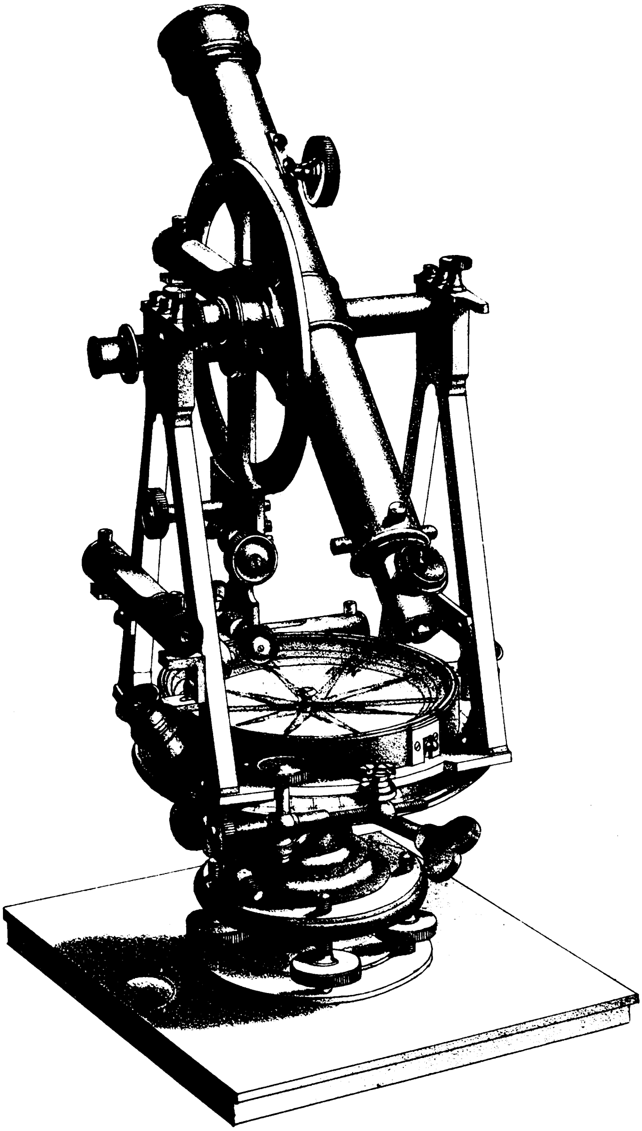
HOSKOLD'S
MINERS TRANSIT THEODOLITE.



MANUFACTURED ONLY BY JOHN ARCHBUTT & SONS, 20, WESTMINSTER BRIDGE ROAD, LAMBETH, S.

Publishers Atchley & C^o. 106, Great Russell S^t. Bedford Square, London.

Francis & Goddard, Lith, 51, Grays Inn Road, W.C.

A PRACTICAL TREATISE

ON

Mining, Land and Railway Surveying, Engineering, &c.

CONTAINING

THE ERRORS OF THE MAGNETIC NEEDLE; PRACTICAL GEOMETRY AND TRIGONOMETRY;

WITH

DESCRIPTION, USE, AND ADJUSTMENTS OF THE MINERS' NEW TRANSIT THEODOLITE;

ALSO, A NEW PLAN OF SETTING OUT UNDERGROUND RAILWAY CURVES; UNDERGROUND LEVELLING;

CONSTRUCTION OF LONGITUDINAL, TRANSVERSE, AND GEOLOGICAL SECTIONS OF MINES, ETC.

WITH TABLES OF DISTANCES FROM PLANES OF THE MERIDIAN AND LATITUDE, TABLES OF NATURAL SINES, SECANTS, TANGENTS, RATIOS OF INCLINED PLANES, ETC.

Illustrated by Numerous Plates and Woodcuts.

BY H. D. HOSKOLD,
MINING ENGINEER AND SURVEYOR.

LONDON:
ATCHLEY AND CO.,
ENGINEERING AND ARCHITECTURAL PUBLISHERS,
106, GREAT RUSSELL STREET, BEDFORD SQUARE.
1863.

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This Work is respectfully Dedicated

TO THE

DEAN FOREST IRON COMPANY,

IN GRATEFUL ACKNOWLEDGMENT OF MANY FAVOURS RECEIVED,

BY THE AUTHOR.

PREFACE.

In the following pages I have endeavoured to place before the student of Mineral Surveying, a complete system of Practical Geometry, as relating to the surface and underground surveying of mines. I have, to the best of my ability, given a practical solution to the various problems which have occurred to me in my own practice, in the hope that this work may be the means of introducing a more accurate system of accomplishing what is so essentially important in all mining operations—viz., correct plans and statistical records of all subterranean drivages and excavations.

I have given, throughout the work, the result of my own observations, and the demonstrations of mathematical truths, and in my own opinion, and what I have no doubt will have been found in the experience of others, a desideratum in useful tables at the end of the work.

Incorrect results from surveying are well known to every surveyor to be a cause of much anxiety and perplexity; and as I have myself arrived at satisfactory and accurate results from pursuing the methods which I now prominently bring forward in the present work, I presume to express a hope that this fact of itself may be a sufficient recommendation of the methods to others.

H. D. HOSKOLD.

Cinderford, Dean Forest,
June, 1863.

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INTRODUCTION,

By MARK FRYAR, F.G.S.

ENGINEER OF MINES, AND LECTURER ON MINING IN THE GLASGOW SCHOOL OF MINES.

Progress in Science and Art has worked wonderful revolutions in every industrial and commercial pursuit followed by the Christian nations of the world. Wherever we discover, by the aid of history or tradition, any phase of the *past* of either mining, manufacture, or navigation, we become at once involuntarily impressed by a contrast with the *present.* Whilst, however, a condition of progress must be admitted as characterizing generally all the industrial arts, we must not close our eyes against the fact that there are very widely differing degrees of progress as respectively applicable to the various branches of industry; and we may, perhaps, derive some useful lesson by investigating the causes which have operated against one branch advancing in economy and development in an equal degree with another.

The rapid strides which have been made during the past century in the construction and application of steam-engines, has been the means of vastly improving both productive and manufacturing art; and in common with other branches the art of mining has participated in the benefits arising from such a source. Although, however, the mineral fields of Europe are unquestionably now being developed in a way which, for extent both in area and depth, has never been equalled in past times, it is nevertheless an undeniable fact, that in some of the main departments of subterranean operations there is an evident stubborn conservatism of plans and modes of operation which time and intelligence have yet to overcome. By defective methods of working minerals—

coals especially—there are year by year hundreds of thousands of pounds' worth of property irrecoverably lost. Defective ventilation, bad carriages and carriage-roads for transporting the minerals, vicious methods of supporting the roof and walls of beds and lodes, and most injudicious division of labour, may at this day be met with to a surprising extent in many mining districts; and by neglecting to survey, or by surveying inaccurately, accidents to both life and property are by no means rare.

Great engineering difficulties are constantly occurring in the practice of Mining Engineers; and to overcome them safely, and with economy, requires no small share of tact and judgment. Underground work is buried away from the "public eye," and is seen only by the few whose duty it is to descend the shaft or "ingoing eye." Many mines are well conducted, and you may see at once, in both arrangements and condition of workings, that a kind of liberal economy is practised, and that the superintending mind is one not only of intelligence, but also of order and care; but in other cases, owing to want of perseverance under difficulties, and to the exercise of common judgment and prudence, as well as to the fact that the results of such cannot be seen and understood by anyone habitually descending the mine; the whole mining operations are marked by such a blundering, day-by-day, "makeshift" character, as to be both productive of accident and cause of unnecessary expenditure.

There is a class of colliery and other mine managers who have been trained from youth upwards in all the departments of mine engineering, or who have been educated liberally preparatory to entering upon an apprenticeship in mine management under some competent and conscientious engineer, and who are therefore fully alive to the importance of attending closely and carefully to the minor details of management. Men of this stamp and character of qualification are to be found in charge of the most extensive and best-conducted collieries and metalliferous mines of the United Kingdom; but in many instances, through a mistaken notion of economy by proprietors, men are employed as responsible managers who are totally ignorant of the most elementary principles of mechanics, the laws of gases, the principle of the safety-lamp, the geometry of figures formed by faults and heaves, and the theory and accurate practice of surveying and levelling.

There cannot be directly any blame attached to either employed or employers for the evil which we have thus indicated. Employers, on the one hand, are naturally anxious to obtain servants at the lowest possible remuneration; and the employed, on the other, are ready to enter upon the responsibility of situations in which they can obtain more wages for less arduous work than has been their lot in the capacity of common workmen. The speediest and most effective remedy that we can suggest is, that all responsible managers of mines be required by Government to obtain Certificates of practical and theoretical competency for their situations before being allowed to enter upon them. Local Boards of Examiners could easily be established for this purpose; and it would be no difficult task so to combine the practical in examinations with the educational and scholastic, as to preclude the possibility of any mere theorist obtaining a certificate. We could adduce many instances of gross mismanagement in various departments of mining, resulting in loss of life and property; but as it is our province, in the present instance, to deal with the surveying of mines, we must refer chiefly to this subject.

The want of accurate surveying of mines has often been forcibly shown by law-suits, by fatal accidents, and by blunders in mine engineering, which have been confined to the proprietors' purse. Any attempt, therefore, which is made to introduce improvements into this department of mining work should be hailed with encouragement and patronage by all interested in mining operations.

The writer had the opportunity of reading in manuscript the work to which this Introduction is prefixed, and he can affirm that in this work the student of Mineral Surveying will find various ingenious devices in surveying, and the principles of the improved systems of surveying, introduced to him in a manner not to be met with in any other published work.

Mr. Hoskold is a notable practical surveyor, and his book has evidently, as a consequence, received a stamp of character—straightforward and to the point—which is best suited to the studies of practical men. The instruction afforded is likely to be the means of increasing accuracy in surveying mines, and of thereby saving both human life and valuable property.

It is well known to surveyors of mines, that the common "miners' dial" is liable to lead to erroneous results, owing to various deviations of the needle from parallel magnetic planes. It must, however, be admitted, on the other hand, that there are many cases of remarkable accuracy in surveying where the common dial or compass has been the only instrument used; and for subterranean surveying, where boundaries, long drivages between shafts, or other important matters, are not involved, the dial is perhaps the best instrument for the purpose, as it is certainly more handy and expeditive than more complicated, although more accurate instruments.

Correct manipulation and readings *may* perchance give accurate results with the dial, when properly constructed and in good working order; with a transit theodolite possessing these qualifications, and with accurate surveying, the results *must* be correct. It therefore follows that for all important surveys the magnetic needle should be dispensed with, and the angles made by the respective lines of survey with each other be measured, instead of measuring the angles which these lines make with the magnetic needle.

The methods of uniting underground surveys to surface ones will be easily understood, and I have no doubt appreciated. These methods have already been ably explained and illustrated by Mr. Beanlands in his paper read before the Newcastle-upon-Tyne Institute of Engineers, and by the late Mr. Herbert Mackworth of Bristol; but hitherto a separate transit instrument has been required for determining a line in the horizontal surface plane which shall be at the same time in the vertical plane of the surveying instrument placed at the bottom of a shaft, whilst Mr. Hoskold has provided an ingenious instrument which combines the purposes of the transit instrument with those of the theodolite and dial; and moreover, it must be stated that there are points in Mr. Hoskold's plan of uniting the surveys which, so far as the writer is aware, have never yet been published.

The plan of setting-out curves for underground railways and other purposes is novel and useful, and will at once recommend itself to the intelligent mining engineer. It will be particularly useful for the long curves leading into level roads from inclined engine planes.

The plan of plotting surveys by means of co-ordinates from two vertical planes intersecting each other at right angles will be found to be correctly and clearly described, and the advantages it possesses, in comparison with the ordinary mode of plotting, should be duly considered by the practical surveyor.

The office form of recording the surveys deserves particular attention. It serves, indeed, more than all the purposes of a duplicate plan: as has been shown and illustrated by the author, it furnishes at all times a ready means of ascertaining any point in the underground survey coming vertically under any given point at the surface; and it is at the same time a handbook record of all the particulars relating to sections of level and to all horizontal surveys of the mine, from which plans and sections, in whole or in parts, can at any time be procured. Had there been during the last half century local mining record offices where such records of mines had been stored up by the Legislature, easily and readily accessible to mine owners, how much of human life and suffering would have been saved, and the irreparable loss of how much property would have been prevented!

The Traverse Tables are newly arranged, and cannot fail to be of great service to surveyors. The Tables of Natural Sines have all been thoroughly revised, and will be at once appreciated as a valuable addition to the former portion of the book. Since 1811, when that useful book appeared, known as Fenwick's "Subterranean Surveying," we have been favoured with such works as Budge's "Miners' Guide," Williams' "Geodesy," and Richards' "Miners' Manual," all containing useful information on the subject of mining surveying; but the present work will be found to occupy a different position from any of the works referred to, and to be much better adapted than they are to the requirements of mineral surveyors.

Magnetic influences and their causes are not thoroughly and clearly understood; it is well known that the surveyor's hand, when in a heated condition, is quite capable of disturbing the needle simply by being placed above the needle whilst holding the candle or lamp for the purpose of reading a bearing. It is the hand and not the lamp which disturbs the needle, the surveyor of course being careful to use a lamp of copper or brass. Iron plates or rails used for tramways, &c., frequently exhibit, in varying degrees of intensity, different magnetic poles; North and South poles being often formed in various places throughout the length of a plate, or, to speak scientifically, the bar is broken up into poles: to talk, therefore, of placing the surveying dial between the railway plates so that one plate may neutralize the effect of the other, is to ignore this circumstance. The only iron-ores, however, which are likely to affect the magnetic needle, are Magnetite and Ilmenite (magnetic oxide of iron and titanate of iron). Specular ore—the Red Hæmatite—is *sometimes slightly* magnetic, but by holding a mass of it to the needle no perceptible effect is produced. Iron-stones of the coal-measures are only magnetic after calcination, but they are occasionally calcined by heat from trap-dykes. An altered piece of black-band from the neighbourhood of a trap-dyke in an Ayrshire coal-pit has been kindly analysed for me by Mr. J. Napier, and is found to contain 4 per cent. of magnetic oxide: it affects the magnetic needle powerfully.

In 1861 I made a series of experiments, with three different surveying dials, in an upper seam of Bankhead Colliery, near Glasgow, the results of which have gone far to convince me of the uncertain and unsatisfactory character of surveys with the common dial. The first observation was made with an instrument placed in the seam at a distance of 4 feet from the near margin of the shaft. When the cage, in descending, approached the seam, the north end of the needle was repelled 10°; in ascending, the cage attracted the north end of the needle 20°. At a distance of 8 feet from the shaft the descending cage repelled the needle 5°; at 15 feet 1°; and at 27 feet ½°. Bearings taken with the three instruments, when the cage was stationary and at the surface, were as follows:—

With 1st instrument the bearing was S. 32° E.
With 2nd „ same line was S. 30½ E.
With 3rd „ „ S. 29½ E.

The same amount of difference between the reading of No. 1 and No. 3 instruments was observed at the surface, a discrepancy which, of course, must have arisen from defective construction.

An ordinary cast-iron tram-plate, four feet long, when placed horizontally at a distance of 2 ft. 9 in. below the instrument, and 14 inches on one side of the centre line of the dial's position, produced a difference of ½° in the position of the needle; two plates so placed made a difference of 1°. The same two plates standing on end at 14 inches on one side of the instrument repelled the needle 4°; when placed on contrary end they attracted the needle 15°; placed at 6 feet from the instrument they made a difference of ¼°; when at 9 feet distance they produced no sensible effect. The same two plates placed horizontally two feet on one side of the instrument, end to-end, and similar poles being together, repelled the needle in the one case 2 °, and in the other attracted it 3°. When dissimilar poles were placed together they neutralized each other, but one of the plates had to be broken to get at the place of its pole.

The methods of surveying and systems of keeping records of such surveys by plans and other means should be of the best possible kinds where so much of life and wealth is at stake; and it is to be hoped that the efforts made by Mr. Hoskold and others may lead to the introduction of improvements into this department of mining work.

THE MINER'S COMPASS

AND

ITS ERRORS.

The miner's compass, or dial, as it is generally called, consists of a brass box, containing a ring or divided circle, graduated into 360 divisions, called degrees,—(how all circles came to be so divided is a matter of speculation; it might have arisen thus, because the radius of every circle is equal to the chord of 60°, or two-thirds of any right angle, which, repeated round the circumference, would exactly come in at six times, consequently $60° \times 6 = 360°$; or it is more probable that the idea first took its rise from the circumstance of the ancient year having been divided into 360 days, as the earth was supposed to describe its orbit in that time),—and numbered from 0, or zero, round to 360. The bottom of the box also is divided into four quadrants, of 90° each, commencing from a line passing through zero and 180°, or the north and south limb; which line is called the dial's meridian, and is numbered 10°, 20°, 30°, &c., to 90° each way, which division marks the east and west points of the compass. In the centre of the compass box there is fixed a pin finely pointed, and made to carry a steel bar, accurately balanced and magnetized, called the magnetic needle. When in use it is allowed to play freely inside the graduated circle until it stands at rest, and then points to its own north, which end is marked differently to the other for the sake of distinction. The box being thus far completed, is fitted with a glass cover to keep the needle free from the effects of the air from the exterior. There are also two projections of brass cast to the bottom plate of the compass box, to receive perpendicular sights. These sights are made to fold over the compass box by means of a pin joint, and are each fastened to the north and south limb of the compass. From the description here given, it will be observed that this kind of instrument is of no very nice construction, and is only intended for rough work, where mere sketches are required only, and as such is well adapted for military and other sketching. It is much to be regretted that the dial still continues in almost general use at the present time among and in mining districts, where, from the very nature of the instrument, it should be quite inadmissible, even if it had no other liability to derangement and inaccuracy than from the proximity to the iron rails in such mines when in use. However, the instrument is liable to so many kinds of derangements, that it should be entirely discarded as an instrument to be depended on for anything like accurate results. The magnetic needle of the above description of instrument coincides with its own magnetic meridian, which meridian is constantly variable, depending on the electrical state of the atmosphere, and is not the same in all places nor at all times of the year, and is called the magnetic variation. There is also a local attraction or variation, caused by metallic or mineral veins in hills, large masses of iron near at hand. Some kind of surface stones will also produce an effect on the needle.

