | 1005 | 84 |
| 86 | 604 | 616 | 627 | 637 | 647 | 656 | 663 | 671 | 86 |
| 88 | 302 | 308 | 314 | 319 | 324 | 328 | 332 | 336 | 88 |
| USE THESE IN FORE-NOON → | 60° | 62° | 64° | 66° | 68° | 70° | 72° | 74° | ← USE THESE IN FORE-NOON |
| | 120 | 118 | 116 | 114 | 112 | 110 | 108 | 106 | |
| USE THESE IN AFTER-NOON → | 240° | 242° | 244° | 246° | 248° | 250° | 252° | 254° | ← USE THESE IN AFTER-NOON |
| | 300 | 298 | 296 | 294 | 292 | 290 | 288 | 286 | |

TRUE BEARING OR AZIMUTH

Table 11. Azimuth

T, THE SHIP'S APPARENT TIME FOR A SUN OBSERVATION,
OR THE HOUR-ANGLE FOR A STAR OBSERVATION

| | | 17 ^h 4 ^m | 17 ^h 12 ^m | 17 ^h 20 ^m | 17 ^h 28 ^m | 17 ^h 36 ^m | 17 ^h 44 ^m | 17 ^h 52 ^m | 18 ^h 0 ^m | | |
|---------------------------|------|---------------------------------------|--|--|--|--|--|---------------------------------------|--------------------------------------|---------------------------|-----------|
| USE THESE IN FORE-NOON → | | 18 56 | 18 48 | 18 40 | 18 32 | 18 24 | 18 16 | 18 8 | 18 0 | ← USE THESE IN FORE-NOON | |
| USE THESE IN AFTER-NOON → | | 5 ^h 4 ^m 6 56 | 5 ^h 12 ^m 6 48 | 5 ^h 20 ^m 6 40 | 5 ^h 28 ^m 6 32 | 5 ^h 36 ^m 6 24 | 5 ^h 44 ^m 6 16 | 5 ^h 52 ^m 6 8 | 6 ^h 0 ^m 6 0 | ← USE THESE IN AFTER-NOON | |
| DECLINATIONS | 0° | 9703 | 9781 | 9849 | 9904 | 9945 | 9974 | 9993 | 10000 | 0° | ALTITUDES |
| | 2 | 9696 | 9774 | 9842 | 9897 | 9940 | 9970 | 9988 | 9993 | 2 | |
| | 4 | 9679 | 9757 | 9824 | 9879 | 9922 | 9951 | 9970 | 9974 | 4 | |
| | 6 | 9649 | 9727 | 9795 | 9849 | 9891 | 9922 | 9940 | 9945 | 6 | |
| | 8 | 9610 | 9687 | 9752 | 9806 | 9849 | 9879 | 9897 | 9904 | 8 | |
| | 10 | 9557 | 9634 | 9699 | 9752 | 9795 | 9824 | 9842 | 9849 | 10 | |
| | 12 | 9491 | 9568 | 9634 | 9687 | 9727 | 9757 | 9774 | 9781 | 12 | |
| | 14 | 9414 | 9491 | 9557 | 9610 | 9649 | 9679 | 9696 | 9703 | 14 | |
| | 16 | 9326 | 9401 | 9466 | 9519 | 9561 | 9590 | 9607 | 9612 | 16 | |
| | 18 | 9228 | 9303 | 9367 | 9419 | 9458 | 9486 | 9506 | 9510 | 18 | |
| | 20 | 9118 | 9191 | 9253 | 9305 | 9346 | 9374 | 9391 | 9397 | 20 | |
| | 22 | 8997 | 9069 | 9131 | 9181 | 9221 | 9249 | 9266 | 9272 | 22 | |
| | 24 | 8863 | 8935 | 8997 | 9046 | 9084 | 9114 | 9131 | 9135 | 24 | |
| | 26 | 8722 | 8792 | 8851 | 8900 | 8939 | 8966 | 8982 | 8989 | 26 | |
| | 28 | 8567 | 8636 | 8696 | 8744 | 8780 | 8808 | 8824 | 8828 | 28 | |
| | 30 | 8403 | 8470 | 8529 | 8576 | 8612 | 8640 | 8656 | 8660 | 30 | |
| | 32 | 8228 | 8284 | 8352 | 8399 | 8433 | 8461 | 8476 | 8480 | 32 | |
| | 34 | 8044 | 8110 | 8164 | 8210 | 8245 | 8269 | 8285 | 8290 | 34 | |
| | 36 | 7850 | 7914 | 7968 | 8011 | 8046 | 8071 | 8085 | 8091 | 36 | |
| | 38 | 7645 | 7707 | 7761 | 7803 | 7836 | 7861 | 7875 | 7879 | 38 | |
| 40 | 7433 | 7494 | 7544 | 7586 | 7619 | 7642 | 7656 | 7661 | 40 | | |
| 42 | 7211 | 7269 | 7318 | 7358 | 7391 | 7413 | 7427 | 7432 | 42 | | |
| 44 | 6979 | 7036 | 7084 | 7124 | 7153 | 7176 | 7190 | 7193 | 44 | | |
| 46 | 6741 | 6795 | 6841 | 6879 | 6908 | 6929 | 6942 | 6947 | 46 | | |
| 48 | 6492 | 6545 | 6591 | 6627 | 6655 | 6676 | 6688 | 6691 | 48 | | |
| 50 | 6237 | 6288 | 6330 | 6365 | 6393 | 6412 | 6424 | 6428 | 50 | | |
| 52 | 5973 | 6022 | 6063 | 6096 | 6124 | 6142 | 6153 | 6156 | 52 | | |
| 54 | 5703 | 5749 | 5789 | 5821 | 5845 | 5864 | 5875 | 5878 | 54 | | |
| 56 | 5426 | 5470 | 5507 | 5538 | 5562 | 5578 | 5589 | 5593 | 56 | | |
| 58 | 5141 | 5183 | 5219 | 5248 | 5270 | 5286 | 5297 | 5299 | 58 | | |
| 60 | 4852 | 4891 | 4923 | 4951 | 4973 | 4987 | 4997 | 5000 | 60 | | |
| 62 | 4555 | 4592 | 4624 | 4649 | 4669 | 4684 | 4692 | 4695 | 62 | | |
| 64 | 4253 | 4287 | 4317 | 4341 | 4360 | 4373 | 4381 | 4383 | 64 | | |
| 66 | 3947 | 3978 | 4005 | 4028 | 4044 | 4058 | 4065 | 4067 | 66 | | |
| 68 | 3635 | 3664 | 3689 | 3710 | 3726 | 3737 | 3744 | 3746 | 68 | | |
| 70 | 3319 | 3346 | 3368 | 3387 | 3402 | 3412 | 3418 | 3421 | 70 | | |
| 72 | 2998 | 3023 | 3043 | 3060 | 3073 | 3082 | 3088 | 3090 | 72 | | |
| 74 | 2674 | 2696 | 2714 | 2730 | 2742 | 2750 | 2755 | 2756 | 74 | | |
| 76 | 2347 | 2367 | 2382 | 2395 | 2406 | 2413 | 2417 | 2419 | 76 | | |
| 78 | 2018 | 2033 | 2047 | 2059 | 2067 | 2074 | 2078 | 2079 | 78 | | |
| 80 | 1685 | 1698 | 1710 | 1720 | 1726 | 1732 | 1736 | 1737 | 80 | | |
| 82 | 1351 | 1361 | 1371 | 1378 | 1384 | 1389 | 1391 | 1392 | 82 | | |
| 84 | 1015 | 1022 | 1029 | 1035 | 1040 | 1042 | 1045 | 1045 | 84 | | |
| 86 | 677 | 682 | 687 | 691 | 694 | 696 | 697 | 698 | 86 | | |
| 88 | 339 | 341 | 344 | 346 | 347 | 348 | 349 | 349 | 88 | | |
| USE THESE IN FORE-NOON → | | 76° | 78° | 80° | 82° | 84° | 86° | 88° | 90° | ← USE THESE IN FORE-NOON | |
| USE THESE IN AFTER-NOON → | | 104 | 102 | 100 | 98 | 96 | 94 | 92 | 90 | ← USE THESE IN AFTER-NOON | |
| | | 256° | 258° | 260° | 262° | 264° | 266° | 268° | 270° | | |
| | | 284 | 282 | 280 | 278 | 276 | 274 | 272 | 270 | | |

TRUE BEARING OR AZIMUTH

Table 12. Auxiliary Azimuth Table

| LATITUDE | DECLINATIONS | | | | | | | | | | | | |
|----------|--------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| | 0° | 2° | 4° | 6° | 8° | 10° | 12° | 14° | 16° | 18° | 20° | 22° | 24° |
| 0° | 0° | | | | | | | | | | | | |
| 2 | 0 | 90° | | | | | | | | | | | |
| 4 | 0 | 30 | 90° | | | | | | | | | | |
| 6 | 0 | 20 | 42 | 90° | | | | | | | | | |
| 8 | 0 | 15 | 30 | 49 | 90° | | | | | | | | |
| 10 | 0 | 12 | 24 | 37 | 53 | 90° | | | | | | | |
| 12 | 0 | 10 | 20 | 30 | 42 | 57 | 90° | | | | | | |
| 14 | 0 | 8 | 17 | 26 | 35 | 46 | 59 | 90° | | | | | |
| 16 | 0 | 7 | 15 | 22 | 30 | 39 | 49 | 61 | 90° | | | | |
| 18 | 0 | 6 | 13 | 20 | 27 | 34 | 42 | 52 | 63 | 90° | | | |
| 20 | 0 | 6 | 12 | 18 | 24 | 31 | 37 | 45 | 54 | 65 | 90° | | |
| 22 | 0 | 5 | 11 | 16 | 22 | 28 | 34 | 40 | 47 | 56 | 66 | 90° | |
| 24 | 0 | 5 | 10 | 15 | 20 | 25 | 31 | 36 | 43 | 49 | 57 | 67 | 90° |
| 26 | 0 | 5 | 9 | 14 | 19 | 23 | 28 | 34 | 39 | 45 | 51 | 59 | 68 |
| 28 | 0 | 4 | 9 | 13 | 17 | 22 | 26 | 31 | 36 | 41 | 47 | 53 | 60 |
| 30 | 0 | 4 | 8 | 12 | 16 | 20 | 25 | 29 | 33 | 38 | 43 | 49 | 54 |
| 32 | 0 | 4 | 8 | 11 | 15 | 19 | 23 | 27 | 31 | 36 | 40 | 45 | 50 |
| 34 | 0 | 4 | 7 | 11 | 14 | 18 | 22 | 26 | 30 | 34 | 38 | 42 | 47 |
| 36 | 0 | 3 | 7 | 10 | 14 | 17 | 21 | 24 | 28 | 32 | 36 | 40 | 44 |
| 38 | 0 | 3 | 7 | 10 | 13 | 16 | 20 | 23 | 27 | 30 | 34 | 37 | 41 |
| 40 | 0 | 3 | 6 | 9 | 12 | 16 | 19 | 22 | 25 | 29 | 32 | 36 | 39 |
| 42 | 0 | 3 | 6 | 9 | 12 | 15 | 18 | 21 | 24 | 28 | 31 | 34 | 37 |
| 44 | 0 | 3 | 6 | 9 | 12 | 14 | 17 | 20 | 23 | 26 | 30 | 33 | 36 |
| 46 | 0 | 3 | 6 | 8 | 11 | 14 | 17 | 20 | 23 | 25 | 28 | 31 | 34 |
| 48 | 0 | 3 | 5 | 8 | 11 | 14 | 16 | 19 | 22 | 25 | 27 | 30 | 33 |
| 50 | 0 | 3 | 5 | 8 | 10 | 13 | 16 | 18 | 21 | 24 | 27 | 29 | 32 |
| 52 | 0 | 3 | 5 | 8 | 10 | 13 | 15 | 18 | 20 | 23 | 26 | 28 | 31 |
| 54 | 0 | 2 | 5 | 7 | 10 | 12 | 15 | 17 | 20 | 22 | 25 | 28 | 30 |
| 56 | 0 | 2 | 5 | 7 | 10 | 12 | 15 | 17 | 19 | 22 | 24 | 27 | 29 |
| 58 | 0 | 2 | 5 | 7 | 9 | 12 | 14 | 17 | 19 | 21 | 24 | 26 | 29 |
| 60 | 0 | 2 | 5 | 7 | 9 | 12 | 14 | 16 | 19 | 21 | 23 | 26 | 28 |

Table 12. Completed

| LATITUDE | DECLINATIONS | | | | | | | | | | | | | |
|----------|--------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--|
| | 26° | 28° | 30° | 32° | 34° | 36° | 38° | 40° | 42° | 44° | 46° | 48° | 50° | |
| 26° | 90° | | | | | | | | | | | | | |
| 28 | 69 | 90° | | | | | | | | | | | | |
| 30 | 61 | 70 | 90° | | | | | | | | | | | |
| 32 | 56 | 62 | 71 | 90° | | | | | | | | | | |
| 34 | 52 | 57 | 63 | 71 | 90° | | | | | | | | | |
| 36 | 48 | 53 | 58 | 64 | 72 | 90° | | | | | | | | |
| 38 | 45 | 50 | 54 | 59 | 65 | 73 | 90° | | | | | | | |
| 40 | 43 | 47 | 51 | 56 | 60 | 66 | 73 | 90° | | | | | | |
| 42 | 41 | 45 | 48 | 53 | 57 | 61 | 67 | 74 | 90° | | | | | |
| 44 | 39 | 43 | 46 | 50 | 54 | 58 | 62 | 68 | 74 | 90° | | | | |
| 46 | 38 | 41 | 44 | 47 | 51 | 55 | 59 | 63 | 68 | 75 | 90° | | | |
| 48 | 36 | 39 | 42 | 45 | 49 | 52 | 56 | 60 | 64 | 69 | 75 | 90° | | |
| 50 | 35 | 38 | 41 | 44 | 47 | 50 | 53 | 57 | 61 | 65 | 70 | 76 | 90° | |
| 52 | 34 | 37 | 39 | 42 | 45 | 48 | 51 | 55 | 58 | 62 | 66 | 71 | 76 | |
| 54 | 33 | 35 | 38 | 41 | 44 | 47 | 50 | 53 | 56 | 59 | 63 | 67 | 71 | |
| 56 | 32 | 34 | 37 | 40 | 42 | 45 | 48 | 51 | 54 | 57 | 60 | 64 | 68 | |
| 58 | 31 | 33 | 36 | 39 | 41 | 44 | 47 | 49 | 52 | 55 | 58 | 61 | 65 | |
| 60 | 30 | 33 | 35 | 38 | 40 | 43 | 45 | 48 | 51 | 53 | 56 | 59 | 62 | |

Table 13. Kelvin's Sumner Line Table

| b | a = 0° | | a = 1° | | a = 2° | | a = 3° | | a = 4° | | a = 5° | | a = 6° | |
|----|--------|-----|--------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| | K | Q | K | Q | K | Q | K | Q | K | Q | K | Q | K | Q |
| 0 | 0 0 | 0 0 | 0 0 | 1 0 | 0 0 | 2 0 | 0 0 | 3 0 | 0 0 | 4 0 | 0 0 | 5 0 | 0 0 | 6 0 |
| 1 | 1 0 | 0 0 | 1 0 | 0 0 | 1 0 | 0 0 | 1 0 | 0 0 | 1 0 | 0 0 | 1 0 | 0 0 | 1 0 | 0 0 |
| 2 | 2 0 | 0 0 | 2 0 | 0 0 | 2 0 | 0 0 | 2 0 | 0 0 | 2 0 | 0 0 | 2 0 | 0 0 | 2 0 | 0 0 |
| 3 | 3 0 | 0 0 | 3 0 | 0 0 | 3 0 | 0 0 | 3 0 | 0 0 | 3 0 | 0 0 | 3 0 | 59 0 | 2 59 | 0 0 |
| 4 | 4 0 | 0 0 | 4 0 | 0 0 | 4 0 | 0 0 | 4 0 | 0 0 | 59 1 | 3 59 | 1 3 59 | 1 3 59 | 1 3 59 | 1 3 59 |
| 5 | 5 0 | 0 0 | 5 0 | 0 0 | 5 0 | 0 0 | 5 0 | 1 4 59 | 1 4 59 | 1 4 59 | 1 4 59 | 1 4 59 | 1 4 59 | 1 4 59 |
| 6 | 6 0 | 0 0 | 6 0 | 0 0 | 6 0 | 1 6 0 | 1 6 0 | 1 5 59 | 1 5 59 | 1 5 59 | 1 5 59 | 2 5 59 | 2 5 59 | 2 5 59 |
| 7 | 7 0 | 0 0 | 7 0 | 0 0 | 7 0 | 1 7 0 | 1 7 0 | 1 6 59 | 1 6 59 | 1 6 59 | 2 6 59 | 2 6 59 | 2 6 59 | 2 6 59 |
| 8 | 8 0 | 0 0 | 8 0 | 1 8 0 | 1 8 0 | 1 7 59 | 1 7 59 | 2 7 59 | 2 7 59 | 2 7 59 | 2 7 59 | 3 7 59 | 3 7 59 | 3 7 59 |
| 9 | 9 0 | 0 0 | 9 0 | 1 9 0 | 1 9 0 | 1 8 59 | 1 8 59 | 2 8 59 | 2 8 59 | 3 8 59 | 3 8 59 | 4 8 59 | 4 8 59 | 4 8 59 |
| 10 | 10 0 | 0 0 | 10 0 | 1 10 0 | 1 10 0 | 2 9 59 | 2 9 59 | 3 9 59 | 3 9 59 | 4 9 59 | 4 9 59 | 5 9 59 | 5 9 59 | 5 9 59 |
| 11 | 11 0 | 0 0 | 11 0 | 1 11 0 | 1 11 0 | 2 10 59 | 2 10 59 | 3 10 59 | 3 10 59 | 4 10 59 | 4 10 59 | 5 10 59 | 5 10 59 | 5 10 59 |
| 12 | 12 0 | 0 0 | 12 0 | 1 12 0 | 1 12 0 | 3 11 59 | 3 11 59 | 4 11 59 | 4 11 59 | 5 11 59 | 5 11 59 | 6 11 59 | 6 11 59 | 6 11 59 |
| 13 | 13 0 | 0 0 | 13 0 | 2 13 0 | 2 13 0 | 3 12 59 | 3 12 59 | 4 12 59 | 4 12 59 | 5 12 59 | 5 12 59 | 6 12 59 | 6 12 59 | 6 12 59 |
| 14 | 14 0 | 0 0 | 14 0 | 2 14 59 | 2 14 59 | 4 13 59 | 4 13 59 | 5 13 59 | 5 13 59 | 6 13 59 | 6 13 59 | 7 13 59 | 7 13 59 | 7 13 59 |
| 15 | 15 0 | 0 0 | 15 0 | 2 15 59 | 2 15 59 | 4 14 59 | 4 14 59 | 5 14 59 | 5 14 59 | 6 14 59 | 6 14 59 | 7 14 59 | 7 14 59 | 7 14 59 |
| 16 | 16 0 | 0 0 | 16 0 | 2 16 59 | 2 16 59 | 5 15 59 | 5 15 59 | 6 15 59 | 6 15 59 | 7 15 59 | 7 15 59 | 8 15 59 | 8 15 59 | 8 15 59 |
| 17 | 17 0 | 0 0 | 17 0 | 3 17 0 | 3 17 0 | 5 16 59 | 5 16 59 | 6 16 59 | 6 16 59 | 7 16 59 | 7 16 59 | 8 16 59 | 8 16 59 | 8 16 59 |
| 18 | 18 0 | 0 0 | 18 0 | 3 17 59 | 3 17 59 | 6 17 59 | 6 17 59 | 7 17 59 | 7 17 59 | 8 17 59 | 8 17 59 | 9 17 59 | 9 17 59 | 9 17 59 |
| 19 | 19 0 | 0 0 | 19 0 | 3 18 59 | 3 18 59 | 7 18 59 | 7 18 59 | 8 18 59 | 8 18 59 | 9 18 59 | 9 18 59 | 10 18 59 | 10 18 59 | 10 18 59 |
| 20 | 20 0 | 0 0 | 20 0 | 4 19 59 | 4 19 59 | 8 19 59 | 8 19 59 | 9 19 59 | 9 19 59 | 10 19 59 | 10 19 59 | 11 19 59 | 11 19 59 | 11 19 59 |
| 21 | 21 0 | 0 0 | 21 0 | 4 20 59 | 4 20 59 | 9 20 59 | 9 20 59 | 10 20 59 | 10 20 59 | 11 20 59 | 11 20 59 | 12 20 59 | 12 20 59 | 12 20 59 |
| 22 | 22 0 | 0 0 | 22 0 | 5 21 59 | 5 21 59 | 9 21 59 | 9 21 59 | 10 21 59 | 10 21 59 | 11 21 59 | 11 21 59 | 12 21 59 | 12 21 59 | 12 21 59 |
| 23 | 23 0 | 0 0 | 23 0 | 5 22 59 | 5 22 59 | 10 22 59 | 10 22 59 | 11 22 59 | 11 22 59 | 12 22 59 | 12 22 59 | 13 22 59 | 13 22 59 | 13 22 59 |
| 24 | 24 0 | 0 0 | 24 0 | 6 23 59 | 6 23 59 | 11 23 59 | 11 23 59 | 12 23 59 | 12 23 59 | 13 23 59 | 13 23 59 | 14 23 59 | 14 23 59 | 14 23 59 |
| 25 | 25 0 | 0 0 | 25 0 | 6 24 59 | 6 24 59 | 12 24 59 | 12 24 59 | 13 24 59 | 13 24 59 | 14 24 59 | 14 24 59 | 15 24 59 | 15 24 59 | 15 24 59 |
| 26 | 26 0 | 0 0 | 26 0 | 7 25 59 | 7 25 59 | 13 25 59 | 13 25 59 | 14 25 59 | 14 25 59 | 15 25 59 | 15 25 59 | 16 25 59 | 16 25 59 | 16 25 59 |
| 27 | 27 0 | 0 0 | 27 0 | 7 26 59 | 7 26 59 | 15 26 59 | 15 26 59 | 16 26 59 | 16 26 59 | 17 26 59 | 17 26 59 | 18 26 59 | 18 26 59 | 18 26 59 |
| 28 | 28 0 | 0 0 | 28 0 | 8 27 59 | 8 27 59 | 16 27 59 | 16 27 59 | 17 27 59 | 17 27 59 | 18 27 59 | 18 27 59 | 19 27 59 | 19 27 59 | 19 27 59 |
| 29 | 29 0 | 0 0 | 29 0 | 9 28 59 | 9 28 59 | 17 28 59 | 17 28 59 | 18 28 59 | 18 28 59 | 19 28 59 | 19 28 59 | 20 28 59 | 20 28 59 | 20 28 59 |
| 30 | 30 0 | 0 0 | 30 0 | 9 29 59 | 9 29 59 | 19 29 59 | 19 29 59 | 20 29 59 | 20 29 59 | 21 29 59 | 21 29 59 | 22 29 59 | 22 29 59 | 22 29 59 |
| 31 | 31 0 | 0 0 | 31 0 | 10 30 59 | 10 30 59 | 20 30 59 | 20 30 59 | 21 30 59 | 21 30 59 | 22 30 59 | 22 30 59 | 23 30 59 | 23 30 59 | 23 30 59 |
| 32 | 32 0 | 0 0 | 32 0 | 11 31 59 | 11 31 59 | 21 31 59 | 21 31 59 | 22 31 59 | 22 31 59 | 23 31 59 | 23 31 59 | 24 31 59 | 24 31 59 | 24 31 59 |
| 33 | 33 0 | 0 0 | 33 0 | 12 32 59 | 12 32 59 | 23 32 59 | 23 32 59 | 24 32 59 | 24 32 59 | 25 32 59 | 25 32 59 | 26 32 59 | 26 32 59 | 26 32 59 |
| 34 | 34 0 | 0 0 | 34 0 | 12 33 59 | 12 33 59 | 25 33 59 | 25 33 59 | 26 33 59 | 26 33 59 | 27 33 59 | 27 33 59 | 28 33 59 | 28 33 59 | 28 33 59 |
| 35 | 35 0 | 0 0 | 35 0 | 13 34 59 | 13 34 59 | 26 34 59 | 26 34 59 | 27 34 59 | 27 34 59 | 28 34 59 | 28 34 59 | 29 34 59 | 29 34 59 | 29 34 59 |
| 36 | 36 0 | 0 0 | 36 0 | 14 35 59 | 14 35 59 | 28 35 59 | 28 35 59 | 29 35 59 | 29 35 59 | 30 35 59 | 30 35 59 | 31 35 59 | 31 35 59 | 31 35 59 |
| 37 | 37 0 | 0 0 | 37 0 | 15 36 59 | 15 36 59 | 30 36 59 | 30 36 59 | 31 36 59 | 31 36 59 | 32 36 59 | 32 36 59 | 33 36 59 | 33 36 59 | 33 36 59 |
| 38 | 38 0 | 0 0 | 38 0 | 16 37 59 | 16 37 59 | 32 37 59 | 32 37 59 | 33 37 59 | 33 37 59 | 34 37 59 | 34 37 59 | 35 37 59 | 35 37 59 | 35 37 59 |
| 39 | 39 0 | 0 0 | 39 0 | 17 38 59 | 17 38 59 | 34 38 59 | 34 38 59 | 35 38 59 | 35 38 59 | 36 38 59 | 36 38 59 | 37 38 59 | 37 38 59 | 37 38 59 |
| 40 | 40 0 | 0 0 | 40 0 | 18 39 59 | 18 39 59 | 37 39 59 | 37 39 59 | 38 39 59 | 38 39 59 | 39 39 59 | 39 39 59 | 40 39 59 | 40 39 59 | 40 39 59 |
| 41 | 41 0 | 0 0 | 41 0 | 19 40 59 | 19 40 59 | 39 40 59 | 39 40 59 | 40 40 59 | 40 40 59 | 41 40 59 | 41 40 59 | 42 40 59 | 42 40 59 | 42 40 59 |
| 42 | 42 0 | 0 0 | 42 0 | 21 41 59 | 21 41 59 | 41 41 59 | 41 41 59 | 42 41 59 | 42 41 59 | 43 41 59 | 43 41 59 | 44 41 59 | 44 41 59 | 44 41 59 |
| 43 | 43 0 | 0 0 | 43 0 | 22 42 59 | 22 42 59 | 44 42 59 | 44 42 59 | 45 42 59 | 45 42 59 | 46 42 59 | 46 42 59 | 47 42 59 | 47 42 59 | 47 42 59 |
| 44 | 44 0 | 0 0 | 59 23 | 43 59 | 43 59 | 47 43 59 | 47 43 59 | 48 43 59 | 48 43 59 | 49 43 59 | 49 43 59 | 50 43 59 | 50 43 59 | 50 43 59 |
| 45 | 45 0 | 0 0 | 44 59 | 25 44 59 | 25 44 59 | 50 44 59 | 50 44 59 | 51 44 59 | 51 44 59 | 52 44 59 | 52 44 59 | 53 44 59 | 53 44 59 | 53 44 59 |