Having occasion, some time since, to mark out a line through a very rugged inclosure with the miner's dial, and having proceeded some time with the measurement, we came to a large heap of some kind of stones, when, all at once, the needle began to play freely; and after waiting some time for it to settle it was not at all disposed to do so—which circumstance was indicative of iron near at hand—and after a vain search none whatever could be found. Our attention was now directed to the heap of stones, and, after some examination, they were found to be sandstones, and strongly tinctured with iron. The line was now proceeded with, and after passing the spot a few yards the effects entirely disappeared, proving at once the cause of the deflection of the needle.

The above-quoted variations in the miner's dial are not the only drawbacks, among other causes of inaccuracy, the instrument is liable to. Angles cannot be read nearer the truth than from one-quarter to one-half a degree; the limb, or divided circle of the dial, rarely admits of a less subdivision; also the horizontal angles pointed out by the needle cannot be read accurately, because the needle is not always parallel to the plane of the instrument, but has one of its poles raised some distance from that plane. Again, the diurnal variations of the needle* are too important to be neglected, as they oftentimes amount to three-quarters of a degree in twelve hours; and in the same localities variations of one degree and a half have been observed in thirty days, and in other places even more than this. To corroborate this, the following table† is given from the *Philosophical Transactions*, Vol. LI.:—

Hours.	Minutes.	Declination West.		Fahr. Ther. Deg.
		Degrees.	Minutes.	
0	18	81	2	62
6	4	18	58	62
8	30	18	55	65
9	2	18	54	67
10	20	18	57	69
11	50	19	4	68.30
0	40	19	19	70
1	38	19	8	70
3	10	19	8	68
7	20	18	59	61
9	12	19	6	59
11	40	18	51	57·30

The following table is also taken as the mean variation of every month in the year:—

January . . .	0°	7′	8″	July	0°	13′	18″
February . . .	0	8	58	August. . . .	0	12	20
March	0	11	17	September. . .	0	11	43
April	0	12	26	October . . .	0	10	36
May	0	13	0	November . . .	0	8	9
June	0	13	14	December . . .	0	6	58

It will have been shown clearly by this time that the common compass is not at all applicable to long and extensive underground surveys, especially in mines containing iron ore, and such minerals as are undoubtedly possessed of magnetic properties. The dial, at best, should never be employed where niceties are required; and when its assistance is required in a survey a bearing

* *Annales des Mines*, tome ix., 1836. Williams's *Practical Geodesy*.
† *Phil. Trans.*, vol. li. Taken by Mr. Canton.

of one line only should be taken, and even then with the greatest possible caution. All iron rails and other metallic substances should be removed to some distance, and the bearing of the same line taken at different points, the mean of which should be employed as the working bearing. We shall now insert a table of annual variations from the year 1576 to the present time, and then will follow examples of work done by the compass:—

Year.	Declination.				Year.	Declination.			
1576	11°	15′	0″	East. (1576–1657)	1789	23°	36′	0″	at London.
1580	11	11	0		1793	23	52	0	„
1612	6	10	0		1797	24	2	0	„
1622	6	0	0		1800	24	6	0	„
1633	4	5	0		1803	24	59	0	„
1657	0	0	0		1804	24	8	4	„
1666	1	34	0		1805	24	7	8	„
1672	2	30	0		1806	24	8	6	„
1683	4	30	0		1807	24	10	2	„
1692	6	9	0		1808	24	10	0	„
1700	8	0	0		1809	24	10	0	„
1717	10	0	0		1810	24	12	4	„
1724	11	45	0		1811	24	14	2	„
1730	13	0	0		1812	24	16	3	„
1735	14	16	0		1813	24	16	40	„
1740	15	40	0		1814	24	16	42	„
1745	16	53	0		1815	24	17	15	„
1750	17	54	0		1816	24	17	54	„
1760	19	12	0		1817	24	17	0	„
1765	20	0	0		1818	24	15	5	„
1770	20	35	0		1819	24	14	47	„
1775	21	28	0		1820	24	11	44	„
1777	21	57	0		1850	22	34	18	„
1779	22	40	0		1857	21	56	20	„
1780	22	26	0		1859	21	10	50	„
1786	23	19	0		1861	22	37	30	at Cinderford.

Thus it will be seen that the magnetic variation has been decreasing eastward at about an average 0° 2′ 9″ 37‴ for a period of 81 years, or from 1576 to 1657, at which time the magnetic meridian coincided with the true meridian. Since that period the variation has been veering to the west, at about 0° 10′ 16″ per year, for a period of 146 years, or until the year 1803, at which date it appears to have attained its maximum variation. After this time the variation has decreased westwardly; and is about 22° 37′ 30″ at this time, April 3rd, 1861, at Cinderford. From the foregoing statement it is a positive established fact, that a survey made in any one year cannot possibly coincide with the same survey made a long time afterwards. That is, any survey performed with the magnetic needle of the miner's dial, and plotted either on the surface or on a drawing, cannot agree with a survey of the same place, and performed with the same instrument, in years afterwards. This occurs from the annual variation. Errors of a like nature happen from local diurnal variations, as also from non-parallelism of the needle; for an error of 30′ on a line of 40 yards, if continued to one mile, produces an error of 15 yds. 1 ft. ·9 in.; and Herbert Mackworth, Esq., in his lecture to the Bristol Mining School, gives an example of this that was presented in the Standedge Canal tunnel, made some years since, when, in driving three-quarters of a mile directly from shaft to shaft the two levels missed each other by more than ten yards. Another example came under my own notice in a colliery in this neighbourhood, the proprietors of which wished to drive a slope or incline from a given point below to the surface: the bearing was said to be S. 64°, E. 33 yards; instead of which, when the incline was driven to land, the bearing was found to be S. 27°, E. 106 yards, and being at a distance of more than 60 yards from the point at land it was expected to come out at.*

Others will teach a method of working out dialing by plane trigonometry, and after working the traverse forwards and backwards, and the resulting calculations approximating, take it for granted they have a mathematical demonstration of its accuracy. Nothing more absurd than to suppose that a trigonometrical calculation can possibly right what the compass or magnetic needle and their own inability have done wrong. To prove that metallic substances produce a great effect on the magnetic needle at a long distance, the following experiments were resorted to for determining the amount of deflection of the magnetic needle. A line of 1000 links was measured on part of an iron permanent railway, and the mean of several observations taken as the true

* Several cases may be adduced to prove the insufficiency and carelessness of those using the miner's compass, but from want of space are not noticed here.

bearing per compass. The line C D, E F, and G H, Fig. 3, Plate I., were then set out (with the theodolite) parallel to that of A B, and (in an open field free from all iron except the adjacent railway), and at a distance of 40 yards from each other, the bearing of the respective lines C D, E F, and G H, were then carefully taken as before, when it was ascertained that the bearing of C D, was N. 5° 35′ E. differing from A B, 20′; that of E F, N. 5° 56′ E. differing from C D, 11′; and that of G H, N. 6° 0′ E. differing from C D, 4′. The experiment was now deemed complete, inasmuch as the last bearing, G H, differing so little from E F, it was not necessary to measure off another parallel line, as probably its bearing would not have differed more than a minute or so from the one last taken. Assuming the bearing of G H as the correct one, we shall readily arrive at a reliable conclusion, especially as the bearing of the last line was taken at a distance of 120 yards from the railway, and therefore comparatively free from its influence. The difference in the first and last bearing is 45′ on a line of 1000 links; this would produce an error amounting to exactly 13 links; and the error on a line of 4000 links would be equal to something more than 52 links, or 11 yds. 1 ft. 4 in. From my own experience in surveying in iron mines with the magnetic needle, I am of opinion that the effects produced from all causes taken together would be about equivalent to the above discrepancy. Any person will at once perceive that if an underground tunnel had been commenced from A, it would never have ended at B, the point intended, but would have terminated 13 links on one side for a distance of 1000 links, or 52 links on a line of 4000; and if the tunnel had been commenced from opposite sides, as at A, and B, it could not possibly have joined when the heading came opposite, but would have been 52 links asunder; that is, if the line A B was set out from A, N. 5° 15′ E., it would have been 26 links on one side of the centre line at 500 links, and also if the same bearing reversed was set out from B, S. 5° 15′ W., it would also have been 26 links from the centre line at a distance of 500 links from B, and if any longer lines were required the difference would then accumulate in the same ratio. In concluding this chapter on the compass, I would just mention that I have made plans of iron mines from surveys taken with the greatest possible care with the magnetic needle, and am confident that at a great distance from the shaft, say two miles, the position of headings as pointed out on the surface could not be depended on from 5 to 10 yards; and this is exactly the case with all maps and plans* (of iron mines at least), constructed from the entire use of this description of instrument. I would therefore recommend any student who intends perfecting himself in mining surveying, that it is much better to go to the price of an instrument that is not only the best but the cheapest in the end, even if it costs three times the price of those generally offered for sale, and not for work, for mining purposes.

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* The magnetic compass is perhaps more adapted for use in lead and coal mines, where there is much less chance of derangement, than in iron mines; and I think it not altogether improbable that at a future day the compass may be so constructed as not to be liable to derangements from local disturbing causes.

PRACTICAL GEOMETRY.

Practical Geometry is intended to explain the method of constructing geometrical figures, and of describing lines according to any possible given conditions. There exist three kinds of magnitudes: lines, surfaces, and solids.

The following chapter refers to figures and lines described upon a plane surface, and contains only those problems and examples that are necessary to the subject in hand.

TO CONSTRUCT A SCALE OF EQUAL PARTS.

Take any opening of the compasses, and apply it to any line previously drawn as A B, Fig. 1, and repeated ten times from A to 0; then with an opening of the compasses equal to A 0, mark off the other equal parts or divisions, 10, 20, 30, &c.; then each division in A 0 will be units, the distance from 0 to 10 will be 10 units, from 0 to 20 will be 20 units, and so on to the end. Now if each division in A 0 be taken as 10 units, then the divisions on the scale equal to A 0 will be hundreds. And if

Fig. 1.

A 0 be taken as a unit, then each division on A 0 will be one-tenth. Then when each division in A 0 represents 10 feet, A B will be equal to 60 feet.

ANGLES AND THEIR MEASURE.

What is meant by angles is the opening formed by two straight lines, meeting each other in a point called their vertices.

As an example, take the angle A B C, Fig. 2, or the angle at B, formed by the lines B A and B C.

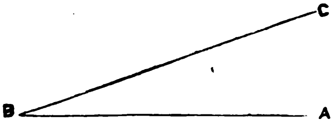


FIG. 2.

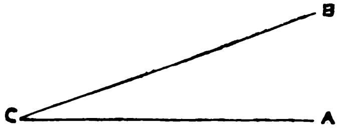


FIG. 3.

Now if we wish to ascertain whether or not the angle at C, Fig. 3, is equal to the angle at B, we put the lines forming the angle C upon the lines forming angle B, in such a way that the point C shall fall upon B, and the line C B shall cover the line B C, then if the line C A cover exactly B A, the angles are equal; thus it appears that the angles do not depend on the length of the lines which form them, but they may be longer or shorter without altering the angle.

The line D C in the semicircle A G B, meeting the line A B, inclines to the right more than to the left; the ∠ D C A is evidently greater than the ∠ D C B, if the lines C G be drawn equidistant between A G B, thereby making the ∠ G C B equal to the angle G C A, then they are called right angles, and the line C G is perpendicular to the line A B; and the angle D C B is called acute because it is less than a right angle, and the angle D C A is called obtuse because it is more than a right angle.

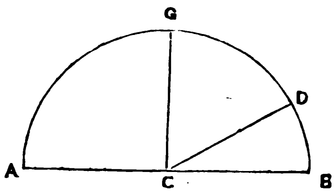


FIG. 4.

The circumference of every circle is divided into 360 parts, each part is called a degree, and the angle formed by any two lines drawn from the points of division to the centre D, Fig. 5, of the circle, will be an angle of 1 degree. Take 30 of these divisions, it will be equal to the ∠ S D B = to 30° 0′ 0″. The angle formed by the lines C D B will be a right angle, or 90°, and the semicircle A C B will contain 180°. Divide any one degree into 60 parts, each part is called a minute, and one of these divisions divided again into 60 parts, each part is called a second. And we write it thus, 40° 20′ 40″: forty degrees, twenty minutes, forty seconds.

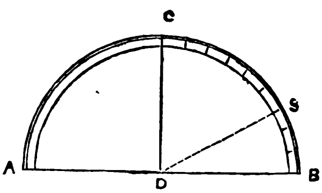


FIG. 5.

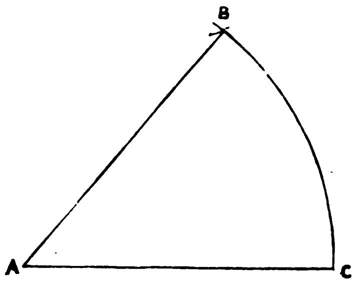


Fig. 6.

To describe any angle on a drawing by the compasses and scale, draw the line A C, Fig. 6, any length; take from a brass circle or line of chords (divided as above) the angle of 60°, set one foot of the compasses at A,* and describe the arc B C.; take from the same circle the angle required, say 45°, set the compasses at C, and describe another arc at B; now join A B, and the lines A C and A B will contain the said angle.

Problem 1.

Given the hypothenuse and a side of a right angled triangle, to construct it, and measure the other parts.

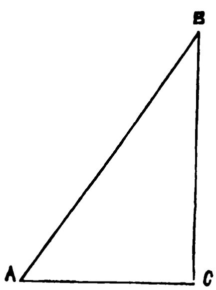


Fig. 7.

Example.—Given the hypothenuse A B, Fig. 7=468 yards, and the side A C = 268 yards, to find the other parts. Draw the line A C=268 yards, and draw also the line C B perpendicular to A C; then from the point A with the radius=468 yards, cut the line C B in B, draw A B, and A C B is the triangle required; measure the perpendicular C B on the scale, and it will be found=to 380 yards, the angle A = to 55° and ∠ B = to 35°.

Problem 2.

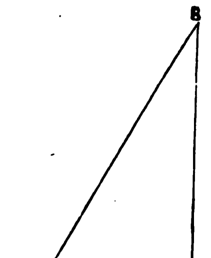


Fig. 8.

Given the two sides about a right-angled triangle, to construct it, and measure all the other parts.

Example.—Given the base A C, Fig. 8,= 250 yards, and the perpendicular C B=490 yards. Draw the line A C=250 yards, and make the line C B perpendicular to A C, and =490 yards, draw also the line A B, and A C B is the required triangle; measure A B on the scale and it will be found=to 550 yards, and the angle A 61° 30′, and the ∠ B =to 28° 30′.

---

* Horn centres may be obtained at sixpence each, which will prevent the compasses damaging or perforating the paper.

PROBLEM 3.

Given the hypothenuse, and one of the oblique angles of a right-angled triangle, to construct it, and measure the other parts.

Example.—Given the hypothenuse A B, Fig. 9=426 yards, and the angle at A=51° 30′. Draw any line A C, apply the protractor to the line A C, and mark off 51° 30′, then draw A B=426 yards, let fall a perpendicular to C, and the triangle A C B is the one required; then B C will be found=334 yards, and the angle at A=51° 30′, ∠ at B=38° 30′. If the angle at B is given instead of angle A, then deduct the angle B from 90° and it will give angle A, and proceed as before.

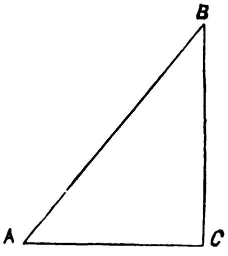


FIG. 9.

PROBLEM 4.

Given one of the sides of a right-angled triangle and an oblique angle, to construct and measure the triangle.

Example.—Given A C, Fig. 10 = 280 yards, and the angle at A 64° 20′, to find the other parts. Draw the line A C=280 yards, and apply the protractor to A, mark off the angle 64° 20′, then from the point C draw the perpendicular C B, now draw A B through the angular point and A C B is the required triangle, A B and C B=648 yards and 580 yards. If angle B is given instead of angle A, proceed as before.

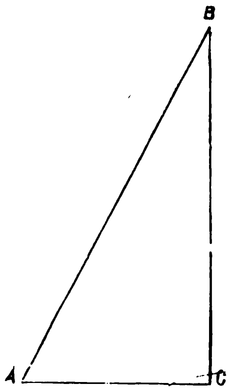


FIG. 10.

PROBLEM 5.

Given one side and two angles of an oblique-angled triangle, to construct it, and measure the other parts.

Example.—Given the base A C, Fig. 11=350 yards, and the angle C A B, 34° 30′, and A C B=29° 40′. Make the line A C B=350 yards, and with a protractor mark off the angles at A and C, 34° 30′ and 29° 40′ respectively; then produce the lines A B and C B until they join at B, then the triangle A B C is that required, and A B and B C measured on the scale=270 and 290

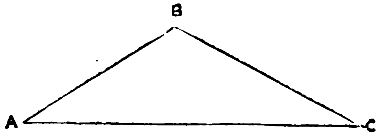


FIG. 11.

yards, and the angle at B = 119° 50′. If the angles A and B, or C and B are given, the amount of both A and B, or C and B must be added together and deducted from 180°, which will give the other angle C or A, as may be required.

Problem 6.

It is required to find the depth of a mine shaft B C Fig. 12, the distance from the croppings out of the underlie or A B, and the depression of the said underlie or pitching with the horizon are given.

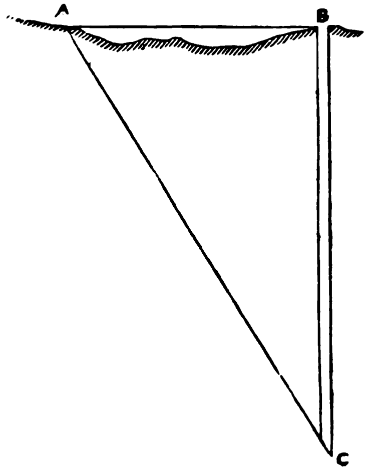


Fig. 12.

Example. — Given the distance A B = 680 links, and the depression of A C or the angle C A B = to 60° 30′. Draw the horizontal line A B, and set off the angle 60° 30′ of depression, or the line A C; measure with the scale 680 links, from A to B, now let fall a line perpendicular from B, and the intersection of B C with A C will be the point required; measure the line B C on the scale, and it will give the depth required in links.

Problem 7.

The depth of a shaft is given, with the distance from the out-croppings, to find the length of heading required to meet the underlie.

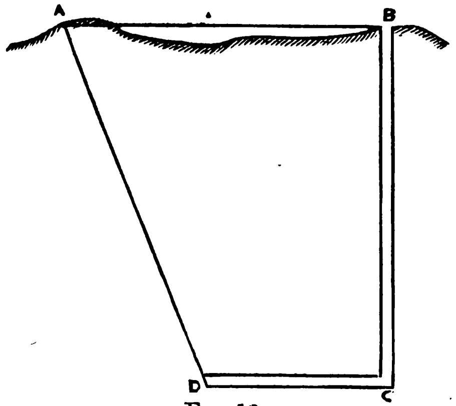


Fig. 13.

Example.—Given the depth of a shaft, 200 yards, and its distance from the out-croppings, 840 yards, with the angle of depression of 69°. Draw the line A B, Fig. 13 = 840 yards, and protract the angle of depression = to 69° (from A); let fall a line perpendicular from B, and set off the depth of the shaft, 200 yards. Draw also the heading C D parallel with A B, and measure it on the scale, which will give the distance required in yards. In like manner the distance from D to A at land may be ascertained by applying the scale to the line D A.

Problem 8.

It is required to find the depth of a shaft where a heading shall strike the underlie when its length is given, with the distance of the shaft from the out-cropping, and the depression of the pitching.

Example.—Given the distance A B, Fig. 14 = to 300 yards; the depression 60°, and the length of heading 10 yds. Draw the horizontal line A B = 300 yards, and from A set off the ∠ of 60° for the depression of the underlie; let fall a perpendicular from the point B to any depth, apply a parallel ruler to the line A B and run the same downward until the heading of 10 yards will fall exactly between the shaft and underlie. The point where the heading touches the shaft will be the depth (which is at C). Now measure the shaft B C on the scale, and it will give the distance required.

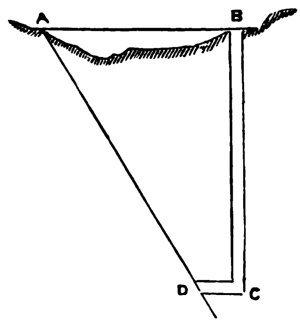


Fig. 14.

Problem 9.

The distance of a shaft from the out-croppings and the depression of the underlie are given, to find the depth of the shaft at the point of intersection with the underlie, and also to find the length of a returned heading, when the shaft is continued below the point of intersection.

Example.—Given the distance of a shaft B, Fig. 15, from A = 400 yards, and the angle of depression = 62° 30′, with the shaft continued 60 yards below the point of intersection with the underlie. Draw the line A B to any length, and from the point A set off with the protractor the ∠ 62° 30′ of de-

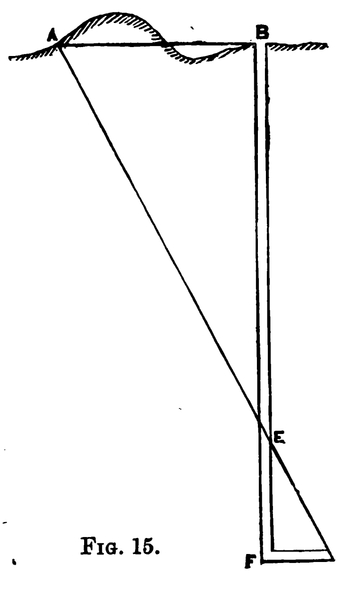


Fig. 15.

pression with the horizon; let fall a perpendicular from B, and the point of intersection at E will be the depth required; now measure B E on the scale, and it will give the distance. Continue the shaft 60 yards below the point E to F, then apply the parallel ruler to the line A B, and run it downwards to the point F; draw F H, and it will be the proposed returned heading, apply the scale to F H, and it will give the required distance.

Problem 10.

It is required to find the distance between two shafts, A and B, on opposite sides of a lake.

Example.—Plant the theodolite at C, Fig. 16, and measure the angle A C B, say = to 94° 45′, measure also the line C A and

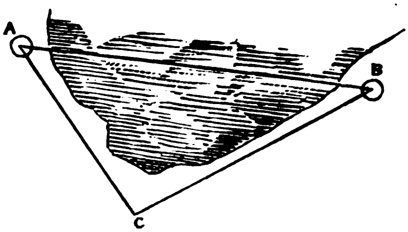


Fig. 16.

C B, say 60 and 70 chains respectively. Draw the line C A, and mark off the angle at C with the protractor = to 94° 45′, apply the scale to C A and mark off 60 chains, also to the line, C B 70 chains; join the line A B, and apply the same scale, which will give the distance required.

Problem 11.

To find the distance between two mine shafts, A B, Fig.

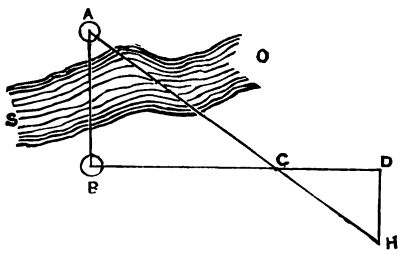


Fig. 17.

17, inaccessible from each other by the intervention of the river S O.

Example.—Set up a staff at B in line with A on the other side of the river, and draw a line at right angles with it and set up a staff at D. Draw a line with D H at right angles with B D and set up a pole at H. Now measure off a given distance from B, say B C, and set up a pole at C; then direct the staff H to be brought in a direct line with C and A, and measure the distance B C, C D, and D H; then because the angle B C A is = to the ∠ D C H and the ∠ B is = to the ∠ D, being each right angles, ∴ C D : D H : : C B : B A; let B C = 400 feet, D C = 200 feet, and D H = 140 feet; then 200 : 140 : : 400 : 280 feet = to B A, the distance required.

Problem 12.

Required the distance between two mine shafts, A and B, which could only be seen at the same time from one station, D.

Example.—Set up a theodolite at D and also a staff at C and E at a given distance. Now measure the angles A D B, A D C, and A C D; the distance from C to D being known,

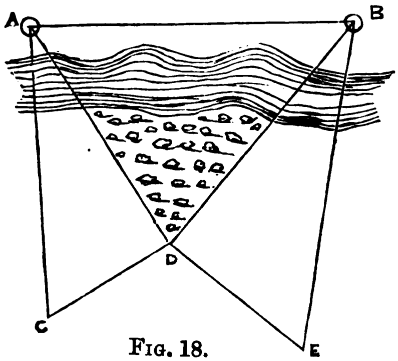


Fig. 18.

the length of the line A D can be ascertained by Problem 5; then measure the angles B D E and D E B and the length of the line D B will be found; then the lines A D and B D being ascertained and also the angle A D B, the length of the line A B will be found by Problem 10.

Problem 13.

The depth of a mine shaft and the angle of elevation of another shaft, with the hypothenuse, are given, to find the depth of the shaft.

Example.—Given the depth of the shaft A B, Fig. 19=120 yards, and the angle of elevation E A C=28° 30′ 40″, and the hypothenuse A C=1060 yards, to find the depth of the shaft C D. Draw the horizontal line B D, measure (with any scale) from B upwards to A=120 yards, apply the protractor to the horizontal

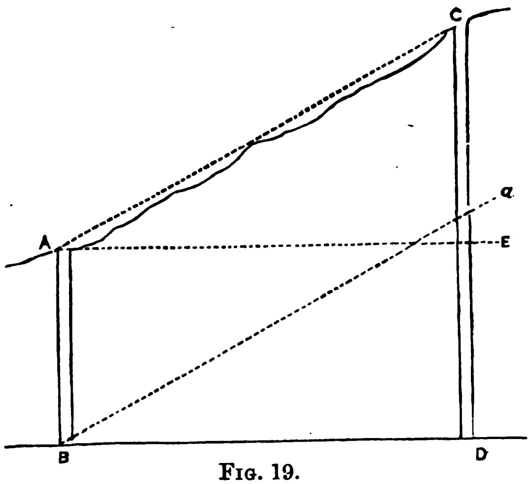


Fig. 19.

line B D with its centre at B, mark off the angle 28° 30′ 40″, set a parallel ruler to the line B *a*, and run it upwards to the point A; draw the line A C, then the ∠ E A C = ∠ D B *a*; now measure off on the line A C 1060 yards, and let fall a perpendicular, D C, which measured on the same scale will give the depth of the shaft required.

Problem 14.

The depth of two shafts, with the angles of depression and the hypothenuse, are given, to find their differences of level.

Example.—Given the depth of two shafts, A B and C D, Fig. 20=130 and 160 yards respectively, with the angles of depression T H A=24° 20′ 40″, ∠ S H C=10° 34′, and A H and H C =800 and 640 links, to find their differences of level. Draw the horizontal line T H S, and from H with the protractor, mark off the angles of depression T H A=24° 20′ 40″, and S H C=10° 34′; draw the lines H A and H C, making H A=800, and H C =640 links, then the points A and C will be the top of the shafts; let fall the perpendiculars T A and S C, which measure on the scale, and their difference will equal the difference of elevation of the two shafts; produce downward the lines A B and C D, and measure on them 130 and 160 yards respectively;

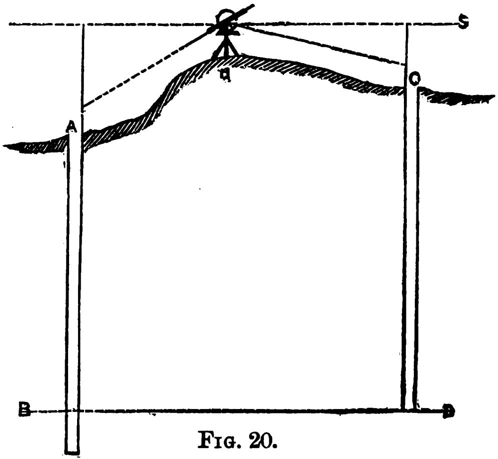


Fig. 20.

draw also the line B D parallel with T S, and the point of intersection of B D with A B will give the difference of level of the bottoms of the shafts.

Problem 15.

Given the angles of elevation of two distant shafts, with the measured hypothenuses, to find their differences of level at the surface.

Example.—Given the angles of elevation H C A, Fig. 21,

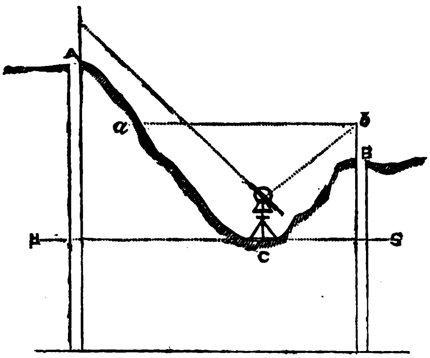


Fig. 21.

$=30° 40'$ and S C B$=26° 10' 40''$, and the line A C and B C$=$ 1100 and 980, to find the differences of level. Draw the horizontal line H S, and mark off the observed angles from C; H C A=30° 40′ and S C B=26° 10′ 40″; measure on the lines A C and C B the distances 1100 and 980 links, then the difference of H A and S B, measured on the scale, will give the difference of level of the two shafts, or set up a transit theodolite at B, and after carefully levelling it, direct an assistant to move a staff (the same height as the instrument) along the surface from C towards A, then when the upper part of the staff is seen in line with the cross hairs in the telescope at *b*, it will be on the same level as the instrument at B *a*; now the difference of level between the point of intersection of the telescope with the staff and A should give the same difference of elevation as before.

Problem 16.

Given the angles of elevation and depression of the top of two shafts from two distant stations, with the distance between the stations, to find their differences of level, and the distance of the shafts from each other.

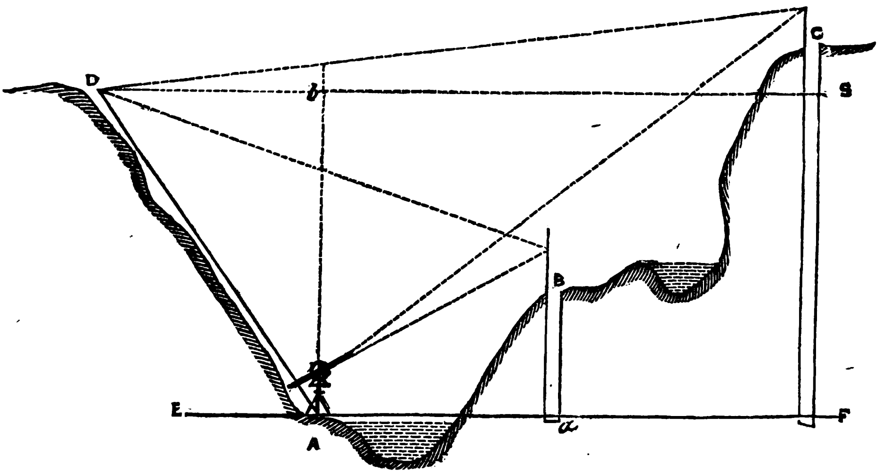


Fig. 22.

Example.—Given the observed angles of elevation, taken with a transit instrument from A to B, Fig. 22,=25° 30′ 20″, from A to C=34° 40′ 40″, and from A to D=55° 45′ 40″. The line A D was measured and found to be 1250 links. The instrument was again planted at D, when the angles of depression from D to B, or ∠ S D B=20° 45′ 20″, and that of elevation from D to C, or ∠ S D C, 3° 32′ 40″. Required the distances A B, A C, B D, and D C, and the difference of elevation from B to C.

Construction.—Draw the horizontal line E F, and set the protractor to the point A, marked by the axis of the theodolite, mark off the angles of elevation, A to B or ∠ F A B = 25° 30′ 20″, A to C or ∠ F A C=34° 40′ 40″, A to D or ∠ E A D=55° 45′ 40″, and call them respectively Nos. 1, 2, and 3; from station No. 1 draw the lines A B, A C, and A D, making A D=1250 links. To prevent confusion, draw also the line D S parallel to A F, and from the point D, the axis of the instrument at the second station, mark off the angles of depression D to B or ∠ S D B=20° 45′ 20″, and that of elevation D C or ∠ S D C=3° 32′ 40″, and call them Nos. 1 and 2; from station No. 2 draw the lines D B and D C, and the point of intersection of D B with A B will be the top of the shaft No. 1. Draw also the line D C, and its intersection with the line A C in C will give the position of shaft No. 2; now apply the same scale (that the line A D was measured with) to the lines *a* B and F C, and their difference will equal the difference of elevation of the two shafts; also, F C will be the total elevation above the station A. In like manner, the scale, applied to the lines F C and A *b*, will give the difference of level of station No. 2. Below the shaft No. 2 it is also evident that the scale applied to the lines A B, A C, D B, and D C, will give the distances required in links.

Problem 17.

Given the observed horizontal angles with two shafts from two distant stations, with the distance between the stations, to find the distance of the two shafts from each other and also from each station.

Example.—Given the observed horizontal angles taken with a transit theodolite ∠ C A B=108° 46′ 40″, the ∠ D A B=89° 40′ 20″, ∠ A B C=24° 10′ 40″, and ∠ A B D=55° 27′ 40″, and the line A B=960 links, to find the distance C D, A C, A D, B C, and B D.

Construction.—Draw the horizontal line A B, Fig. 23, and make it the exact length of 960 links (with any convenient scale), apply the protractor to the line A B with its centre at A, and mark off the ∠ C A B=108° 46′ 40″, and with the protractor in the same position mark off the ∠ D A B=89° 40′ 20″; remove the instrument, and draw the lines A C and A D to any convenient length; again set the protractor to the line A B, with its centre at B, mark off the ∠ A B C=24° 10′ 40″ and ∠ A B D=55° 27′ 40″; again remove the instrument, and draw the line B C and B D; the point of intersection of B C with A C will give the posi-

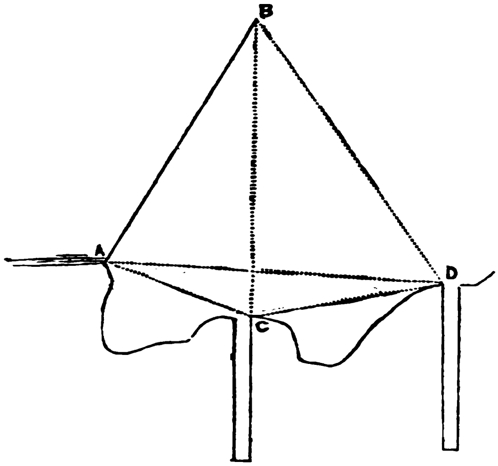


Fig. 23.

tion of the first shaft, the intersection of B D with A D will also give the position of the second shaft; now apply the scale to the line C D, which will give the distance between the shafts A C, A D. Then B C and B D, measured on the same scale, will give the distances of the two stations A and B from each shaft respectively.

PRACTICAL METHODS OF MEASURING INACCESSIBLE DISTANCES, AND AVOIDING IMPEDIMENTS IN THE RUNNING OF LINES.

Many cases of obstruction in the measurement of lines will occur in wooded districts; and from the intervention of lakes, buildings, rivers, &c. &c. The following problems are intended to assist the surveyor in surmounting these difficulties; and as the more simple cases may be effected by the chain only, those more complex will require a good angular instrument at hand, together with the aid of plane trigonometry, which will enable any person to overcome these difficulties. The student should be very careful to range his lines so that they may pass clear of all impediments, if possible. But after all his ingenuity has been expended, he will find it quite impossible to avoid them entirely.