Table 13. Kelvin's Summer Line Table

| b | a = 0° | | a = 1° | | a = 2° | | a = 3° | | a = 4° | | a = 5° | | a = 6° | |
|----|--------|-----|--------|----------|-------------|-----------|----------|----------|----------|-------------|----------|------|--------|------|
| | K | Q | K | Q | K | Q | K | Q | K | Q | K | Q | K | Q |
| 45 | 45 0 | 0 0 | 44 59 | 1 25 | 44 58 | 2 50 | 44 55 | 4 14 | 44 52 | 5 39 | 44 47 | 7 3 | 44 41 | 8 27 |
| 46 | 46 0 | 0 0 | 45 59 | 26 45 | 58 53 | 45 55 | 19 45 | 51 45 | 45 46 | 11 45 | 41 36 | | | |
| 47 | 47 0 | 0 0 | 46 59 | 28 46 | 58 56 | 46 55 | 24 46 | 51 46 | 46 46 | 19 46 | 40 46 | | | |
| 48 | 48 0 | 0 0 | 47 59 | 30 47 | 58 59 | 47 55 | 29 47 | 51 47 | 47 45 | 27 47 | 39 56 | | | |
| 49 | 49 0 | 0 0 | 48 59 | 31 48 | 58 3 3 | 48 55 | 34 48 | 50 6 5 | 48 45 | 36 48 | 38 9 6 | | | |
| 50 | 50 0 | 0 0 | 49 59 | 33 49 | 58 7 49 | 54 40 | 49 50 | 13 49 | 44 45 | 49 38 17 | | | | |
| 51 | 51 0 | 0 0 | 50 59 | 35 50 | 57 11 50 | 54 46 | 50 50 | 21 50 | 44 55 | 50 37 29 | | | | |
| 52 | 52 0 | 0 0 | 51 59 | 37 51 | 57 15 51 | 54 52 | 51 49 | 29 51 | 43 8 5 | 51 36 41 | | | | |
| 53 | 53 0 | 0 0 | 52 59 | 40 52 | 57 19 52 | 54 59 | 52 49 | 38 52 | 43 16 | 52 35 54 | | | | |
| 54 | 54 0 | 0 0 | 53 59 | 42 53 | 57 24 53 | 54 5 6 | 53 49 | 47 53 | 42 28 | 53 34 10 8 | | | | |
| 55 | 55 0 | 0 0 | 54 59 | 45 54 | 57 29 54 | 53 13 | 54 48 | 57 54 | 41 40 | 54 33 23 | | | | |
| 56 | 56 0 | 0 0 | 55 59 | 47 55 | 57 34 55 | 53 21 | 55 48 | 7 8 | 55 41 | 53 32 39 | | | | |
| 57 | 57 0 | 0 0 | 56 59 | 50 56 | 57 40 56 | 53 30 | 56 47 | 19 56 | 40 9 7 | 56 31 55 | | | | |
| 58 | 58 0 | 0 0 | 57 59 | 53 57 | 57 46 57 | 52 39 | 57 47 | 31 57 | 39 22 | 57 30 11 13 | | | | |
| 59 | 59 0 | 0 0 | 58 59 | 56 58 | 57 53 58 | 52 49 | 58 46 | 44 58 | 38 38 | 58 29 32 | | | | |
| 60 | 60 0 | 0 0 | 59 59 | 2 0 59 | 56 4 0 59 | 52 59 | 59 46 | 58 59 | 37 56 | 59 28 52 | | | | |
| 61 | 61 0 | 0 0 | 60 59 | 4 60 | 56 7 60 | 52 6 10 | 60 45 | 8 13 | 60 36 | 10 14 60 | 26 12 14 | | | |
| 62 | 62 0 | 0 0 | 61 59 | 8 61 | 56 15 61 | 51 22 | 61 44 | 28 61 | 35 33 | 61 25 37 | | | | |
| 63 | 63 0 | 0 0 | 62 59 | 12 62 | 56 24 62 | 51 35 | 62 44 | 45 62 | 34 54 | 62 23 13 2 | | | | |
| 64 | 64 0 | 0 0 | 63 59 | 17 63 | 56 33 63 | 50 49 | 63 43 | 9 4 63 | 33 11 17 | 63 22 29 | | | | |
| 65 | 65 0 | 0 0 | 64 59 | 22 64 | 56 43 64 | 50 7 4 64 | 42 24 | 64 32 42 | 64 20 58 | | | | | |
| 66 | 66 0 | 0 0 | 65 59 | 27 65 | 55 54 65 | 49 20 | 65 41 | 45 65 | 31 12 8 | 65 18 14 29 | | | | |
| 67 | 67 0 | 0 0 | 66 59 | 33 66 | 55 5 6 66 | 49 38 | 66 40 | 10 9 66 | 29 37 | 66 16 15 3 | | | | |
| 68 | 68 0 | 0 0 | 67 59 | 40 67 | 55 19 67 | 48 58 | 67 39 | 34 67 | 28 13 9 | 67 14 40 | | | | |
| 69 | 69 0 | 0 0 | 68 59 | 47 68 | 55 34 68 | 48 8 19 | 68 38 | 11 2 68 | 26 43 | 68 12 16 21 | | | | |
| 70 | 70 0 | 0 0 | 69 59 | 55 69 | 54 50 69 | 47 43 | 69 37 | 33 69 | 25 14 21 | 69 9 17 5 | | | | |
| 71 | 71 0 | 0 0 | 70 58 | 3 4 70 | 54 6 7 70 | 46 9 9 | 70 36 | 12 7 70 | 23 15 2 | 70 6 54 | | | | |
| 72 | 72 0 | 0 0 | 71 58 | 14 71 | 54 27 71 | 46 38 | 71 35 | 45 71 | 20 48 | 71 3 18 47 | | | | |
| 73 | 73 0 | 0 0 | 72 58 | 25 72 | 53 49 72 | 45 10 10 | 72 33 | 13 27 72 | 18 16 40 | 72 0 19 46 | | | | |
| 74 | 74 0 | 0 0 | 73 58 | 37 73 | 53 7 13 73 | 44 46 73 | 31 14 14 | 73 15 17 | 37 56 | 20 52 | | | | |
| 75 | 75 0 | 0 0 | 74 58 | 51 74 | 52 41 74 | 43 11 27 | 74 29 | 15 7 74 | 12 18 41 | 73 52 22 6 | | | | |
| 76 | 76 0 | 0 0 | 75 58 | 4 8 75 | 52 8 13 75 | 41 12 13 | 75 27 | 16 7 75 | 9 19 53 | 74 47 23 29 | | | | |
| 77 | 77 0 | 0 0 | 76 58 | 26 76 | 51 50 76 | 40 13 7 | 76 25 | 17 16 76 | 5 21 15 | 75 42 25 3 | | | | |
| 78 | 78 0 | 0 0 | 77 58 | 48 77 | 50 9 32 77 | 38 14 9 | 77 22 | 18 35 77 | 1 22 49 | 76 36 26 49 | | | | |
| 79 | 79 0 | 0 0 | 78 57 | 5 14 78 | 49 10 22 78 | 36 15 22 | 78 18 | 20 8 56 | 24 38 | 77 29 28 51 | | | | |
| 80 | 80 0 | 0 0 | 79 57 | 44 79 | 48 11 22 79 | 34 16 48 | 79 14 | 21 56 78 | 50 26 44 | 78 21 31 11 | | | | |
| 81 | 81 0 | 0 0 | 80 57 | 6 22 80 | 47 12 35 80 | 31 18 31 | 80 9 | 24 5 79 | 43 29 13 | 79 12 33 54 | | | | |
| 82 | 82 0 | 0 0 | 81 56 | 7 9 81 | 45 14 5 81 | 28 20 38 | 81 4 | 26 41 80 | 34 32 9 | 80 1 37 4 | | | | |
| 83 | 83 0 | 0 0 | 82 56 | 8 9 82 | 43 15 59 82 | 23 23 16 | 57 29 | 51 81 | 24 35 40 | 47 40 47 | | | | |
| 84 | 84 0 | 0 0 | 83 55 | 9 29 83 | 41 18 28 83 | 18 26 38 | 82 48 | 33 47 82 | 12 39 56 | 81 31 45 9 | | | | |
| 85 | 85 0 | 0 0 | 84 54 | 11 20 84 | 37 21 50 84 | 10 31 1 | 83 36 | 38 44 56 | 45 7 82 | 12 50 20 | | | | |
| 86 | 86 0 | 0 0 | 85 53 | 14 3 85 | 32 26 36 85 | 0 36 55 | 84 21 | 45 4 83 | 36 51 26 | 48 56 26 | | | | |
| 87 | 87 0 | 0 0 | 86 50 | 18 27 86 | 24 33 43 45 | 45 2 85 | 0 53 11 | 84 10 | 59 7 83 | 18 63 32 | | | | |
| 88 | 88 0 | 0 0 | 87 46 | 26 34 87 | 10 45 1 86 | 24 56 20 | 32 63 | 29 37 68 | 15 41 71 | 38 41 71 38 | | | | |
| 89 | 89 0 | 0 0 | 88 35 | 45 0 46 | 63 27 50 | 71 35 53 | 75 59 54 | 78 43 55 | 80 34 | | | | | |
| 90 | 90 0 | 0 0 | 89 0 | 90 0 | 88 0 | 90 0 | 87 0 | 90 0 | 86 0 | 90 0 | 85 0 | 90 0 | 84 0 | 90 0 |

Table 13. Kelvin's Sumner Line Table

| b | a = 7° | | a = 8° | | a = 9° | | a = 10° | | a = 11° | | a = 12° | | a = 13° | | |
|----|--------|-----|---------|-----|---------|-----|---------|------|---------|------|---------|------|----------|------|---|
| | K | Q | K | Q | K | Q | K | Q | K | Q | K | Q | K | Q | |
| 0 | 0 0 | 7 0 | 0 0 | 8 0 | 0 0 | 9 0 | 0 0 | 10 0 | 0 0 | 11 0 | 0 0 | 12 0 | 0 0 | 13 0 | |
| 1 | 1 0 | 0 | 59 | 0 | 59 | 0 | 59 | 0 | 59 | 0 | 59 | 0 | 58 | 0 | |
| 2 | 59 | 0 | 1 59 | 0 | 1 59 | 0 | 1 58 | 0 | 1 58 | 0 | 1 57 | 0 | 1 57 | 0 | |
| 3 | 2 59 | 1 | 2 58 | 1 | 2 58 | 1 | 2 57 | 1 | 2 57 | 1 | 2 56 | 1 | 2 55 | 1 | |
| 4 | 3 58 | 1 | 3 58 | 1 | 3 57 | 1 | 3 56 | 1 | 3 56 | 2 | 3 55 | 2 | 3 54 | 2 | |
| 5 | 4 58 | 2 | 4 57 | 2 | 4 56 | 2 | 4 55 | 2 | 4 54 | 3 | 4 53 | 3 | 4 52 | 3 | |
| 6 | 5 57 | 2 | 5 56 | 3 | 5 56 | 3 | 5 55 | 3 | 5 53 | 4 | 5 52 | 4 | 5 51 | 4 | |
| 7 | 6 57 | 3 | 6 56 | 4 | 6 55 | 4 | 6 54 | 4 | 6 52 | 5 | 6 51 | 5 | 6 49 | 6 | |
| 8 | 7 56 | 4 | 7 55 | 5 | 7 54 | 5 | 7 53 | 6 | 7 51 | 6 | 7 49 | 7 | 7 48 | 8 | |
| 9 | 8 56 | 5 | 8 55 | 6 | 8 53 | 7 | 8 52 | 7 | 8 50 | 8 | 8 48 | 9 | 8 46 | 10 | |
| 10 | 9 55 | 6 | 9 54 | 7 | 9 53 | 8 | 9 51 | 9 | 9 49 | 10 | 9 47 | 11 | 9 44 | 12 | |
| 11 | 10 55 | 8 | 10 53 | 9 | 10 52 | 10 | 10 50 | 11 | 10 48 | 12 | 10 45 | 13 | 10 43 | 14 | |
| 12 | 11 55 | 9 | 11 53 | 11 | 11 51 | 12 | 11 49 | 13 | 11 47 | 14 | 11 44 | 16 | 11 41 | 17 | |
| 13 | 12 54 | 11 | 12 52 | 13 | 12 50 | 14 | 12 48 | 15 | 12 45 | 17 | 12 43 | 19 | 12 40 | 20 | |
| 14 | 13 54 | 13 | 13 52 | 15 | 13 49 | 16 | 13 47 | 18 | 13 44 | 20 | 13 41 | 22 | 13 38 | 23 | |
| 15 | 14 53 | 15 | 14 51 | 17 | 14 49 | 19 | 14 46 | 21 | 14 43 | 23 | 14 40 | 25 | 14 36 | 26 | |
| 16 | 15 53 | 17 | 15 50 | 19 | 15 48 | 21 | 15 45 | 24 | 15 42 | 26 | 15 38 | 28 | 15 35 | 30 | |
| 17 | 16 52 | 19 | 16 50 | 22 | 16 47 | 24 | 16 44 | 27 | 16 41 | 29 | 16 37 | 32 | 16 33 | 34 | |
| 18 | 17 52 | 21 | 17 49 | 24 | 17 46 | 27 | 17 43 | 30 | 17 39 | 33 | 17 36 | 36 | 17 31 | 39 | |
| 19 | 18 51 | 24 | 18 48 | 27 | 18 45 | 30 | 18 42 | 34 | 18 38 | 37 | 18 34 | 40 | 18 30 | 43 | |
| 20 | 19 51 | 27 | 19 48 | 30 | 19 45 | 34 | 19 41 | 38 | 19 37 | 41 | 19 33 | 45 | 19 28 | 48 | |
| 21 | 20 50 | 30 | 20 47 | 34 | 20 44 | 38 | 20 40 | 42 | 20 36 | 46 | 20 31 | 50 | 20 26 | 53 | |
| 22 | 21 50 | 33 | 21 46 | 37 | 21 43 | 42 | 21 39 | 46 | 21 35 | 51 | 21 30 | 55 | 21 24 | 59 | |
| 23 | 22 49 | 36 | 22 46 | 41 | 22 42 | 46 | 22 38 | 51 | 22 33 | 56 | 22 28 | 13 | 0 22 23 | 14 | 5 |
| 24 | 23 49 | 39 | 23 45 | 45 | 23 41 | 50 | 23 37 | 56 | 23 32 | 12 | 1 23 27 | 6 | 23 21 | 11 | |
| 25 | 24 48 | 43 | 24 44 | 49 | 24 40 | 55 | 24 36 | 11 | 1 24 31 | 6 | 24 25 | 12 | 24 19 | 17 | |
| 26 | 25 48 | 47 | 25 44 | 53 | 25 39 | 10 | 0 25 35 | 6 | 25 29 | 12 | 25 23 | 18 | 25 17 | 24 | |
| 27 | 26 47 | 51 | 26 43 | 58 | 26 38 | 5 | 26 33 | 12 | 26 28 | 18 | 26 22 | 25 | 26 15 | 31 | |
| 28 | 27 46 | 55 | 27 42 | 9 | 3 27 38 | 10 | 27 32 | 18 | 27 27 | 25 | 27 20 | 32 | 27 13 | 39 | |
| 29 | 28 46 | 59 | 28 41 | 8 | 28 37 | 16 | 28 31 | 24 | 28 25 | 32 | 28 18 | 40 | 28 11 | 47 | |
| 30 | 29 45 | 8 | 4 29 41 | 13 | 29 36 | 22 | 29 30 | 31 | 29 24 | 39 | 29 17 | 48 | 29 9 | 56 | |
| 31 | 30 45 | 9 | 30 40 | 19 | 30 35 | 28 | 30 29 | 38 | 30 22 | 47 | 30 15 | 56 | 30 7 | 15 | 5 |
| 32 | 31 44 | 14 | 31 39 | 25 | 31 34 | 35 | 31 27 | 45 | 31 21 | 55 | 31 13 | 14 | 4 31 5 | 14 | |
| 33 | 32 43 | 20 | 32 38 | 31 | 32 33 | 42 | 32 26 | 52 | 32 19 | 13 | 3 32 11 | 13 | 32 3 | 24 | |
| 34 | 33 43 | 26 | 33 37 | 37 | 33 32 | 49 | 33 25 | 12 | 0 33 18 | 12 | 33 10 | 23 | 33 1 | 34 | |
| 35 | 34 42 | 32 | 34 37 | 44 | 34 30 | 57 | 34 24 | 9 | 34 16 | 21 | 34 8 | 33 | 59 | 44 | |
| 36 | 35 41 | 38 | 35 36 | 51 | 35 29 | 11 | 5 35 22 | 18 | 35 14 | 31 | 35 6 | 43 | 34 56 | 55 | |
| 37 | 36 41 | 45 | 36 35 | 59 | 36 28 | 13 | 36 21 | 27 | 36 13 | 41 | 36 4 | 54 | 35 54 | 16 | 7 |
| 38 | 37 40 | 52 | 37 34 | 10 | 7 37 27 | 22 | 37 19 | 37 | 37 11 | 51 | 37 2 | 15 | 6 36 52 | 20 | |
| 39 | 38 39 | 59 | 38 33 | 15 | 38 26 | 31 | 38 18 | 47 | 38 9 | 14 | 2 38 0 | 18 | 37 49 | 33 | |
| 40 | 39 39 | 9 | 6 39 32 | 24 | 39 25 | 41 | 39 16 | 58 | 39 7 | 14 | 57 | 31 | 38 47 | 46 | |
| 41 | 40 38 | 14 | 40 31 | 33 | 40 23 | 51 | 40 15 | 13 | 9 40 5 | 27 | 39 55 | 44 | 39 44 | 17 | 0 |
| 42 | 41 37 | 23 | 41 30 | 43 | 41 22 | 12 | 2 41 13 | 21 | 41 3 | 40 | 40 53 | 58 | 40 41 | 15 | |
| 43 | 42 36 | 32 | 42 29 | 53 | 42 21 | 13 | 42 12 | 33 | 42 1 | 53 | 41 51 | 16 | 12 41 39 | 31 | |
| 44 | 43 35 | 41 | 43 28 | 11 | 3 43 19 | 25 | 43 10 | 46 | 59 | 15 | 7 42 48 | 28 | 42 36 | 48 | |
| 45 | 44 34 | 51 | 44 27 | 14 | 44 18 | 38 | 44 8 | 14 | 0 43 57 | 22 | 43 46 | 44 | 43 33 | 18 | 5 |

Table 13. Kelvin's Sumner Line Table

| b | a = 7° | | a = 8° | | a = 9° | | a = 10° | | a = 11° | | a = 12° | | a = 13° | |
|----|--------|-------|--------|-------|--------|-------|---------|-------|---------|-------|---------|-------|---------|-------|
| | K | Q | K | Q | K | Q | K | Q | K | Q | K | Q | K | Q |
| 45 | 44 34 | 9 51 | 44 27 | 11 14 | 44 18 | 12 38 | 44 8 | 14 0 | 43 57 | 15 22 | 43 46 | 16 44 | 43 33 | 18 5 |
| 46 | 45 34 | 10 1 | 45 26 | 26 45 | 45 16 | 51 45 | 6 | 15 | 44 55 | 38 | 44 43 | 17 1 | 44 30 | 23 |
| 47 | 46 33 | 12 | 46 24 | 39 46 | 46 15 | 13 5 | 46 4 | 30 | 45 53 | 55 | 45 40 | 19 | 45 27 | 42 |
| 48 | 47 32 | 24 | 47 23 | 52 47 | 47 13 | 19 | 47 2 | 46 | 46 51 | 16 12 | 46 38 | 37 | 46 24 | 19 2 |
| 49 | 48 31 | 36 | 48 22 | 12 6 | 48 12 | 34 | 48 0 | 15 3 | 47 48 | 30 | 47 35 | 57 | 47 20 | 23 |
| 50 | 49 30 | 49 | 49 20 | 20 | 49 10 | 51 | 58 | 20 | 48 46 | 50 | 48 32 | 18 18 | 48 17 | 45 |
| 51 | 50 29 | 11 2 | 50 19 | 35 | 50 8 | 14 8 | 49 56 | 39 | 49 43 | 17 10 | 49 29 | 40 | 49 13 | 20 9 |
| 52 | 51 27 | 17 | 51 18 | 52 | 51 6 | 26 | 50 54 | 59 | 50 40 | 31 | 50 26 | 19 3 | 50 9 | 33 |
| 53 | 52 26 | 32 | 52 16 | 13 9 | 52 4 | 45 | 51 52 | 16 20 | 51 37 | 54 | 51 22 | 27 | 51 5 | 59 |
| 54 | 53 25 | 48 | 53 14 | 27 | 53 2 | 15 5 | 52 49 | 42 | 52 34 | 18 18 | 52 19 | 53 | 52 1 | 21 27 |
| 55 | 54 24 | 12 5 | 54 13 | 46 | 54 0 | 26 | 53 47 | 17 5 | 53 31 | 43 | 53 15 | 20 20 | 57 | 56 |
| 56 | 55 22 | 23 | 55 11 | 14 6 | 58 | 49 | 54 44 | 30 | 54 28 | 19 10 | 54 11 | 49 | 53 53 | 22 26 |
| 57 | 56 21 | 42 | 56 9 | 28 | 55 56 | 16 13 | 55 41 | 56 | 55 25 | 39 | 55 7 | 21 19 | 54 48 | 58 |
| 58 | 57 19 | 13 3 | 57 7 | 51 | 56 53 | 39 | 56 38 | 18 24 | 56 21 | 20 9 | 56 3 | 51 | 55 43 | 23 33 |
| 59 | 58 18 | 25 | 58 5 | 15 16 | 57 51 | 17 6 | 57 35 | 54 | 57 17 | 41 | 59 | 22 26 | 56 38 | 24 9 |
| 60 | 59 16 | 48 | 59 3 | 42 | 58 48 | 35 | 58 32 | 19 26 | 58 13 | 21 15 | 57 54 | 23 2 | 57 33 | 47 |
| 61 | 60 14 | 14 13 | 60 1 | 16 10 | 59 45 | 18 6 | 59 28 | 59 | 59 9 | 51 | 58 49 | 41 | 58 27 | 25 28 |
| 62 | 61 12 | 39 | 58 | 40 | 60 42 | 39 | 60 24 | 20 35 | 60 5 | 22 30 | 59 44 | 24 22 | 59 21 | 26 11 |
| 63 | 62 10 | 15 8 | 61 56 | 17 12 | 61 39 | 19 14 | 61 20 | 21 14 | 61 0 | 23 11 | 60 38 | 25 5 | 60 15 | 57 |
| 64 | 63 8 | 39 | 62 53 | 47 | 62 36 | 52 | 62 16 | 55 | 55 | 55 | 61 32 | 52 | 61 8 | 27 46 |
| 65 | 64 6 | 16 12 | 63 50 | 18 24 | 63 32 | 20 33 | 63 12 | 22 39 | 62 50 | 24 42 | 62 26 | 26 42 | 62 1 | 28 39 |
| 66 | 65 4 | 48 | 64 47 | 19 4 | 64 28 | 21 17 | 64 7 | 23 26 | 63 44 | 25 33 | 63 20 | 27 36 | 53 | 29 35 |
| 67 | 66 1 | 17 27 | 65 43 | 47 | 65 24 | 22 4 | 65 2 | 24 17 | 64 38 | 26 27 | 64 13 | 28 33 | 63 45 | 30 35 |
| 68 | 67 58 | 18 9 | 66 39 | 20 34 | 66 19 | 55 | 56 | 25 12 | 65 32 | 27 26 | 65 5 | 29 34 | 64 37 | 31 39 |
| 69 | 67 55 | 55 | 67 35 | 21 25 | 67 14 | 23 51 | 66 50 | 26 12 | 66 25 | 28 29 | 57 | 30 40 | 65 28 | 32 47 |
| 70 | 68 52 | 19 45 | 68 31 | 22 20 | 68 9 | 24 51 | 67 44 | 27 16 | 67 17 | 29 37 | 66 48 | 31 52 | 66 18 | 34 1 |
| 71 | 69 48 | 20 40 | 69 26 | 23 21 | 69 3 | 25 56 | 68 37 | 28 26 | 68 9 | 30 50 | 67 39 | 33 8 | 67 7 | 35 20 |
| 72 | 70 44 | 21 40 | 70 21 | 24 27 | 57 27 | 8 | 69 29 | 29 43 | 69 0 | 32 10 | 68 29 | 34 31 | 55 | 36 46 |
| 73 | 71 39 | 22 47 | 71 16 | 25 40 | 70 50 | 28 27 | 70 21 | 31 6 | 50 | 33 37 | 69 18 | 36 1 | 68 43 | 38 18 |
| 74 | 72 34 | 24 1 | 72 10 | 27 1 | 71 42 | 29 53 | 71 12 | 32 36 | 70 40 | 35 12 | 70 6 | 37 38 | 69 30 | 39 57 |
| 75 | 73 29 | 25 23 | 73 3 | 28 30 | 72 34 | 31 28 | 72 2 | 34 16 | 71 28 | 36 55 | 53 | 39 24 | 70 15 | 41 44 |
| 76 | 74 23 | 26 55 | 55 | 30 9 | 73 24 | 33 13 | 51 | 36 5 | 72 16 | 38 47 | 71 38 | 41 18 | 59 | 43 40 |
| 77 | 75 16 | 28 38 | 74 46 | 32 0 | 74 14 | 35 9 | 73 39 | 38 5 | 73 2 | 40 50 | 72 23 | 43 23 | 71 42 | 45 45 |
| 78 | 76 8 | 30 34 | 75 37 | 34 4 | 75 2 | 37 18 | 74 26 | 40 18 | 47 | 43 4 | 73 6 | 45 38 | 72 23 | 48 0 |
| 79 | 59 | 32 46 | 76 26 | 36 23 | 49 | 39 42 | 75 11 | 42 44 | 74 30 | 45 32 | 47 | 48 5 | 73 2 | 50 26 |
| 80 | 77 49 | 35 16 | 77 13 | 38 59 | 76 35 | 42 22 | 54 | 45 26 | 75 11 | 48 13 | 74 26 | 50 45 | 39 | 53 3 |
| 81 | 78 37 | 38 8 | 59 | 41 56 | 77 18 | 45 21 | 76 35 | 48 25 | 49 | 51 10 | 75 2 | 53 39 | 74 14 | 55 53 |
| 82 | 79 23 | 41 25 | 78 42 | 45 17 | 59 | 48 42 | 77 13 | 51 43 | 76 26 | 54 24 | 37 | 56 47 | 46 | 58 55 |
| 83 | 80 7 | 45 13 | 79 23 | 49 4 | 78 37 | 52 25 | 49 | 55 21 | 59 | 57 55 | 76 8 | 60 10 | 75 16 | 62 10 |
| 84 | 47 | 49 36 | 80 1 | 53 22 | 79 12 | 56 35 | 78 21 | 59 20 | 77 29 | 61 44 | 36 | 63 49 | 42 | 65 38 |
| 85 | 81 24 | 54 38 | 35 | 58 12 | 43 | 61 11 | 50 | 63 42 | 56 | 65 51 | 77 1 | 67 42 | 76 5 | 69 19 |
| 86 | 57 | 60 24 | 81 4 | 63 36 | 80 9 | 66 14 | 79 14 | 68 25 | 78 18 | 70 16 | 22 | 71 50 | 25 | 73 11 |
| 87 | 82 23 | 66 55 | 28 | 69 35 | 31 | 71 43 | 34 | 73 28 | 36 | 74 56 | 38 | 76 10 | 40 | 77 14 |
| 88 | 43 | 74 8 | 45 | 76 3 | 47 | 77 34 | 48 | 78 48 | 49 | 79 49 | 50 | 80 41 | 51 | 81 24 |
| 89 | 56 | 81 55 | 56 | 82 55 | 57 | 83 43 | 57 | 84 21 | 57 | 84 52 | 58 | 85 18 | 58 | 85 41 |
| 90 | 83 0 | 90 0 | 82 0 | 90 0 | 81 0 | 90 0 | 80 0 | 90 0 | 79 0 | 90 0 | 78 0 | 90 0 | 77 0 | 90 0 |

Table 13. Kelvin's Summer Line Table

| b. | a = 14° | | a = 15° | | a = 16° | | a = 17° | | a = 18° | | a = 19° | | a = 20° | | | | | | | | | | |
|----|---------|------|---------|------|---------|------|---------|------|---------|------|---------|------|---------|------|-------|----|-------|----|----|----|----|----|----|
| | K | Q | K | Q | K | Q | K | Q | K | Q | K | Q | K | Q | | | | | | | | | |
| 0 | 0 0 | 14 0 | 0 0 | 15 0 | 0 0 | 16 0 | 0 0 | 17 0 | 0 0 | 18 0 | 0 0 | 19 0 | 0 0 | 20 0 | | | | | | | | | |
| 1 | 58 | 0 | 58 | 0 | 58 | 0 | 57 | 0 | 57 | 0 | 57 | 0 | 56 | 0 | | | | | | | | | |
| 2 | 1 56 | 0 | 1 56 | 1 | 1 55 | 1 | 1 55 | 1 | 1 54 | 1 | 1 54 | 1 | 1 53 | 1 | | | | | | | | | |
| 3 | 2 55 | 1 | 2 54 | 1 | 2 53 | 1 | 2 52 | 1 | 2 51 | 1 | 2 50 | 2 | 2 49 | 2 | | | | | | | | | |
| 4 | 3 53 | 2 | 3 52 | 2 | 3 51 | 2 | 3 49 | 2 | 3 48 | 2 | 3 47 | 3 | 3 46 | 3 | | | | | | | | | |
| 5 | 4 51 | 3 | 4 50 | 3 | 4 48 | 3 | 4 47 | 4 | 4 45 | 4 | 4 44 | 4 | 4 42 | 4 | | | | | | | | | |
| 6 | 5 49 | 4 | 5 48 | 5 | 5 46 | 5 | 5 44 | 5 | 5 42 | 6 | 5 40 | 6 | 5 38 | 6 | | | | | | | | | |
| 7 | 6 47 | 6 | 6 46 | 7 | 6 44 | 7 | 6 42 | 7 | 6 39 | 8 | 6 37 | 8 | 6 35 | 8 | | | | | | | | | |
| 8 | 7 46 | 8 | 7 44 | 9 | 7 41 | 9 | 7 39 | 9 | 7 36 | 10 | 7 34 | 10 | 7 31 | 11 | | | | | | | | | |
| 9 | 8 44 | 10 | 8 41 | 11 | 8 39 | 11 | 8 36 | 12 | 8 33 | 13 | 8 30 | 13 | 8 27 | 14 | | | | | | | | | |
| 10 | 9 42 | 12 | 9 39 | 13 | 9 37 | 14 | 9 34 | 15 | 9 30 | 16 | 9 27 | 16 | 9 23 | 17 | | | | | | | | | |
| 11 | 10 40 | 15 | 10 37 | 16 | 10 34 | 17 | 10 31 | 18 | 10 27 | 19 | 10 24 | 20 | 10 20 | 21 | | | | | | | | | |
| 12 | 11 38 | 18 | 11 35 | 19 | 11 32 | 20 | 11 28 | 21 | 11 24 | 23 | 11 20 | 24 | 11 16 | 25 | | | | | | | | | |
| 13 | 12 36 | 21 | 12 33 | 22 | 12 29 | 24 | 12 25 | 25 | 12 21 | 27 | 12 17 | 28 | 12 12 | 29 | | | | | | | | | |
| 14 | 13 35 | 25 | 13 31 | 26 | 13 27 | 28 | 13 23 | 29 | 13 18 | 31 | 13 13 | 32 | 13 8 | 34 | | | | | | | | | |
| 15 | 14 33 | 28 | 14 29 | 30 | 14 24 | 32 | 14 20 | 34 | 14 15 | 36 | 14 10 | 37 | 14 5 | 39 | | | | | | | | | |
| 16 | 15 31 | 32 | 15 26 | 35 | 15 22 | 37 | 15 17 | 39 | 15 12 | 41 | 15 6 | 42 | 15 1 | 44 | | | | | | | | | |
| 17 | 16 29 | 37 | 16 24 | 39 | 16 19 | 42 | 16 14 | 44 | 16 9 | 46 | 16 3 | 48 | 57 | 50 | | | | | | | | | |
| 18 | 17 27 | 41 | 17 22 | 44 | 17 17 | 47 | 17 11 | 49 | 17 6 | 52 | 59 | 54 | 16 53 | 56 | | | | | | | | | |
| 19 | 18 25 | 46 | 18 20 | 49 | 18 14 | 52 | 18 8 | 55 | 18 2 | 58 | 17 56 | 20 | 17 49 | 21 | 3 | | | | | | | | |
| 20 | 19 23 | 52 | 19 17 | 55 | 19 12 | 58 | 19 5 | 18 | 1 | 59 | 19 | 4 | 18 52 | 8 | 18 45 | 10 | | | | | | | |
| 21 | 20 21 | 57 | 20 15 | 16 | 1 | 20 | 9 | 17 | 4 | 20 | 2 | 8 | 19 56 | 11 | 19 48 | 15 | 19 41 | 18 | | | | | |
| 22 | 21 19 | 15 | 3 | 21 | 13 | 7 | 21 | 6 | 11 | 59 | 15 | 20 | 52 | 19 | 20 | 45 | 22 | 20 | 37 | 26 | | | |
| 23 | 22 17 | 9 | 22 | 10 | 14 | 22 | 4 | 18 | 21 | 56 | 22 | 21 | 49 | 27 | 21 | 41 | 30 | 21 | 32 | 34 | | | |
| 24 | 23 15 | 16 | 23 | 8 | 21 | 23 | 1 | 26 | 22 | 53 | 30 | 22 | 45 | 35 | 22 | 37 | 39 | 22 | 28 | 43 | | | |
| 25 | 24 13 | 23 | 24 | 6 | 28 | 58 | 34 | 23 | 50 | 38 | 23 | 42 | 43 | 23 | 33 | 48 | 23 | 24 | 53 | | | | |
| 26 | 25 10 | 30 | 25 | 3 | 36 | 24 | 55 | 42 | 24 | 47 | 47 | 24 | 38 | 52 | 24 | 29 | 58 | 24 | 20 | 22 | 3 | | |
| 27 | 26 8 | 38 | 26 | 1 | 44 | 25 | 52 | 50 | 25 | 44 | 56 | 25 | 35 | 20 | 2 | 25 | 25 | 21 | 8 | 25 | 15 | 13 | |
| 28 | 27 6 | 46 | 58 | 53 | 26 | 50 | 59 | 26 | 41 | 19 | 6 | 26 | 31 | 12 | 26 | 21 | 18 | 26 | 11 | 24 | | | |
| 29 | 28 4 | 55 | 27 | 55 | 17 | 2 | 27 | 47 | 18 | 9 | 27 | 37 | 16 | 27 | 27 | 23 | 27 | 17 | 29 | 27 | 6 | 36 | |
| 30 | 29 1 | 16 | 4 | 28 | 53 | 12 | 28 | 44 | 19 | 28 | 34 | 27 | 28 | 24 | 34 | 28 | 13 | 41 | 28 | 2 | 48 | | |
| 31 | 59 | 13 | 29 | 50 | 22 | 29 | 41 | 30 | 29 | 30 | 38 | 29 | 20 | 46 | 29 | 9 | 53 | 57 | 23 | 1 | | | |
| 32 | 30 57 | 23 | 30 | 47 | 32 | 30 | 37 | 41 | 30 | 27 | 50 | 30 | 16 | 58 | 30 | 4 | 22 | 6 | 29 | 52 | 14 | | |
| 33 | 31 54 | 33 | 31 | 44 | 43 | 31 | 34 | 53 | 31 | 23 | 20 | 2 | 31 | 12 | 21 | 11 | 31 | 0 | 19 | 30 | 47 | 28 | |
| 34 | 32 52 | 44 | 32 | 42 | 55 | 32 | 31 | 19 | 5 | 32 | 20 | 15 | 32 | 8 | 24 | 55 | 33 | 31 | 42 | 42 | | | |
| 35 | 33 49 | 56 | 33 | 39 | 18 | 7 | 33 | 28 | 18 | 33 | 16 | 28 | 33 | 4 | 38 | 32 | 51 | 48 | 32 | 37 | 57 | | |
| 36 | 34 46 | 17 | 8 | 34 | 36 | 20 | 34 | 24 | 31 | 34 | 12 | 42 | 59 | 53 | 33 | 46 | 23 | 3 | 33 | 32 | 24 | 13 | |
| 37 | 35 44 | 20 | 35 | 33 | 33 | 35 | 21 | 45 | 35 | 8 | 57 | 34 | 55 | 22 | 8 | 34 | 41 | 19 | 34 | 26 | 30 | 8 | |
| 38 | 36 41 | 33 | 36 | 29 | 47 | 36 | 17 | 20 | 0 | 36 | 4 | 21 | 12 | 35 | 50 | 24 | 35 | 36 | 36 | 35 | 21 | 48 | |
| 39 | 37 38 | 47 | 37 | 26 | 19 | 1 | 37 | 13 | 15 | 37 | 0 | 28 | 36 | 46 | 41 | 36 | 31 | 54 | 36 | 15 | 25 | 6 | |
| 40 | 38 35 | 18 | 2 | 38 | 23 | 17 | 38 | 10 | 31 | 56 | 45 | 37 | 41 | 59 | 37 | 26 | 24 | 12 | 37 | 9 | 25 | | |
| 41 | 39 32 | 17 | 39 | 19 | 33 | 39 | 6 | 48 | 38 | 52 | 22 | 3 | 38 | 36 | 23 | 18 | 38 | 20 | 32 | 38 | 3 | 45 | |
| 42 | 40 29 | 33 | 40 | 16 | 50 | 40 | 2 | 21 | 6 | 39 | 47 | 22 | 39 | 31 | 37 | 39 | 15 | 52 | 57 | 26 | 6 | | |
| 43 | 41 26 | 50 | 41 | 12 | 20 | 7 | 58 | 25 | 40 | 42 | 41 | 40 | 26 | 57 | 40 | 9 | 25 | 13 | 39 | 51 | 27 | | |
| 44 | 42 23 | 19 | 7 | 42 | 9 | 26 | 41 | 54 | 44 | 41 | 38 | 23 | 2 | 41 | 21 | 24 | 18 | 41 | 3 | 35 | 40 | 45 | 50 |
| 45 | 43 19 | 25 | 43 | 5 | 45 | 42 | 49 | 22 | 4 | 42 | 33 | 23 | 42 | 16 | 41 | 57 | 58 | 41 | 39 | 27 | 14 | | |

Table 13. Kelvin's Sumner Line Table

| b | a = 14° | | a = 15° | | a = 16° | | a = 17° | | a = 18° | | a = 19° | | a = 20° | |
|----|---------|---------------|-------------|--------------|---------------|-------------|-------------|----------------|----------|-------|---------|-------|---------|-------|
| | K | Q | K | Q | K | Q | K | Q | K | Q | K | Q | K | Q |
| 45 | 43 19 | 19 25 | 43 5 | 20 45 | 42 49 | 22 4 | 42 33 | 23 23 | 42 16 | 24 41 | 41 57 | 25 58 | 41 39 | 27 14 |
| 46 | 44 16 | 45 44 | 1 21 | 6 43 45 | 26 43 28 | 45 43 10 | 25 4 | 42 51 | 26 22 | 42 32 | 39 | | | |
| 47 | 45 12 | 20 5 | 57 | 27 44 40 | 48 44 23 | 24 9 | 44 4 | 28 43 45 | 47 43 25 | 28 5 | | | | |
| 48 | 46 8 | 26 45 53 | 49 45 35 | 23 12 | 45 18 | 33 | 58 | 54 44 39 | 27 14 | 44 18 | 33 | | | |
| 49 | 47 4 | 48 46 48 | 22 13 | 46 30 | 37 46 12 | 59 45 52 | 26 21 | 45 32 | 42 45 10 | 29 1 | | | | |
| 50 | 48 0 | 21 12 47 44 | 38 47 25 | 24 3 47 6 | 25 26 46 46 | 49 46 25 | 28 11 | 46 2 | 31 | | | | | |
| 51 | 56 | 37 48 39 | 23 4 48 20 | 30 48 0 | 55 47 39 | 27 18 | 47 18 | 41 | 54 30 3 | | | | | |
| 52 | 49 52 | 22 3 49 34 | 31 49 15 | 59 54 26 | 25 48 32 | 49 48 10 | 29 13 | 47 46 | 36 | | | | | |
| 53 | 50 48 | 30 50 29 | 24 0 50 9 | 25 29 49 48 | 56 49 25 | 28 22 | 49 2 | 47 48 38 | 31 10 | | | | | |
| 54 | 51 43 | 59 51 24 | 30 51 3 | 26 0 50 41 | 27 29 50 18 | 56 | 54 30 22 | 49 29 | 46 | | | | | |
| 55 | 52 38 | 23 30 52 18 | 25 2 57 34 | 51 34 28 4 | 51 10 29 32 | 50 46 | 59 50 20 | 32 24 | | | | | | |
| 56 | 53 33 | 24 2 53 12 | 36 52 50 | 27 9 52 27 | 40 52 2 30 10 | 51 37 | 31 37 | 51 10 33 3 | | | | | | |
| 57 | 54 28 | 36 54 6 | 26 12 53 43 | 46 53 20 | 29 18 | 54 49 52 28 | 32 18 | 52 0 45 | | | | | | |
| 58 | 55 22 | 25 12 55 0 | 49 54 36 | 28 25 54 12 | 59 53 46 | 31 31 | 53 18 | 33 1 | 50 34 29 | | | | | |
| 59 | 56 16 | 50 53 27 | 29 55 29 | 29 6 55 4 | 30 42 54 37 | 32 15 | 54 8 | 46 53 39 | 35 15 | | | | | |
| 60 | 57 10 | 26 30 56 46 | 28 11 56 21 | 50 55 31 27 | 55 27 33 1 | 58 34 33 | 54 28 | 36 3 | | | | | | |
| 61 | 58 4 | 27 13 57 39 | 56 57 13 | 30 36 56 46 | 32 14 56 17 | 50 55 47 | 35 23 | 55 16 54 | | | | | | |
| 62 | 57 | 59 58 31 | 29 43 58 4 | 31 25 57 36 | 33 4 57 7 | 34 41 56 36 | 36 16 | 56 4 37 47 | | | | | | |
| 63 | 59 50 | 28 47 59 23 | 30 33 55 32 | 17 58 26 | 57 56 35 35 | 57 24 | 37 11 | 51 38 43 | | | | | | |
| 64 | 60 42 | 29 38 60 15 | 31 26 59 46 | 33 11 59 16 | 34 53 58 44 | 36 33 58 11 | 38 9 | 57 38 39 42 | | | | | | |
| 65 | 61 34 | 30 32 61 6 | 32 23 60 36 | 34 9 60 5 | 35 53 59 32 | 37 33 58 39 | 10 58 24 | 40 44 | | | | | | |
| 66 | 62 25 | 31 31 56 33 | 23 61 25 | 35 11 53 36 | 56 60 19 | 38 37 59 44 | 40 15 | 59 9 41 49 | | | | | | |
| 67 | 63 16 | 32 33 62 46 | 34 27 62 14 | 36 17 61 41 | 38 3 61 6 | 39 45 | 60 30 | 41 23 53 42 58 | | | | | | |
| 68 | 64 7 | 33 39 63 35 | 35 35 63 2 | 37 26 62 28 | 39 13 52 40 | 56 61 15 | 42 35 | 60 36 44 11 | | | | | | |
| 69 | 56 34 | 50 64 23 | 36 47 49 38 | 40 63 14 | 40 28 62 37 | 42 12 58 43 | 51 61 19 | 45 27 | | | | | | |
| 70 | 65 45 | 36 5 65 11 | 38 4 64 36 | 39 58 59 41 | 48 63 21 | 43 32 62 41 | 45 11 62 1 | 46 47 | | | | | | |
| 71 | 66 33 | 37 27 58 39 | 27 65 21 | 41 22 64 43 | 43 12 64 4 | 44 56 63 23 | 46 36 41 | 48 11 | | | | | | |
| 72 | 67 20 | 38 54 66 44 | 40 56 66 6 | 42 52 65 26 | 44 42 65 26 | 48 1 43 49 | 40 59 51 | 14 49 40 | | | | | | |
| 73 | 68 7 | 40 27 67 29 | 42 30 49 44 | 27 66 8 | 46 17 65 26 | 48 1 43 49 | 40 59 51 | 14 49 40 | | | | | | |
| 74 | 52 42 | 8 68 12 | 44 11 67 31 | 46 8 49 47 | 58 66 6 | 49 42 65 21 | 51 19 64 36 | 52 52 | | | | | | |
| 75 | 69 36 | 43 56 55 45 | 59 68 12 | 47 56 67 29 | 49 45 44 51 | 28 58 53 | 4 65 11 | 54 35 | | | | | | |
| 76 | 70 18 | 45 52 69 36 | 47 55 52 49 | 51 68 7 | 51 39 67 20 | 53 20 66 33 | 54 55 45 | 56 23 | | | | | | |
| 77 | 59 47 | 57 70 15 | 49 59 69 30 | 51 53 43 53 | 39 55 55 | 18 67 7 | 56 51 66 18 | 58 17 | | | | | | |
| 78 | 71 38 | 50 11 53 52 | 12 70 6 54 | 3 69 18 | 55 47 68 29 | 57 23 39 58 | 53 48 60 | 16 48 60 16 | | | | | | |
| 79 | 72 16 | 52 35 71 28 | 54 33 40 56 | 21 50 58 | 2 69 0 59 | 35 68 9 61 | 0 67 17 | 62 20 | | | | | | |
| 80 | 51 55 | 9 72 2 57 3 | 71 12 58 48 | 70 21 60 24 | 29 61 53 | 37 63 14 | 44 64 30 | | | | | | | |
| 81 | 73 24 | 57 54 34 59 | 43 42 61 | 23 50 62 54 | 56 64 18 | 69 3 65 34 | 68 9 66 45 | | | | | | | |
| 82 | 55 60 | 50 73 3 62 33 | 72 9 64 7 | 71 16 65 31 | 70 21 66 49 | 27 68 0 | 31 69 5 | | | | | | | |
| 83 | 74 23 | 63 57 29 65 | 32 34 66 59 | 39 68 16 | 44 69 26 | 48 70 31 | 51 71 29 | | | | | | | |
| 84 | 48 67 | 15 52 68 41 | 56 69 59 | 72 0 71 7 | 71 3 72 10 | 70 7 73 7 | 69 9 73 59 | | | | | | | |
| 85 | 75 9 | 70 44 74 12 | 71 59 73 15 | 73 6 18 74 5 | 20 74 59 | 23 75 48 | 25 76 32 | | | | | | | |
| 86 | 27 74 | 22 29 75 25 | 31 76 20 | 33 77 9 | 35 77 53 | 36 78 33 | 37 79 9 | | | | | | | |
| 87 | 41 78 | 9 43 78 57 | 44 79 39 | 45 80 17 | 46 80 51 | 46 81 22 | 47 81 49 | | | | | | | |
| 88 | 52 82 | 2 52 82 35 | 53 83 4 | 53 83 29 | 54 83 52 | 54 84 13 | 54 84 31 | | | | | | | |
| 89 | 58 86 | 0 58 86 16 | 58 86 31 | 58 86 44 | 58 86 55 | 58 87 6 | 59 87 15 | | | | | | | |
| 90 | 76 0 | 90 0 75 0 | 90 0 74 0 | 90 0 73 0 | 90 0 72 0 | 90 0 71 0 | 90 0 70 0 | | | | | | | |

Table 13. Kelvin's Sumner Line Table

| b | a = 21° | | a = 22° | | a = 23° | | a = 24° | | a = 25° | | a = 26° | | a = 27° | |
|----|---------|-------|---------|-------|---------|-------|---------|-------|---------|-------|---------|-------|---------|------|
| | K | Q | K | Q | K | Q | K | Q | K | Q | K | Q | K | Q |
| 0 | 0 0 | 21 0 | 0 0 | 22 0 | 0 0 | 23 0 | 0 0 | 24 0 | 0 0 | 25 0 | 0 0 | 26 0 | 0 0 | 27 0 |
| 1 | 56 | 0 | 56 | 0 | 55 | 0 | 55 | 0 | 54 | 0 | 54 | 0 | 53 | 0 |
| 2 | 1 52 | 1 1 | 1 51 | 1 1 | 1 51 | 1 1 | 1 50 | 1 1 | 1 49 | 1 1 | 1 48 | 1 1 | 1 47 | 1 |
| 3 | 2 48 | 2 2 | 2 47 | 2 2 | 2 46 | 2 2 | 2 44 | 2 2 | 2 43 | 2 2 | 2 42 | 2 2 | 2 40 | 2 |
| 4 | 3 44 | 3 3 | 3 42 | 3 3 | 3 41 | 3 3 | 3 39 | 3 3 | 3 38 | 3 3 | 3 36 | 3 3 | 3 34 | 3 |
| 5 | 4 40 | 4 4 | 4 38 | 5 4 | 4 36 | 5 4 | 4 34 | 5 4 | 4 32 | 5 4 | 4 30 | 5 4 | 4 27 | 5 |
| 6 | 5 36 | 6 5 | 5 34 | 7 5 | 5 31 | 7 5 | 5 29 | 7 5 | 5 26 | 7 5 | 5 23 | 7 5 | 5 21 | 8 |
| 7 | 6 32 | 9 6 | 6 29 | 9 6 | 6 26 | 9 6 | 6 24 | 10 6 | 6 20 | 10 6 | 6 17 | 10 6 | 6 14 | 11 |
| 8 | 7 28 | 11 7 | 7 25 | 12 7 | 7 22 | 12 7 | 7 18 | 13 7 | 7 15 | 13 7 | 7 11 | 13 7 | 7 7 | 14 |
| 9 | 8 24 | 14 8 | 8 20 | 15 8 | 8 17 | 15 8 | 8 13 | 16 8 | 8 9 | 16 8 | 8 5 | 17 8 | 8 1 | 17 |
| 10 | 9 20 | 18 9 | 9 16 | 18 9 | 9 12 | 19 9 | 9 8 | 20 9 | 9 3 | 20 9 | 59 | 21 5 | 54 | 21 |
| 11 | 10 16 | 22 10 | 10 11 | 22 10 | 10 7 | 23 10 | 10 2 | 24 10 | 57 | 24 9 | 53 | 25 9 | 47 | 26 |
| 12 | 11 12 | 26 11 | 11 7 | 26 11 | 11 2 | 27 11 | 57 | 28 10 | 52 | 29 10 | 46 | 30 10 | 41 | 31 |
| 13 | 12 7 | 30 12 | 12 2 | 31 5 | 12 2 | 32 11 | 52 | 33 11 | 46 | 34 11 | 40 | 35 11 | 34 | 36 |
| 14 | 13 3 | 35 13 | 58 | 36 12 | 52 | 38 12 | 46 | 39 12 | 40 | 40 12 | 34 | 41 12 | 27 | 42 |
| 15 | 59 | 40 13 | 53 | 42 13 | 47 | 43 13 | 41 | 45 13 | 34 | 46 13 | 27 | 47 13 | 20 | 49 |
| 16 | 14 55 | 46 14 | 48 | 48 14 | 42 | 49 14 | 35 | 51 14 | 28 | 53 14 | 21 | 54 14 | 13 | 56 |
| 17 | 15 50 | 52 15 | 44 | 54 15 | 37 | 56 15 | 29 | 58 15 | 22 | 26 0 | 15 14 | 27 1 | 15 6 | 28 3 |
| 18 | 16 46 | 59 16 | 39 | 23 1 | 16 32 | 24 3 | 16 24 | 25 5 | 16 16 | 7 16 | 8 9 | 9 5 | 9 5 | 11 |
| 19 | 17 42 | 22 6 | 17 34 | 8 17 | 26 8 | 11 17 | 18 13 | 17 10 | 15 17 | 1 17 | 16 52 | 19 19 | | |
| 20 | 18 37 | 13 18 | 29 | 16 18 | 21 | 19 18 | 12 | 21 18 | 3 | 23 54 | 26 17 | 45 28 | | |
| 21 | 19 33 | 21 19 | 24 | 24 19 | 16 | 27 19 | 7 | 30 57 | 32 18 | 47 35 | 18 37 | | | |
| 22 | 20 28 | 29 20 | 19 | 33 20 | 10 | 36 20 | 1 | 39 19 | 51 | 42 45 | 19 30 | | | |
| 23 | 21 24 | 38 21 | 14 | 42 21 | 5 | 45 55 | 49 | 20 44 | 52 | 20 33 | 55 20 | | | |
| 24 | 22 19 | 47 22 | 9 | 52 59 | 55 21 | 49 59 | 21 38 | 27 3 | 21 26 | 28 6 | 21 15 | | | |
| 25 | 23 14 | 57 23 | 4 | 24 2 | 22 54 | 25 6 | 22 43 | 26 10 | 22 31 | 14 22 | 19 17 | | | |
| 26 | 24 9 | 23 8 | 59 | 12 23 | 48 | 17 23 | 37 | 21 23 | 25 | 25 23 | 12 29 | | | |
| 27 | 25 4 | 19 24 | 54 | 23 24 | 42 | 28 24 | 30 | 33 24 | 18 | 37 24 | 5 42 | | | |
| 28 | 59 | 30 25 | 48 | 35 25 | 36 | 40 25 | 24 | 46 25 | 11 | 50 57 | 55 24 | | | |
| 29 | 26 54 | 42 26 | 43 | 48 26 | 30 | 53 26 | 17 | 59 26 | 4 | 28 4 | 25 50 | | | |
| 30 | 27 49 | 54 27 | 37 | 25 1 | 27 24 | 26 7 | 27 11 | 27 13 | 57 | 18 26 | 42 23 | | | |
| 31 | 28 44 | 24 7 | 28 32 | 14 28 | 18 | 21 28 | 4 | 27 27 | 50 | 33 27 | 34 38 | | | |
| 32 | 29 39 | 21 29 | 26 | 28 29 | 12 | 35 57 | 42 | 28 42 | 48 | 28 26 | 54 28 | | | |
| 33 | 30 34 | 36 30 | 20 | 43 30 | 5 | 51 29 | 50 | 58 29 | 35 | 29 4 | 29 18 | | | |
| 34 | 31 28 | 51 31 | 14 | 59 27 | 7 | 30 43 | 28 | 14 30 | 27 | 21 30 | 10 28 | | | |
| 35 | 32 23 | 25 7 | 32 8 | 26 15 | 31 52 | 24 31 | 36 | 31 31 | 19 | 39 31 | 2 46 | | | |
| 36 | 33 17 | 23 33 | 1 | 32 32 | 45 | 41 32 | 29 | 49 32 | 11 | 58 53 | 31 5 | | | |
| 37 | 34 11 | 40 50 | 33 38 | 59 33 | 21 29 | 8 33 | 3 | 30 17 | 32 | 45 25 | 32 26 | | | |
| 38 | 35 5 | 58 34 | 48 | 27 9 | 34 31 | 28 18 | 34 13 | 28 55 | 37 | 33 36 | 45 33 | | | |
| 39 | 59 | 26 17 | 35 42 | 28 35 | 24 | 38 35 | 5 | 49 34 | 47 | 58 34 | 27 32 | | | |
| 40 | 36 53 | 37 36 | 35 | 48 36 | 17 | 59 57 | 30 | 10 35 | 38 | 31 20 | 35 18 | | | |
| 41 | 37 46 | 58 37 | 28 | 28 10 | 37 9 | 29 21 | 36 49 | 32 36 | 29 | 43 36 | 8 52 | | | |
| 42 | 38 40 | 27 19 | 38 21 | 32 38 | 1 | 44 37 | 41 | 56 37 | 20 | 32 7 | 58 33 | | | |
| 43 | 39 33 | 42 39 | 13 | 55 53 | 30 8 | 38 32 | 31 | 20 38 | 11 | 31 37 | 48 42 | | | |
| 44 | 40 26 | 28 5 | 40 6 | 29 19 | 39 45 | 33 39 | 23 | 45 39 | 1 | 57 38 | 38 34 | | | |
| 45 | 41 19 | 30 58 | 44 40 | 37 59 | 40 14 | 32 12 | 51 33 | 24 39 | 28 | 36 39 | 3 47 | | | |