In measuring a line, A B, Fig. 24, an obstruction of a lake came in the direct line of measurement. To avoid which, set up staves at C D E, and at right angles to the points *o o′ o″*, and after having measured this new line past the obstruction and

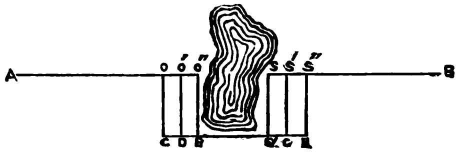


Fig. 24.

parallel to it, a return was made by setting up staves *s s′ s″* at right angles to E C H, points in the new line, and at the same distance as before the original direction of the line is continued to the end.

To pass a similar object with the use of an angular instrument and the chain, as follows :—

In measuring the line A B, Fig. 25, I come against an impenetrable inclosure; to avoid the obstacle, I measured an angle A C D=120°, and after measuring along the line C D a sufficient distance to clear the inclosure at D, the theodolite was set

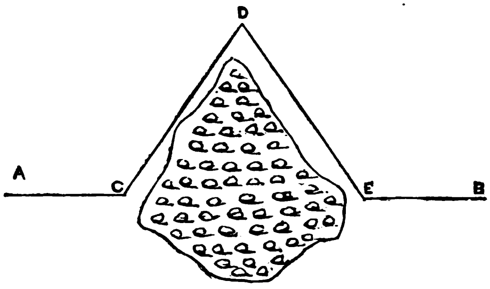


Fig. 25.

up at D, and an angle measured off equal to the supplement of 120°, or in this instance equal to 60° ; then measure along the line D E exactly the same distance as C D, which will be a point in the same straight line A B; and as it is impossible to see the back station A, the direction of the forward station B will be found by setting up the transit at E, directing the telescope on D, make the instrument read exactly 120°, or equal the angle D E B; now a staff brought into the line marked by the cross hairs of the telescope will give the exact direction; then, if it is possible to sight the station A from B, the station E should be in the same straight line, if the above process has been gone through correctly.

"Required along the line A B, Fig. 26 continued, the distance B O, inaccessible to direct measurement with the chain."*

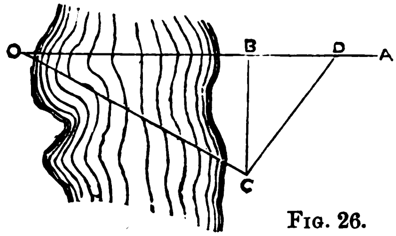


FIG. 26.

Set up a staff at C, and make the line B C perpendicular to A B, then set out the line C D perpendicular to C O, and continue it until it joins A B in D: measure B D; then as B D : B C : : B C : B O.

Given B D 400 and B C 600 feet. Then as 400 : 600 : : 600 : 900 = B O.

To solve the above problem by the instrument, set up the theodolite at B, Fig. 27, and raise a perpendicular B D to any

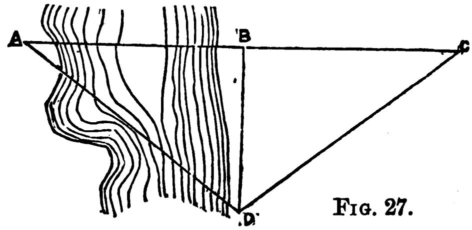


FIG. 27.

convenient length, then remove the theodolite to the station D, and make the angle B D A = to ∠ B D C; measure B C, then B C will equal B A.

It is required to find the distance B A, Fig. 28. Set up the

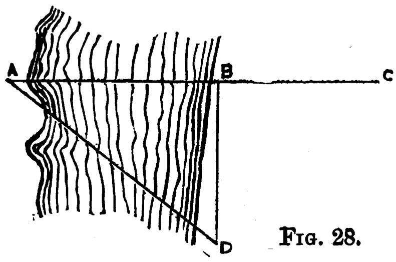


FIG. 28.

theodolite at B, and measure any angle, say about 90°, then

* Williams's *Practical Geodesy*.

walk along the line B D until you find the instrument reads half the angle, or 45° ; then measure the side B D, and B D will be equal to B A, the distance required.

The following is another method of passing obstacles by equal triangles :—After having measured up to A, Fig. 29, the line A D

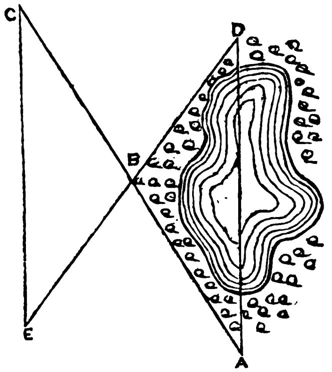


FIG. 29.

was broken by the intervention of a sheet of water and nursery. Set up the theodolite at B, and continue the lines B A to C, and also B D to E, then measure the lines B A and B D, making B A equal to B C, and B D equal to B E; then measure the line; C E will be equal to A D, the distance required.

A great many other methods, more or less simple, may be contrived by the ingenious student to solve any of those questions. They all, more or less, are based on the principle of similar and equal-sided triangles constructed on accessible planes, in conjunction with those on inaccessible planes.

PRACTICAL PLANE TRIGONOMETRY: RIGHT-ANGLED.

TRIGONOMETRY is one branch of the mathematics which treats of the relations existing between the sides and angles of triangles. The kind introduced here will be as simple and practical as possible, and sufficiently extensive for all the purposes of the underground surveyor; and as I have proposed to work out all the necessary calculations by one method, or by the table of natural sines, tangents, &c., any other methods of calculation will not be resorted to except where they can be more advantageously employed.

DEFINITIONS.

1. The complement of an arc is the difference of that arc from a quadrant, or 90°, either in defect or excess.

2. The supplement of any arc is the difference of the arc from a semicircle, or 180°.

3. The complement of an angle is the difference from a right angle.

4. The supplement of an angle is the difference of the angle from two right angles.

5. The sine of an arc is a straight line drawn from one extremity of the arc perpendicular to the radius drawn through the other extremity.

6. The tangent of an arc is the straight line drawn from the outer extremity of the radius, touching the circle in that point.

7. The secant of an arc is the straight line passing through the circumference of the circle, and from its centre, until it touches the tangent produced.

8. The sine, tangent, and secant of the complement of an arc are called the cosine, cotangent, cosecant of that arc.

RIGHT-ANGLED TRIGONOMETRY.

Proposition.—If in a right-angled triangle we make the hypothenuse radius, then its side becomes the sine of the opposite angle, or the cosine of the adjacent angle. Then if the hypothenuse A C, Fig. 30, is radius of the arc C D, B C will then be the sine of C D, and is also the sine of the ∠ A. Also, if C is the centre of the arc A E, described by the radius C A, and cutting the line C E in B, then A B is the sine of A E, is also the sine ∠ C, that is, A B and B C are the sines of the opposite angles. The three angles of every triangle are = to two right angles. Hence the oblique angles of a right-angled triangle are each other's complements.

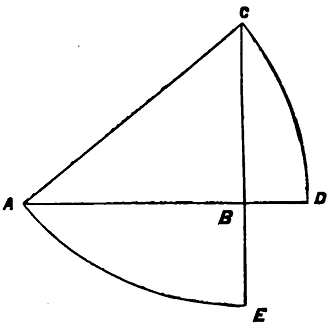


FIG. 30.

Therefore, since the angles A and C are each other's complements, B C, the sine of A, is also the cosine of C, and A B, the sine of C, is the cosine of A, that is, A B and B C are the cosines of the adjacent angles. When one of the sides about the right angle of a right-angled triangle is made radius, the other side becomes the tangent of the opposite angle, and the hypothenuse the secant of the same, or the other side becomes the cotangent of the adjacent angle, and the hypothenuse the cosecant of the same. Let A B, Fig. 31, be a side of the right-angled triangle A B C, and made radius, then B C is a tangent of the angle A, and therefore also the cotangent of the angle C, which is the complement of A. Also, A C is the secant of the angle A, or cosecant of C.

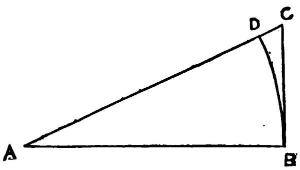


FIG. 31.

PROBLEM 1.

If we have given in any right-angled triangle one of the sides containing the right angle, and one of the acute angles, to find the other sides.

Before proceeding to a more general method of calculation, I shall here introduce a simple and accurate method of finding arithmetically the sides of any plane triangle, having the base and one of the angles given.

Example.—Given the ∠ A, Fig. 32, = 32°, and the side A B=440 links, to find the other sides and angles.

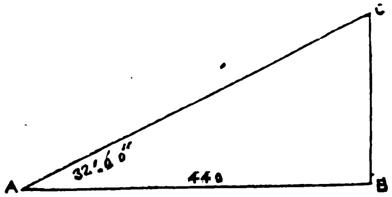


FIG. 32.

Rule.—Square the angle at A, and add to the result $\frac{1}{3}$ of itself, which call the dividend, then add 100 to the angle at A= 132, call this number the divisor, then add to the quotient the ∠ at C=58°, and call this new number the hypothenuse, by supposition = to A C. Then say by proportion, as 58°, the ∠ at C : to the base A B = 440 links : : 68.34 the false hypothenuse to 518.34=the true hypothenuse.

$(32)^2$ or $32 \times 32 + \frac{1}{3} = 1365 \div 132 = 10.34 + 58° = 68.34$ the false hypothenuse. Then say 58° : 440 : : 68.34 : 518.43 the true hypothenuse.

To find the Perpendicular.

Rule.—Square the ∠ at A, and multiply it by 3. Then divide this number by 1000, and add to the quotient the constant number 57.3. Call the result the false perpendicular, then say by proportion, as the false perpendicular 60.0 is to the true hypothenuse, so is the angle at A to the true perpendicular.

$(32)^2 \times 3 \div 1000 = 2.072 + 57.3 = 60.37$ the false perpendicular.

Then 60.37 : : 518.43 : 32° : 274.8 the true perpendicular. The proof of the hypothenuse may be obtained from the 46th Proposition of Euclid, as follows : $\sqrt{(AB)^2 + (BC)^2} = AC$, or $\sqrt{(440)^2 + (274.8)^2} = AC$ the hypothenuse.

We will now prove the truth of the perpendicular from the tangent of the angle at A.

Natural tangent ∠ = 32° =	.624869
Multiplied by the base A B =	440
	24994760
	2499476
Perpendicular =	274.942360

The result, as obtained by the above process, is of course more accurate than that found by the arithmetical process, but the difference in the latter is so small that it may be relied on as a near approximation to the truth.

PROBLEM 2.

Given the hypothenuse and one of the acute angles of a right-angled triangle, to find the other sides and angle.

Example. — In the right-angled triangle A B C, Fig. 33, given A C=800 links, and the angle at A=20° 30′, to find the other parts.

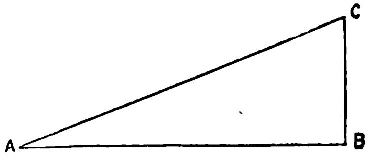


FIG. 33.

To find the adjacent ∠ C *in all cases.*

90°−20° 30′ ∠ at A=69° 30′ ∠ at C.

Natural sine of the ∠ at A=20° 30′ =	.3502074
Which multiplied by the line A C =	800
The perpendicular B C =	280.1659200

To find the Base A B.

Natural cosine of the ∠ A=20° 30′=	.9366722
Which multiply by the line A C =	800
Therefore the base A B =	749.3377600

PROBLEM 3.

Given the depth of a shaft sunk from a point in the out-croppings with the angle of depression, to find the length of a cross drift that shall again strike the underlie.

Example.—The depth of a shaft, A C, Fig. 34, = 80 yards, and the ∠ B A C = 40° 30′, to find the length B C.

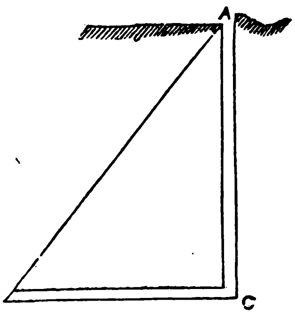


FIG. 34.

Natural tangent of ∠ B A C 40° 30′ =	.854080
Multiplied by the depth A C . . =	80
The cross drift B C=	68.326400

Problem 4.

It is required to find the depth of a mine shaft, B C, Fig. 35, that shall strike the underlie when its distance from the out-croppings and the ∠ of depression of the underlie are given.

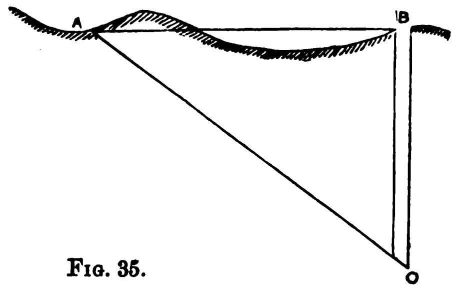


Fig. 35.

Example.—Given the distance A B=700 yards, and the depression of A C=32° 15′.

Natural tangent of the ∠ C A B 32° 15′=	.630953
Which multiplied by the distance A B =	700
Depth of shaft required=	441.667100

Or B C is about 441½ yards.

Problem 5.

The distance of a mine shaft from the out-cropping, with its depth and the depression of the underlie, are given, to find the length of a cross cut, to be driven from the bottom of the shaft so as to strike the underlie.

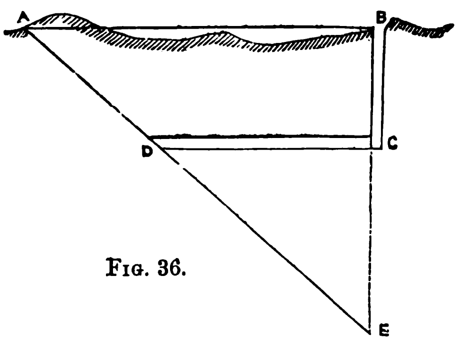


Fig. 36.

Example.—Given the distance A B, Fig. 36, 420 yards, and the depth B C 140 yards, with the angle of depression 41° 15′.

Natural tangent of the ∠ E A B=41° 15′	=	.876976
Which multiply by the distance A B .	=	420
		17539520
		3507904
Total distance from B to E	=	368.329920
From which deduct from B to C . . .	=	140
Therefore the distance of C E . . .	=	228.329920

To find the Angle at E.

90°− ∠ at A=41° 15′= ∠ at E=48° 15′. We have now the distance E C and the ∠ at E, to find the cross cut C D.

Natural tangent of the ∠ at E=48° 15′	=	1.120405
Which multiply by the distance C E	=	228
		8963240
		2240810
		2240810
Therefore the length of the cross cut C D	=	255.452340

Problem 6.

Given the distance of a shaft from the out-cropping and the angle of depression, to find the depth of the shaft at its intersection

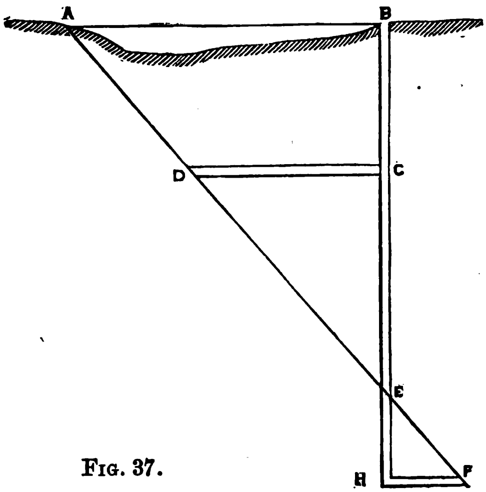


Fig. 37.

with the underlie, also the length of two cross cuts, one at a given distance above, and the other below the point of intersection.

Example.—Given the distance A B, Fig. 37, $=220$ yards, and the ∠ of depression $=46° \ 20'$, B C $=60$ yards, and E H 80 yards, to find B E, C D and H F.

To find B E.

Natural tangent of the ∠ at A $=46° \ 20'$	=	1.047659
Which multiply by the distance A B	=	220
		20953180
		2095318
Depth of the shaft at the intersection	=	230.484980
Deduct the depth from B to C . .	=	60
The distance from E to C . . .	=	170.484980

The angle at E $=90° - 46° \ 20' = 43° \ 40' =$ ∠ at E.

To find C D.

Natural tangent of the ∠ at E $=43° \ 40'$	=	.954508
Which multiplied by the distance E C	=	170
Therefore the cross cut C D	=	162.266360

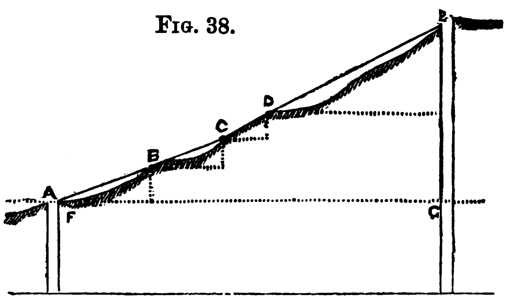
Then to find H F we have given the distance E H, and the ∠ at E.

The natural tangent of the ∠ at E $=43° \ 40'$	=	.954508
Which multiplied by the distance E H	=	80
Therefore the cross cut H F	=	76.360640

Problem 7.

It is required to find the difference of level of two mine

Fig. 38.



shafts, having given the measured hypothenuses and angles of elevation.

Example.—Given the angles of elevation taken with the transit from A, B, C, D and E, Fig. 38, =20° 20′, 15° 40′, 24° 0′, and 20°, and the hypothenuses A B, B C, C D, and D E, =to 200, 300, 340, and 600 yards, to find the difference of level and the total length of the base F G.

To find the Perpendiculars.

Multiply the sine of the angles by the hypothenuses.