Table 13. Kelvin's Summer Line Table

| b | a = 21° | | a = 22° | | a = 23° | | a = 24° | | a = 25° | | a = 26° | | a = 27° | |
|----|---------|-------|---------|-------|---------|-------|---------|-------|---------|-------|---------|-------|---------|-------|
| | K | Q | K | Q | K | Q | K | Q | K | Q | K | Q | K | Q |
| 45 | 41 19 | 28 30 | 40 58 | 29 44 | 40 37 | 30 59 | 40 14 | 32 12 | 39 51 | 33 24 | 39 28 | 34 36 | 39 3 | 35 47 |
| 46 | 42 11 | 55 41 | 50 30 | 11 41 | 28 31 | 26 41 | 5 39 | 40 41 | 52 40 | 17 35 | 4 52 | 36 16 | | |
| 47 | 43 4 | 29 22 | 42 42 | 39 42 | 19 54 | 55 33 | 8 41 | 31 34 | 22 41 | 6 34 | 40 40 | 46 | | |
| 48 | 56 | 50 43 | 33 31 | 8 43 | 10 32 | 23 42 | 45 38 | 42 20 | 52 55 | 36 5 | 41 28 | 37 17 | | |
| 49 | 44 48 | 30 20 | 44 24 | 38 44 | 0 54 | 43 35 | 34 10 | 43 9 | 35 24 | 42 43 | 37 42 | 15 50 | | |
| 50 | 45 40 | 51 45 | 15 32 | 9 50 | 33 26 | 44 25 | 43 58 | 57 43 | 31 37 | 11 43 | 2 38 | 24 | | |
| 51 | 46 31 | 31 23 | 46 6 | 42 45 | 40 34 | 0 45 | 14 35 | 17 44 | 47 36 | 32 44 | 18 46 | 49 39 | 0 | |
| 52 | 47 22 | 57 56 | 33 17 | 46 30 | 35 46 | 3 53 | 45 35 | 37 8 | 45 5 | 38 23 | 44 36 | 37 | | |
| 53 | 48 13 | 32 32 | 47 46 | 53 47 | 19 35 | 12 51 | 36 30 | 46 22 | 46 52 | 39 1 | 45 22 | 40 15 | | |
| 54 | 49 3 | 33 9 | 48 36 | 34 30 | 48 8 | 50 47 | 39 37 | 9 47 | 9 38 | 26 46 | 39 41 | 46 7 | 55 | |
| 55 | 53 48 | 49 25 | 35 10 | 56 36 | 30 48 | 27 49 | 56 39 | 7 47 | 25 40 | 23 52 | 41 37 | | | |
| 56 | 50 43 | 34 28 | 50 14 | 51 49 | 44 37 | 12 49 | 14 38 | 32 48 | 42 49 | 48 10 | 41 6 | 47 37 | 42 20 | |
| 57 | 51 32 | 35 11 | 51 2 | 36 34 | 50 32 | 56 50 | 1 39 | 16 49 | 28 40 | 34 55 | 51 48 | 21 43 | 5 | |
| 58 | 52 21 | 55 50 | 37 19 | 51 19 | 38 42 | 47 40 | 2 50 | 14 41 | 21 49 | 40 42 | 38 49 | 5 52 | | |
| 59 | 53 9 | 36 42 | 52 38 | 38 7 | 52 6 | 39 30 | 51 33 | 50 59 | 42 9 | 50 24 | 43 26 | 48 44 | 41 | |
| 60 | 57 37 | 31 53 | 25 56 | 52 40 | 20 52 | 18 41 | 41 51 | 43 43 | 0 51 | 7 44 | 17 50 | 30 45 | 32 | |
| 61 | 54 44 | 38 22 | 54 11 | 39 48 | 53 37 | 41 12 | 53 2 | 42 34 | 52 26 | 53 49 | 45 10 | 51 12 | 46 25 | |
| 62 | 55 31 | 39 16 | 57 40 | 43 54 | 22 42 | 7 46 | 43 29 | 53 9 | 44 48 | 52 31 | 46 6 | 53 47 | 21 | |
| 63 | 56 17 | 40 13 | 55 42 | 41 40 | 55 6 | 43 5 | 54 29 | 44 27 | 51 45 | 46 53 | 13 47 | 3 52 | 33 48 | 18 |
| 64 | 57 3 | 41 13 | 56 27 | 42 40 | 49 44 | 5 55 | 11 45 | 27 54 | 33 46 | 46 53 | 48 3 | 53 13 | 49 18 | |
| 65 | 48 42 | 15 57 | 11 43 | 43 56 | 32 45 | 8 53 | 46 30 | 55 13 | 47 49 | 54 33 | 49 5 | 51 50 | 20 | |
| 66 | 58 32 | 43 21 | 54 44 | 49 57 | 14 46 | 13 56 | 34 47 | 35 53 | 48 54 | 55 12 | 50 10 | 54 29 | 51 | 24 |
| 67 | 59 15 | 44 30 | 58 36 | 45 58 | 55 47 | 22 57 | 14 48 | 44 56 | 32 50 | 2 50 | 51 18 | 55 6 | 52 31 | |
| 68 | 57 45 | 42 59 | 17 47 | 10 58 | 35 48 | 34 53 | 49 55 | 57 10 | 51 13 | 56 27 | 52 28 | 42 53 | 41 | |
| 69 | 60 39 | 46 58 | 57 48 | 26 59 | 15 49 | 50 58 | 31 51 | 10 47 | 52 27 | 57 3 | 53 42 | 56 17 | 54 53 | |
| 70 | 61 19 | 48 18 | 60 36 | 49 45 | 53 51 | 8 59 | 8 52 | 28 58 | 23 53 | 44 38 | 54 58 | 51 56 | 8 | |
| 71 | 58 49 | 42 61 | 14 51 | 8 60 | 30 52 | 31 44 | 53 49 | 58 55 | 5 58 | 12 56 | 17 57 | 24 57 | 25 | |
| 72 | 62 36 | 51 10 | 51 52 | 35 61 | 6 53 | 57 60 | 19 55 | 14 59 | 32 56 | 28 44 | 57 39 | 56 58 | 46 | |
| 73 | 63 13 | 52 42 | 62 27 | 54 7 | 41 55 | 27 53 | 56 42 | 60 5 | 57 55 | 59 16 | 59 4 | 58 26 | 60 9 | |
| 74 | 49 54 | 19 63 | 2 55 | 42 62 | 14 57 | 0 61 | 25 58 | 14 36 | 59 25 | 46 60 | 32 55 | 61 35 | | |
| 75 | 64 23 | 56 1 | 35 57 | 21 46 | 58 38 | 56 59 | 50 61 | 6 60 | 58 60 | 15 62 | 3 59 | 23 63 | 4 | |
| 76 | 56 57 | 47 64 | 7 59 | 5 63 | 16 60 | 19 62 | 26 61 | 29 34 | 62 35 | 42 63 | 37 50 | 64 36 | | |
| 77 | 65 27 | 59 38 | 37 60 | 53 45 | 62 5 | 54 63 | 12 62 | 1 64 | 15 61 | 8 65 | 14 60 | 15 66 | 11 | |
| 78 | 57 61 | 34 65 | 5 62 | 46 64 | 13 63 | 54 63 | 20 64 | 58 26 | 65 58 | 32 66 | 55 38 | 67 48 | | |
| 79 | 66 25 | 63 34 | 32 64 | 43 38 | 65 48 | 44 66 | 48 50 | 67 45 | 55 68 | 38 61 | 0 69 | 28 | | |
| 80 | 50 65 | 40 56 | 66 44 | 65 2 | 67 45 | 64 7 | 68 42 | 63 12 | 69 35 | 62 16 | 70 24 | 20 71 | 11 | |
| 81 | 67 14 | 67 50 | 66 19 | 68 50 | 23 69 | 46 28 | 70 39 | 32 71 | 27 35 | 72 13 | 39 72 | 56 | 3 | |
| 82 | 36 70 | 4 40 | 71 0 | 43 71 | 51 43 | 72 39 | 47 72 | 39 50 | 73 23 | 53 74 | 4 56 | 74 43 | | |
| 83 | 55 72 | 23 58 | 73 13 | 66 1 | 73 59 | 65 3 | 74 42 | 64 6 | 75 21 | 63 8 | 75 58 | 62 10 | 76 33 | |
| 84 | 68 12 | 74 46 | 67 14 | 75 30 | 16 76 | 10 18 | 76 47 | 20 77 | 22 77 | 54 23 | 78 24 | | | |
| 85 | 26 77 | 12 28 | 77 50 | 29 78 | 24 31 | 78 55 | 32 79 | 25 33 | 79 52 | 35 80 | 18 | | | |
| 86 | 38 79 | 42 39 | 80 12 | 40 80 | 40 41 | 81 6 | 42 81 | 30 43 | 81 52 | 44 82 | 12 | | | |
| 87 | 48 82 | 14 48 | 82 37 | 49 82 | 58 49 | 83 18 | 50 83 | 36 50 | 83 53 | 51 84 | 8 | | | |
| 88 | 55 84 | 48 55 | 85 4 | 55 85 | 18 55 | 85 18 | 55 85 | 31 56 | 85 43 | 56 85 | 5 | | | |
| 89 | 59 87 | 24 59 | 87 32 | 59 87 | 39 59 | 87 45 | 59 87 | 51 59 | 87 51 | 59 87 | 57 59 | 88 2 | | |
| 90 | 69 0 | 90 0 | 68 0 | 90 0 | 67 0 | 90 0 | 66 0 | 90 0 | 65 0 | 90 0 | 64 0 | 90 0 | 63 0 | 90 0 |

Table 13. Kelvin's Sumner Line Table

| b | a = 28° | | a = 29° | | a = 30° | | a = 31° | | a = 32° | | a = 33° | | a = 34° | | | | | |
|----|----------|------|---------|------|---------|-------|---------|-------|----------|-------|----------|--------|----------|---------|--------|--------|--------|-----|
| | K | Q | K | Q | K | Q | K | Q | K | Q | K | Q | K | Q | | | | |
| 0 | 0 0 | 28 0 | 0 0 | 29 0 | 0 0 | 30 0 | 0 0 | 31 0 | 0 0 | 32 0 | 0 0 | 33 0 | 0 0 | 34 0 | | | | |
| 1 | 53 | 0 | 52 | 0 | 52 | 0 | 51 | 0 | 51 | 0 | 50 | 0 | 50 | 0 | | | | |
| 2 | 1 46 | 1 | 1 45 | 1 | 1 44 | 1 | 1 43 | 1 | 1 42 | 1 | 1 41 | 1 | 1 39 | 1 | | | | |
| 3 | 2 39 | 2 | 2 37 | 2 | 2 36 | 2 | 2 34 | 2 | 2 33 | 2 | 2 31 | 2 | 2 29 | 2 | | | | |
| 4 | 3 32 | 3 | 3 30 | 4 | 3 28 | 4 | 3 26 | 4 | 3 23 | 4 | 3 21 | 4 | 3 19 | 4 | | | | |
| 5 | 4 25 | 5 | 4 22 | 6 | 4 20 | 6 | 4 17 | 6 | 4 14 | 6 | 4 12 | 6 | 4 9 | 6 | | | | |
| 6 | 5 18 | 8 | 5 15 | 8 | 5 12 | 8 | 5 8 | 8 | 5 5 | 8 | 5 2 | 9 | 5 8 | 9 | | | | |
| 7 | 6 11 | 11 | 6 7 | 11 | 6 4 | 11 | 6 0 | 11 | 5 6 | 11 | 5 2 | 12 | 5 4 8 | 12 | | | | |
| 8 | 7 4 | 14 | 5 9 | 14 | 5 5 | 15 | 5 1 | 15 | 6 4 7 | 15 | 6 4 2 | 15 | 6 3 8 | 16 | | | | |
| 9 | 5 6 | 18 | 7 5 2 | 18 | 7 4 7 | 19 | 7 4 3 | 19 | 7 3 7 | 19 | 7 3 2 | 19 | 7 2 7 | 20 | | | | |
| 10 | 8 4 9 | 22 | 8 4 4 | 22 | 8 3 9 | 23 | 8 3 4 | 23 | 8 2 8 | 24 | 8 2 2 | 24 | 8 1 7 | 25 | | | | |
| 11 | 9 4 2 | 27 | 9 3 6 | 27 | 9 3 1 | 28 | 9 2 5 | 28 | 9 1 9 | 29 | 9 1 2 | 29 | 9 6 | 30 | | | | |
| 12 | 10 3 5 | 32 | 10 2 9 | 32 | 10 2 2 | 33 | 10 1 6 | 34 | 10 9 | 34 | 10 2 | 35 | 5 6 | 35 | | | | |
| 13 | 11 2 7 | 37 | 11 2 1 | 38 | 11 1 4 | 39 | 11 7 | 40 | 11 0 | 40 | 5 2 | 41 | 10 4 5 | 41 | | | | |
| 14 | 12 2 0 | 43 | 12 1 3 | 44 | 12 6 | 45 | 5 8 | 46 | 5 0 | 47 | 11 4 2 | 48 | 11 3 4 | 48 | | | | |
| 15 | 13 1 3 | 50 | 13 5 | 51 | 5 7 | 52 | 12 4 9 | 53 | 12 4 1 | 54 | 12 3 2 | 55 | 12 2 3 | 56 | | | | |
| 16 | 14 5 | 57 | 5 7 | 58 | 13 4 9 | 59 | 13 4 0 | 32 | 1 13 3 1 | 33 | 2 13 2 2 | 34 | 3 13 1 3 | 35 4 | | | | |
| 17 | 5 8 | 29 | 4 14 | 49 | 30 | 6 14 | 40 | 31 | 7 14 | 31 | 9 14 | 21 | 10 14 | 12 | | | | |
| 18 | 15 5 0 | 12 | 15 4 1 | 14 | 15 3 1 | 16 | 15 2 2 | 17 | 15 1 2 | 18 | 15 1 | 20 | 5 1 | 21 | | | | |
| 19 | 16 4 2 | 21 | 16 3 3 | 23 | 16 2 3 | 25 | 16 1 2 | 26 | 16 2 | 27 | 5 1 | 29 | 15 4 0 | 30 | | | | |
| 20 | 17 3 5 | 30 | 17 2 4 | 32 | 17 1 4 | 34 | 17 3 | 36 | 5 2 | 37 | 16 4 0 | 39 | 16 2 8 | 40 | | | | |
| 21 | 18 2 7 | 40 | 18 1 6 | 42 | 18 5 | 44 | 5 3 | 46 | 17 4 2 | 48 | 17 2 9 | 49 | 17 1 7 | 51 | | | | |
| 22 | 19 1 9 | 50 | 19 8 | 52 | 5 6 | 55 | 18 4 4 | 57 | 18 3 1 | 59 | 18 1 9 | 35 | 0 18 | 6 36 2 | | | | |
| 23 | 20 1 1 | 30 | 1 | 59 | 31 | 3 19 | 4 7 | 32 | 6 19 | 34 | 8 19 | 21 | 34 | 10 19 8 | 12 | 5 4 | 14 | |
| 24 | 21 3 | 12 | 20 5 0 | 15 | 20 3 7 | 18 | 20 2 4 | 20 | 20 1 1 | 22 | 5 7 | 24 | 19 4 2 | 26 | | | | |
| 25 | 5 5 | 24 | 21 4 1 | 27 | 21 2 8 | 30 | 21 1 4 | 33 | 21 0 | 35 | 20 4 6 | 37 | 20 3 0 | 39 | | | | |
| 26 | 22 4 6 | 37 | 22 3 2 | 40 | 22 1 9 | 43 | 22 4 | 46 | 4 4 9 | 48 | 21 3 4 | 51 | 21 1 8 | 53 | | | | |
| 27 | 23 3 8 | 50 | 23 2 3 | 53 | 23 9 | 57 | 5 4 | 34 | 0 22 | 38 | 35 | 2 22 | 23 | 36 | 5 22 | 6 37 8 | | |
| 28 | 24 2 9 | 31 | 3 24 | 14 | 32 | 7 5 9 | 33 | 11 23 | 44 | 14 | 23 2 7 | 17 | 23 1 1 | 20 | 5 4 | 23 | | |
| 29 | 25 2 1 | 18 | 25 5 | 22 | 24 4 9 | 26 | 24 3 3 | 29 | 24 1 6 | 33 | 5 9 | 36 | 23 4 2 | 38 | | | | |
| 30 | 26 1 2 | 33 | 5 6 | 37 | 25 3 9 | 41 | 25 2 3 | 45 | 25 5 | 49 | 24 4 7 | 52 | 24 2 9 | 55 | | | | |
| 31 | 27 3 | 49 | 26 4 7 | 53 | 26 2 9 | 58 | 26 1 2 | 35 | 2 | 54 | 36 | 6 25 | 35 | 37 | 9 | 25 1 6 | 38 1 2 | |
| 32 | 5 4 | 32 | 5 27 | 37 | 33 | 10 27 | 19 | 34 | 15 2 7 | 1 | 19 | 26 | 4 2 | 23 | 26 2 3 | 27 | 26 3 | 30 |
| 33 | 28 4 5 | 22 | 28 2 7 | 28 | 28 9 | 33 | 5 0 | 37 | 27 3 0 | 41 | 27 1 1 | 45 | 5 0 | 49 | | | | |
| 34 | 29 3 5 | 40 | 29 1 7 | 46 | 5 8 | 51 | 28 3 9 | 56 | 28 1 8 | 37 | 0 | 58 | 38 | 4 | 27 3 7 | 39 | 8 | |
| 35 | 30 2 6 | 59 | 30 7 | 34 | 5 29 | 47 | 35 | 11 29 | 27 | 36 | 16 2 9 | 6 | 20 | 28 | 4 5 | 24 | 28 2 4 | 28 |
| 36 | 31 1 6 | 33 | 19 5 6 | 25 | 30 3 6 | 31 | 30 1 5 | 36 | 5 4 | 41 | 29 3 2 | 45 | 29 1 0 | 49 | | | | |
| 37 | 32 6 | 39 | 31 4 6 | 46 | 31 2 5 | 52 | 31 3 | 57 | 30 4 1 | 38 | 2 30 | 19 | 39 | 7 | 5 6 | 40 | 1 1 | |
| 38 | 5 6 | 34 | 1 32 | 35 | 35 | 7 32 | 13 | 36 | 14 | 51 | 37 | 20 3 1 | 28 | 25 | 31 5 | 30 | 30 4 2 | 34 |
| 39 | 33 4 6 | 23 | 33 2 4 | 30 | 33 1 | 37 | 32 3 9 | 43 | 32 1 5 | 48 | 5 1 | 53 | 31 2 7 | 57 | | | | |
| 40 | 34 3 5 | 46 | 34 1 3 | 53 | 4 9 | 37 | 0 33 | 26 | 38 | 7 33 | 2 39 | 12 32 | 37 | 40 | 17 32 | 12 | 41 2 2 | |
| 41 | 35 2 4 | 35 | 10 35 | 1 | 36 | 18 34 | 37 | 25 | 34 | 13 | 31 | 48 | 37 | 33 | 23 | 43 | 5 7 | 47 |
| 42 | 36 1 3 | 35 | 4 9 | 43 | 35 2 5 | 51 | 35 0 | 57 | 34 3 4 | 40 | 4 3 4 | 8 | 41 | 9 | 33 | 4 2 | 42 | 1 4 |
| 43 | 37 2 3 6 | 1 | 36 3 7 | 37 | 10 36 | 12 38 | 17 | 46 | 39 | 24 35 | 20 | 31 | 5 3 | 36 | 34 | 2 6 | 41 | |
| 44 | 5 0 | 28 | 37 2 5 | 37 | 5 9 | 45 | 36 3 3 | 52 | 36 6 | 59 | 35 3 8 | 42 | 5 35 | 10 | 43 | 10 | | |
| 45 | 38 3 8 | 57 | 38 1 2 | 38 | 5 37 | 46 | 39 1 4 | 37 | 19 40 | 21 | 5 1 | 41 | 28 36 | 22 | 34 | 5 3 | 39 | |

Table 13. Kelvin's Sumner Line Table

| b | a = 28° | | a = 29° | | a = 30° | | a = 31° | | a = 32° | | a = 33° | | a = 34° | |
|----|---------|-------|---------|-------|---------|-------|---------|-------|---------|-------|---------|-------|---------|----------|
| | K | Q | K | Q | K | Q | K | Q | K | Q | K | Q | K | Q |
| 45 | 38 38 | 36 57 | 38 12 | 38 5 | 37 46 | 39 14 | 37 19 | 40 21 | 36 51 | 41 28 | 36 22 | 42 34 | 35 53 | 43 39 |
| 46 | 39 26 | 37 26 | 59 | 35 | 38 32 | 44 | 38 4 | 52 | 37 36 | 58 | 37 6 | 43 4 | 36 36 | 44 9 |
| 47 | 40 13 | 56 | 39 46 | 39 6 | 39 18 | 40 15 | 49 | 41 23 | 38 20 | 42 30 | 50 | 36 | 37 19 | 41 |
| 48 | 41 0 | 38 28 | 40 32 | 38 | 40 4 | 47 | 39 34 | 55 | 39 4 | 43 2 | 38 33 | 44 9 | 38 2 | 45 14 |
| 49 | 47 39 | 1 41 | 18 40 | 11 49 | 41 21 | 40 19 | 42 29 | 48 | 36 | 39 16 | 43 | 44 | 48 | |
| 50 | 42 34 | 36 | 42 4 | 46 | 41 34 | 56 | 41 3 | 43 4 | 40 31 | 44 11 | 59 | 45 18 | 39 26 | 46 23 |
| 51 | 43 20 | 40 12 | 49 | 41 22 | 42 18 | 42 32 | 46 | 40 | 41 14 | 48 | 40 41 | 54 | 40 7 | 59 |
| 52 | 44 5 | 49 | 43 34 | 42 0 | 43 2 | 43 10 | 42 29 | 44 18 | 56 | 45 26 | 41 22 | 46 32 | 48 | 47 37 |
| 53 | 50 41 | 28 44 | 18 39 | 46 | 49 | 43 12 | 57 | 42 38 | 46 5 | 42 3 | 47 11 | 41 28 | 48 16 | |
| 54 | 45 35 | 42 8 | 45 2 | 43 19 | 44 29 | 44 29 | 54 | 45 38 | 43 19 | 45 | 44 | 51 | 42 7 | 56 |
| 55 | 46 19 | 50 | 46 44 | 1 45 | 11 45 | 11 44 | 36 46 | 20 44 | 0 47 | 27 43 | 24 48 | 33 46 | 49 37 | |
| 56 | 47 3 | 43 34 | 46 29 | 45 | 53 | 55 | 45 17 | 47 4 | 40 | 48 10 | 44 3 | 49 16 | 43 25 | 50 20 |
| 57 | 46 44 | 19 47 | 11 45 | 30 | 46 35 | 46 40 | 58 | 49 | 45 20 | 55 | 42 50 | 1 44 | 3 51 | 5 |
| 58 | 48 29 | 45 6 | 53 | 46 17 | 47 16 | 47 27 | 46 38 | 48 35 | 59 | 49 42 | 45 20 | 47 | 40 | 51 |
| 59 | 49 11 | 55 | 48 34 | 47 6 | 56 | 48 16 | 47 17 | 49 24 | 46 38 | 50 30 | 58 | 51 35 | 45 17 | 52 38 |
| 60 | 52 46 | 46 49 | 14 57 | 48 36 | 49 6 | 56 | 50 14 | 47 16 | 51 20 | 46 35 | 52 24 | 53 | 53 27 | |
| 61 | 50 33 | 47 38 | 54 | 48 50 | 49 15 | 59 | 48 34 | 51 6 | 53 | 52 12 | 47 11 | 53 15 | 46 28 | 54 18 |
| 62 | 51 13 | 48 33 | 50 33 | 49 44 | 53 | 50 53 | 49 11 | 52 0 | 48 29 | 53 5 | 46 54 | 8 47 | 3 55 | 10 |
| 63 | 53 49 | 30 51 | 12 50 | 41 | 50 30 | 51 49 | 48 | 56 | 49 5 | 54 0 | 48 21 | 55 3 | 37 | 56 4 |
| 64 | 52 31 | 50 30 | 49 51 | 40 51 | 7 52 | 48 50 | 24 53 | 53 | 40 | 57 | 55 | 59 | 48 10 | 59 |
| 65 | 53 9 | 51 31 | 52 26 | 52 41 | 43 | 53 48 | 59 | 54 53 | 50 14 | 55 56 | 49 28 | 56 57 | 42 | 57 56 |
| 66 | 46 52 | 35 53 | 2 53 | 44 52 | 18 54 | 50 51 | 33 55 | 55 | 47 | 56 56 | 50 1 | 57 57 | 49 14 | 58 55 |
| 67 | 54 22 | 53 41 | 37 | 54 49 | 52 | 55 55 | 52 | 6 56 | 58 51 | 19 57 | 59 | 32 58 | 58 | 44 59 55 |
| 68 | 57 54 | 50 54 | 11 55 | 57 | 53 25 | 57 1 | 38 | 58 3 | 50 | 59 4 | 51 2 | 60 1 | 50 14 | 60 57 |
| 69 | 55 31 | 56 1 | 44 | 57 7 | 57 | 58 10 | 53 9 | 59 11 | 52 21 | 60 10 | 32 | 61 6 | 43 | 62 1 |
| 70 | 56 4 | 57 15 | 55 16 | 58 19 | 54 28 | 59 21 | 39 | 60 21 | 50 61 | 18 52 | 1 62 | 13 51 | 10 63 | 7 |
| 71 | 36 58 | 31 47 | 59 34 | 58 | 60 35 | 54 8 | 61 33 | 53 18 | 62 29 | 28 | 63 22 | 37 | 64 14 | |
| 72 | 57 7 | 59 50 | 56 17 | 60 52 | 55 27 | 61 51 | 36 | 62 47 | 45 | 63 41 | 54 | 64 33 | 52 | 3 65 23 |
| 73 | 36 61 | 12 46 | 62 12 | 55 | 63 9 | 55 3 | 64 3 | 54 11 | 64 56 | 53 19 | 65 46 | 27 | 66 34 | |
| 74 | 58 4 | 62 36 | 57 13 | 63 34 | 56 21 | 64 29 | 29 | 65 21 | 36 | 66 12 | 43 | 67 0 | 50 | 67 46 |
| 75 | 31 64 | 3 39 | 64 58 | 46 | 65 51 | 53 | 66 42 | 55 0 | 67 30 | 54 6 | 68 16 | 53 12 | 69 0 | |
| 76 | 57 65 | 32 58 | 4 66 | 25 57 | 10 67 | 16 56 | 16 68 | 4 22 | 68 50 | 28 | 69 34 | 33 | 70 16 | |
| 77 | 59 21 | 67 4 | 27 | 67 54 | 33 | 68 43 | 38 | 69 29 | 43 | 70 12 | 48 | 70 54 | 53 | 71 33 |
| 78 | 44 68 | 39 49 | 69 26 | 54 | 70 12 | 58 | 70 55 | 56 3 | 71 36 | 55 7 | 72 15 | 54 11 | 72 52 | |
| 79 | 60 5 | 70 16 | 59 9 | 71 0 | 58 13 | 71 43 | 57 17 | 72 23 | 21 | 73 1 | 25 | 73 38 | 28 | 74 12 |
| 80 | 24 71 | 55 28 | 72 36 | 31 | 73 16 | 35 | 73 53 | 38 | 74 28 | 41 | 75 2 | 44 | 75 34 | |
| 81 | 42 73 | 36 45 | 74 14 | 48 | 74 50 | 51 | 75 24 | 53 | 75 57 | 56 | 76 27 | 58 | 76 57 | |
| 82 | 58 75 | 20 60 | 0 75 | 54 59 | 3 76 | 27 58 | 5 76 | 57 57 | 7 77 | 27 56 | 9 77 | 54 | 55 11 | 78 21 |
| 83 | 61 12 | 77 6 | 14 77 | 36 | 78 5 | 16 78 | 5 18 | 78 32 | 19 | 78 58 | 21 | 79 22 | 22 | 79 46 |
| 84 | 25 78 | 53 | 26 79 | 19 | 28 79 | 44 | 29 80 | 8 30 | 80 30 | 31 | 80 51 | 32 | 81 12 | |
| 85 | 36 80 | 42 36 | 81 4 | 38 | 81 25 | 38 | 81 45 | 39 | 82 4 | 40 | 82 21 | 41 | 82 38 | |
| 86 | 44 82 | 32 45 | 82 50 | 46 | 83 7 | 46 | 83 23 | 47 | 83 38 | 47 | 83 52 | 48 | 84 6 | |
| 87 | 51 84 | 23 51 | 84 36 | 52 | 84 49 | 52 | 85 1 | 53 | 85 13 | 53 | 85 23 | 53 | 85 34 | |
| 88 | 56 86 | 15 56 | 86 24 | 56 | 86 32 | 56 | 86 40 | 57 | 86 48 | 57 | 86 55 | 57 | 87 2 | |
| 89 | 59 88 | 7 59 | 88 12 | 59 | 88 16 | 59 | 88 20 | 59 | 88 24 | 59 | 88 27 | 59 | 88 31 | |
| 90 | 62 0 | 90 0 | 61 0 | 90 0 | 60 0 | 90 0 | 59 0 | 90 0 | 58 0 | 90 0 | 57 0 | 90 0 | 56 0 | 90 0 |