∠ at A=20° 20′=	sine .3474812	× 200=	69.4962400
∠ at B=15 40 =	sine .2700403	× 300=	81.0120900
∠ at C=24 00 =	sine .4067366	× 340=	138.2904440
∠ at D=20 00 =	sine .342020	× 600=	205.2120000
		Total difference of level=	494.0007740

To find the Base F G.

Multiply the cosine of the angles by the hypothenuses.

∠ A =20° 20′=	cosine .9376869	× 200=	187.5373800
∠ B =15 40 =	cosine .9628490	× 300=	288.8547000
∠ C =24 00 =	cosine .9135455	× 340=	310.6054700
∠ D=20 00 =	cosine .9396926	× 600=	563.8155600
		The total length of base F G=	1350.8131100

These calculations have resolved the above diagram into one large triangle, whose perpendicular G E is equal 494.0 and the base F G=to 1350.8 yards.

PROBLEM 8.

It is required to find the depth of a mine shaft at the same level with another shaft whose depth and angles of elevation with the hypothenuses are given.

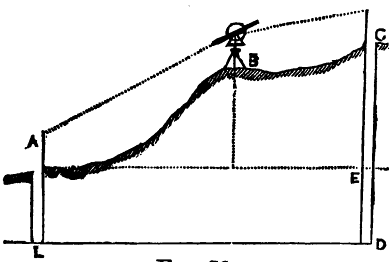


FIG. 39.

Example.—Given the depth of the shaft A L, Fig. 39, = 100 yards, and the observed vertical angles=to angle at A = 31° 21′ and ∠ at B 24° 10′, with the hypothenuses A B and B C = 920 and 840 yards, to find C D.

Multiply the sine of the ∠ of elevation by the hypothenuse for the perpendicular, and the cosine of the ∠ of elevation for the base.

∠ at A = 31° 21′ = sine .5202646 × 920 = 478.6434320
∠ at B = 24 15 = sine .4107189 × 840 = 345.0038760

Total difference of level C E . .	= 823.6473080
Depth of the shaft A L	+ 100
Total depth of shaft C D	= 923.6473080

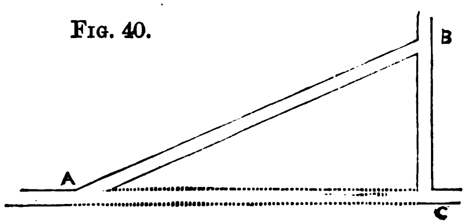
The base may be obtained from the cosines of the angles and measures of the hypothenuses as previously explained. The student should carefully construct these diagrams as explained in practical geometry from the data given in the example, then if the result as obtained from the construction approximates with the calculation it will be a satisfactory conclusion; otherwise it must be recalculated or constructed until they do agree.

Problem 9.

It is required to find the angle of direction and length of a heading to be driven from a fixed point below ground so as to strike at right angles to another fixed point, having given two measured distances.

Rule.—Divide the given side opposite the required angle by the hypothenuse, the quotient is the sine of the angle of direction.

Fig. 40.



Example.—Given two under-ground drifts A B and B C (Fig. 40) = 420 and 160 yards, to find ∠ of direction at A and the side A C.

420)1600000(.38095 = sine 22° 24′
1260
3400
3360
4000
3780
2200
2100

To find the ∠ at B
90° − 22° 24′ = ∠ at B =
67° 36′

The length of the side A C may now be found from Problem 2 from the cosine of the ∠ at A, or from Problem 3 from the tangent of the ∠ B.

To find the Side A C.

By Problem 2. Natural cosine of ∠ A 22° 24′ =	.9245460
Multiplied by A B =	420
	184909200
	36981840
The side A C =	388.3093200
By Problem 3. Natural tangent ∠ B 67° 36′ =	.2426181
Multiplied by the side B C =	160
	.145570860
	2426181
Therefore the side A C, nearly the same as before =	388.188960

Problem 10.

Given the depth of a shaft, with its distance from a fixed point on the surface, to find the length and angle of elevation of an incline to be driven from the bottom of the shaft so as to strike the fixed point at surface.

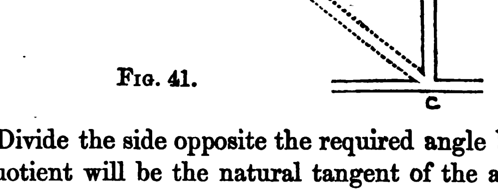


Fig. 41.

Rule.—Divide the side opposite the required angle by the other side; the quotient will be the natural tangent of the angle.

Example.—Given the depth of a shaft B C, Fig. 41, = 260, and the distance A B = 180 yards, to find the angle of elevation C A B and the length of the incline C A.

260)180.000000(.692307 = tangent 34° 42′
1560
2400
2340
600
520
800
780
2000
1820

To find the ∠ C A B 90° − ∠ at C 34° 42′ = ∠ at A 55° 18′.

To find the Hypothenuse A C.

Natural secant ∠ at A 55° 18′ =	1.7566063
Multiplied by A B =	180
	1405285040
	17566063
∴ The incline or side A C =	316.1891340

I have been induced to add the following examples calculated by logarithms, to suit the convenience of those who may have occasion to deal in large numbers; as in that case the multiplication in the preceding method becomes very laborious.

The general rule in logarithmic calculations* is to add together the two last terms, deducting therefrom the first term for the answer.

Problem 11.

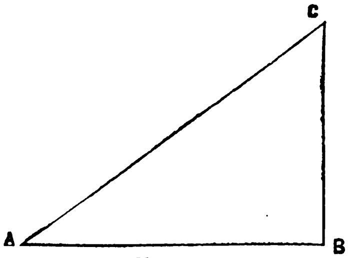


Fig. 42.

Given the hypothenuse and one of the oblique angles, to find the other parts.

Example.—Given the hypothenuse A C, Fig. 42, = 849 yards, and the ∠ A = 40° 16′, to find the other parts.

∠ at C = 90° − ∠ A = 40° 16′ = ∠ C = 49° 44′.

* It is desirable that the student should read the chapter on Logarithms before proceeding to calculate with them.

To find B C.

: Logarithm radius	=	−10.0000000
: : Logarithm sine of the ∠ A = 40° 16′	=	+9.8104650
: Logarithm of A C 849 . . .	=	+2.9289077
Logarithm B C 548.75	=	2.7393727

To find A B.

Logarithm radius	=	−10.0000000
Logarithm cosine of A = 40° 16′ .	=	+9.8825499
Logarithm of A C 849	=	+2.9283959
Logarithm of A B 647.06 . . .	=	2.8109458

PROBLEM 12.

Given the base of a right-angled triangle and one of the oblique angles, to find the other parts.

Example. — Given the base A B, Fig. 43, = 1620 chains, and the ∠ at A = 53° 7′, to find the other parts.

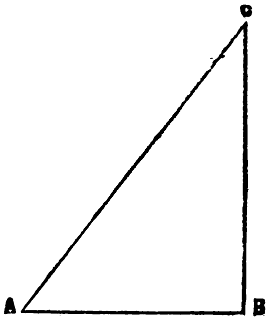


FIG. 43.

To find B C.

The logarithm radius	=	−10.0000000
Logarithm tangent ∠ A 53° 7′ .	=	+10.1247266
Logarithm A B 1620	=	+ 3.2095150
Logarithm B C = 2159.6 . . .	=	3.3342416

PROBLEM 13.

Given the base and perpendicular of a right-angled triangle, to find the other parts.

Example.—Given A B 5300 and B C 6700 yards, to find the other parts of the triangle.

To find the ∠ *at* A.

Logarithm of A B 5300	=−	3.7242759
Logarithm of B C 6700	=+	3.8260748
Logarithm radius	=+	10.0000000
		13.8260748
Deduct the first term		3.7242759
Logarithm tangent of ∠ A 51° 39′ 10″	=	10.1017989

To find A C.

Logarithm radius	=−	10.0000000
Logarithm secant of ∠ A 51° 39′ 10″	=+	10.2073837
Logarithm of A B 5300	=+	3.7242759
The side A C 8543.9	=	3.9316596

NATURE AND USE OF LOGARITHMS.

In the progress of the previous calculations no great difficulties have been encountered, but when some of the problems require a much greater number of figures to be employed, the computation becomes a work of much labour, and it is then of great importance to be enabled to perform trigonometrical calculations with greater facility; for which purpose a series of artificial or decimal numbers has been invented and tabulated for use, called *logarithms*.

We may define logarithms to be the numerical exponent of ratios, or a series of numbers in arithmetical progression answering to another series of numbers in geometrical progression.

Numbers said to be in arithmetical progression are those that continually increase or decrease by the constant addition or subtraction of the same numbers.

Thus, 1, 2, 3, 4, 5, 6, 7, 8, 9 are in arithmetical progression; and numbers in geometrical progression are those which are constantly multiplied by the same numbers. Thus, 1, 2, 4, 8, 16, 32, 64, 128, 256, &c., are in geometrical progression. If now we arrange the arithmetical series of progression (having previously prefixed a cypher to the commencement of the series) above the geometrical series, it will stand thus:

Indices or logarithms .	0,	1,	2,	3,	4,	5,	6,	7,	8,	&c.
Geometrical proportion	1,	2,	4,	8,	16,	32,	64,	128,	256,	&c.

Indices	0,	1,	2,	3,	4,	5,	&c.
Progression . .	1,	10,	100,	1000,	10,000,	100,000,	&c.

It will now be evident that the same indices serve equally for any geometrical series, and that there may be an endless variety of systems of logarithms to the same common number by only changing the second term, 2, 3, or 10, &c., of the geometrical series of whole numbers. It now plainly appears that if any two indices are added together, their sum will be the index of that number which is equivalent to the produce of the two terms in the geometrical progression to which the indices belong.

"Thus the indices 4+3=7, and the corresponding terms, 16 × 8, to those indices, produce 128, which correspond to 7. It will also appear that if any one index be subtracted from another, the difference will be the index of that number that is equal to the quotient of the two corresponding terms. Thus, the index 7 — the index 3=4, and the terms corresponding to these indices are 128 and 8, whose quotient is 16, the number corresponding to the index 4, and if the logarithm of any number be multiplied by the index of its power, the produce will be equal to the logarithm of that power. Thus the index or log. of 4 in the above series is =2, which multiply by 3=6, which is the logarithm 64 or the cube of 4.

"And if the logarithm of any number be divided by the index of its root, the quotient will be equal to the logarithm of that root; the index or logarithm of 64 (in the first series) is 6, if divided by 2=3, which is the logarithm of 8 or the square root of 64."*

The logarithms most convenient for use are such as are adapted to the geometrical series, increasing in a tenfold proportion, as in the last or preceding series, and are those which are generally found in common tables.

In which system of logarithms, the index or logarithm of 1 is 0, that of 10 is 1, of 100 is 2, of 1000 is 3, of 10,000 is 4, &c., whence it is evident that the logarithm of any intermediate number between 1 and 10 and 100 will be some fractional part, and so on for any number whatever.

And as we always know the value of the index of a logarithm by the number of integrals in the natural number, the index to the logarithms is not prefixed to the tables, but must be supplied by the calculator himself.

To explain the method of supplying the indices, the following numbers and logarithms are given. Thus:

Numbers.	Logarithms.
1806	3.2567177
180.6	2.2567177
18.06	1.2567177
1.806	0.2567177
.1806	$\bar{1}$.2567177
.01806	$\bar{2}$.2567177
.001806	$\bar{3}$.2567177

* Moore's *Nautical Astronomy*.

The index of the logarithm of a number is one less than the number of integral figures contained in the natural number. That is, if the number contains 4 integral figures, the index is 3; if it contains 3, the index is 2, and so on. Sometimes the number has no integral figures, then the index of its logarithm is negative, and is 1 more than the number of cyphers immediately after the decimal place. Thus in the table we find the number 1806, its logarithm = .2567177; then, because there are four places in the natural number 1806, I prefix the index 3 before the decimal part of the logarithm; it will then stand thus: 3.2567177, showing that the index is 1 less than the number of integrals in the said number. In like manner take the same number, first prefixing a decimal point before it, thus .1806 = its logarithm .2567177. Then, because there are no integrals in the number, but all decimals, the index will be one more than the number of cyphers prefixed to the number, consequently the index to the number .1806 will be negative or $\bar{1}$ with the logarithm following;—thus, number .1806, its log. = $\bar{1}.2567177$, and so on of others. Supposing the student has procured a set of tables, he should proceed to find the logarithm of any numbers, and to supply the indices. Find the logarithm of the number 1686, the decimal part of the logarithm as found in the tables is = .2268576, and as the number contains four integral places, we must annex the index 3 as a whole number. Then the logarithm will stand thus: 3.2268576. Find the logarithms of the following numbers:—

8464	4689.25
.3148	·000214

It is required to find the number to the following logarithm: 3.3181886. At first sight we know that the number must contain four places, and to find it run down the columns until the first part of the logarithm 318 is found, and to the left and opposite is the number 2080, and as the number is not complete, we look into the adjoining columns for the remainder of the logarithm, or 1886, which number will complete the logarithm, and will stand as above, 3.3181886. The number answering to the last part of the logarithm is .6, which annex to the number previously found; it will then stand thus, 2080.6, the number required.

To find the produce of any two numbers by the logarithms as follows:

Rule.—Add the logarithms of the given numbers together, and find the number corresponding to their sum, which number is the produce required.

Example 1.—What is the produce of 4864 multiplied by 26?

Logarithm of 4864	=3.6869936
„ „ 26	=1.4149733
„ „ the produce 12646.4	=5·1019669

Thus it appears that multiplication is performed by addition. The utility of logarithms is thus sufficiently obvious when large numbers have to be dealt with.

Example 2.—Find the continual produce of 384., .462, and 89.8.

Logarithm of 384	=2.5843312
„ „ .462	$=\bar{1}.6646420$
„ „ 89.8	=1.9532763
„ „ the produce, 15930.1234	=4.2022495

Division by Logarithms.

Rule.—Subtract the logarithm of the divisor from the logarithm of the dividend, the remainder is the logarithm of the quotient.

Example 1.—Divide 6854.3 by 422.

Logarithm of 6854.3	=4.8359631
„ „ 422	=2.6253125
„ „ the quotient 162.4141	=2.2106506

Example 2.—Divide .462 by .023.

Logarithm of .462	= $\bar{1}.6646420$
„ „ .023	= $\bar{2}.3617278$
„ „ the quotient 20.086	= +1.3029142

The Rule of Three direct by Logarithms.

Rule.—Add the second and third term together, and from that sum deduct the first term; the remainder is the logarithm of the fourth term.

Example.—Find a fourth proportional to the numbers 69, 800, and 164.

Logarithm of 800	=2.9030900
" " 164	=2.2148438
Sum of logarithms of 2nd and 3rd term	=5.1179338
Logarithm of 69, 1st term	=1.8388491
" " 4th term, 1901.44 . .	=3.2790847

The student will now be prepared to work out any problems in trigonometry by the logarithms, and with the assistance of the logarithm, sines, tangents, &c., which will all be found in Chambers' *Mathematical Tables*, a work at once so portable and cheap that all persons making these kind of calculations should be provided with a copy.

PRACTICAL PLANE TRIGONOMETRY: OBLIQUE-ANGLED.

In any oblique-angled triangle, when two angles and a side opposite to either of them are given, all the other parts can be found.

The sides of all oblique triangles are in proportion to the sines of the opposite angles.

Rule.—To find a side, begin with the angle opposite the given side; that is, the sine of the angle opposite the given side is to the sine of the angle opposite the required side as the given side is to the required side. And when two angles of any oblique triangle are given, the third may be found by subtracting their sums from two right angles.

Before proceeding to work out other trigonometrical quantities by the logarithms, I shall insert in this place a method of finding the sides of oblique triangles by Problem 1 of right-angled trigonometry.

Problem 14.

Given two angles and a side of an oblique-angled triangle, to find the other parts.

Example.—Given the angles D A B and A D B=40° 12′ and 10° 30′, to find the other parts. (Fig. 44.)

To find the Angles

A B S, S B D, and D B C. 90°− ∠ at A, 40° 12′=to 49° 48′ ∠ at B. And 90°− ∠ S D B, 10° 30′=79° 30′ ∠ at D B S. Also to find the ∠ D B C, 180°− ∠ A B S+ ∠ D B S=180°−49° 48′ −79° 30′=50° 42′ ∠ D B C.

To find the Side B S.

Rule.—Divide 48′, the fractional parts of a degree, in the angle A B S by 6=.8, enter down the degrees in the same angle as a whole number, with the decimal .8 appended thus: 49.8. Square this number, or 49.8, by 49.8=2480.04, add one-third of this number to itself=3306.72, also add to the first number, or 49.8, 100=149.8. Divide $\frac{3306.72}{149.8}$=22.07; to this quotient add the angle at A, 40° 12′=62° 20′, which call the hypothenuse.

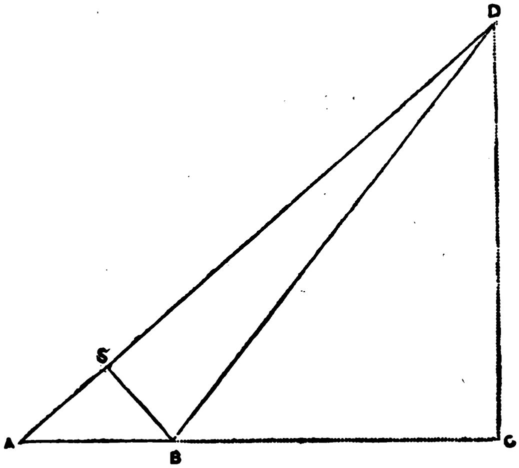


FIG. 44.

Then say, as 62.20, the false hypothenuse, is to the base A B 384, so is 40.2, the angle at A, to the side B S=248.18.

The operation is given in full as follows:—

49.8	
49.8	Then as 62.20 : 384 : : 40.2
3984	384
4482	768
1992	15360
⅓)2480.04	62.20)1543680(248.18=B S
826.68	12440
149.8)3306.72(22.07	29968
2996	24880
8107	50880
2996	49760
11120	11200
10486	6220
	49800
	49760

To find the Side B D.