Table 13. Kelvin's Summer Line Table

| b | a = 35° | | a = 36° | | a = 37° | | a = 38° | | a = 39° | | a = 40° | | a = 41° | |
|----|---------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| | K | Q | K | Q | K | Q | K | Q | K | Q | K | Q | K | Q |
| 0 | 0 0 | 35 0 | 0 0 | 36 0 | 0 0 | 37 0 | 0 0 | 38 0 | 0 0 | 39 0 | 0 0 | 40 0 | 0 0 | 41 0 |
| 1 | 49 0 | 0 49 | 0 49 | 0 49 | 0 48 | 0 47 | 0 47 | 0 47 | 0 47 | 0 46 | 0 46 | 0 45 | 0 45 | 0 45 |
| 2 | 1 38 | 1 1 37 | 1 1 37 | 1 1 36 | 1 1 36 | 1 1 35 | 1 1 35 | 1 1 33 | 1 1 33 | 1 1 32 | 1 1 32 | 1 1 31 | 1 1 31 | 1 1 31 |
| 3 | 2 27 | 2 2 26 | 2 2 26 | 2 2 24 | 2 2 24 | 2 2 22 | 2 2 22 | 2 2 20 | 2 2 20 | 2 2 18 | 2 2 18 | 2 2 16 | 2 2 16 | 2 2 16 |
| 4 | 3 17 | 4 3 14 | 4 3 14 | 4 3 12 | 4 3 12 | 4 3 9 | 4 3 9 | 4 3 7 | 4 3 7 | 4 3 4 | 4 3 4 | 4 3 1 | 4 3 1 | 4 3 1 |
| 5 | 4 6 | 6 4 3 | 6 4 3 | 6 5 9 | 6 5 9 | 6 5 6 | 6 5 6 | 6 5 3 | 6 5 3 | 6 5 0 | 6 5 0 | 6 4 6 | 6 4 6 | 6 4 6 |
| 6 | 5 55 | 9 5 1 | 9 5 1 | 9 4 47 | 9 4 47 | 9 4 44 | 9 4 44 | 9 4 40 | 9 4 40 | 9 4 36 | 9 4 36 | 9 4 31 | 9 4 31 | 9 4 31 |
| 7 | 5 44 | 12 5 39 | 12 5 39 | 12 5 35 | 12 5 35 | 12 5 31 | 12 5 31 | 12 5 26 | 12 5 26 | 12 5 21 | 12 5 21 | 12 5 17 | 12 5 17 | 12 5 17 |
| 8 | 6 33 | 16 6 28 | 16 6 28 | 16 6 23 | 16 6 23 | 16 6 18 | 16 6 18 | 16 6 13 | 16 6 13 | 16 6 7 | 16 6 7 | 16 6 2 | 16 6 2 | 16 6 2 |
| 9 | 7 22 | 20 7 16 | 20 7 16 | 20 7 11 | 20 7 11 | 20 7 5 | 20 7 5 | 21 5 9 | 21 5 9 | 21 5 3 | 21 5 3 | 21 4 7 | 21 4 7 | 21 4 7 |
| 10 | 8 11 | 25 8 5 | 25 8 5 | 25 5 8 | 25 5 8 | 25 5 2 | 25 5 2 | 26 7 45 | 26 7 45 | 26 7 39 | 26 7 39 | 26 7 32 | 26 7 32 | 26 7 32 |
| 11 | 9 0 | 30 8 46 | 30 8 46 | 31 8 39 | 31 8 39 | 31 8 32 | 31 8 32 | 31 8 26 | 31 8 26 | 31 8 20 | 31 8 20 | 31 8 17 | 31 8 17 | 31 8 17 |
| 12 | 48 36 | 9 41 36 | 9 41 36 | 9 34 37 | 9 34 37 | 9 26 37 | 9 26 37 | 9 18 37 | 9 18 37 | 9 10 37 | 9 10 37 | 9 2 37 | 9 2 37 | 9 2 37 |
| 13 | 10 37 | 42 10 29 | 42 10 29 | 43 10 21 | 43 10 21 | 43 10 13 | 43 10 13 | 43 10 4 | 43 10 4 | 44 5 55 | 44 5 55 | 44 4 47 | 44 4 47 | 44 4 47 |
| 14 | 11 26 | 49 11 17 | 49 11 17 | 50 11 8 | 50 11 8 | 50 5 9 | 50 5 9 | 50 5 0 | 50 5 0 | 51 10 41 | 51 10 41 | 51 10 31 | 51 10 31 | 51 10 31 |
| 15 | 12 14 | 56 12 5 | 56 12 5 | 57 12 43 | 57 12 43 | 58 12 33 | 58 12 33 | 59 12 22 | 59 12 22 | 60 12 11 | 60 12 11 | 61 12 0 | 61 12 0 | 62 7 16 |
| 16 | 13 36 | 4 53 37 | 4 53 37 | 5 12 30 | 5 12 30 | 6 13 19 | 6 13 19 | 7 13 8 | 7 13 8 | 8 16 56 | 8 16 56 | 9 16 45 | 9 16 45 | 10 16 16 |
| 17 | 51 36 | 13 13 41 | 13 13 41 | 14 13 30 | 14 13 30 | 14 6 23 | 14 6 23 | 14 5 24 | 14 5 24 | 15 13 41 | 15 13 41 | 15 13 29 | 15 13 29 | 16 26 26 |
| 18 | 14 40 | 22 14 29 | 22 14 29 | 22 14 17 | 22 14 17 | 23 14 6 | 23 14 6 | 24 14 40 | 24 14 40 | 25 14 26 | 25 14 26 | 25 14 13 | 25 14 13 | 26 36 36 |
| 19 | 15 28 | 31 15 16 | 31 15 16 | 32 15 4 | 32 15 4 | 33 5 57 | 33 5 57 | 34 5 46 | 34 5 46 | 35 15 11 | 35 15 11 | 35 14 36 | 35 14 36 | 36 46 46 |
| 20 | 16 16 | 41 16 4 | 41 16 4 | 43 16 38 | 43 16 38 | 44 16 24 | 44 16 24 | 45 16 10 | 45 16 10 | 46 16 56 | 46 16 56 | 47 15 41 | 47 15 41 | 48 57 57 |
| 21 | 17 4 | 52 17 38 | 52 17 38 | 54 17 25 | 54 17 25 | 55 17 10 | 55 17 10 | 56 17 7 | 56 17 7 | 57 16 41 | 57 16 41 | 58 16 25 | 58 16 25 | 59 43 9 |
| 22 | 52 37 | 4 17 38 | 4 17 38 | 5 17 25 | 5 17 25 | 6 17 10 | 6 17 10 | 7 17 40 | 7 17 40 | 8 16 41 | 8 16 41 | 9 16 25 | 9 16 25 | 10 22 22 |
| 23 | 18 40 | 16 18 25 | 16 18 25 | 17 18 11 | 17 18 11 | 18 5 56 | 18 5 56 | 19 17 40 | 19 17 40 | 20 17 25 | 20 17 25 | 21 17 9 | 21 17 9 | 22 35 35 |
| 24 | 19 28 | 28 19 12 | 28 19 12 | 30 19 42 | 30 19 42 | 31 18 32 | 31 18 32 | 32 18 25 | 32 18 25 | 33 18 9 | 33 18 9 | 34 18 53 | 34 18 53 | 35 49 49 |
| 25 | 20 15 | 41 20 46 | 41 20 46 | 43 20 29 | 43 20 29 | 45 20 13 | 45 20 13 | 46 20 41 | 46 20 41 | 47 20 55 | 47 20 55 | 48 19 37 | 48 19 37 | 49 44 3 |
| 26 | 21 3 | 55 21 33 | 55 21 33 | 57 21 15 | 57 21 15 | 58 13 40 | 58 13 40 | 59 15 20 | 59 15 20 | 60 16 20 | 60 16 20 | 61 17 20 | 61 17 20 | 62 18 18 |
| 27 | 50 38 | 10 21 33 | 10 21 33 | 12 21 43 | 12 21 43 | 13 21 29 | 13 21 29 | 14 21 43 | 14 21 43 | 15 21 30 | 15 21 30 | 16 21 5 | 16 21 5 | 17 33 33 |
| 28 | 22 37 | 25 22 19 | 25 22 19 | 27 22 47 | 27 22 47 | 28 22 28 | 28 22 28 | 29 22 8 | 29 22 8 | 30 22 48 | 30 22 48 | 31 21 28 | 31 21 28 | 32 49 49 |
| 29 | 23 24 | 41 23 5 | 41 23 5 | 43 23 32 | 43 23 32 | 44 23 12 | 44 23 12 | 45 23 3 | 45 23 3 | 46 23 5 | 46 23 5 | 47 22 31 | 47 22 31 | 48 6 6 |
| 30 | 24 11 | 57 24 37 | 57 24 37 | 17 24 17 | 17 24 17 | 19 24 57 | 19 24 57 | 21 23 36 | 21 23 36 | 22 23 14 | 22 23 14 | 23 23 52 | 23 23 52 | 24 43 43 |
| 31 | 57 39 | 15 24 37 | 15 24 37 | 17 24 17 | 17 24 17 | 19 24 57 | 19 24 57 | 21 23 36 | 21 23 36 | 22 23 14 | 22 23 14 | 23 23 52 | 23 23 52 | 24 43 43 |
| 32 | 25 44 | 33 25 23 | 33 25 23 | 35 25 2 | 35 25 2 | 37 24 41 | 37 24 41 | 39 24 19 | 39 24 19 | 41 24 57 | 41 24 57 | 42 23 34 | 42 23 34 | 43 43 43 |
| 33 | 26 30 | 52 26 9 | 52 26 9 | 54 26 32 | 54 26 32 | 56 26 9 | 56 26 9 | 58 25 43 | 58 25 43 | 59 25 20 | 59 25 20 | 60 24 40 | 60 24 40 | 61 46 2 |
| 34 | 27 16 | 40 11 54 | 40 11 54 | 41 14 26 | 41 14 26 | 42 16 26 | 42 16 26 | 43 18 45 | 43 18 45 | 44 20 25 | 44 20 25 | 45 21 58 | 45 21 58 | 46 22 22 |
| 35 | 28 2 | 31 27 39 | 31 27 39 | 34 27 16 | 34 27 16 | 37 27 52 | 37 27 52 | 39 26 28 | 39 26 28 | 40 26 4 | 40 26 4 | 41 25 39 | 41 25 39 | 42 42 42 |
| 36 | 47 52 | 28 24 56 | 28 24 56 | 28 0 58 | 28 0 58 | 27 35 44 | 27 35 44 | 27 11 45 | 27 11 45 | 27 2 46 | 27 2 46 | 26 20 47 | 26 20 47 | 27 3 3 |
| 37 | 29 32 | 41 14 29 | 41 14 29 | 42 18 44 | 42 18 44 | 43 20 28 | 43 20 28 | 44 22 53 | 44 22 53 | 45 24 27 | 45 24 27 | 46 25 27 | 46 25 27 | 47 25 25 |
| 38 | 30 17 | 37 52 41 | 37 52 41 | 39 29 27 | 39 29 27 | 40 29 1 | 40 29 1 | 41 28 35 | 41 28 35 | 42 28 8 | 42 28 8 | 43 48 48 | 43 48 48 | 44 41 41 |
| 39 | 31 2 | 42 1 30 | 42 1 30 | 43 4 30 | 43 4 30 | 44 7 44 | 44 7 44 | 45 9 29 | 45 9 29 | 46 11 49 | 46 11 49 | 47 12 28 | 47 12 28 | 48 12 12 |
| 40 | 46 26 | 31 20 29 | 31 20 29 | 32 20 53 | 32 20 53 | 33 20 26 | 33 20 26 | 34 20 34 | 34 20 34 | 35 29 30 | 35 29 30 | 36 29 1 | 36 29 1 | 37 37 37 |
| 41 | 32 30 | 51 32 3 | 51 32 3 | 55 31 36 | 55 31 36 | 58 31 8 | 58 31 8 | 60 30 39 | 60 30 39 | 61 30 10 | 61 30 10 | 62 41 49 | 62 41 49 | 63 2 2 |
| 42 | 33 14 | 43 18 46 | 43 18 46 | 44 21 32 | 44 21 32 | 45 24 49 | 45 24 49 | 46 31 20 | 46 31 20 | 47 28 50 | 47 28 50 | 48 30 20 | 48 30 20 | 49 28 28 |
| 43 | 58 45 | 45 33 29 | 45 33 29 | 49 33 0 | 49 33 0 | 52 32 30 | 52 32 30 | 53 32 0 | 53 32 0 | 55 31 30 | 55 31 30 | 55 59 55 | 55 59 55 | 56 55 55 |
| 44 | 34 41 | 44 14 34 | 44 14 34 | 45 17 42 | 45 17 42 | 46 20 33 | 46 20 33 | 47 22 40 | 47 22 40 | 48 23 32 | 48 23 32 | 49 24 31 | 49 24 31 | 50 23 23 |
| 45 | 35 24 | 43 54 46 | 43 54 46 | 34 23 49 | 34 23 49 | 52 51 51 | 52 51 51 | 53 20 52 | 53 20 52 | 48 53 48 | 48 53 48 | 53 32 15 | 53 32 15 | 52 52 52 |

Table 13. Kelvin's Summer Line Table

| b | a = 35° | | a = 36° | | a = 37° | | a = 38° | | a = 39° | | a = 40° | | a = 41° | |
|----|---------|-------|---------|-------|---------|-------|---------|-------|---------|-------|---------|-------|---------|-------|
| | K | Q | K | Q | K | Q | K | Q | K | Q | K | Q | K | Q |
| 45 | 35 24 | 44 43 | 34 54 | 45 46 | 34 23 | 46 49 | 33 52 | 47 51 | 33 20 | 48 52 | 32 48 | 49 53 | 32 15 | 50 52 |
| 46 | 36 6 | 45 14 | 35 35 | 46 17 | 35 4 | 47 20 | 34 32 | 48 22 | 59 | 49 23 | 33 26 | 50 23 | 53 | 51 22 |
| 47 | 48 | 45 | 36 16 | 49 | 44 | 51 | 35 12 | 53 | 34 38 | 54 | 34 4 | 54 | 33 30 | 53 |
| 48 | 37 30 | 46 18 | 57 | 47 21 | 36 24 | 48 24 | 51 | 49 25 | 35 17 | 50 26 | 42 | 51 26 | 34 7 | 52 25 |
| 49 | 38 11 | 52 | 37 38 | 55 | 37 4 | 57 | 36 30 | 59 | 55 | 59 | 35 19 | 59 | 43 | 57 |
| 50 | 52 | 47 27 | 38 18 | 48 30 | 43 | 49 32 | 37 8 | 50 33 | 36 32 | 51 33 | 56 | 52 33 | 35 19 | 53 31 |
| 51 | 39 32 | 48 3 | 57 | 49 6 | 38 22 | 50 8 | 46 | 51 9 | 37 9 | 52 9 | 36 32 | 53 8 | 55 | 54 6 |
| 52 | 40 12 | 41 | 39 36 | 43 | 39 0 | 45 | 38 23 | 46 | 46 | 45 | 37 8 | 44 | 36 30 | 42 |
| 53 | 52 | 49 19 | 40 15 | 50 22 | 38 | 51 23 | 39 0 | 52 24 | 38 22 | 53 23 | 43 | 54 21 | 37 4 | 55 18 |
| 54 | 41 31 | 59 | 53 | 51 2 | 40 15 | 52 3 | 36 | 53 3 | 57 | 54 2 | 38 18 | 59 | 38 | 56 |
| 55 | 42 9 | 50 41 | 41 30 | 43 | 52 | 43 | 40 12 | 43 | 39 32 | 41 | 52 | 55 39 | 38 11 | 56 35 |
| 56 | 47 | 51 23 | 42 7 | 52 25 | 41 28 | 53 25 | 47 | 54 24 | 40 7 | 55 22 | 39 26 | 56 19 | 44 | 57 15 |
| 57 | 43 24 | 52 7 | 43 | 53 9 | 42 3 | 54 8 | 41 22 | 55 7 | 41 | 56 4 | 59 | 57 1 | 39 16 | 56 |
| 58 | 44 0 | 53 | 43 19 | 54 | 38 | 53 | 56 | 51 | 41 14 | 48 | 40 31 | 44 | 48 | 58 38 |
| 59 | 36 | 53 40 | 54 | 54 40 | 43 12 | 55 39 | 42 29 | 56 36 | 46 | 57 33 | 41 3 | 58 28 | 40 19 | 59 21 |
| 60 | 45 11 | 54 28 | 44 29 | 55 28 | 46 | 56 26 | 43 2 | 57 23 | 42 18 | 58 19 | 34 | 59 13 | 49 | 60 6 |
| 61 | 46 | 55 18 | 45 2 | 56 17 | 44 19 | 57 15 | 34 | 58 11 | 49 | 59 6 | 42 4 | 59 | 41 18 | 51 |
| 62 | 46 20 | 56 10 | 35 | 57 8 | 51 | 58 5 | 44 5 | 59 0 | 43 20 | 54 | 34 | 60 47 | 47 | 61 38 |
| 63 | 53 | 57 3 | 46 7 | 58 0 | 45 22 | 56 | 36 | 50 | 50 | 60 43 | 43 3 | 61 35 | 42 15 | 62 25 |
| 64 | 47 25 | 57 | 39 | 54 | 52 | 59 49 | 45 6 | 60 42 | 44 19 | 61 34 | 31 | 62 25 | 43 | 63 14 |
| 65 | 56 | 58 53 | 47 9 | 59 49 | 46 22 | 60 43 | 35 | 61 35 | 47 | 62 26 | 58 | 63 16 | 43 9 | 64 4 |
| 66 | 48 27 | 59 51 | 39 | 60 46 | 51 | 61 39 | 46 3 | 62 30 | 45 14 | 63 20 | 44 25 | 64 8 | 35 | 65 55 |
| 67 | 56 | 60 50 | 48 8 | 61 44 | 47 19 | 62 36 | 30 | 63 26 | 40 | 64 15 | 51 | 65 2 | 44 0 | 65 48 |
| 68 | 49 25 | 61 51 | 36 | 62 44 | 46 | 63 34 | 56 | 64 23 | 46 6 | 65 11 | 45 16 | 57 | 24 | 66 41 |
| 69 | 53 | 62 54 | 49 3 | 63 45 | 48 13 | 64 34 | 47 22 | 65 22 | 31 | 66 8 | 40 | 66 53 | 48 | 67 36 |
| 70 | 50 20 | 63 58 | 29 | 64 48 | 38 | 65 35 | 46 | 66 22 | 55 | 67 6 | 46 3 | 67 50 | 45 10 | 68 31 |
| 71 | 46 | 65 4 | 54 | 65 52 | 49 2 | 66 38 | 48 10 | 67 23 | 47 17 | 68 6 | 25 | 68 48 | 32 | 69 28 |
| 72 | 51 10 | 66 11 | 50 18 | 66 58 | 26 | 67 42 | 33 | 68 25 | 39 | 69 7 | 46 | 69 47 | 52 | 70 26 |
| 73 | 34 | 67 20 | 41 | 68 5 | 48 | 68 48 | 54 | 69 29 | 48 0 | 70 9 | 47 6 | 70 47 | 46 12 | 71 25 |
| 74 | 57 | 68 31 | 51 3 | 69 14 | 50 9 | 69 55 | 49 15 | 70 34 | 20 | 71 12 | 26 | 71 49 | 30 | 72 25 |
| 75 | 52 18 | 69 43 | 24 | 70 24 | 29 | 71 3 | 34 | 71 40 | 39 | 72 16 | 44 | 72 51 | 48 | 73 25 |
| 76 | 38 | 70 56 | 43 | 71 35 | 48 | 72 12 | 52 | 72 48 | 57 | 73 22 | 48 1 | 73 55 | 47 5 | 74 27 |
| 77 | 57 | 72 11 | 52 1 | 72 48 | 51 6 | 73 23 | 50 9 | 73 56 | 49 13 | 74 29 | 17 | 75 0 | 20 | 75 30 |
| 78 | 53 15 | 73 28 | 18 | 74 2 | 22 | 74 35 | 25 | 75 6 | 29 | 75 36 | 32 | 76 5 | 35 | 76 33 |
| 79 | 31 | 74 45 | 34 | 75 17 | 37 | 75 47 | 40 | 76 17 | 43 | 76 45 | 46 | 77 11 | 48 | 77 37 |
| 80 | 46 | 76 4 | 49 | 76 33 | 51 | 77 1 | 54 | 77 28 | 56 | 77 54 | 58 | 78 18 | 48 0 | 78 42 |
| 81 | 54 0 | 77 24 | 53 2 | 77 51 | 52 4 | 78 16 | 51 6 | 78 41 | 50 8 | 79 4 | 49 10 | 79 26 | 12 | 79 48 |
| 82 | 13 | 78 46 | 14 | 79 9 | 16 | 79 32 | 17 | 79 54 | 19 | 80 15 | 20 | 80 35 | 22 | 80 54 |
| 83 | 24 | 80 8 | 25 | 80 29 | 26 | 80 49 | 27 | 81 8 | 29 | 81 27 | 29 | 81 44 | 31 | 82 1 |
| 84 | 33 | 81 31 | 34 | 81 49 | 35 | 82 6 | 36 | 82 23 | 37 | 82 39 | 37 | 82 54 | 39 | 83 9 |
| 85 | 41 | 82 54 | 42 | 83 10 | 43 | 83 24 | 43 | 83 38 | 44 | 83 52 | 44 | 84 4 | 45 | 84 17 |
| 86 | 48 | 84 19 | 49 | 84 31 | 49 | 84 43 | 49 | 84 54 | 50 | 85 5 | 50 | 85 15 | 50 | 85 25 |
| 87 | 53 | 85 44 | 54 | 85 53 | 54 | 86 2 | 54 | 86 10 | 54 | 86 18 | 54 | 86 26 | 54 | 86 33 |
| 88 | 57 | 87 9 | 57 | 87 15 | 57 | 87 21 | 57 | 87 26 | 57 | 87 32 | 57 | 87 37 | 57 | 87 42 |
| 89 | 59 | 88 34 | 59 | 88 37 | 59 | 88 40 | 59 | 88 43 | 59 | 88 46 | 59 | 88 48 | 59 | 88 51 |
| 90 | 55 0 | 90 0 | 54 0 | 90 0 | 53 0 | 90 0 | 52 0 | 90 0 | 51 0 | 90 0 | 50 0 | 90 0 | 49 0 | 90 0 |

Table 13. Kelvin's Summer Line Table

| b | a = 42° | | a = 43° | | a = 44° | | a = 45° | | a = 46° | | a = 47° | | a = 48° | |
|----|---------|-------|---------|-------|---------|---------|---------|-------|---------|-------|---------|-------|---------|-------|
| | K | Q | K | Q | K | Q | K | Q | K | Q | K | Q | K | Q |
| 0 | 0 0 | 42 0 | 0 0 | 43 0 | 0 0 | 44 0 | 0 0 | 45 0 | 0 0 | 46 0 | 0 0 | 47 0 | 0 0 | 48 0 |
| 1 | 45 | 0 | 44 | 0 | 43 | 0 | 42 | 0 | 42 | 0 | 41 | 0 | 40 | 0 |
| 2 | 1 29 | 1 | 1 28 | 1 | 1 26 | 1 | 1 25 | 1 | 1 23 | 1 | 1 22 | 1 | 1 20 | 1 |
| 3 | 2 14 | 2 | 2 12 | 2 | 2 10 | 2 | 2 7 | 2 | 2 5 | 2 | 2 3 | 2 | 2 0 | 2 |
| 4 | 58 | 4 | 55 | 4 | 53 | 4 | 50 | 4 | 47 | 4 | 44 | 4 | 40 | 4 |
| 5 | 3 43 | 6 | 3 39 | 6 | 3 36 | 6 | 3 32 | 6 | 3 28 | 6 | 3 25 | 6 | 3 20 | 6 |
| 6 | 4 27 | 9 | 4 23 | 9 | 4 19 | 9 | 4 14 | 9 | 4 10 | 9 | 4 5 | 9 | 4 0 | 9 |
| 7 | 5 12 | 13 | 5 7 | 13 | 5 2 | 13 | 5 7 | 13 | 5 1 | 13 | 4 6 | 13 | 4 0 | 13 |
| 8 | 5 56 | 17 | 5 1 | 17 | 4 45 | 17 | 5 39 | 17 | 5 33 | 17 | 5 27 | 17 | 5 20 | 17 |
| 9 | 6 41 | 21 | 6 34 | 21 | 6 28 | 21 | 6 21 | 21 | 6 14 | 21 | 6 7 | 21 | 6 0 | 21 |
| 10 | 7 25 | 26 | 7 18 | 26 | 7 11 | 26 | 7 3 | 26 | 5 6 | 26 | 4 8 | 26 | 4 0 | 26 |
| 11 | 8 9 | 32 | 8 1 | 32 | 5 3 | 32 | 4 5 | 32 | 7 37 | 32 | 7 29 | 32 | 7 20 | 32 |
| 12 | 53 | 38 | 45 | 38 | 8 36 | 38 | 8 27 | 38 | 8 18 | 38 | 8 9 | 38 | 8 0 | 38 |
| 13 | 9 37 | 45 | 9 28 | 45 | 9 19 | 45 | 9 9 | 45 | 5 9 | 45 | 4 9 | 45 | 3 9 | 44 |
| 14 | 10 21 | 52 | 10 11 | 52 | 10 1 | 52 | 5 1 | 52 | 9 40 | 52 | 9 30 | 52 | 9 19 | 51 |
| 15 | 11 5 | 59 | 5 5 | 44 0 | 44 45 | 0 10 33 | 46 0 | 10 21 | 47 0 | 10 10 | 48 0 | 5 8 | 5 9 | 5 9 |
| 16 | 49 | 43 8 | 11 38 | 8 | 11 26 | 8 | 11 15 | 8 | 11 2 | 8 | 5 0 | 8 | 10 38 | 49 7 |
| 17 | 12 33 | 17 | 12 21 | 17 | 12 8 | 17 | 5 6 | 17 | 4 3 | 17 | 11 30 | 17 | 11 17 | 16 |
| 18 | 13 17 | 26 | 13 4 | 26 | 5 0 | 26 | 12 37 | 26 | 12 24 | 26 | 12 10 | 26 | 5 6 | 25 |
| 19 | 14 0 | 36 | 4 6 | 36 | 13 32 | 36 | 13 18 | 36 | 13 4 | 36 | 5 0 | 36 | 12 35 | 35 |
| 20 | 44 | 47 | 14 29 | 47 | 14 14 | 47 | 5 9 | 47 | 4 5 | 47 | 13 29 | 46 | 13 14 | 46 |
| 21 | 15 27 | 58 | 15 12 | 58 | 5 6 | 58 | 14 40 | 58 | 14 25 | 58 | 14 9 | 57 | 5 3 | 5 7 |
| 22 | 16 10 | 44 10 | 5 4 | 45 10 | 15 38 | 46 10 | 15 21 | 47 10 | 15 5 | 48 10 | 4 8 | 49 9 | 14 31 | 50 9 |
| 23 | 53 | 22 | 16 36 | 22 | 16 19 | 22 | 16 2 | 22 | 4 5 | 22 | 15 27 | 21 | 15 9 | 21 |
| 24 | 17 36 | 35 | 17 18 | 35 | 17 1 | 35 | 4 3 | 35 | 16 25 | 35 | 16 6 | 34 | 4 7 | 34 |
| 25 | 18 19 | 49 | 18 0 | 49 | 4 2 | 49 | 17 23 | 49 | 17 5 | 49 | 4 5 | 48 | 16 25 | 47 |
| 26 | 19 1 | 45 3 | 4 2 | 46 3 | 18 23 | 47 3 | 18 3 | 48 3 | 4 4 | 49 3 | 17 24 | 50 2 | 17 3 | 51 1 |
| 27 | 43 | 18 | 19 24 | 18 | 19 4 | 18 | 4 3 | 18 | 18 23 | 17 | 18 2 | 17 | 4 1 | 16 |
| 28 | 20 25 | 34 | 20 5 | 34 | 4 4 | 34 | 19 23 | 33 | 19 2 | 33 | 4 0 | 32 | 18 19 | 31 |
| 29 | 21 7 | 50 | 4 6 | 50 | 20 25 | 50 | 20 3 | 49 | 4 1 | 49 | 19 18 | 48 | 5 6 | 47 |
| 30 | 49 | 46 7 | 21 27 | 47 7 | 21 5 | 48 7 | 4 2 | 49 6 | 20 20 | 50 6 | 5 6 | 51 5 | 19 33 | 52 3 |
| 31 | 22 30 | 25 | 22 8 | 25 | 4 5 | 25 | 21 21 | 24 | 5 8 | 23 | 20 34 | 22 | 20 10 | 20 |
| 32 | 23 11 | 43 | 4 8 | 43 | 22 25 | 43 | 22 0 | 42 | 21 36 | 41 | 21 11 | 40 | 4 6 | 38 |
| 33 | 52 | 47 2 | 23 28 | 48 2 | 23 4 | 49 2 | 3 9 | 50 1 | 22 14 | 51 0 | 4 8 | 58 | 21 22 | 56 |
| 34 | 24 33 | 22 | 24 8 | 22 | 4 3 | 21 | 23 18 | 20 | 5 2 | 19 | 22 25 | 52 17 | 5 8 | 53 15 |
| 35 | 25 14 | 42 | 4 8 | 42 | 24 22 | 42 | 5 6 | 41 | 23 29 | 39 | 23 2 | 37 | 22 34 | 35 |
| 36 | 54 | 48 4 | 25 28 | 49 3 | 25 1 | 50 3 | 24 34 | 51 2 | 24 6 | 52 0 | 3 8 | 58 | 23 10 | 56 |
| 37 | 26 34 | 26 | 26 7 | 25 | 3 9 | 25 | 25 11 | 23 | 4 3 | 22 | 24 14 | 53 19 | 4 5 | 54 17 |
| 38 | 27 14 | 49 | 4 6 | 48 | 26 17 | 47 | 4 8 | 46 | 25 19 | 44 | 5 0 | 41 | 24 20 | 39 |
| 39 | 53 | 49 12 | 27 24 | 50 12 | 5 5 | 51 11 | 26 25 | 52 9 | 5 5 | 53 7 | 25 25 | 54 4 | 5 4 | 5 1 |
| 40 | 28 32 | 37 | 28 2 | 36 | 27 32 | 35 | 27 2 | 33 | 26 31 | 31 | 26 0 | 28 | 25 28 | 24 |
| 41 | 29 11 | 50 2 | 4 0 | 51 1 | 28 9 | 52 0 | 3 8 | 58 | 27 7 | 55 | 3 5 | 52 | 26 2 | 48 |
| 42 | 49 | 28 | 29 18 | 27 | 4 6 | 25 | 28 14 | 53 23 | 4 2 | 54 20 | 27 9 | 55 17 | 3 6 | 56 13 |
| 43 | 30 27 | 55 | 5 5 | 54 | 29 23 | 52 | 5 0 | 49 | 28 17 | 46 | 4 3 | 42 | 27 9 | 38 |
| 44 | 31 5 | 51 23 | 30 32 | 52 21 | 5 9 | 53 19 | 29 25 | 54 16 | 5 1 | 55 13 | 28 17 | 56 9 | 4 2 | 57 4 |
| 45 | 42 | 51 | 31 9 | 50 | 30 34 | 47 | 30 0 | 44 | 29 25 | 40 | 5 0 | 36 | 28 14 | 31 |

Table 13. Kelvin's Sumner Line Table

| b | a = 49° | | a = 50° | | a = 51° | | a = 52° | | a = 53° | | a = 54° | | a = 55° | |
|----|---------|------|----------|------|---------|------|----------|------|----------|---------|---------|-------|----------|------|
| | K | Q | K | Q | K | Q | K | Q | K | Q | K | Q | K | Q |
| 0 | 0 0 | 49 0 | 0 0 | 50 0 | 0 0 | 51 0 | 0 0 | 52 0 | 0 0 | 53 0 | 0 0 | 54 0 | 0 0 | 55 0 |
| 1 | 39 | 0 | 39 | 0 | 38 | 0 | 37 | 0 | 36 | 0 | 35 | 0 | 34 | 0 |
| 2 | 1 19 | 1 | 1 17 | 1 | 1 16 | 1 | 1 14 | 1 | 1 12 | 1 | 1 11 | 1 | 1 9 | 1 |
| 3 | 58 | 2 | 56 | 2 | 53 | 2 | 51 | 2 | 48 | 2 | 46 | 2 | 43 | 2 |
| 4 | 2 37 | 4 | 2 34 | 4 | 2 31 | 4 | 2 28 | 4 | 2 24 | 4 | 2 21 | 4 | 2 18 | 4 |
| 5 | 3 17 | 6 | 3 13 | 6 | 3 9 | 6 | 3 5 | 6 | 3 0 | 6 | 56 | 6 | 52 | 6 |
| 6 | 56 | 9 | 51 | 9 | 47 | 9 | 41 | 9 | 36 | 9 | 3 31 | 9 | 3 26 | 9 |
| 7 | 4 35 | 13 | 4 30 | 13 | 4 24 | 13 | 4 18 | 12 | 4 12 | 12 | 4 6 | 12 | 4 0 | 12 |
| 8 | 5 14 | 17 | 5 8 | 17 | 5 2 | 17 | 55 | 16 | 48 | 16 | 41 | 16 | 35 | 16 |
| 9 | 53 | 21 | 46 | 21 | 39 | 21 | 5 32 | 21 | 5 24 | 20 | 5 16 | 20 | 5 9 | 20 |
| 10 | 6 32 | 26 | 6 25 | 26 | 6 16 | 26 | 6 8 | 26 | 6 0 | 25 | 51 | 25 | 43 | 25 |
| 11 | 7 11 | 32 | 7 3 | 31 | 54 | 31 | 45 | 31 | 36 | 30 | 6 26 | 30 | 6 17 | 30 |
| 12 | 50 | 38 | 41 | 37 | 7 31 | 37 | 7 21 | 37 | 7 11 | 36 | 7 1 | 36 | 51 | 36 |
| 13 | 8 29 | 44 | 8 19 | 44 | 8 8 | 44 | 58 | 43 | 47 | 43 | 36 | 42 | 7 25 | 42 |
| 14 | 9 8 | 51 | 57 | 51 | 45 | 51 | 8 34 | 50 | 8 22 | 50 | 8 11 | 49 | 59 | 49 |
| 15 | 47 | 59 | 9 35 | 59 | 9 22 | 58 | 9 10 | 58 | 58 | 57 | 45 | 56 | 8 32 | 56 |
| 16 | 10 25 | 50 | 7 10 | 51 | 7 59 | 52 | 6 46 | 53 | 6 9 33 | 54 | 5 9 19 | 55 | 4 9 6 | 56 |
| 17 | 11 4 | 16 | 50 | 15 | 10 36 | 15 | 10 22 | 14 | 10 8 | 13 | 54 | 12 | 39 | 11 |
| 18 | 42 | 25 | 11 28 | 24 | 11 13 | 24 | 58 | 23 | 43 | 22 | 10 28 | 21 | 10 13 | 20 |
| 19 | 12 20 | 35 | 12 5 | 34 | 49 | 34 | 11 34 | 33 | 11 18 | 32 | 11 2 | 31 | 46 | 29 |
| 20 | 58 | 45 | 42 | 45 | 12 26 | 44 | 12 9 | 43 | 53 | 42 | 36 | 41 | 11 19 | 39 |
| 21 | 13 36 | 56 | 13 19 | 56 | 13 2 | 55 | 45 | 54 | 12 27 | 52 | 12 10 | 51 | 52 | 49 |
| 22 | 14 14 | 51 | 8 56 | 52 | 7 38 | 53 | 6 13 20 | 54 | 5 13 2 | 55 | 3 43 | 56 | 2 12 25 | 57 |
| 23 | 51 | 20 | 14 33 | 19 | 14 14 | 18 | 55 | 17 | 36 | 15 | 13 17 | 14 | 57 | 12 |
| 24 | 15 29 | 33 | 15 9 | 32 | 50 | 30 | 14 30 | 29 | 14 10 | 27 | 50 | 26 | 13 30 | 24 |
| 25 | 16 6 | 46 | 46 | 45 | 15 26 | 43 | 15 5 | 42 | 44 | 40 | 14 23 | 38 | 14 2 | 36 |
| 26 | 43 | 52 | 0 16 22 | 59 | 16 1 | 57 | 40 | 55 | 15 18 | 53 | 56 | 51 | 34 | 49 |
| 27 | 17 20 | 14 | 58 | 53 | 13 36 | 54 | 11 16 14 | 55 | 9 51 | 56 | 7 15 29 | 57 | 5 15 6 | 58 |
| 28 | 56 | 29 | 17 34 | 28 | 17 11 | 26 | 48 | 24 | 16 25 | 22 | 16 1 | 19 | 37 | 16 |
| 29 | 18 33 | 45 | 18 10 | 44 | 46 | 42 | 17 22 | 39 | 58 | 37 | 33 | 34 | 16 9 | 31 |
| 30 | 19 9 | 53 | 2 45 | 54 | 0 18 20 | 58 | 56 | 55 | 17 31 | 52 | 17 5 | 49 | 40 | 46 |
| 31 | 45 | 19 | 19 20 | 17 | 55 | 55 | 14 18 29 | 56 | 11 18 3 | 57 | 8 37 | 58 | 5 17 11 | 59 |
| 32 | 20 21 | 36 | 55 | 34 | 19 29 | 31 | 19 2 | 28 | 36 | 25 | 18 9 | 22 | 42 | 18 |
| 33 | 56 | 54 | 20 30 | 52 | 20 3 | 49 | 35 | 46 | 19 8 | 42 | 40 | 39 | 18 12 | 35 |
| 34 | 21 31 | 54 | 13 21 | 4 55 | 11 37 | 56 | 7 20 8 | 57 | 4 40 | 58 | 0 19 11 | 56 | 42 | 52 |
| 35 | 22 6 | 33 | 38 | 30 | 21 10 | 26 | 41 | 23 | 20 12 | 19 | 42 | 59 | 14 19 12 | 60 |
| 36 | 41 | 53 | 22 12 | 50 | 43 | 46 | 21 13 | 42 | 43 | 38 | 20 13 | 33 | 42 | 28 |
| 37 | 23 15 | 55 | 14 46 | 56 | 10 22 | 16 | 57 7 | 45 | 58 | 2 21 14 | 58 | 43 | 52 | 20 |
| 38 | 49 | 35 | 23 19 | 32 | 48 | 28 | 22 17 | 23 | 45 | 59 | 18 | 21 13 | 60 | 12 |
| 39 | 24 23 | 57 | 52 | 54 | 23 20 | 49 | 48 | 44 | 22 15 | 39 | 43 | 33 | 21 10 | 27 |
| 40 | 57 | 56 | 20 24 24 | 57 | 16 52 | 58 | 11 23 19 | 59 | 6 45 | 60 | 0 22 12 | 54 | 38 | 48 |
| 41 | 25 30 | 44 | 56 | 39 | 24 23 | 34 | 50 | 29 | 23 15 | 22 | 41 | 61 | 16 22 | 6 |
| 42 | 26 3 | 57 | 8 25 28 | 58 | 3 54 | 58 | 24 20 | 52 | 45 | 22 | 41 | 61 | 16 22 | 6 |
| 43 | 35 | 33 | 26 0 | 28 | 25 25 | 59 | 22 50 | 60 | 15 24 14 | 61 | 8 38 | 62 | 1 23 | 2 |
| 44 | 27 7 | 59 | 31 | 53 | 55 | 47 | 25 19 | 40 | 43 | 32 | 24 6 | 25 | 29 | 63 |
| 45 | 38 | 58 | 25 27 | 2 59 | 19 26 | 25 | 60 12 | 48 | 61 5 | 25 | 11 57 | 34 | 49 | 56 |

Table 13. Kelvin's Summer Line Table

| b | a = 49° | | | a = 50° | | | a = 51° | | | a = 52° | | | a = 53° | | | a = 54° | | | a = 55° | | | | | | | | | | | | | | | |
|----|---------|----|----|---------|----|----|---------|----|----|---------|----|----|---------|----|----|---------|----|----|---------|----|----|----|----|----|----|----|----|----|----|----|----|---|----|----|
| | K | Q | | K | Q | | K | Q | | K | Q | | K | Q | | K | Q | | K | Q | | | | | | | | | | | | | | |
| 45 | 27 | 38 | 58 | 25 | 27 | 2 | 59 | 19 | 26 | 25 | 60 | 12 | 25 | 48 | 61 | 5 | 25 | 11 | 61 | 57 | 24 | 34 | 62 | 49 | 23 | 56 | 63 | 40 | | | | | | |
| 46 | 28 | 9 | 52 | 32 | 46 | | 55 | 38 | 26 | 17 | | 31 | 39 | 62 | 22 | 25 | 1 | 63 | 13 | 24 | 22 | 64 | 4 | 24 | 22 | 64 | 4 | | | | | | | |
| 47 | 40 | 59 | 20 | 28 | 2 | 60 | 13 | 27 | 24 | 61 | 5 | 46 | 57 | 26 | 7 | 48 | | 28 | 38 | 48 | | 38 | 48 | 29 | | | 29 | | | | | | | |
| 48 | 29 | 11 | 49 | 32 | 41 | | 53 | 33 | 27 | 14 | 62 | 24 | 34 | 63 | 15 | 54 | 64 | 4 | 25 | 14 | 4 | 25 | 14 | 54 | | | 54 | | | | | | | |
| 49 | 41 | 60 | 18 | 29 | 1 | 61 | 10 | 28 | 21 | 62 | 1 | 41 | 52 | 27 | 1 | 42 | 26 | 20 | 31 | 39 | 65 | 20 | | | | | 39 | 65 | 20 | | | | | |
| 50 | 30 | 10 | 48 | 30 | 40 | | 49 | 30 | 28 | 8 | 63 | 20 | 27 | 64 | 9 | 46 | 58 | 26 | 4 | 46 | | | | | | | | 46 | | | | | | |
| 51 | 39 | 61 | 19 | 58 | 62 | 10 | 29 | 17 | 63 | 0 | 35 | 49 | 53 | 38 | 27 | 11 | 65 | 26 | 28 | 66 | 13 | | | | | | | 28 | 66 | 13 | | | | |
| 52 | 31 | 8 | 51 | 30 | 26 | 41 | 44 | 30 | 29 | 1 | 64 | 19 | 28 | 19 | 65 | 7 | 36 | 54 | 52 | 41 | | | | | | | | 52 | 41 | | | | | |
| 53 | 36 | 62 | 23 | 53 | 63 | 13 | 30 | 10 | 64 | 1 | 27 | 49 | 44 | 36 | 28 | 0 | 66 | 23 | 27 | 16 | 67 | 9 | | | | | | 27 | 16 | 67 | 9 | | | |
| 54 | 32 | 3 | 56 | 31 | 20 | 45 | 36 | 33 | 52 | 65 | 20 | 29 | 8 | 66 | 6 | 24 | 52 | 39 | 38 | | | | | | | | | 39 | 38 | | | | | |
| 55 | 30 | 63 | 30 | 46 | 64 | 18 | 31 | 2 | 65 | 5 | 30 | 17 | 52 | 32 | 37 | 47 | 67 | 22 | 28 | 2 | 68 | 7 | | | | | | 28 | 2 | 68 | 7 | | | |
| 56 | 57 | 64 | 5 | 32 | 12 | 52 | 27 | 38 | 41 | 66 | 24 | 56 | 67 | 9 | 29 | 10 | 53 | 24 | 37 | | | | | | | | | 24 | 37 | | | | | |
| 57 | 33 | 23 | 40 | 37 | 65 | 26 | 51 | 66 | 12 | 31 | 5 | 57 | 30 | 19 | 41 | 32 | 68 | 25 | 45 | 69 | 8 | | | | | | | 45 | 69 | 8 | | | | |
| 58 | 48 | 65 | 16 | 33 | 2 | 66 | 2 | 32 | 15 | 47 | 28 | 67 | 31 | 41 | 68 | 14 | 54 | 57 | 29 | 6 | 39 | | | | | | | 29 | 6 | 39 | | | | |
| 59 | 34 | 13 | 53 | 26 | 38 | | 39 | 67 | 22 | 51 | 68 | 5 | 31 | 3 | 47 | 30 | 15 | 69 | 29 | 7 | 70 | 10 | | | | | | 29 | 7 | 70 | 10 | | | |
| 60 | 37 | 66 | 31 | 50 | 67 | 14 | 33 | 2 | 58 | 32 | 13 | 40 | 25 | 69 | 21 | 36 | 70 | 2 | 47 | 42 | | | | | | | | 47 | 42 | | | | | |
| 61 | 35 | 1 | 67 | 9 | 34 | 13 | 52 | 24 | 68 | 34 | 35 | 69 | 15 | 46 | 56 | 56 | 36 | 30 | 7 | 71 | 15 | | | | | | | 30 | 7 | 71 | 15 | | | |
| 62 | 24 | 48 | | 35 | 68 | 30 | 45 | 69 | 11 | 56 | 51 | 32 | 6 | 70 | 31 | 31 | 16 | 71 | 10 | 26 | 48 | | | | | | | 26 | 48 | | | | | |
| 63 | 46 | 68 | 28 | 56 | 69 | 9 | 34 | 6 | 49 | 33 | 16 | 70 | 28 | 26 | 71 | 7 | 35 | 45 | 44 | 72 | 22 | | | | | | | 44 | 72 | 22 | | | | |
| 64 | 36 | 8 | 69 | 8 | 35 | 17 | 48 | 27 | 70 | 27 | 36 | 71 | 6 | 45 | 43 | 53 | 72 | 20 | 31 | 2 | 56 | | | | | | | 31 | 2 | 56 | | | | |
| 65 | 29 | 50 | | 38 | 70 | 28 | 47 | 71 | 6 | 55 | 44 | 33 | 3 | 72 | 20 | 32 | 11 | 56 | 19 | 73 | 31 | | | | | | | 19 | 73 | 31 | | | | |
| 66 | 49 | 70 | 32 | 58 | 71 | 9 | 35 | 6 | 46 | 34 | 13 | 72 | 22 | 21 | 58 | 28 | 73 | 32 | 36 | 74 | 6 | | | | | | | 36 | 74 | 6 | | | | |
| 67 | 37 | 9 | 71 | 14 | 36 | 17 | 51 | 24 | 72 | 26 | 31 | 73 | 1 | 38 | 73 | 36 | 45 | 74 | 9 | 52 | 42 | | | | | | | 52 | 42 | | | | | |
| 68 | 28 | 58 | | 35 | 72 | 33 | 42 | 73 | 7 | 48 | 41 | 55 | 74 | 14 | 33 | 1 | 46 | 32 | 8 | 75 | 18 | | | | | | | 32 | 8 | 75 | 18 | | | |
| 69 | 46 | 72 | 42 | 53 | 73 | 16 | 59 | 49 | 35 | 5 | 74 | 21 | 34 | 11 | 53 | 17 | 75 | 24 | 23 | 55 | | | | | | | | 23 | 55 | | | | | |
| 70 | 38 | 3 | 73 | 27 | 37 | 10 | 59 | 36 | 15 | 74 | 31 | 21 | 75 | 2 | 26 | 75 | 33 | 32 | 76 | 3 | 37 | 76 | 32 | | | | | 37 | 76 | 32 | | | | |
| 71 | 20 | 74 | 12 | 26 | 74 | 43 | 31 | 75 | 14 | 36 | 44 | 41 | 76 | 13 | 46 | 42 | 51 | 77 | 9 | 51 | 77 | 9 | | | | | | 51 | 77 | 9 | | | | |
| 72 | 36 | 58 | | 41 | 75 | 28 | 46 | 57 | 50 | 76 | 26 | 55 | 54 | 59 | 77 | 21 | 33 | 4 | 47 | | | | | | | | | 33 | 4 | 47 | | | | |
| 73 | 51 | 75 | 44 | 56 | 76 | 13 | 37 | 0 | 76 | 41 | 36 | 4 | 77 | 8 | 35 | 8 | 77 | 35 | 34 | 12 | 78 | 1 | 16 | 78 | 26 | | | 16 | 78 | 26 | | | | |
| 74 | 39 | 6 | 76 | 31 | 38 | 10 | 59 | 13 | 77 | 25 | 17 | 51 | 21 | 78 | 16 | 24 | 41 | 28 | 79 | 5 | | | | | | | | 28 | 79 | 5 | | | | |
| 75 | 19 | 77 | 19 | 23 | 77 | 45 | 26 | 78 | 10 | 29 | 78 | 34 | 33 | 58 | 35 | 79 | 21 | 39 | 44 | | | | | | | | | 39 | 44 | | | | | |
| 76 | 32 | 78 | 7 | 35 | 78 | 32 | 38 | 55 | 41 | 79 | 18 | 44 | 79 | 40 | 46 | 80 | 2 | 49 | 80 | 23 | | | | | | | | 49 | 80 | 23 | | | | |
| 77 | 44 | 56 | | 47 | 79 | 19 | 49 | 79 | 41 | 52 | 80 | 2 | 54 | 80 | 23 | 56 | 43 | 59 | 81 | 3 | | | | | | | | 59 | 81 | 3 | | | | |
| 78 | 55 | 79 | 45 | 57 | 80 | 6 | 59 | 80 | 27 | 37 | 2 | 46 | 36 | 4 | 81 | 6 | 35 | 6 | 81 | 25 | 34 | 8 | 43 | | | | | 34 | 8 | 43 | | | | |
| 79 | 40 | 5 | 80 | 35 | 39 | 7 | 54 | 38 | 9 | 81 | 13 | 11 | 81 | 31 | 13 | 49 | 14 | 82 | 7 | 16 | 82 | 23 | | | | | | 16 | 82 | 23 | | | | |
| 80 | 15 | 81 | 25 | 16 | 81 | 42 | 18 | 82 | 0 | 19 | 82 | 16 | 21 | 82 | 33 | 22 | 49 | 24 | 83 | 4 | | | | | | | | 24 | 83 | 4 | | | | |
| 81 | 23 | 82 | 15 | 24 | 82 | 31 | 26 | 47 | 27 | 83 | 2 | 28 | 83 | 17 | 29 | 83 | 31 | 31 | 45 | | | | | | | | | 31 | 45 | | | | | |
| 82 | 31 | 83 | 6 | 32 | 83 | 20 | 33 | 83 | 34 | 34 | 48 | 35 | 84 | 1 | 36 | 84 | 13 | 37 | 84 | 26 | | | | | | | | 37 | 84 | 26 | | | | |
| 83 | 38 | 57 | | 38 | 84 | 10 | 39 | 84 | 22 | 40 | 84 | 34 | 41 | 45 | 41 | 56 | 42 | 85 | 7 | | | | | | | | | 42 | 85 | 7 | | | | |
| 84 | 44 | 84 | 48 | 44 | 59 | | 45 | 85 | 10 | 45 | 85 | 20 | 46 | 85 | 30 | 46 | 85 | 39 | 47 | 49 | | | | | | | | 47 | 49 | | | | | |
| 85 | 49 | 85 | 40 | 49 | 85 | 49 | 49 | 58 | 50 | 86 | 6 | 50 | 86 | 15 | 50 | 86 | 23 | 51 | 86 | 30 | | | | | | | | 51 | 86 | 30 | | | | |
| 86 | 53 | 86 | 32 | 53 | 86 | 39 | 53 | 86 | 46 | 53 | 53 | 54 | 87 | 0 | 54 | 87 | 6 | 54 | 87 | 12 | | | | | | | | 54 | 87 | 12 | | | | |
| 87 | 56 | 87 | 24 | 56 | 87 | 29 | 56 | 87 | 34 | 56 | 87 | 39 | 57 | 45 | 57 | 49 | 57 | 49 | 57 | 54 | | | | | | | | 57 | 54 | | | | | |
| 88 | 58 | 88 | 16 | 58 | 88 | 19 | 58 | 88 | 23 | 58 | 88 | 26 | 59 | 88 | 30 | 59 | 88 | 33 | 59 | 88 | 36 | | | | | | | 59 | 88 | 36 | | | | |
| 89 | 41 | 0 | 89 | 8 | 40 | 0 | 89 | 10 | 39 | 0 | 89 | 11 | 38 | 0 | 89 | 13 | 37 | 0 | 89 | 15 | 36 | 0 | 89 | 16 | 35 | 0 | 89 | 18 | | | 35 | 0 | 89 | 18 |
| 90 | 0 | 90 | 0 | 0 | 90 | 0 | 0 | 90 | 0 | 0 | 90 | 0 | 0 | 90 | 0 | 0 | 90 | 0 | 0 | 90 | 0 | | | | | | | | 0 | 90 | 0 | | | |

Table 13. Kelvin's Sumner Line Table

| b | a = 56° | | a = 57° | | a = 58° | | a = 59° | | a = 60° | | a = 61° | | a = 62° | |
|----|---------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| | K | Q | K | Q | K | Q | K | Q | K | Q | K | Q | K | Q |
| 0 | 0 0 | 56 0 | 0 0 | 57 0 | 0 0 | 58 0 | 0 0 | 59 0 | 0 0 | 60 0 | 0 0 | 61 0 | 0 0 | 62 0 |
| 1 | 34 | 0 | 33 | 0 | 32 | 0 | 31 | 0 | 30 | 0 | 29 | 0 | 28 | 0 |
| 2 | 1 7 | 1 1 | 5 1 | 1 1 | 4 1 | 1 1 | 2 1 | 1 1 | 0 1 | 1 1 | 58 1 | 1 56 | 1 56 | 1 2 |
| 3 | 41 | 2 38 | 2 38 | 2 38 | 2 35 | 2 33 | 2 32 | 2 30 | 2 30 | 2 1 | 27 2 | 1 25 | 2 2 | 2 2 |
| 4 | 2 14 | 4 2 11 | 4 2 11 | 4 2 11 | 4 2 7 | 4 2 4 | 4 2 4 | 4 2 0 | 4 2 0 | 4 4 | 56 4 | 4 53 | 3 3 | 3 3 |
| 5 | 48 | 6 43 | 6 43 | 6 39 | 6 34 | 6 30 | 6 25 | 6 20 | 6 15 | 6 11 | 6 7 | 6 3 | 6 0 | 6 0 |
| 6 | 3 21 | 9 3 16 | 9 3 16 | 9 3 11 | 8 3 5 | 8 3 0 | 8 2 5 | 8 2 0 | 8 1 5 | 8 1 0 | 8 5 | 8 0 | 8 0 | 8 0 |
| 7 | 54 | 12 48 | 12 48 | 12 42 | 11 36 | 11 30 | 11 25 | 11 20 | 11 15 | 11 10 | 11 5 | 11 0 | 11 0 | 11 0 |
| 8 | 4 28 | 16 4 21 | 15 4 14 | 15 4 7 | 15 4 1 | 15 3 5 | 15 3 0 | 15 2 5 | 15 2 0 | 15 1 5 | 15 1 0 | 15 0 5 | 15 0 0 | 15 0 0 |
| 9 | 5 1 | 20 5 3 | 19 4 5 | 19 3 7 | 19 3 1 | 19 2 5 | 19 2 0 | 19 1 5 | 19 1 0 | 19 0 5 | 19 0 0 | 19 0 0 | 19 0 0 | 19 0 0 |
| 10 | 34 | 24 5 26 | 24 5 17 | 24 5 8 | 23 5 2 | 23 4 6 | 23 4 0 | 23 3 4 | 23 2 8 | 23 2 2 | 23 1 6 | 23 1 0 | 23 0 4 | 23 0 0 |
| 11 | 6 7 | 29 5 8 | 29 4 8 | 29 3 8 | 28 3 2 | 28 2 6 | 28 2 0 | 28 1 4 | 28 0 8 | 28 0 2 | 28 0 0 | 28 0 0 | 28 0 0 | 28 0 0 |
| 12 | 40 | 35 6 30 | 35 6 20 | 34 6 9 | 33 6 3 | 33 5 7 | 33 5 1 | 33 4 5 | 33 3 9 | 33 3 3 | 33 2 7 | 33 2 1 | 33 1 5 | 33 0 9 |
| 13 | 7 13 | 41 7 2 | 41 6 1 | 40 5 5 | 39 4 9 | 39 4 3 | 39 3 7 | 39 3 1 | 39 2 5 | 39 1 9 | 39 1 3 | 39 0 7 | 39 0 1 | 39 0 0 |
| 14 | 46 | 48 3 4 | 47 2 2 | 46 1 1 | 45 0 5 | 45 0 0 | 45 0 0 | 45 0 0 | 45 0 0 | 45 0 0 | 45 0 0 | 45 0 0 | 45 0 0 | 45 0 0 |
| 15 | 8 19 | 55 8 6 | 54 7 5 | 53 6 4 | 52 5 3 | 52 4 2 | 52 3 1 | 52 2 0 | 52 1 0 | 52 0 0 | 52 0 0 | 52 0 0 | 52 0 0 | 52 0 0 |
| 16 | 52 57 | 3 38 58 | 2 8 24 | 2 7 18 | 2 6 12 | 2 5 6 | 2 4 0 | 2 3 4 | 2 2 8 | 2 2 2 | 2 1 6 | 2 1 0 | 2 0 4 | 2 0 0 |
| 17 | 9 25 | 11 9 10 | 10 8 4 | 10 7 8 | 9 6 2 | 9 5 6 | 9 5 0 | 9 4 4 | 9 3 8 | 9 3 2 | 9 2 6 | 9 2 0 | 9 1 4 | 9 0 8 |
| 18 | 57 | 19 9 2 | 18 8 6 | 18 7 0 | 17 6 4 | 17 5 8 | 17 5 2 | 17 4 6 | 17 4 0 | 17 3 4 | 17 2 8 | 17 2 2 | 17 1 6 | 17 1 0 |
| 19 | 10 29 | 28 10 13 | 27 9 7 | 27 8 1 | 26 7 5 | 26 6 0 | 26 5 4 | 26 4 8 | 26 4 2 | 26 3 6 | 26 3 0 | 26 2 4 | 26 1 8 | 26 1 2 |
| 20 | 11 1 | 38 4 4 | 36 3 8 | 35 3 2 | 34 2 6 | 34 2 0 | 34 1 4 | 34 0 8 | 34 0 2 | 34 0 0 | 34 0 0 | 34 0 0 | 34 0 0 | 34 0 0 |
| 21 | 33 | 48 11 15 | 46 10 9 | 45 9 3 | 44 8 7 | 44 8 1 | 44 7 5 | 44 7 0 | 44 6 4 | 44 5 8 | 44 5 2 | 44 4 6 | 44 4 0 | 44 3 4 |
| 22 | 12 5 | 59 4 6 | 57 3 0 | 56 2 4 | 55 1 8 | 55 1 2 | 55 0 6 | 55 0 0 | 55 0 0 | 55 0 0 | 55 0 0 | 55 0 0 | 55 0 0 | 55 0 0 |
| 23 | 37 | 58 10 12 | 57 9 6 | 56 8 0 | 55 7 4 | 55 6 8 | 55 6 2 | 55 5 6 | 55 5 0 | 55 4 4 | 55 3 8 | 55 3 2 | 55 2 6 | 55 2 0 |
| 24 | 13 9 | 22 4 8 | 19 3 2 | 18 2 6 | 17 2 0 | 17 1 4 | 17 0 8 | 17 0 2 | 17 0 0 | 17 0 0 | 17 0 0 | 17 0 0 | 17 0 0 | 17 0 0 |
| 25 | 40 | 34 13 19 | 31 12 13 | 30 11 7 | 29 10 1 | 29 9 5 | 29 8 9 | 29 8 3 | 29 7 7 | 29 7 1 | 29 6 5 | 29 6 0 | 29 5 4 | 29 4 8 |
| 26 | 14 11 | 47 4 9 | 44 3 3 | 43 2 7 | 42 2 1 | 42 1 5 | 42 0 9 | 42 0 3 | 42 0 0 | 42 0 0 | 42 0 0 | 42 0 0 | 42 0 0 | 42 0 0 |
| 27 | 42 59 | 0 14 19 | 0 13 13 | 0 12 13 | 0 11 13 | 0 10 13 | 0 9 13 | 0 8 13 | 0 7 13 | 0 6 13 | 0 5 13 | 0 4 13 | 0 3 13 | 0 2 13 |
| 28 | 15 13 | 14 4 9 | 14 3 3 | 14 2 7 | 14 1 1 | 14 0 5 | 14 0 0 | 14 0 0 | 14 0 0 | 14 0 0 | 14 0 0 | 14 0 0 | 14 0 0 | 14 0 0 |
| 29 | 44 | 28 15 19 | 24 14 13 | 23 13 7 | 22 12 1 | 22 11 5 | 22 10 9 | 22 10 3 | 22 9 7 | 22 9 1 | 22 8 5 | 22 7 9 | 22 7 3 | 22 6 7 |
| 30 | 16 14 | 43 4 8 | 39 3 2 | 38 2 6 | 37 2 0 | 37 1 4 | 37 0 8 | 37 0 2 | 37 0 0 | 37 0 0 | 37 0 0 | 37 0 0 | 37 0 0 | 37 0 0 |
| 31 | 44 | 58 16 17 | 54 15 11 | 53 14 5 | 52 13 0 | 52 12 4 | 52 11 8 | 52 11 2 | 52 10 6 | 52 10 0 | 52 9 4 | 52 8 8 | 52 8 2 | 52 7 6 |
| 32 | 17 14 | 60 14 46 | 61 13 40 | 60 12 34 | 59 11 28 | 59 10 22 | 59 9 16 | 59 8 10 | 59 7 4 | 59 6 8 | 59 6 2 | 59 5 6 | 59 5 0 | 59 4 4 |
| 33 | 44 | 30 17 15 | 26 16 9 | 25 15 3 | 24 14 7 | 24 14 1 | 24 13 5 | 24 12 9 | 24 12 3 | 24 11 7 | 24 11 1 | 24 10 5 | 24 9 9 | 24 9 3 |
| 34 | 18 13 | 47 4 4 | 42 3 8 | 41 3 2 | 40 2 6 | 40 2 0 | 40 1 4 | 40 0 8 | 40 0 2 | 40 0 0 | 40 0 0 | 40 0 0 | 40 0 0 | 40 0 0 |
| 35 | 42 61 | 5 18 12 | 5 17 12 | 5 16 12 | 5 15 12 | 5 14 12 | 5 13 12 | 5 12 12 | 5 11 12 | 5 10 12 | 5 9 12 | 5 8 12 | 5 7 12 | 5 6 12 |
| 36 | 19 11 | 23 4 0 | 22 3 4 | 22 2 8 | 22 1 12 | 22 0 16 | 22 0 10 | 22 0 4 | 22 0 0 | 22 0 0 | 22 0 0 | 22 0 0 | 22 0 0 | 22 0 0 |
| 37 | 40 | 41 19 8 | 35 18 2 | 34 17 6 | 33 16 10 | 33 15 14 | 33 14 18 | 33 13 22 | 33 12 26 | 33 11 30 | 33 10 34 | 33 9 38 | 33 8 42 | 33 7 46 |
| 38 | 20 8 | 62 0 36 | 54 19 3 | 53 18 7 | 52 17 11 | 52 16 15 | 52 15 19 | 52 14 23 | 52 13 27 | 52 12 31 | 52 11 35 | 52 10 39 | 52 9 43 | 52 8 47 |
| 39 | 36 | 20 20 3 | 63 13 29 | 64 12 23 | 63 11 17 | 63 10 11 | 63 9 5 | 63 8 0 | 63 7 4 | 63 6 8 | 63 5 12 | 63 4 16 | 63 3 20 | 63 2 24 |
| 40 | 21 4 | 40 30 33 | 55 29 27 | 54 28 21 | 53 27 15 | 53 26 9 | 53 25 3 | 53 24 0 | 53 23 4 | 53 22 8 | 53 21 12 | 53 20 16 | 53 19 20 | 53 18 24 |
| 41 | 31 63 | 1 56 20 | 21 45 20 | 20 44 14 | 19 43 8 | 19 42 2 | 19 41 0 | 19 40 4 | 19 39 8 | 19 38 12 | 19 37 16 | 19 36 20 | 19 35 24 | 19 34 28 |
| 42 | 58 | 23 21 22 | 64 20 14 | 65 19 8 | 64 18 2 | 64 17 0 | 64 16 4 | 64 15 8 | 64 14 12 | 64 13 16 | 64 12 20 | 64 11 24 | 64 10 28 | 64 9 32 |
| 43 | 22 25 | 45 4 8 | 36 3 2 | 35 2 6 | 34 2 0 | 34 1 4 | 34 0 8 | 34 0 2 | 34 0 0 | 34 0 0 | 34 0 0 | 34 0 0 | 34 0 0 | 34 0 0 |
| 44 | 51 64 | 7 22 14 | 58 21 11 | 57 20 5 | 56 19 0 | 56 18 4 | 56 17 8 | 56 17 2 | 56 16 6 | 56 16 0 | 56 15 4 | 56 14 8 | 56 13 12 | 56 12 16 |
| 45 | 23 17 | 30 3 9 | 65 20 22 | 66 19 16 | 65 18 10 | 65 17 4 | 65 16 0 | 65 15 4 | 65 14 8 | 65 14 2 | 65 13 6 | 65 12 10 | 65 11 14 | 65 10 18 |