Rule.—Divide 30′, the odd minutes in the angle at D, by 6=.5, enter down 10° in the angle at D as a whole number, with the decimal .5 appended as before=10.5. Square this number, or 10.5 × 10.5 = 110.25, multiply this number by 3 = 330.75, which divide by 1000, the quotient, = .3, to which add the constant number 57.3=57.6; then say, as the angle at D 10.5 is to the side B S, so is the number 57.6 to the side B D.

```
          10.5
          10.5
          ─────────
          110.25 × 3
1000)33075    (  .3
              57.3=the constant number.
              ────
              57.6
```

Then say, as 10.5 : 248.2 : : 57.6 : 1361.05=B D.

Problem 15.

Given two angles and a side of an oblique-angled triangle, to find the other parts.

Example.—In the triangle A B C, Fig. 45, there are given ∠ A 34° 20′ and ∠ B=40° 40′, with the side B C=800 links.

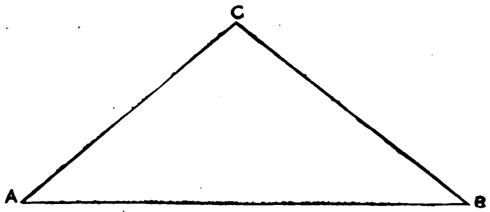


Fig. 45.

To find the Angle C.

180° − A + B = 180° − 34° 20′ + 40° 40′ = 180° − 75° = 105°.

To find the Side A C.

The logarithmic sine of A 34° 20′ .	=	− 9.7512842
The logarithm sine of B 40° 40′ . .	=	+ 9.8140192
The logarithm of B C 800 . . .	=	+ 2.9030900
The two last terms added	=	12.7171092
Deduct the first term	=	9.7512842
Fourth term=the side A C=924.32	=	2.9658250

To find the Side A B.

Logarithm sine ∠ A 34° 20′	=	−9.7512842
„ „ ∠ C 75°	=	+9.9849438
„ B C 800	=	+2.9030900
The two last terms added	=	12.8880338
The first term deducted	=	9.7512842
The fourth term or side A B=1370.	=	3.1367496

In any oblique-angled triangle, when two sides and an angle opposite either of them are given, to find the other parts.

Rule.—To find an angle, commence with the side opposite the given angle; that is, the side opposite the given angle is to the side opposite to the required angle as the sine of the given angle is to the sine of the required angle.

Problem 16.

Given two sides of an oblique-angled triangle and the containing angle, to find the other part.

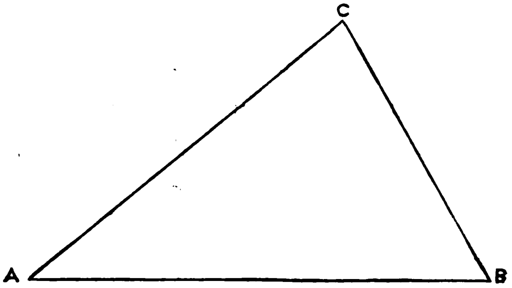


Fig. 46.

Example.—Given the side A C and B C, Fig. 46, 640 and 470 yards, with the containing angle A C B equal to 79° 40′.

To find the Angles A *and* B.

The side A C is greater than the side B C, and the angles opposite the former exceed the ∠ A opposite the latter. Also the ∠ A+B=180− ∠ at C.

$$=180°-79° 40'=100° 20' \text{ and } \tfrac{1}{2}(A+B)=50° 10'.$$

Logarithm A C+B C=640+470=1110 .	=	−3.0453230
,, of A C−B C=640−470=170	=	+2.2304489
,, tangent of $\frac{1}{2}$ (A+B)=50° 10′ .	=	+10.0787534
The two last terms added together . . .	=	12.3092023
Deduct the first term	=	3.0453230
Logarithm tangent of $\frac{1}{2}$ (B+A)=10° 24′	=	9.2638793
To which add the angle $\frac{1}{2}$ (B+A)=50 10		
Hence the angle at B . . . =60° 34′		

Then ∠ C + ∠ B = 79° 40′+60° 34′ = 140° 14′, and 180°−140° 14′=to 39° 46′, the angle at A.

To find the Side A B.

Logarithm sine of ∠ B 60° 34′ . .	=	−9.9399823
,, ,, ∠ C 79° 40′ . .	=	+9.9928984
,, of A C 640 yards . .	=	+2.8061800
The two last terms added together .	=	12.7990784
The first term deducted	=	9.9399823
The side A B =722.93	=	2.8590961

Problem 17.

Given the three sides of an oblique-angled triangle, to find the angles and the difference of the segments of the base.

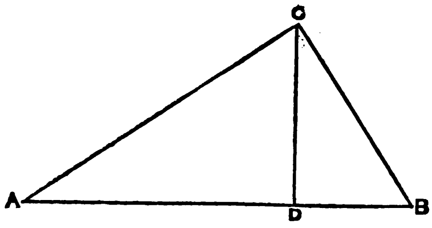


Fig. 47.

Rule.—Make the longest side the base, and let fall a perpendicular upon it from the opposite angle. Then, as the base or sum of the segments made by the perpendicular is to the sum of the other two sides, so is the difference of those sides to the difference of the segment of the base, and half the difference added to the half base will give the greater segment, or that nearest the greatest side, and subtract it from it, will give the less. Then in each of the right-angled triangles formed by the perpendiculars, two sides are known, consequently all the other parts can be found.

Example.—Given A C, B C, and A D, Fig. 47, 667, 446, and 800 yards.

To find the Difference of the Segments.

A D and D B segment of the base.

The logarithm of the base A B, 800 .	=	−2.9030900
The side A C=667+B C=446=1113	=	+3.0464952
„ A C=667−B C=446= 221	=	+2.3443923
The two last terms added	=	5.3908875
Deduct the first term.	=	2.9030900
Logarithm difference between segments of the base=307.46	=	2.4877975

Then the half base$=\frac{800}{2}=400=$half base, and 400+153.86, or half difference of the segment=to 553.86=to A D, and 400−153.73=246.14=to D B ∴ A D=553.86+246.14 D B=800.00 total base.

To find the Angle at C *in Triangle* A C B.

Logarithm of the side A C 667 . .	=	−2.8241258
„ „ A B=553.86	=	+2.7434000
„ radius ∠ D	=	10.0000000
The two last terms added . . .		12.7434000
The first term deducted		2.8241258
The logarithmic sine ∠ C 56° 9′ . .	=	9.9192742

90°− ∠ C 56° 9′= ∠ at A=33° 51′.

To find the Angle C *in the Triangle* D C B.

Logarithm of the side B C=446 .	=	−2.6493349
„ „ B D=246.14	=	+2.3911822
„ „ radius	=	10.0000000
The two last terms added . . .	=	12.3913315
The first term deducted	=	2.6493349
Logarithm sine of ∠ C=33° 29′ .	=	9.7418473

90° − ∠ C 33° 30′ = ∠ B 56° 31′.

To find the Angle A C B.

Add together the angle A C D + the ∠ D C B = 56° 6′ + 33° 30′ = 89° 36′, the angle required.

Problem 18.

To find the distance between two mine shafts on the opposite sides of a river from the observer.

Observation.—Measure the base line A B, Fig. 48, and set

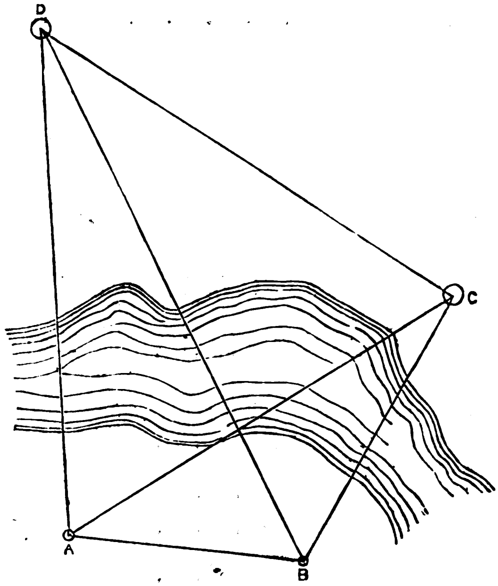


Fig. 48.

up the transit instrument at the stations A and B. Measure the angles (B A D), (C A D), (A B D) and (D B C), then the

∠ C = 180° − (A + B), and in the triangle B A D, the ∠ D 180° − (A + B).

Example.—Required the distance between the two pits D and C in the above figure from the following data: the angles A B C = 105° 20′; A B D, 60° 40′; B A D, 96° 49′; B A C, 45° 40′ 20″, and the base A B 2400 yards. In the triangle A B C ∠ C = 180° − (A + B) = 28° 59′ 40″, and in the triangle B A D, D = 180° − (A + B) = 22° 30′ 40″.

To find A C *in the Triangle* A B C.

Logarithm sine of ∠ C = 28° 59′ 40″	=	−9.6853452
„ of A B 2400	=	+3.3802112
„ sine of ∠ B = 74° 40′ .	=	+9.9842589
The two last terms added together .	=	13.3644701
The first term deducted	=	9.6853452
The side A C = 4777	=	3.6791249

To find A D *in the Triangle* A D B.

Logarithm sine ∠ D = 22° 30′ 40″ .	=	−9.5831445
„ of A B = 2400 . . .	=	+3.3802112
„ sine ∠ B = 60° 40′ . .	=	+9.9404091
The two last terms added . . .	=	13.3206203
The first term deducted	=	9.5831445
The side A D = 5463.56	=	3.7374758

To find the Angles D *and* C *in the Triangles* A D C *and* B C D.

(D + C) is = to 180 − A = 180° − 51° 9′ = 128° 51′.

Logarithm of A C + A D = 10292.05	=	−4.0124998
„ „ A C − A D = 738.04 .	=	+2.8680564
The tangent of ½ B + C = 64° 25′ 30″	=	10.3198802
		13.1879366
The first term deducted	=	4.0124998
„ „ ½ (D − C) = 8° 31′ 00″	=	9.1754368
And ½ (D + C) . . . 64 25 30		
Hence the ∠ D . . . = 72 56 30		

90° − ∠ D 72° 56′ 30″ = ∠ at C 17° 3′ 30″.

To find D C *in triangle* A D C.

Logarithm sine ∠ D = 72° 56′ 30″ .	=	−9.9804415
" " of ∠ A = 51° 9′ . .	=	+9.8914208
" of the side A D = 5515.14	=	+3.7415566
The two last terms added . . .	=	13.6329774
The first term deducted		9.9804415
Therefore the side D C = 4493 . .	=	3.6529359

∴ The distance between the two mine shafts is 4493, that required.

When the figure in Problem 13 is employed to find the height of an object, as D C, the same rule may be applied as that for the side D S, or B D. In this case the angle B C D must be the one to be squared, and the quotient thus becomes the first term in the proportion; the side B D is the second term, and the angle at D C B the third term. The fourth term will be the height of the object C D.

If in the figure Problem 13, it is required to find the distance A D, the angles B S A and B S D may be found by setting up an instrument at the station B, and observing the angles; then the angles at A and D will be the complement of those found by observation. The side B S must be found according to the rule given for that purpose.

The side A D may now be found either by the natural tangent or by logarithms, as follows:

Example.—In figure Problem 13, given the side S B, and the ∠ A B S and S B D = 49° 48′ and 79° 30′, to find the side A D.

The natural tangent of the ∠ A B S 49° 48′	=	1.183340
Multiplied by the side S B	=	248
		9466720
		4733360
		2366680
The side A S	=	293.468320

To find the Side S D.

Natural tangent ∠ S B D=79° 30′ .	=	5.395517
Multiplied by the side B S . . .	=	248
		43164136
		21582068
		10791034
The side S D	=	1338.088216
„ A S	=	293.468320
Therefore side A D.	=	1631.556536

To prove the preceding process by logarithms, as follows:

Logarithm radius	=	10.0000000
„ tangent 49° 48′ . . .	=	10.0731096
„ of the side S B 248 . .	=	2.3944517
The side A S=293.46	=	2.4675613

To find S D.

Logarithm radius.		=	10.0000000
„ tangent ∠ 79° 30′ . . .		=	10.7320331
The logarithm of the side S B=248 .		=	2.3944517
The side S D.	=1338.08	=	3.1264848
„ A S.	= 293.46		
„ A D.	=1631.54		

The preceding trigonometrical problems are the principal ones employed in general surveying in order to determine the height and distance of any distant objects, and for mining purposes they are sufficiently extensive. Cases may occur in practice requiring some modification; but, from what has been previously shown, it will be evident that in every triangle three parts must be known, and at least one side must be given in order to arrive at a conclusion, either by calculation or construction.

When it is required to find the height of an object, as from C D, or the distance A D, in Problem 13, the base A B should be taken more in proportion to the distance A D, so as to form well-conditioned triangles. The angle D in the triangle A B D is therefore an ill-conditioned one, arising from the non-proportion existing between the base A B and the distance A D. In all cases the angle at D in the triangle should never be less than about 25° if possible; the results as obtained will then be more to be depended on, being free from errors, which are liable when small angles are employed.

THE VERNIER SCALE AS APPLIED TO SURVEYING INSTRUMENTS.

"THE vernier is a most beautiful modern contrivance for measuring small parts of space contained between the equidistant divisions of a graduated scale.* Such a scale is made equal to a certain number of parts of the one to be subdivided depending on the degree of minuteness to which the subdivisions are intended to be carried, but it is divided into parts which in number are one more or one less than those on the primary scale taken for the length of the vernier in modern instruments; the parts on the vernier are generally one more than are contained in the same space on the primary scale. The spaces between the degrees on the limb of the miner's transit theodolite are divided into two parts; the short divisions represent, and are equal to 30′, and the divisions on the vernier are each equal to 1′; and on the six-inch transit theodolite the spaces between the degrees are divided into three parts representing 20′ each, and by the help of the vernier reads to 20″."

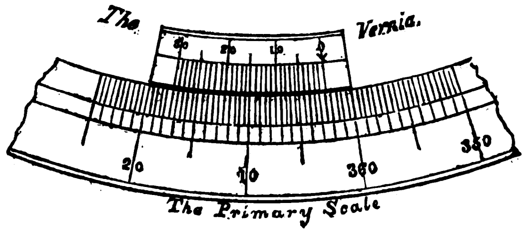
The subjoining diagrams are given to illustrate the method of reading off the limbs of the above-mentioned instruments.

Fig. 49 represents part of the limb of the miner's transit, but the divisions are made much larger than the reality for the sake of distinctness. The divisions on the limb are 30′ each; they are subdivided by the vernier to 1′, the reading is 2° 36′; and as a general rule, when reading this instrument, the observer takes an account of the degrees and parts of a degree passed over by the index of the vernier on the primary arc (or lower plate of the instrument), then for the fractional parts he must look along the vernier until he finds one of its divisions coincide with a division on the primary arc, then this part added to that previously read off will be the angle. Take figure 49 as an example; on examining

* Troughton and Simms on *Mathematical Instruments.*

the vernier I find its arrow has passed from the zero or 360 of the instrument to the left something more than $2\frac{1}{2}°$, and as the vernier arrow is in advance of the half degree, the reading $2° 30'$ is not the correct angle, but I find that the 6th division from the arrow towards the left coincides with a division on the primary arc, therefore it will be $6'$ to be added to the angle previously found; the reading will now be $2° 30' + 6' = 2° 36'$, the true angle pointed out. And if the vernier precedes, or does not come up to the half degree on the primary scale, the minutes must then be taken from the vernier altogether, without reference to the primary arc, except for the coincidence of one of its divisions, that is, the fractional part being under $30'$ cannot be read from the primary scale. If the student has an instrument of the above description before him, he will observe that in reading angles, when the vernier arrow has passed any number of whole degrees, its first division may be opposite a division on the lower

Fig. 49.

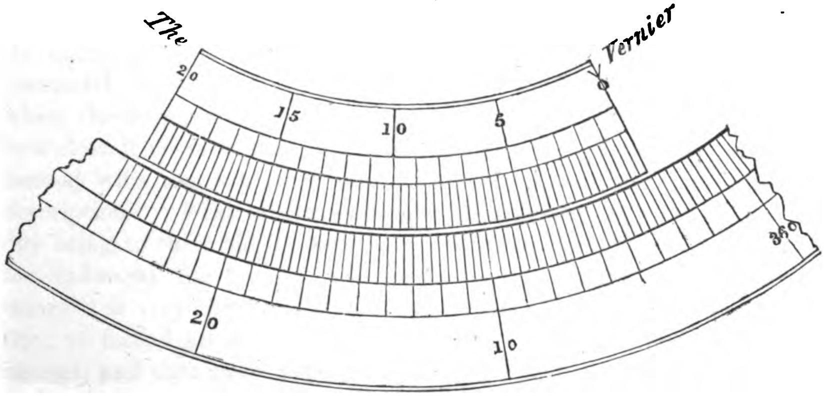


plate; in that case the additional part to be added would be $1'$; by turning the tangent screw the vernier may be made to pass successively from $1'$ to $29'$, which is its greatest reading under half a degree on the primary arc. If then it is made to move $1'$ more the reading will be confined to the lower limb of the transit or primary arc, and also in reading from the half degree to the left; the greatest reading of the vernier under a whole degree will also be $29' + 30'$, the half degree on the lower plate $= 59'$, and by moving it exactly $1'$ more we shall make up another whole degree, &c.

Figure 50 represents part of the limb of the six-inch transit theodolite, the divisions of which are drawn much larger than the reality for the purpose of rendering it more intelligible, and are each equal to $20'$, and are subdivided by the vernier into $20''$. A general rule for reading with the vernier may be expressed as follows:—First observe the number of parts on the primary scale (or lower plate of the transit) that is equal in length to the same number plus one on the vernier; this last number will be the denominator of a fraction, the numerator of which will be equal to unity, which expresses the subdivision of the parts on the lower plate of the transit.