Table 13. Kelvin's Sumner Line Table

| b | a = 63° | | a = 64° | | a = 65° | | a = 66° | | a = 67° | | a = 68° | | a = 69° | | | | | | | | | | | | | | | | |
|----|---------|------|---------|----|---------|-------|---------|----|---------|-------|---------|----|---------|-------|----|-------|---|-------|----|-------|---|-------|----|----|----|-------|------|----|----|
| | K | Q | K | Q | K | Q | K | Q | K | Q | K | Q | K | Q | | | | | | | | | | | | | | | |
| 0 | 0 | 0 | 63 | 0 | 0 | 0 | 64 | 0 | 0 | 0 | 65 | 0 | 0 | 0 | 66 | 0 | 0 | 0 | 67 | 0 | 0 | 0 | 68 | 0 | 0 | 0 | 69 | 0 | |
| 1 | | 27 | | 0 | | 26 | | 0 | | 25 | | 0 | | 24 | | 0 | | 23 | | 0 | | 22 | | 0 | | 21 | | 0 | |
| 2 | | 54 | | 1 | | 53 | | 1 | | 51 | | 1 | | 49 | | 1 | | 47 | | 1 | | 45 | | 1 | | 43 | | 1 | |
| 3 | | 1 22 | | 2 | | 1 19 | | 2 | | 1 16 | | 2 | | 1 13 | | 2 | | 1 10 | | 2 | | 1 7 | | 2 | | 1 5 | | 2 | |
| 4 | | 49 | | 3 | | 45 | | 3 | | 41 | | 3 | | 38 | | 3 | | 34 | | 3 | | 30 | | 3 | | 26 | | 3 | |
| 5 | | 2 16 | | 5 | | 2 11 | | 5 | | 2 7 | | 5 | | 2 2 | | 5 | | 57 | | 5 | | 52 | | 5 | | 47 | | 4 | |
| 6 | | 43 | | 7 | | 38 | | 7 | | 32 | | 7 | | 26 | | 7 | | 2 20 | | 7 | | 2 15 | | 7 | | 2 9 | | 6 | |
| 7 | | 3 10 | | 10 | | 3 4 | | 10 | | 57 | | 10 | | 50 | | 9 | | 44 | | 9 | | 37 | | 9 | | 30 | | 8 | |
| 8 | | 37 | | 13 | | 30 | | 13 | | 3 22 | | 13 | | 3 15 | | 12 | | 3 7 | | 12 | | 59 | | 12 | | 52 | | 11 | |
| 9 | | 4 4 | | 17 | | 56 | | 17 | | 47 | | 16 | | 39 | | 16 | | 30 | | 15 | | 3 22 | | 15 | | 3 13 | | 14 | |
| 10 | | 31 | | 21 | | 4 22 | | 21 | | 4 12 | | 20 | | 4 3 | | 20 | | 53 | | 19 | | 44 | | 18 | | 34 | | 17 | |
| 11 | | 58 | | 26 | | 48 | | 25 | | 37 | | 24 | | 27 | | 24 | | 4 16 | | 23 | | 4 6 | | 22 | | 55 | | 21 | |
| 12 | | 5 25 | | 31 | | 5 14 | | 30 | | 5 2 | | 29 | | 5 1 | | 28 | | 39 | | 27 | | 28 | | 26 | | 4 16 | | 25 | |
| 13 | | 52 | | 36 | | 40 | | 35 | | 27 | | 34 | | 5 15 | | 33 | | 5 2 | | 32 | | 5 0 | | 31 | | 37 | | 29 | |
| 14 | | 6 18 | | 42 | | 6 5 | | 40 | | 52 | | 39 | | 39 | | 38 | | 25 | | 37 | | 5 12 | | 36 | | 58 | | 34 | |
| 15 | | 45 | | 48 | | 31 | | 46 | | 6 17 | | 45 | | 6 3 | | 44 | | 48 | | 42 | | 34 | | 41 | | 5 19 | | 39 | |
| 16 | | 7 11 | | 54 | | 56 | | 53 | | 41 | | 51 | | 26 | | 50 | | 6 11 | | 48 | | 56 | | 47 | | 40 | | 45 | |
| 17 | | 38 | 64 | 1 | | 7 22 | 65 | 0 | | 7 6 | | 58 | | 50 | | 56 | | 34 | | 54 | | 6 17 | | 53 | | 6 1 | | 51 | |
| 18 | | 8 4 | | 9 | | 47 | | 7 | | 30 | 66 | 5 | | 7 13 | 67 | 3 | | 56 | 68 | 1 | | 39 | | 59 | | 22 | | 57 | |
| 19 | | 30 | | 17 | | 8 12 | | 15 | | 54 | | 12 | | 37 | | 10 | | 7 19 | | 8 | | 7 0 | 69 | 6 | | 42 | 70 | 3 | |
| 20 | | 56 | | 25 | | 37 | | 23 | | 8 18 | | 20 | | 8 0 | | 18 | | 41 | | 15 | | 22 | | 13 | | 7 3 | | 10 | |
| 21 | | 9 22 | | 34 | | 9 2 | | 31 | | 42 | | 28 | | 23 | | 26 | | 8 3 | | 23 | | 43 | | 20 | | 23 | | 17 | |
| 22 | | 48 | | 43 | | 27 | | 40 | | 9 6 | | 37 | | 46 | | 34 | | 25 | | 31 | | 8 4 | | 28 | | 43 | | 24 | |
| 23 | 10 | 13 | | 52 | | 52 | | 49 | | 30 | | 46 | | 9 9 | | 43 | | 47 | | 39 | | 25 | | 36 | | 8 3 | | 32 | |
| 24 | | 39 | 65 | 2 | | 10 16 | | 59 | | 54 | | 56 | | 31 | | 52 | | 9 9 | | 48 | | 46 | | 44 | | 23 | | 40 | |
| 25 | 11 | 4 | | 13 | | 41 | 66 | 9 | | 10 17 | 67 | 6 | | 54 | 68 | 2 | | 30 | | 57 | | 9 7 | | 53 | | 43 | | 49 | |
| 26 | | 29 | | 24 | | 11 5 | | 20 | | 41 | | 16 | | 10 16 | | 12 | | 52 | 69 | 7 | | 27 | 70 | 2 | | 9 2 | | 58 | |
| 27 | | 54 | | 35 | | 29 | | 31 | | 11 4 | | 26 | | 38 | | 22 | | 10 13 | | 17 | | 48 | | 12 | | 22 | 71 | 7 | |
| 28 | 12 | 19 | | 47 | | 53 | | 42 | | 27 | | 37 | | 11 0 | | 32 | | 34 | | 27 | | 10 8 | | 22 | | 41 | | 17 | |
| 29 | | 43 | | 59 | | 12 16 | | 54 | | 50 | | 49 | | 22 | | 43 | | 55 | | 38 | | 28 | | 32 | | 10 0 | | 27 | |
| 30 | 13 | 7 | 66 | 11 | | 40 | 67 | 6 | | 12 12 | 68 | 1 | | 44 | | 55 | | 11 16 | | 49 | | 48 | | 43 | | 19 | | 37 | |
| 31 | | 31 | | 24 | | 13 3 | | 19 | | 34 | | 13 | | 12 6 | 69 | 7 | | 37 | 70 | 0 | | 11 8 | | 54 | | 38 | | 47 | |
| 32 | | 55 | | 38 | | 26 | | 32 | | 56 | | 25 | | 27 | | 19 | | 57 | | 12 | | 27 | 71 | 5 | | 57 | | 58 | |
| 33 | 14 | 19 | | 52 | | 49 | | 45 | | 13 18 | | 38 | | 48 | | 31 | | 12 17 | | 24 | | 46 | | 17 | | 11 15 | 72 | 9 | |
| 34 | | 43 | 67 | 6 | | 14 12 | | 59 | | 40 | | 52 | | 13 9 | | 44 | | 37 | | 37 | | 12 5 | | 29 | | 33 | | 21 | |
| 35 | 15 | 6 | | 21 | | 34 | 68 | 13 | | 14 2 | 69 | 6 | | 30 | | 58 | | 57 | | 50 | | 24 | | 41 | | 51 | | 33 | |
| 36 | | 29 | | 36 | | 56 | | 28 | | 23 | | 20 | | 50 | | 70 | | 12 | | 13 17 | | 3 | 43 | | 54 | | 12 9 | 45 | |
| 37 | | 52 | | 51 | | 15 18 | | 43 | | 44 | | 34 | | 14 10 | | 26 | | 36 | | 16 | | 13 2 | 72 | 7 | | 27 | | 57 | |
| 38 | 16 | 14 | 68 | 7 | | 40 | | 59 | | 15 5 | | 49 | | 30 | | 40 | | 55 | | 30 | | 20 | | 20 | | 45 | 73 | 10 | |
| 39 | | 36 | | 24 | | 16 1 | 69 | 15 | | 26 | 70 | 5 | | 50 | | 55 | | 14 14 | | 44 | | 38 | | 34 | | 13 2 | | 23 | |
| 40 | | 58 | | 41 | | 22 | | 31 | | 46 | | 21 | | 15 9 | | 71 | | 10 | | 33 | | 59 | | 56 | | 48 | | 19 | 37 |
| 41 | 17 | 20 | | 58 | | 43 | | 48 | | 16 6 | | 37 | | 28 | | 26 | | 51 | | 72 14 | | 14 14 | 73 | 2 | | 36 | | 51 | |
| 42 | | 41 | 69 | 16 | | 17 4 | 70 | 5 | | 26 | | 53 | | 47 | | 42 | | 15 9 | | 29 | | 31 | | 17 | | 53 | 74 | 5 | |
| 43 | 18 | 2 | | 34 | | 24 | | 22 | | 45 | 71 | 10 | | 16 6 | | 58 | | 27 | | 45 | | 48 | | 32 | | 14 9 | | 19 | |
| 44 | | 23 | | 52 | | 44 | | 40 | | 17 4 | | 27 | | 25 | | 72 14 | | 45 | | 73 1 | | 15 5 | | 48 | | 25 | | 34 | |
| 45 | | 44 | 70 | 11 | | 18 4 | | 58 | | 23 | | 45 | | 43 | | 31 | | 16 2 | | 18 | | 22 | 74 | 3 | | 41 | | 49 | |

Table 13. Kelvin's Summer Line Table

| b | a = 77° | | a = 78° | | a = 79° | | a = 80° | | a = 81° | | a = 82° | | a = 83° | | | | | |
|----|---------|----|---------|----|---------|----|---------|----|---------|----|---------|----|---------|----|-----|-----|----|----|
| | K | Q | K | Q | K | Q | K | Q | K | Q | K | Q | K | Q | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| 1 | 14 | 0 | 12 | 0 | 11 | 0 | 10 | 0 | 9 | 0 | 8 | 0 | 7 | 0 | | | | |
| 2 | 27 | 0 | 25 | 0 | 23 | 0 | 21 | 0 | 19 | 0 | 17 | 0 | 15 | 0 | | | | |
| 3 | 41 | 1 | 37 | 1 | 34 | 1 | 31 | 1 | 28 | 1 | 25 | 1 | 22 | 1 | | | | |
| 4 | 54 | 2 | 50 | 2 | 46 | 2 | 42 | 1 | 38 | 1 | 33 | 1 | 29 | 1 | | | | |
| 5 | 1 | 7 | 3 | 1 | 2 | 3 | 57 | 3 | 52 | 2 | 47 | 2 | 42 | 2 | | | | |
| 6 | 21 | 4 | 15 | 4 | 1 | 9 | 4 | 1 | 2 | 3 | 56 | 3 | 50 | 3 | | | | |
| 7 | 34 | 6 | 27 | 5 | 20 | 5 | 13 | 4 | 1 | 6 | 4 | 58 | 4 | 51 | 3 | | | |
| 8 | 48 | 7 | 39 | 7 | 31 | 6 | 23 | 6 | 15 | 5 | 1 | 7 | 5 | 58 | 4 | | | |
| 9 | 2 | 1 | 9 | 52 | 9 | 43 | 8 | 33 | 7 | 24 | 6 | 15 | 6 | 1 | 6 | 5 | | |
| 10 | 14 | 11 | 2 | 4 | 11 | 54 | 10 | 44 | 9 | 33 | 8 | 23 | 7 | 13 | 6 | 8 | | |
| 11 | 28 | 14 | 17 | 13 | 2 | 5 | 12 | 54 | 11 | 43 | 10 | 31 | 9 | 20 | 8 | 6 | | |
| 12 | 41 | 16 | 29 | 15 | 16 | 14 | 2 | 4 | 13 | 52 | 12 | 40 | 10 | 27 | 9 | 9 | | |
| 13 | 54 | 19 | 41 | 18 | 28 | 16 | 14 | 15 | 2 | 1 | 14 | 48 | 12 | 34 | 11 | 11 | | |
| 14 | 3 | 7 | 22 | 53 | 21 | 39 | 19 | 24 | 17 | 10 | 16 | 56 | 14 | 41 | 12 | 12 | | |
| 15 | 20 | 26 | 3 | 5 | 24 | 50 | 22 | 34 | 20 | 19 | 18 | 2 | 4 | 16 | 48 | 14 | | |
| 16 | 33 | 29 | 17 | 27 | 3 | 1 | 25 | 44 | 23 | 28 | 20 | 12 | 18 | 55 | 16 | 16 | | |
| 17 | 46 | 33 | 29 | 30 | 12 | 28 | 54 | 26 | 37 | 23 | 20 | 21 | 2 | 2 | 18* | 18* | | |
| 18 | 59 | 37 | 41 | 34 | 23 | 31 | 3 | 4 | 29 | 46 | 26 | 28 | 23 | 9 | 20 | 20 | | |
| 19 | 4 | 12 | 41 | 53 | 38 | 34 | 35 | 14 | 32 | 55 | 29 | 36 | 26 | 16 | 23 | 23 | | |
| 20 | 25 | 45 | 4 | 5 | 42 | 45 | 39 | 24 | 35 | 3 | 4 | 32 | 44 | 29 | 23 | 25 | | |
| 21 | 37 | 50 | 17 | 46 | 55 | 43 | 34 | 39 | 13 | 35 | 52 | 32 | 30 | 28 | 28 | 28 | | |
| 22 | 50 | 55 | 28 | 51 | 4 | 6 | 47 | 44 | 43 | 22 | 39 | 59 | 35 | 37 | 30 | 30 | | |
| 23 | 5 | 3 | 78 | 0 | 40 | 56 | 17 | 51 | 53 | 47 | 30 | 42 | 3 | 7 | 38 | 44 | 33 | |
| 24 | 15 | 5 | 51 | 79 | 1 | 27 | 56 | 4 | 3 | 51 | 39 | 46 | 15 | 41 | 50 | 36 | 36 | |
| 25 | 27 | 11 | 5 | 3 | 6 | 38 | 80 | 1 | 13 | 55 | 47 | 50 | 22 | 44 | 57 | 39 | 39 | |
| 26 | 39 | 17 | 14 | 11 | 48 | 6 | 22 | 81 | 0 | 56 | 54 | 30 | 48 | 3 | 4 | 42 | 42 | |
| 27 | 51 | 23 | 25 | 16 | 58 | 11 | 31 | 4 | 4 | 5 | 58 | 37 | 52 | 10 | 45 | 45 | 45 | |
| 28 | 6 | 3 | 29 | 36 | 22 | 5 | 8 | 16 | 41 | 9 | 13 | 82 | 2 | 45 | 56 | 17 | 49 | |
| 29 | 15 | 35 | 47 | 28 | 18 | 21 | 50 | 14 | 21 | 7 | 52 | 83 | 0 | 23 | 52 | 52 | 52 | |
| 30 | 27 | 41 | 58 | 34 | 28 | 27 | 59 | 19 | 29 | 11 | 59 | 4 | 30 | 56 | 56 | 56 | 56 | |
| 31 | 39 | 48 | 6 | 9 | 40 | 38 | 33 | 5 | 8 | 24 | 37 | 16 | 4 | 7 | 8 | 36 | 84 | 0 |
| 32 | 51 | 55 | 20 | 47 | 48 | 39 | 17 | 30 | 45 | 21 | 14 | 12 | 42 | 3 | 3 | 3 | 3 | 3 |
| 33 | 7 | 2 | 79 | 3 | 30 | 54 | 58 | 45 | 26 | 35 | 53 | 26 | 21 | 17 | 48 | 7 | 7 | 7 |
| 34 | 14 | 10 | 41 | 80 | 1 | 6 | 8 | 51 | 34 | 41 | 5 | 1 | 31 | 28 | 21 | 54 | 11 | 11 |
| 35 | 25 | 17 | 51 | 8 | 17 | 57 | 43 | 47 | 9 | 36 | 35 | 26 | 4 | 0 | 15 | 15 | 15 | 15 |
| 36 | 36 | 25 | 7 | 1 | 15 | 27 | 81 | 4 | 52 | 53 | 17 | 42 | 42 | 31 | 6 | 20 | 20 | 20 |
| 37 | 47 | 33 | 11 | 22 | 36 | 11 | 6 | 0 | 59 | 24 | 47 | 48 | 36 | 12 | 24 | 24 | 24 | 24 |
| 38 | 58 | 41 | 21 | 29 | 45 | 18 | 8 | 82 | 5 | 32 | 53 | 55 | 41 | 18 | 28 | 28 | 28 | 28 |
| 39 | 8 | 8 | 50 | 31 | 37 | 54 | 25 | 16 | 12 | 39 | 59 | 5 | 2 | 46 | 24 | 33 | 33 | 33 |
| 40 | 19 | 58 | 41 | 45 | 7 | 3 | 32 | 24 | 18 | 46 | 83 | 5 | 8 | 51 | 30 | 38 | 38 | 38 |
| 41 | 29 | 80 | 7 | 51 | 53 | 12 | 39 | 32 | 25 | 53 | 11 | 14 | 57 | 35 | 42 | 42 | 42 | 42 |
| 42 | 39 | 16 | 8 | 0 | 81 | 1 | 20 | 47 | 40 | 32 | 6 | 0 | 17 | 21 | 84 | 2 | 41 | 47 |
| 43 | 49 | 25 | 9 | 10 | 29 | 55 | 48 | 39 | 7 | 23 | 27 | 8 | 46 | 52 | 52 | 52 | 52 | 52 |
| 44 | 59 | 34 | 18 | 18 | 37 | 82 | 2 | 56 | 46 | 14 | 30 | 33 | 14 | 52 | 57 | 57 | 57 | 57 |
| 45 | 9 | 9 | 43 | 27 | 27 | 45 | 10 | 7 | 3 | 54 | 21 | 37 | 39 | 20 | 57 | 85 | 2 | 2 |

Table 14. Sumner Intersection

| LARGER BEARING | SMALLER BEARING | | | | |
|----------------|-----------------|------|------|------|------|
| | 2° | 4° | 6° | 8° | 10° |
| 34° | 0.07 | 0.14 | 0.22 | 0.32 | 0.43 |
| 36 | .06 | .13 | .21 | .30 | .40 |
| 38 | .06 | .12 | .20 | .28 | .37 |
| 40 | .06 | .12 | .19 | .26 | .35 |
| 42 | .05 | .11 | .18 | .25 | .33 |
| 44 | .05 | .11 | .17 | .24 | .31 |
| 46 | .05 | .10 | .16 | .23 | .30 |
| 48 | .05 | .10 | .16 | .22 | .28 |
| 50 | .05 | .10 | .15 | .21 | .27 |
| 52 | .05 | .09 | .15 | .20 | .26 |
| 54 | .04 | .09 | .14 | .19 | .25 |
| 56 | .04 | .09 | .14 | .19 | .24 |
| 58 | .04 | .09 | .13 | .18 | .23 |
| 60 | .04 | .08 | .13 | .18 | .23 |
| 62 | .04 | .08 | .13 | .17 | .22 |
| 64 | .04 | .08 | .12 | .17 | .21 |
| 66 | .04 | .08 | .12 | .16 | .21 |
| 68 | .04 | .08 | .12 | .16 | .20 |
| 70 | .04 | .08 | .12 | .16 | .20 |
| 72 | .04 | .08 | .11 | .15 | .20 |
| 74 | .04 | .07 | .11 | .15 | .19 |
| 76 | .04 | .07 | .11 | .15 | .19 |
| 78 | .04 | .07 | .11 | .15 | .19 |
| 80 | .04 | .07 | .11 | .15 | .18 |
| 82 | .04 | .07 | .11 | .14 | .18 |
| 84 | .04 | .07 | .11 | .14 | .18 |
| 86 | .04 | .07 | .11 | .14 | .18 |
| 88 | .04 | .07 | .11 | .14 | .18 |
| 90 | .03 | .07 | .11 | .14 | .18 |
| 92 | .03 | .07 | .10 | .14 | .18 |
| 94 | .03 | .07 | .10 | .14 | .17 |
| 96 | .03 | .07 | .10 | .14 | .17 |
| 98 | .04 | .07 | .10 | .14 | .17 |
| 100 | .04 | .07 | .11 | .14 | .17 |
| 102 | .04 | .07 | .11 | .14 | .17 |
| 104 | .04 | .07 | .11 | .14 | .17 |
| 106 | .04 | .07 | .11 | .14 | .17 |
| 108 | .04 | .07 | .11 | .14 | .18 |
| 110 | .04 | .07 | .11 | .14 | .18 |
| 112 | .04 | .07 | .11 | .14 | .18 |
| 114 | .04 | .07 | .11 | .15 | .18 |
| 116 | .04 | .07 | .11 | .15 | .18 |
| 118 | .04 | .08 | .11 | .15 | .18 |
| 120 | .04 | .08 | .11 | .15 | .18 |
| 122 | .04 | .08 | .12 | .15 | .19 |
| 124 | .04 | .08 | .12 | .16 | .19 |
| 126 | .04 | .08 | .12 | .16 | .19 |
| 128 | .04 | .08 | .12 | .16 | .20 |
| 130 | .04 | .09 | .13 | .17 | .20 |
| 132 | .05 | .09 | .13 | .17 | .20 |
| 134 | .05 | .09 | .13 | .17 | .21 |
| 136 | .05 | .09 | .14 | .18 | .21 |
| 138 | .05 | .10 | .14 | .18 | .22 |
| 140 | .05 | .10 | .15 | .19 | .23 |
| 142 | .05 | .10 | .15 | .19 | .23 |
| 144 | .06 | .11 | .16 | .20 | .24 |
| 146 | .06 | .12 | .16 | .21 | .25 |
| 148 | .06 | .12 | .17 | .22 | .26 |
| 150 | .07 | .12 | .18 | .23 | .27 |
| 152 | .07 | .13 | .19 | .24 | .28 |
| 154 | .07 | .14 | .20 | .25 | .30 |
| 156 | .08 | .15 | .21 | .26 | .31 |
| 158 | .09 | .16 | .22 | .28 | .33 |
| 160 | .09 | .17 | .24 | .30 | .35 |

| LARGER BEARING | SMALLER BEARING | | | | |
|----------------|-----------------|------|------|------|------|
| | 12° | 14° | 16° | 18° | 20° |
| 42° | 0.42 | 0.52 | 0.63 | 0.76 | 0.91 |
| 44 | .39 | .48 | .59 | .70 | .84 |
| 46 | .37 | .46 | .55 | .66 | .78 |
| 48 | .35 | .43 | .52 | .62 | .73 |
| 50 | .34 | .41 | .49 | .58 | .68 |
| 52 | .32 | .39 | .47 | .55 | .65 |
| 54 | .31 | .38 | .45 | .52 | .61 |
| 56 | .30 | .36 | .43 | .50 | .58 |
| 58 | .29 | .35 | .41 | .48 | .56 |
| 60 | .28 | .34 | .40 | .46 | .53 |
| 62 | .27 | .33 | .38 | .44 | .51 |
| 64 | .26 | .32 | .37 | .43 | .49 |
| 66 | .26 | .31 | .36 | .42 | .48 |
| 68 | .25 | .30 | .35 | .40 | .46 |
| 70 | .24 | .29 | .34 | .39 | .45 |
| 72 | .24 | .28 | .33 | .38 | .43 |
| 74 | .23 | .28 | .32 | .37 | .42 |
| 76 | .23 | .27 | .32 | .36 | .41 |
| 78 | .23 | .27 | .31 | .36 | .40 |
| 80 | .22 | .26 | .31 | .35 | .39 |
| 82 | .22 | .26 | .30 | .34 | .39 |
| 84 | .22 | .26 | .30 | .34 | .38 |
| 86 | .22 | .25 | .29 | .33 | .37 |
| 88 | .21 | .25 | .29 | .33 | .37 |
| 90 | .21 | .25 | .29 | .32 | .36 |
| 92 | .21 | .25 | .28 | .32 | .36 |
| 94 | .21 | .25 | .28 | .32 | .36 |
| 96 | .21 | .24 | .28 | .32 | .35 |
| 98 | .21 | .24 | .28 | .31 | .35 |
| 100 | .21 | .24 | .28 | .31 | .35 |
| 102 | .21 | .24 | .28 | .31 | .35 |
| 104 | .21 | .24 | .28 | .31 | .34 |
| 106 | .21 | .24 | .28 | .31 | .34 |
| 108 | .21 | .24 | .28 | .31 | .34 |
| 110 | .21 | .24 | .28 | .31 | .34 |
| 112 | .21 | .24 | .28 | .31 | .34 |
| 114 | .21 | .24 | .28 | .31 | .34 |
| 116 | .21 | .25 | .28 | .31 | .34 |
| 118 | .22 | .25 | .28 | .31 | .35 |
| 120 | .22 | .25 | .28 | .32 | .35 |
| 122 | .22 | .25 | .29 | .32 | .35 |
| 124 | .22 | .26 | .29 | .32 | .35 |
| 126 | .23 | .26 | .29 | .32 | .36 |
| 128 | .23 | .26 | .30 | .33 | .36 |
| 130 | .23 | .27 | .30 | .33 | .36 |
| 132 | .24 | .27 | .31 | .34 | .37 |
| 134 | .24 | .28 | .31 | .34 | .37 |
| 136 | .25 | .28 | .32 | .35 | .38 |
| 138 | .26 | .29 | .32 | .36 | .39 |
| 140 | .26 | .30 | .33 | .36 | .39 |
| 142 | .27 | .31 | .34 | .37 | .40 |
| 144 | .28 | .32 | .35 | .38 | .41 |
| 146 | .29 | .33 | .36 | .39 | .42 |
| 148 | .30 | .34 | .37 | .40 | .43 |
| 150 | .31 | .35 | .38 | .42 | .45 |
| 152 | .32 | .36 | .40 | .43 | .46 |
| 154 | .34 | .38 | .41 | .44 | .48 |
| 156 | .35 | .39 | .43 | .46 | .49 |
| 158 | .37 | .41 | .45 | .48 | .51 |
| 160 | .39 | .43 | .47 | .50 | .53 |
| 162 | .41 | .46 | .49 | .52 | .56 |
| 164 | .44 | .48 | .52 | .55 | .58 |
| 166 | .47 | .52 | .55 | .58 | .61 |
| 168 | .50 | .55 | .59 | .62 | .65 |

Table 14. Sumner Intersection

| LARGER BEARING | SMALLER BEARING | | | | |
|----------------|-----------------|------|------|------|------|
| | 22° | 24° | 26° | 28° | 30° |
| 54° | 0.71 | 0.81 | 0.93 | 1.07 | 1.23 |
| 56 | .67 | .77 | .88 | 1.00 | 1.14 |
| 58 | .64 | .73 | .83 | 0.94 | 1.07 |
| 60 | .61 | .69 | .78 | .89 | 1.00 |
| 62 | .58 | .66 | .75 | .84 | 0.94 |
| 64 | .56 | .63 | .71 | .80 | .89 |
| 66 | .54 | .61 | .68 | .76 | .85 |
| 68 | .52 | .59 | .66 | .73 | .81 |
| 70 | .50 | .57 | .63 | .70 | .78 |
| 72 | .49 | .55 | .61 | .68 | .75 |
| 74 | .48 | .53 | .59 | .65 | .72 |
| 76 | .46 | .52 | .57 | .63 | .70 |
| 78 | .45 | .50 | .56 | .61 | .67 |
| 80 | .44 | .49 | .54 | .60 | .65 |
| 82 | .43 | .48 | .53 | .58 | .63 |
| 84 | .42 | .47 | .52 | .57 | .62 |
| 86 | .42 | .46 | .51 | .55 | .60 |
| 88 | .41 | .45 | .50 | .54 | .59 |
| 90 | .40 | .45 | .49 | .53 | .58 |
| 92 | .40 | .44 | .48 | .52 | .57 |
| 94 | .39 | .43 | .47 | .51 | .56 |
| 96 | .39 | .43 | .47 | .51 | .55 |
| 98 | .39 | .42 | .46 | .50 | .54 |
| 100 | .38 | .42 | .46 | .49 | .53 |
| 102 | .38 | .42 | .45 | .49 | .53 |
| 104 | .38 | .41 | .45 | .48 | .52 |
| 106 | .38 | .41 | .45 | .48 | .52 |
| 108 | .38 | .41 | .44 | .48 | .51 |
| 110 | .37 | .41 | .44 | .47 | .51 |
| 112 | .37 | .41 | .44 | .47 | .50 |
| 114 | .37 | .41 | .44 | .47 | .50 |
| 116 | .38 | .41 | .44 | .47 | .50 |
| 118 | .38 | .41 | .44 | .47 | .50 |
| 120 | .38 | .41 | .44 | .47 | .50 |
| 122 | .38 | .41 | .44 | .47 | .50 |
| 124 | .38 | .41 | .44 | .47 | .50 |
| 126 | .39 | .42 | .45 | .47 | .50 |
| 128 | .39 | .42 | .45 | .48 | .50 |
| 130 | .39 | .42 | .45 | .48 | .51 |
| 132 | .40 | .43 | .46 | .48 | .51 |
| 134 | .40 | .43 | .46 | .49 | .52 |
| 136 | .41 | .44 | .47 | .49 | .52 |
| 138 | .42 | .45 | .47 | .50 | .53 |
| 140 | .42 | .45 | .48 | .51 | .53 |
| 142 | .43 | .46 | .49 | .51 | .54 |
| 144 | .44 | .47 | .50 | .52 | .55 |
| 146 | .45 | .48 | .51 | .53 | .56 |
| 148 | .46 | .49 | .52 | .54 | .57 |
| 150 | .48 | .50 | .53 | .55 | .58 |
| 152 | .49 | .52 | .54 | .57 | .59 |
| 154 | .50 | .53 | .56 | .58 | .60 |
| 156 | .52 | .55 | .57 | .60 | .62 |
| 158 | .54 | .57 | .59 | .61 | .63 |
| 160 | .56 | .59 | .61 | .63 | .65 |
| 162 | .58 | .61 | .63 | .65 | .67 |
| 164 | .61 | .63 | .66 | .68 | .70 |
| 166 | .64 | .66 | .68 | .70 | .72 |
| 168 | .67 | .69 | .71 | .73 | .75 |
| 170 | .71 | .73 | .75 | .76 | .78 |
| 172 | .75 | .77 | .78 | .80 | .81 |
| 174 | .80 | .81 | .83 | .84 | .85 |
| 176 | .85 | .87 | .88 | .89 | .89 |
| 178 | .92 | .93 | .93 | .94 | .94 |

| LARGER BEARING | SMALLER BEARING | | | | |
|----------------|-----------------|------|------|------|------|
| | 32° | 34° | 36° | 38° | 40° |
| 62° | 1.06 | 1.19 | 1.34 | 1.51 | 1.72 |
| 64 | 1.00 | 1.12 | 1.25 | 1.40 | 1.58 |
| 66 | 0.95 | 1.06 | 1.18 | 1.31 | 1.47 |
| 68 | .90 | 1.00 | 1.11 | 1.23 | 1.37 |
| 70 | .86 | 0.95 | 1.05 | 1.16 | 1.29 |
| 72 | .82 | .91 | 1.00 | 1.10 | 1.21 |
| 74 | .79 | .87 | 0.95 | 1.05 | 1.15 |
| 76 | .76 | .84 | .91 | 1.00 | 1.09 |
| 78 | .74 | .80 | .88 | 0.96 | 1.04 |
| 80 | .71 | .78 | .85 | .92 | 1.00 |
| 82 | .69 | .75 | .82 | .89 | 0.96 |
| 84 | .67 | .73 | .79 | .86 | .93 |
| 86 | .66 | .71 | .77 | .83 | .89 |
| 88 | .64 | .69 | .75 | .80 | .86 |
| 90 | .62 | .67 | .73 | .78 | .84 |
| 92 | .61 | .66 | .71 | .76 | .82 |
| 94 | .60 | .65 | .69 | .74 | .79 |
| 96 | .59 | .63 | .68 | .73 | .78 |
| 98 | .58 | .62 | .67 | .71 | .76 |
| 100 | .57 | .61 | .65 | .70 | .74 |
| 102 | .56 | .60 | .64 | .68 | .73 |
| 104 | .56 | .60 | .63 | .67 | .72 |
| 106 | .55 | .59 | .63 | .66 | .70 |
| 108 | .55 | .58 | .62 | .66 | .69 |
| 110 | .54 | .58 | .61 | .65 | .68 |
| 112 | .54 | .57 | .61 | .64 | .68 |
| 114 | .54 | .57 | .60 | .63 | .67 |
| 116 | .53 | .56 | .60 | .63 | .66 |
| 118 | .53 | .56 | .59 | .63 | .66 |
| 120 | .53 | .56 | .59 | .62 | .65 |
| 122 | .53 | .56 | .59 | .62 | .65 |
| 124 | .53 | .56 | .59 | .62 | .65 |
| 126 | .53 | .56 | .59 | .62 | .64 |
| 128 | .53 | .56 | .59 | .62 | .64 |
| 130 | .54 | .56 | .59 | .62 | .64 |
| 132 | .54 | .56 | .59 | .62 | .64 |
| 134 | .54 | .57 | .59 | .62 | .64 |
| 136 | .55 | .57 | .60 | .62 | .65 |
| 138 | .55 | .58 | .60 | .63 | .65 |
| 140 | .56 | .58 | .61 | .63 | .65 |
| 142 | .56 | .59 | .61 | .63 | .66 |
| 144 | .57 | .60 | .62 | .64 | .66 |
| 146 | .58 | .60 | .63 | .65 | .67 |
| 148 | .59 | .61 | .63 | .66 | .68 |
| 150 | .60 | .62 | .64 | .66 | .68 |
| 152 | .61 | .63 | .65 | .67 | .69 |
| 154 | .62 | .65 | .67 | .68 | .70 |
| 156 | .64 | .66 | .68 | .70 | .72 |
| 158 | .66 | .67 | .69 | .71 | .73 |
| 160 | .67 | .69 | .71 | .73 | .74 |
| 162 | .69 | .71 | .73 | .74 | .76 |
| 164 | .71 | .73 | .75 | .76 | .78 |
| 166 | .74 | .75 | .77 | .78 | .79 |
| 168 | .76 | .78 | .79 | .80 | .82 |
| 170 | .79 | .80 | .82 | .83 | .84 |
| 172 | .82 | .84 | .85 | .86 | .86 |
| 174 | .86 | .87 | .88 | .89 | .89 |
| 176 | .90 | .91 | .91 | .92 | .93 |
| 178 | .95 | .95 | .95 | .96 | .96 |

Table 14. Sumner Intersection

| LARGER BEARING | SMALLER BEARING | | | | |
|----------------|-----------------|------|------|------|------|
| | 42° | 44° | 46° | 48° | 50° |
| 72° | 1.34 | 1.48 | 1.64 | 1.83 | 2.04 |
| 74 | 1.26 | 1.39 | 1.53 | 1.70 | 1.88 |
| 76 | 1.20 | 1.31 | 1.44 | 1.58 | 1.75 |
| 78 | 1.14 | 1.24 | 1.36 | 1.49 | 1.63 |
| 80 | 1.09 | 1.18 | 1.28 | 1.40 | 1.53 |
| 82 | 1.04 | 1.13 | 1.22 | 1.33 | 1.45 |
| 84 | 1.00 | 1.08 | 1.17 | 1.26 | 1.37 |
| 86 | 0.96 | 1.04 | 1.12 | 1.21 | 1.30 |
| 88 | .93 | 1.00 | 1.08 | 1.16 | 1.24 |
| 90 | .90 | 0.97 | 1.04 | 1.11 | 1.19 |
| 92 | .87 | .93 | 1.00 | 1.07 | 1.14 |
| 94 | .85 | .91 | 0.97 | 1.03 | 1.10 |
| 96 | .83 | .88 | .94 | 1.00 | 1.06 |
| 98 | .81 | .86 | .91 | 0.97 | 1.03 |
| 100 | .79 | .84 | .89 | .94 | 1.00 |
| 102 | .77 | .82 | .87 | .92 | 0.97 |
| 104 | .76 | .80 | .85 | .90 | .95 |
| 106 | .74 | .79 | .83 | .88 | .92 |
| 108 | .73 | .77 | .81 | .86 | .90 |
| 110 | .72 | .76 | .80 | .84 | .88 |
| 112 | .71 | .75 | .79 | .83 | .87 |
| 114 | .70 | .74 | .78 | .81 | .85 |
| 116 | .70 | .73 | .77 | .80 | .84 |
| 118 | .69 | .72 | .76 | .79 | .83 |
| 120 | .68 | .72 | .75 | .78 | .82 |
| 122 | .68 | .71 | .74 | .77 | .81 |
| 124 | .68 | .71 | .74 | .77 | .80 |
| 126 | .67 | .70 | .73 | .76 | .79 |
| 128 | .67 | .70 | .73 | .75 | .78 |
| 130 | .67 | .70 | .72 | .75 | .78 |
| 132 | .67 | .70 | .72 | .75 | .77 |
| 134 | .67 | .69 | .72 | .74 | .77 |
| 136 | .67 | .70 | .72 | .74 | .77 |
| 138 | .67 | .70 | .72 | .74 | .77 |
| 140 | .68 | .70 | .72 | .74 | .77 |
| 142 | .68 | .70 | .72 | .74 | .77 |
| 144 | .68 | .71 | .73 | .75 | .77 |
| 146 | .69 | .71 | .73 | .75 | .77 |
| 148 | .70 | .72 | .74 | .76 | .77 |
| 150 | .70 | .72 | .74 | .76 | .78 |
| 152 | .71 | .73 | .75 | .77 | .78 |
| 154 | .72 | .74 | .76 | .77 | .79 |
| 156 | .73 | .75 | .77 | .78 | .80 |
| 158 | .74 | .76 | .78 | .79 | .81 |
| 160 | .76 | .77 | .79 | .80 | .82 |
| 162 | .77 | .79 | .80 | .81 | .83 |
| 164 | .79 | .80 | .81 | .83 | .84 |
| 166 | .81 | .82 | .83 | .84 | .85 |
| 168 | .83 | .84 | .85 | .86 | .87 |
| 170 | .85 | .86 | .87 | .88 | .88 |
| 172 | .87 | .88 | .89 | .90 | .90 |
| 174 | .90 | .91 | .91 | .92 | .92 |
| 176 | .93 | .93 | .94 | .94 | .95 |
| 178 | .96 | .97 | .97 | .97 | .97 |

| LARGER BEARING | SMALLER BEARING | | | | |
|----------------|-----------------|------|------|------|------|
| | 52° | 54° | 56° | 58° | 60° |
| 82° | 1.58 | 1.72 | 1.89 | 2.08 | 2.31 |
| 84 | 1.49 | 1.62 | 1.77 | 1.93 | 2.13 |
| 86 | 1.41 | 1.53 | 1.66 | 1.81 | 1.98 |
| 88 | 1.34 | 1.45 | 1.56 | 1.70 | 1.84 |
| 90 | 1.28 | 1.38 | 1.48 | 1.60 | 1.73 |
| 92 | 1.23 | 1.31 | 1.41 | 1.52 | 1.63 |
| 94 | 1.18 | 1.26 | 1.35 | 1.44 | 1.55 |
| 96 | 1.13 | 1.21 | 1.29 | 1.38 | 1.47 |
| 98 | 1.10 | 1.16 | 1.24 | 1.32 | 1.41 |
| 100 | 1.06 | 1.12 | 1.19 | 1.27 | 1.35 |
| 102 | 1.03 | 1.09 | 1.15 | 1.22 | 1.29 |
| 104 | 1.00 | 1.06 | 1.12 | 1.18 | 1.25 |
| 106 | 0.97 | 1.03 | 1.09 | 1.14 | 1.20 |
| 108 | .95 | 1.00 | 1.05 | 1.11 | 1.17 |
| 110 | .93 | 0.98 | 1.02 | 1.08 | 1.13 |
| 112 | .91 | .95 | 1.00 | 1.05 | 1.10 |
| 114 | .89 | .93 | 0.98 | 1.02 | 1.07 |
| 116 | .88 | .92 | .96 | 1.00 | 1.04 |
| 118 | .86 | .90 | .94 | 0.98 | 1.02 |
| 120 | .85 | .89 | .91 | .96 | 1.00 |
| 122 | .84 | .87 | .90 | .95 | 0.98 |
| 124 | .83 | .86 | .90 | .93 | .96 |
| 126 | .82 | .85 | .88 | .91 | .95 |
| 128 | .81 | .84 | .87 | .90 | .93 |
| 130 | .81 | .83 | .86 | .89 | .92 |
| 132 | .80 | .83 | .85 | .88 | .91 |
| 134 | .80 | .82 | .85 | .87 | .90 |
| 136 | .80 | .82 | .84 | .87 | .89 |
| 138 | .79 | .81 | .84 | .86 | .89 |
| 140 | .79 | .81 | .83 | .86 | .88 |
| 142 | .79 | .81 | .83 | .85 | .87 |
| 144 | .79 | .81 | .83 | .85 | .87 |
| 146 | .79 | .81 | .83 | .85 | .87 |
| 148 | .79 | .81 | .83 | .85 | .87 |
| 150 | .80 | .81 | .83 | .85 | .87 |
| 152 | .80 | .82 | .83 | .85 | .87 |
| 154 | .81 | .82 | .84 | .85 | .87 |
| 156 | .81 | .83 | .84 | .86 | .87 |
| 158 | .82 | .83 | .85 | .86 | .87 |
| 160 | .83 | .84 | .85 | .86 | .88 |
| 162 | .84 | .85 | .86 | .87 | .89 |
| 164 | .85 | .86 | .87 | .88 | .89 |
| 166 | .86 | .87 | .88 | .89 | .90 |
| 168 | .88 | .89 | .90 | .90 | .91 |
| 170 | .89 | .90 | .90 | .91 | .92 |
| 172 | .91 | .92 | .91 | .93 | .93 |
| 174 | .93 | .93 | .94 | .95 | .95 |
| 176 | .95 | .95 | .96 | .96 | .96 |
| 178 | .97 | .98 | .98 | .98 | .98 |

Table 14. Sumner Intersection

| LARGER BEARING | SMALLER BEARING | | | | |
|----------------|-----------------|------|------|------|------|
| | 62° | 64° | 66° | 68° | 70° |
| 92° | 1.77 | 1.91 | 2.08 | 2.28 | 2.51 |
| 94 | 1.67 | 1.80 | 1.95 | 2.12 | 2.31 |
| 96 | 1.58 | 1.70 | 1.83 | 1.97 | 2.14 |
| 98 | 1.50 | 1.61 | 1.72 | 1.85 | 2.00 |
| 100 | 1.43 | 1.53 | 1.63 | 1.75 | 1.88 |
| 102 | 1.37 | 1.46 | 1.55 | 1.66 | 1.77 |
| 104 | 1.32 | 1.40 | 1.48 | 1.58 | 1.68 |
| 106 | 1.27 | 1.34 | 1.42 | 1.51 | 1.60 |
| 108 | 1.23 | 1.29 | 1.37 | 1.44 | 1.53 |
| 110 | 1.19 | 1.25 | 1.32 | 1.39 | 1.46 |
| 112 | 1.15 | 1.21 | 1.27 | 1.33 | 1.40 |
| 114 | 1.12 | 1.17 | 1.23 | 1.29 | 1.35 |
| 116 | 1.09 | 1.14 | 1.19 | 1.25 | 1.31 |
| 118 | 1.07 | 1.11 | 1.16 | 1.21 | 1.26 |
| 120 | 1.04 | 1.08 | 1.13 | 1.18 | 1.23 |
| 122 | 1.02 | 1.06 | 1.10 | 1.15 | 1.19 |
| 124 | 1.00 | 1.04 | 1.08 | 1.12 | 1.16 |
| 126 | 0.98 | 1.02 | 1.05 | 1.09 | 1.13 |
| 128 | .97 | 1.00 | 1.03 | 1.07 | 1.11 |
| 130 | .95 | 0.98 | 1.02 | 1.05 | 1.09 |
| 132 | .94 | .97 | 1.00 | 1.03 | 1.06 |
| 134 | .93 | .96 | 0.99 | 1.01 | 1.04 |
| 136 | .92 | .95 | .97 | 1.00 | 1.03 |
| 138 | .91 | .94 | .96 | 0.99 | 1.01 |
| 140 | .90 | .93 | .95 | .97 | 1.00 |
| 142 | .90 | .92 | .94 | .96 | 0.99 |
| 144 | .89 | .91 | .93 | .96 | .98 |
| 146 | .89 | .91 | .93 | .95 | .97 |
| 148 | .89 | .90 | .92 | .94 | .96 |
| 150 | .88 | .90 | .92 | .94 | .95 |
| 152 | .88 | .90 | .92 | .93 | .95 |
| 154 | .88 | .90 | .91 | .93 | .94 |
| 156 | .89 | .90 | .91 | .93 | .94 |
| 158 | .89 | .90 | .91 | .93 | .94 |
| 160 | .89 | .90 | .91 | .93 | .94 |
| 162 | .90 | .91 | .92 | .93 | .94 |
| 164 | .90 | .91 | .92 | .93 | .94 |
| 166 | .91 | .92 | .93 | .93 | .94 |
| 168 | .92 | .93 | .93 | .94 | .94 |
| 170 | .93 | .94 | .94 | .95 | .95 |
| 172 | .94 | .95 | .95 | .96 | .96 |
| 174 | .95 | .96 | .96 | .96 | .97 |
| 176 | .97 | .97 | .97 | .97 | .98 |
| 178 | .98 | .98 | .99 | .99 | .99 |

| LARGER BEARING | SMALLER BEARING | | | | |
|----------------|-----------------|------|------|------|------|
| | 72° | 74° | 76° | 78° | 80° |
| 102° | 1.90 | 2.05 | 2.21 | 2.40 | 2.63 |
| 104 | 1.79 | 1.92 | 2.07 | 2.23 | 2.42 |
| 106 | 1.70 | 1.81 | 1.94 | 2.08 | 2.25 |
| 108 | 1.62 | 1.72 | 1.83 | 1.96 | 2.10 |
| 110 | 1.54 | 1.64 | 1.74 | 1.85 | 1.97 |
| 112 | 1.48 | 1.56 | 1.65 | 1.75 | 1.86 |
| 114 | 1.42 | 1.50 | 1.58 | 1.66 | 1.76 |
| 116 | 1.37 | 1.44 | 1.51 | 1.59 | 1.68 |
| 118 | 1.32 | 1.38 | 1.45 | 1.52 | 1.60 |
| 120 | 1.28 | 1.34 | 1.40 | 1.46 | 1.53 |
| 122 | 1.24 | 1.29 | 1.35 | 1.41 | 1.47 |
| 124 | 1.21 | 1.25 | 1.31 | 1.36 | 1.42 |
| 126 | 1.18 | 1.22 | 1.27 | 1.32 | 1.37 |
| 128 | 1.15 | 1.19 | 1.23 | 1.28 | 1.33 |
| 130 | 1.12 | 1.16 | 1.20 | 1.24 | 1.29 |
| 132 | 1.10 | 1.13 | 1.17 | 1.21 | 1.25 |
| 134 | 1.08 | 1.11 | 1.14 | 1.18 | 1.22 |
| 136 | 1.06 | 1.09 | 1.12 | 1.15 | 1.19 |
| 138 | 1.04 | 1.07 | 1.10 | 1.13 | 1.16 |
| 140 | 1.03 | 1.05 | 1.08 | 1.11 | 1.14 |
| 142 | 1.01 | 1.04 | 1.06 | 1.09 | 1.12 |
| 144 | 1.00 | 1.02 | 1.05 | 1.07 | 1.10 |
| 146 | 0.99 | 1.01 | 1.03 | 1.05 | 1.08 |
| 148 | .98 | 1.00 | 1.02 | 1.04 | 1.06 |
| 150 | .97 | 0.99 | 1.01 | 1.03 | 1.05 |
| 152 | .97 | .98 | 1.00 | 1.02 | 1.04 |
| 154 | .96 | .98 | 0.99 | 1.01 | 1.02 |
| 156 | .96 | .97 | .99 | 1.00 | 1.01 |
| 158 | .95 | .97 | .98 | 0.99 | 1.01 |
| 160 | .95 | .96 | .98 | .99 | 1.00 |
| 162 | .95 | .96 | .98 | .99 | 1.00 |
| 164 | .95 | .96 | .98 | .99 | 0.99 |
| 166 | .96 | .96 | .98 | .99 | .99 |
| 168 | .96 | .96 | .98 | .99 | .99 |
| 170 | .97 | .97 | .98 | .99 | .99 |
| 172 | .97 | .97 | .99 | .99 | .99 |
| 174 | .98 | .98 | .99 | .99 | .99 |
| 176 | .99 | .98 | .99 | .99 | .99 |
| 178 | .99 | .99 | .99 | .99 | .99 |

Table 14. Sumner Intersection

| LARGER BEARING | SMALLER BEARING | | | | |
|-------------------|-----------------|------|------|------|------|
| | 82° | 84° | 86° | 88° | 90° |
| 112° | 1.98 | 2.12 | 2.28 | 2.46 | 2.67 |
| 114 | 1.87 | 1.99 | 2.12 | 2.28 | 2.46 |
| 116 | 1.77 | 1.88 | 2.00 | 2.13 | 2.28 |
| 118 | 1.68 | 1.78 | 1.88 | 2.00 | 2.13 |
| 120 | 1.61 | 1.69 | 1.78 | 1.89 | 2.00 |
| 122 | 1.54 | 1.62 | 1.70 | 1.79 | 1.89 |
| 124 | 1.48 | 1.55 | 1.62 | 1.70 | 1.79 |
| 126 | 1.43 | 1.48 | 1.55 | 1.62 | 1.70 |
| 128 | 1.38 | 1.43 | 1.49 | 1.55 | 1.62 |
| 130 | 1.33 | 1.38 | 1.44 | 1.49 | 1.56 |
| 132 | 1.29 | 1.34 | 1.39 | 1.44 | 1.49 |
| 134 | 1.26 | 1.30 | 1.34 | 1.39 | 1.44 |
| 136 | 1.22 | 1.26 | 1.30 | 1.34 | 1.39 |
| 138 | 1.19 | 1.23 | 1.27 | 1.30 | 1.35 |
| 140 | 1.17 | 1.20 | 1.23 | 1.27 | 1.31 |
| 142 | 1.14 | 1.17 | 1.20 | 1.24 | 1.27 |
| 144 | 1.12 | 1.15 | 1.18 | 1.21 | 1.24 |
| 146 | 1.10 | 1.13 | 1.15 | 1.18 | 1.21 |
| 148 | 1.08 | 1.11 | 1.13 | 1.15 | 1.18 |
| 150 | 1.07 | 1.09 | 1.11 | 1.13 | 1.15 |
| 152 | 1.05 | 1.07 | 1.09 | 1.11 | 1.13 |
| 154 | 1.04 | 1.06 | 1.08 | 1.09 | 1.11 |
| 156 | 1.03 | 1.05 | 1.06 | 1.08 | 1.09 |
| 158 | 1.02 | 1.03 | 1.05 | 1.06 | 1.08 |
| 160 | 1.01 | 1.02 | 1.04 | 1.05 | 1.06 |
| 162 | 1.00 | 1.01 | 1.03 | 1.03 | 1.05 |
| 164 | 1.00 | 1.00 | 1.02 | 1.02 | 1.04 |
| 166 | 1.00 | 1.00 | 1.01 | 1.02 | 1.03 |
| 168 | 1.00 | 1.00 | 1.00 | 1.01 | 1.02 |
| 170 | 0.99 | 1.00 | 1.00 | 1.00 | 1.01 |
| 172 | .99 | 1.00 | 1.00 | 1.00 | 1.01 |
| 174 | .99 | 0.99 | 1.00 | 1.00 | 1.00 |
| 176 | .99 | .99 | 0.99 | 1.00 | 1.00 |
| 178 | .99 | .99 | 0.99 | 0.99 | 1.00 |

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