Take the figure number 50 as an example. The lower plate is divided into 360°, each degree being subdivided by shorter lines into 20′, and for the length of the vernier a space equal in length to 59 of these subdivisions is taken and divided in 60 parts; therefore each of these parts on the vernier is smaller than those on the lower plate by $\frac{1}{60}$ of 20′, or equal to 20″. In reading the same rule applies as that for the other instrument spoken of before, only in this instrument there are three quantities instead

Fig. 50.



The Primary Arc or Circle.

of two, viz., degrees, minutes, and seconds; the degrees and parts of a degree are first read off from the primary circle, or lower plate of the theodolite, and the remaining minutes and seconds (if any) from the vernier. Taking the above figure as an example, I find the vernier arrow has passed from the zero on the lower plate to 3°, and something more, which cannot be estimated on the primary circle. By running the eye along the vernier scale towards the left, I find that there are two minutes and something more to be added to that previously read off for the true angle, and as we said before that every short line between the large ones is twenty seconds each, the second subdivision coincides with a division on the primary circle; the quantity therefore to be added is 2′ 40′ + 3° 0′ = 3° 2′ 40″, the angle pointed out by the vernier. The student will experience a little more difficulty in reading with this kind of vernier than he would with the one previously explained, but after a little examination and practice, it may be as easily read as the one for single minutes. If the student should be lucky enough to have an instrument of the above description before him, he will do well to make the vernier pass through a whole degree, noting at the same time the different readings; thus the first division on the vernier coincides with one on the primary arc, then the angle will be 20″; the third also coincides, the angle will be equal to 1′; the 14th division coincides, the angle will be equal to 4′ 20″; the 31st coincides, the angle is equal 10′ 20″; the 59th coincides equal to 19′ 59″, the 60th coincides equal 20′. The vernier will now have passed through one of the divisions on the primary arc, and so on through a whole degree.

SUBTERRANEOUS OR MINING SURVEYING.

SECTION I.

Underground surveying has often been considered of less importance than that of the surface, where, from the circumstance of its affording greater facility than is offered underground, it is presumed that no approach to accuracy can be obtained except when the best instruments are applied; and if this is established, how does it come to pass that underground surveys may be performed with less attention and with instruments of an inferior description? Most of our eminent civil engineers of the present day bring to their aid (in setting out working tunnels and shafts for railways) the transit instrument of best construction. In mines it is very rare to find employed even the ordinary theodolite; in fact, I know of but few instances where it is used in this district, and then only occasionally. I have been at much trouble and expense in having produced an instrument that shall be alike suitable for surface and underground surveys, and have no hesitation in recommending it as the best yet produced for the latter purpose, for which it was principally constructed.

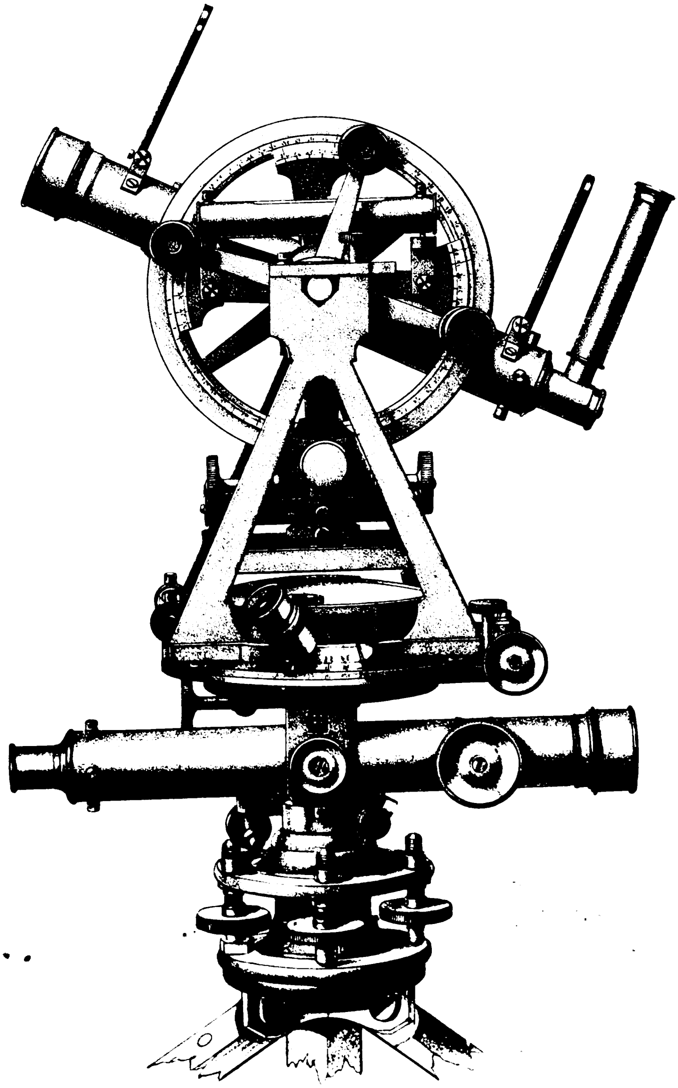
DESCRIPTION OF THE NEW MINER'S TRANSIT THEODOLITE.

The miner's transit theodolite, as an angular instrument, may be considered as the most important one applicable to underground surveys. The above description of instrument is only made by Messrs. John Archbutt and Sons, mathematical instrument makers, 20, Bridge-road, London, to whom I had given directions as to its construction. The instrument differs from an ordinary transit theodolite in the arrangement of the upper plate, which is made to project over the lower plate in the places where the upright supports are attached to it, in order to allow of greater space on the plate than is usual, to receive a large compass. When the limb of the instrument is made five inches in diameter, it will carry a 4½-inch compass, differing half an inch only from the size of its own limb; whereas in the ordinarily constructed theodolite the same sized limb admits of a compass 2½ inches only, which is quite useless except for ornament. Another advantage in the new over the old construction is, that the compass of the former is quite free and open, and can be read quite round the circle, but in the latter it is so darkened up with the appendages of the upper plate, as to render it impossible to be read at all. Another and more valuable addition to the transit is the application of a particular diagonal eye-piece, which when screwed into the telescope will allow it to be pointed directly vertical or in the zenith, and can then in that position be as easily read as when horizontal.

This superiority over all other instruments hitherto applied to mining purposes will be appreciated by those who find it a frequent and necessary operation to connect underground with surface surveys, which can be easily performed by this instrument without the assistance of the compass. The instrument will also be found superior in traversing, as its construction allows the telescope to revolve, and consequently back and fore observations may be taken in the same manner as by the common dial, the readings in all cases to be taken from the limb. When it is required to take a bearing with this instrument per compass, the vernier arrow should be first brought to zero of the lower limb, and the whole body turned round until the needle points to its own zero; then after releasing the upper plate, and bisecting the object with the cross hairs of the telescope, the bearing will be obtained to thirty seconds, from the theodolite limb instead of from the compass. I shall now explain the use and adjustment of the different parts, with a sketch of the instrument.

This instrument, as represented on the subjoining page, is a mechanical contrivance of a number of parts, the most important consisting in two horizontal circular plates, A and B, called the lower and upper *limb*. The upper or vernier plate, A, is made to move upon the lower, both having a free horizontal motion communicated to them by the vertical axis C. This axis is made in two parts, external and internal; the former is made fast to the graduated circle B, and the latter to the vernier circle A. They are

HOSKOLD'S
MINERS TRANSIT THEODOLITE.
WITH SUPPLEMENTARY TELESCOPE & PLAIN SIGHTS



MANUFACTURED ONLY BY JOHN ARCHBUTT & SONS, 20, WESTMINSTER BRIDGE ROAD, LAMBETH, S.

Publishers Atchley & C° 106, Great Russell S^t Bedford Square, London.

Francis & Goddard Lith. 51 Grays Inn Road W.C.

made conical in form, and are nicely fitted and ground into each other, which gives an easy and steady motion; the external centre also fits into a ball at H, and the parts are held together by means of a screw at the bottom of the internal axis.

The edge of the diameter of the lower plate is chamfered off and covered with silver to receive the graduations; the upper plate is made to project over the lower one, where the upright supports are attached (and also projects downwards like a conical concentric ring to protect the graduations on lower plate,) to it as at I. This arrangement gives a greater space between the telescope uprights, to admit a larger compass than is usual. On opposite sides of this plate, or 180° apart, a short space is also chamfered and covered with silver, which forms the vernier. The lower limb is graduated to 30′ of a degree, and subdivided to minutes and seconds, as explained when speaking of the vernier.

There is also a second or supplementary telescope attached to the main centre of the theodolite and under the lower plate, and has a free horizontal motion quite round the centre; it has also a vertical motion given to it of about 20° of elevation or depression. The principal use of this second telescope being to determine whether the lower plate has in the least moved from the place it was set when the first observation was made; and we may at all times find out if any displacement has taken place, while measuring any number of angles with the upper work and telescope.

The plan of using the second telescope is, after the theodolite is set up and levelled, and the upper telescope set on the back station—to point it to either the back station or other object, and clamp it fast; then measure the required angle with the upper telescope; now, by looking through the lower telescope, we can see if any deviation has taken place, to affect the angles as observed from the upper plate.

The parallel plates D E are held together by a ball and socket joint at H, and are set parallel to each other by four conjugate or milled-headed screws, of which three only are seen in the diagram as *a a′ a″*; they turn in sockets bored and bossed into the upper parallel plate; their heads press against the upper side of the lower plate; they are set in pairs opposite each other, and of course act in contrary directions, and by this means the instrument is brought level for use.

Underneath the parallel plates there is a screw called the female screw, joined to the staff head, and connected by brass joints to three legs forming the tripod stand of the instrument.

There is a clamp fixed at *o*, round the exterior axis C, and by tightening its screw S, the lower horizontal plate can be fixed in any position, and the bisection of any object with the cross hairs of the telescope is made by turning the tangent screw G. In the same manner the upper plate can be fixed to the lower in any position by its clamp and tangent screws *b* and *c*.

Upon the ends of the projections of the vernier plates outside the upright supports a spirit level *d* is fixed, and at right angles to it and screwed to the back upright is another spirit level, as at *e*, with their proper adjusting screws; their use is to bring the instrument to a level position.

There is also a large 4½-inch compass fixed on top of the upper plate at K, and being open and free from adjacent appendages can be read quite round the circle.

The upright supports L L carry the pivots of the horizontal transit axis of the vertical circle P.* The telescope Q is screwed into the axis, and forms one piece, which revolves vertically altogether with the vertical circle. The vertical circle has three verniers at *h h′ h″*, reading in opposite directions, connected by a brass bar *g*, and made to move on the transit axis as a centre. To this bar is fixed a spirit level, *m*, to bring the vernier to a level position; there are two screws not seen in the diagram, for bringing the axis bubble or level to a level position, and consequently the verniers also; the circle has also its clamp and tangent screw, as shown at *o* and *p*. The vertical circle is inlaid with silver, and divided down to 30″ by the help of its verniers, which are read through the microscopes at 10, 10′. The other side shows the difference between the hypothenuse and base of a right-angled triangle up to about 50° or 60°. There are placed in the focus of the eye-glass two lines, one horizontal and the other perpendicular, by which the distant object is nicely bisected; the screws adjusting the diaphragm or wire plate are shown at *i i′ i″*. There is also a focus screw for pushing out the object glass of the telescope, to show an object distinctly. There are also four eye-pieces, an astronomical inverted and also an erect eye-piece, for long distances; there is also a diagonal, and an extra one to be screwed into the diagonal one at D, or set for

* The theodolite is now made with two telescopes, the supplementary one being placed under the lower plate, and has a free motion round the main centre, its principal arc being a check on all angles measured with the instrument.

sighting directly vertical, or from the bottom to the top of a shaft. There are also fixed to the top of the telescope at 20′ 20″ a pair of plain hinged jointed sights, similar to those on the common dial; their use is to enable persons to take short sights where the telescope would not command. The whole are packed in a mahogany case quite free from injury.

ADJUSTMENTS OF THE MINER'S TRANSIT THEODOLITE.

Draw out the tube of the eye-piece until the cross hairs appear well defined, and to be free from the effects of parallax* that may arise from optical displacement of the cross hairs when the eye is placed in a lateral position. If when the telescope of the instrument is pointed to any distant object its image remains fixed when the eye is moved to the right or left, or in a lateral position out of the optical axis of the telescope, no parallax exists; on the contrary, if the image of the distant object does not remain steady, the tube must be drawn out, more or less, until the required steadiness of the image take place.

To adjust the Line of Collimation.

Set up the theodolite at B, Fig. 51, as a station, and after carefully levelling the instrument, set the index of the upper plate to zero on the lower limb; direct the telescope to a distant object A; fix the cross hairs on the object with the body tangent; now release the clamp of the upper plate, and bisect the object C with the tangent of that plate; read off the angle, say 60° 32′ 20″, leaving the upper part of the instrument clamped at the last reading; revolve the telescope vertically in the direction of D; turn the whole body of the instrument round in the direction of C; clamp and bisect the object C with the body tangent; release the upper plate, and turn it round in the direction of A; and again clamp and bisect with the upper tangent. If

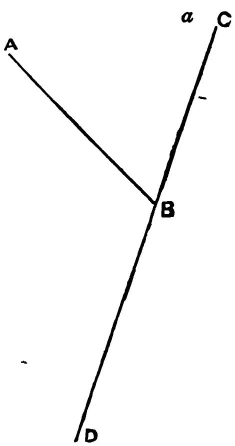


FIG. 51.

* Parallax is a term in general use to denote the difference between the true and apparent place of any objects.

the index of the vernier points exactly to zero on the lower plate the line of collimation is correct, but if it does not, half the difference is the amount of error in arc.

The line of collimation may also be adjusted as follows: place the instrument at B, last figure, and level it; clamp all fast; direct the cross hairs by means of the body tangent-screw, to an object D; revolve the telescope vertically with great care, so as not to disturb the instrument in position; fix the cross hairs on the object C, then release the lower clamp, and turn the body of the instrument quite round; clamp it again, and make the cross hairs bisect D; then again revolve the telescope vertically, and if the cross hairs strike C as before, it is in adjustment, but if not, fix another object, *a*, in the place where it does strike; now, by altering the screw placed in the wire-plate, the cross hairs must be made to strike half way between C and *a*; a few more trials will generally be needed before the adjustment is perfect.

Another method is sometimes employed to perfect this adjustment. The instrument is set up as usual at B, and the telescope directed to C, the cross hairs of which are made to bisect the object nicely. The telescope, circle, axis, &c., must now be carefully lifted out of its bearings, or Y, Y, and replaced with the axis reversed; revolve vertically, and point the telescope again to the object C; and if it be still bisected, the adjustment for the line of collimation is correct. If, on the contrary, it is not bisected, move the wire one-half the error by turning the screws, holding the wire-plate (near the eye end of the telescope), and the other half by the body tangent-screw, which will complete the adjustment if half the difference has been correctly estimated. If, after a second trial, it is not exactly in adjustment, the same operation must be gone through again until it is quite perfect. Or the adjustment may be performed as follows: measure some horizontal angle, say, 128° 39′ 20″, revolve the telescope vertically, let go the lower screws, and measure the same angle again in this reversed position; then if the angle is the same, the adjustment is correct; but if one angle is larger than the other, take a mean, thus: $\frac{128^\circ\ 39'\ 20'' + 127^\circ\ 42'\ 40''}{2} = 128^\circ\ 11'\ 30''$. The vernier should now be set to this angle without moving the instrument the least in position, and the vertical hair moved by giving motion to the diaphragm screws until it cuts through the object. Then if the angle is measured in reversed position it will be the same, and consequently, the line of collimation correct.

To adjust the Azimuthal Axis.

Bring the bubble of the axis level to the centre of its run by the screw attached to the arm; then release the upper plate, and revolve it half round; then if the bubble remain in the centre it is correct in this direction; but if otherwise, half the difference must be corrected by the parallel plate-screws, over which the telescope lies, and half by elevating or depressing the axis level by the milled head adjusting screw attached to the bar carrying the verniers and level; after having done which, turn the upper plate backward 90°, and the telescope will be over the other pair of parallel screws, and by their motion set it horizontal, after having levelled the instrument with the axis level. The other bubbles fixed on the vernier plate and frame, may be brought to their runs by giving motion to the screws which fasten them in their places.

To adjust the Vertical Circle.

After the preceding operation has been gone through, level the bubble to vertical circle with the conjugate screws, and point the telescope to some well-defined distant object—the more distant the better—and make the horizontal wire cut the object; read off the vertical circle, say, vernier A $=24° 26'$, and vernier B $=24° 27'$, and $\frac{24° 26' + 24° 27'}{2} = 24° 26' 30''$ mean angle. Reverse the instrument: attend to the axis level; revolve the telescope vertically, and again point the telescope to the same distant object; read off the angle from vertical circle as before, say, vernier A $=28° 40'$, and B $=28° 41'$; then $\frac{28° 40' + 28° 41'}{2} = 26° 32' 30''$.

Then $\frac{24° 26' 30'' + 26° 32' 30''}{2} = 25° 29' 30''$. Set the verniers to this mean angle, taking care all through the operation that the axis bubble is perfect, and move the vertical screws in the wire plate until the horizontal wire cuts nicely through the distant object employed for the purpose; then if the operation has been accurately gone through, the vertical angle will be found to be the same in both positions. Sometimes, however, a few trials will be required to perfect this important adjustment, for if it is neglected for a long time, any angles taken with the circle cannot possibly give accurate results.

TO MEASURE HORIZONTAL ANGLES WITH THE MINER'S TRANSIT THEODOLITE.

The adjustments, as previously explained, having been carefully tested and rectified, the instrument is set over a peg driven into the ground, to form the station, from whence the angles are to be taken by means of a plummet suspended to a hook screwed into the lower side of the table plate of the staff head. The instrument is then set level by the parallel plate screws by bringing the telescope and vertical circle clamped to zero over each pair in succession.

There are several methods of measuring angles with this instrument; the first of which is to clamp the upper plate at zero and the telescope with the body tangent-screw, to the left-hand station; release the upper plate, and turn it round in the direction of the right-hand station; clamp and bisect with the slow-motion screw attached to the upper plate: the vernier will now point out the angle in degrees and minutes; the minutes and seconds, if any, should also be read from the opposite vernier, the average of the two to be used as the mean correct angle. A second method of observing angles is to clamp the lower horizontal plate in any position; direct the telescope to one of the stations; clamp the upper plate, and turn the tangent screw attached until the bisection of the hairs and object takes place; read off the two verniers which are marked A and B, entering down the degrees, minutes, and seconds from vernier A, and the minutes and seconds from vernier B, taking the mean of the two readings respectively.

Then release the upper plate, and turn it round until the telescope is pointed to the second station: clamp the upper plate, and make the bisection with its tangent screw as before; again read off the verniers, taking their mean; the difference between this and first mean reading will be the angle required:—

	Vernier A.	Vernier B.	Mean angle.
The first reading	=164° 42′ 40″	. 43′ 0″ .	164° 42′ 50″
The second reading	=246 32 20	. 32 40 .	246 32 30
Correct angle=diff.			81 49 40

The reason of reading off the two verniers placed opposite to each other is to counteract any error that may arise from inaccurate centering and graduating the plates, which is found in practice to be almost an impossibility.

Another, and more perfect method of observing angles (when great accuracy is required), is to set up the instrument, and measure the angles as in the first method, noting down the reading; then release the body clamp screw, and turn the whole instrument round in the direction of the first station, leaving the upper plate clamped at the last reading; make the bisection with the body tangent, and release the upper plate; turn it round in the direction of the second station; make the bisection with the upper tangent, and read off as before, entering down the reading each time; repeat the operation as often as thought necessary, always remembering to set the last reading on the first station; then either of the readings divided by the number of repetitions that produce it will be the correct angle free from eccentricity, &c.:—

Second reading	=143°	39′	0″	÷2	=71°	49′	30″
Third ,,	=215	28	20	÷3	=71	49	27
Fourth ,,	=287	18	0	÷4	=71	49	30
Fifth ,,	=359	7	30	÷5	=71	49	30

The above example shows that either of the readings would be sufficiently accurate, and is only given to explain the method; others, more simple, would be found convenient in practice.

Another method, somewhat similar to the above, is in general use amongst the best surveyors. The instrument is set up at the commencement of the traverse, and the first angle measured by setting the zero on the back, or first station; and at every successive station the proceeding forward readings are set on the back station; the reading of the horizontal limb for the forward angles shows the direction of each station with reference to the first line on which the telescope of the instrument was set, and in that case becomes the first meridian; the traverse may therefore be calculated by trigonometry, the registered angle and measured distance become one of the angles and sides of a right-angled triangle.

The last method I shall mention is that which, from its simplicity, should be employed in mining operations: it can only, however, be practised with an instrument carrying a revolving telescope, and is quite new as far as I know: clamp the upper plate to the lower, and bring the vernier arrow to zero; release the body of the transit, and turn it round; bisect the back station with the teleseope wires by the body tangent screw; then revolve the telescope vertically, and release the upper plate; turn it round until the telescope is in the direction of the forward station; clamp and bisect with the upper clamp and tangent screw; then if the forward line inclines to the right of the back line, the vernier will have moved forward in the direction of the graduations, but if to the left, it will have moved backwards, or in a contrary direction to the graduations.

In the former case the angles, as read off, become minus (or to be deducted), and in the latter plus (or to be added). When the successive angles are reduced to plotting angles from one station, the angles in the former case require no change previous to their being employed in the reduction; but in the latter the augles, as read off, must in all cases be deducted from 360°; the difference is that to be employed in the reduction.

TO MEASURE VERTICAL ANGLES.

Vertical angles are those that are measured in a vertical plane, taken from an imaginary line passing through the transit axis carrying the telescope and circle, and parallel to the sensible horizon, and are said to be positive or negative as they are above or below this line. Bring the bubble of the spirit level attached to the verniers of the vertical circle to the centre of its run, by giving motion to the milled-head screws working in the vernier arm bar; or if the levels on the instrument are all parallel (which they should be) they may be all levelled at the same time by the parallel plate screws; then direct the telescope to the object whose altitude or depression is required, making the bisection with the tangent screw to vertical circle, the angle may then be obtained from either of the verniers.

TRAVERSING UNDERGROUND.

The term traverse is used and applied to underground surveys to denote a continuous line in a zigzag direction; and it is the business of the surveyor to determine the amount of inclination of the lines composing the traverse with reference to one another, and also to the first line, continued as a common meridian to the whole; and if he intends carrying out his surveys with all possible accuracy he must tutor his assistants to their work to do this. He should instruct them to measure a surface line (whose exact length he knows) backwards and forwards as many times as he should think necessary, or until they bring the measure three or four times the same; and also enforce upon them the necessity of the greatest attention to the accurate measurement of the lines composing a survey; or if he is not sufficiently confident in the ability of his chainmen, he may proceed to go through all the operations himself separately.

TO PEG OUT THE LINES, ETC.

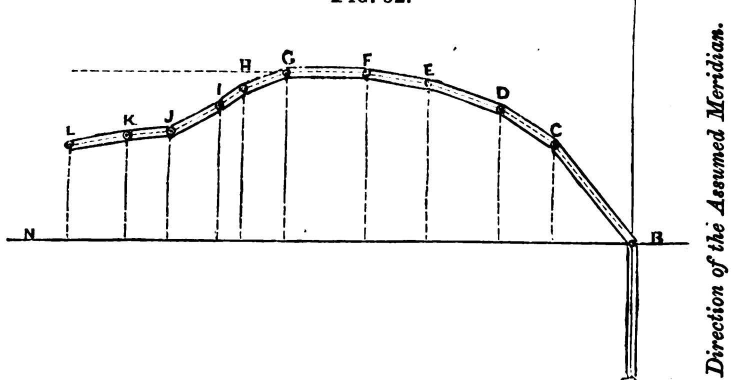
Suspend a fine copper wire or chain, with a plumb-bob attached, down the centre of the shaft A, Fig. 52, or, in absence of these, make a countersink hole in the cast-iron stricker-plate in the centre of the shaft; then place a lamp directly over this, and advancing along the line to the next turn in the road, drive into the ground an iron peg as at B, the first station; proceed along the line, and at every bend drive an iron peg to mark the successive stations; it will also be a good precaution to mark the sides of the rock with white paint, to point out the stations more readily. The surveyor may now return to the commencement, and after setting the instrument exactly over the centre of the station B, level it, and clamp the upper plate to zero of the lower plate, and release the body clamp; turn the whole instrument round in the direction of the lamp A, in the centre of the shaft, and bisect it, with the cross hairs of the upper telescope, by the body tangent; release the upper plate, and turn it round till the telescope bears on the second or forward station C (or the flame of the lamp placed over the iron peg previously driven); clamp and make the bisection as before with the upper tangent screw; read off the angle, say, 140° 20′. If now the same operation is gone through of bringing the plates to zero, and sighting to the forward station C as a back station, and also on A as a forward station, the second reading plus the first should be exactly 360°, say the second reading, 219° 40′+140° 20′=360°.* The instrument may now be removed to the second station C, and again set up and levelled, thus bringing the plates again to zero, and on the lamp brought forward to the first station B; the upper plate is then released, and directed to the lamp placed over the third station D; the bisection is now made, and the angle read off as before. The instrument is then taken forward to the fourth station E, and the same operation gone through, the theodolite and lamps changing places alternately from station to station, until the whole is completed.

The surveyor may then return and proceed to measure the distances between the stations; the lamps are again to be placed on the forward stations in turns, and the surveyor, taking the hind part of the chain, directing the forechain man in line, and towards the forward station, entering down from time to time the measure of the different lengths (as also any particulars or remarks he may find necessary) until the whole are measured. He must be prepared with a survey-book ruled into as many columns as will be required, and headed—1st, No. of drafts or hypothenuses; 2nd, angles of inclination; 3rd, measured distance in links; 4th, horizontal angles; 5th, remarks, &c. The surveyor being now provided with proper tutored assistants, and a book of the form stated above, he will commence a survey of the heading A B C D E, &c., to L. From a chain suspended down the shaft at A set up the theodolite at B, and after levelling and clamping the plates at zero, bisect the chain with the cross hairs of the telescope; release the upper plate, and direct the telescope to the forward station C, entering down 0 or zero in the column headed horizontal angles, and the length of the line A B in its proper column opposite it; now read off the angle pointed out on the instrument, and enter it down in the column appointed for the horizontal angles. His assistants will then measure the line B C, which he will enter down in its own column, also any remarks

* If the surveyor is certain of his first reading, and has brought the second or lower telescope into use as a check, there may be no occasion to measure the supplementary angle.

that may occur at the time; remove the instrument to the station C, level, clamp at zero, and bisect the back station B; again release the upper plate, and point the wires to the station D, read the angle off the limb, and enter it down in its column, while the chainmen are measuring the line C D; they will now

FIG. 52.



Plotted from the Plane of Latitude.

call out the measurement, which must be entered down as before. It is to be remembered that, after reading off the horizontal angles, the vertical ones are also to be read off, if any, from the vertical circle, and entered down as elevation or depression accordingly. Proceeding as above, we arrive at the conclusion of the survey, which will stand in the survey-book as follows:—

SURVEY BOOK, No. 1.

No. of Hypothenuses.	Angles of Inclination.		Measured Distance in Links.	Horizontal Angles.	Remarks.
	Elevation.	Depression.			
1	0° 0′	0° 0′	400	00 zero	Opposite No. 1, cross cut.
2	......	......	700	140° 20′	
3	......	......	300	160 10	
4	......	......	400	170 40	
5	......	......	350	166 30	
6	......	......	420	172 20	Opposite to a fault, going up.
7	......	......	250	156 20	
8	......	......	150	164 40	
9	......	......	300	192 20	Opposite No. 2, cross cut.
10	......	......	220	196 40	
11	......	......	300	184 20	

If it is required to draw a plan of the traverse from the preceding survey-book, it may be accomplished with the assistance of a circular protractor and chain-scale, the former to be divided into minutes, as on the theodolite. The horizontal angles are, however, to be reduced to angles from the first line, as a meridian to the whole, previous to their being plotted.

TO REDUCE HORIZONTAL ANGLES TO PLOTTING ANGLES FROM ONE STATION.

Rule 1st. If the first line in any survey is assumed as a meridian, and going southward, and the first observed angle from it is less than 180°, it inclines to the east, but if more than 180° to the west of the first line; in the former the angle as observed is to be called No. 1, and in the latter, the difference between it and 180° is to be called No. 1 plotting angle; but if the first line, assumed as a meridian, is going northward, and the observed angles are less than 180°, it inclines to the west, and if more to the east of the first line, the angle in the former, and its difference from 180° in the latter, to be called No. 1 plotting angle.

Rule 2nd. To No. 1 plotting angle add the next observed horizontal angle; if the sum exceeds 180°, take that amount from it, the remainder will be No. 2 plotting angle; to No. 2 add the next horizontal angle, and proceed as before for the plotting angles. Sometimes, however, the sum will exceed 360°, and in that case a whole circle, or 360°, must be deducted from it for the plotting angle, taking the horizontal angles in survey-book No. 1 as an example. The first angle is 140° 20′, and to the eastward of the first meridian; and the reduction to angles from one station are explained as follows:—

140° 20′ 0″	= No. 1 Plotting Angle.	97° 40′ 0″	= No. 4 Plotting Angle.
160 10 0		172 20 0	
300 30 0		270 0 0	
180 0 0		180 0 0	
120 30 0	= No. 2 ,, ,,	90 0 0	= No. 5 ,, ,,
170 40 0		156 20 0	
291 10 0		246 20 0	
180 0 0		180 0 0	
111 10 0	= No. 3 ,, ,,	66 20 0	= No. 6 ,, ,,
166 30 0		164 40 0	
277 40 0		231 0 0	
180 0 0		180 0 0	
97 40 0	= No. 4 ,, ,,	51 0 0	= No. 7 ,,

51° 0′ 0″ = No. 7 Plotting Angle.		80° 0′ 0″ = No. 9 Plotting Angle.	
192 20 0		184 20 0	
243 20 0		264 20 0	
180 0 0		180 0 0	
63 20 0	= No. 8 „ „	84 20 0	= No. 10 „ „
196 40 0			
260 0 0			
180 0 0			
80 0 0	= No. 9 „ „		

The reduced angles should now be collected (from amongst the preceding work) into a tabular form ready to be plotted on the drawings, as below—

Plotting Angles.					Plotting Angles.				
No. 1	=	140°	20′	0″	No. 6	=	66°	20′	0″
„ 2	=	120	30	0	„ 7	=	51	0	0
„ 3	=	111	10	0	„ 8	=	63	20	0
„ 4	=	97	40	0	„ 9	=	80	0	0
„ 5	=	90	0	0	„ 10	=	84	20	0

TO CONSTRUCT THE PLAN.

Draw a line through any convenient part of the paper intended to receive the plan, and make a fine pencil mark on it; apply the centre of the protractor to this mark and the notches marking the zero and 180° on the instrument on the same line, (to prove if the protractor has been properly set, bring the vernier to zero, and unfold the arms of the protractor, carrying small fine needle points at each end; if these points strike exactly in the line it is properly set); the angles No, 1, 2, 3, 4, &c., to 10, may now be marked off, taking care to number them in the drawing in succession as they were taken from the table; remove the protractor, and apply a chain scale; mark off 400 links on the back, or zero line, A B, Fig. 52; set a rolling parallel ruler to angle No. 1, and the centre it was marked off from; run it to station B, draw the line in this direction, and lay off with the same scale 700 links; bring up also angle No. 2 to the station C, and draw also another line in this direction; mark off on it the distance 300 links; apply the parallel ruler to each angle in succession, bringing them to the last station arrived at, remembering to make every line its proper length before bringing up another angle; proceed in this manner until you arrive at the last station L; lines may now be drawn parallel to the centre ones, which will represent the sides of the heading, and the plan will be completed. The plan may also be constructed from data calculated from the elements given in the survey-book without the use of the protractor. The detail of which method I now intend to explain; and the first step is that of reducing the observed horizontal angles contained in survey-book No. 1 to angles from the first line A B as a meridian, or their complements, from the east line B N.

Rule 1st. If the angles are less than 180° deduct it from 180°, and call the difference plus +; and if more than 180° deduct 180° from it, and call the difference minus —.

Rule 2nd. Add together the angles marked plus + and deduct those marked minus —, the remainder will be the angles to be employed, if the horizontal angle were taken from the east line or plane of latitude, or their complements, if taken from the assumed meridian.

Taking again the observed angles in survey-book No. 1 as an example, the reduction will be as follows:—

No. 1	=	180°	0′	−	140°	20′	=	39°	40′	+
„ 2	=	180	0	−	160	10	=	19	50	+
„ 3	=	180	0	−	170	40	=	9	20	+
„ 4	=	180	0	−	166	30	=	13	30	+
„ 5	=	180	0	−	172	20	=	7	40	+
„ 6	=	180	0	−	156	20	=	23	40	+
„ 7	=	180	0	−	164	40	=	15	20	+
„ 8	=	192	20	−	180	0	=	12	20	−
„ 9	=	196	40	−	180	0	=	16	40	−
„ 10	=	184	20	−	180	0	=	4	20	−

The angles marked + and — may now be collected and disposed in the following manner:—

				Complements to the first Series.
No. 1 =	39° 40′ +	No. 6 =	23° 40′	50° 20′ 0″
	19 50 +		15 20 +	
„ 2 =	59 30	„ 7 =	39 0	30 30 0
	9 20 +		12 20 −	
„ 3 =	68 50	„ 8 =	26 40	21 10 0
	13 30 +		16 40 −	
„ 4 =	82 20	„ 9 =	10 0	7 40 0
	7 40 +		4 20 −	
„ 5 =	90 0	„ 10 =	5 40	0 0 0

The angles No. 1, 2, 3, &c., to 10, are those to be employed in the calculation, and are separated into two series, the first as far as No. 5, which last is in an east direction; and it would be much easier in the plotting to assume this as a new zero line. The data found by calculation from the first series may then be called a positive, and that from the second a negative quantity. The sines of the complements of angles of the former, multiplied by the measured distances, will give the perpendicular, and the cosine the base; in the latter, the sines of the angles, multiplied by the measured distance in links, will give the perpendicular, and the cosines of the angles, multiplied by the measured distance, the base.

To find the different quantities it will be necessary to enter the particulars in a ruled form similar to the Table on the next page.

The form is ruled into eight columns, the first contains the number of drafts, or hypothenuses, the second and third the reduced angles of direction with reference to the plane of the meridian; the fourth, the complements of the angles of direction, or the angles of direction with reference to the plane of latitude; the fifth contains the sines of the complements of angles of direction × by the measured distance, and producing the perpendiculars; the sixth, the cosines of the complements of the angles of direction × by the measured distance, or hypothenuse, producing the bases; the seventh, the distance in links of each station from the plane of latitude; and the eighth, the total bases or distance of each station from the plane of the meridian. The calculations having been completed in the preceding manner, are entered as explained in the columns seven and eight, which will contain the projections of perpendiculars and bases requisite for constructing the plan; to do which, draw the line A B, Fig. 52, passing through the centre of the shaft and first station, and mark off on it 400 links; continue this line to an indefinite length, and call it the assumed meridian; draw also another line B N through the first station, and at right angles to the former, this line will then be the east, or plane of latitude; apply any chain scale, say a three-chain scale, to the line B N, with its zero at the first station B, and mark off the different bases from column eight as 446.82, 705.30, &c., to the last 2973.98. Now apply the parallel ruler to the meridian A B, and run it to the several pencil marks left on the line B N, and draw perpendiculars; then with the same scale mark off on these perpendiculars the several distances from column seven, as 528.82, 691.09, to the last

OFFICE FORM, No. 1.

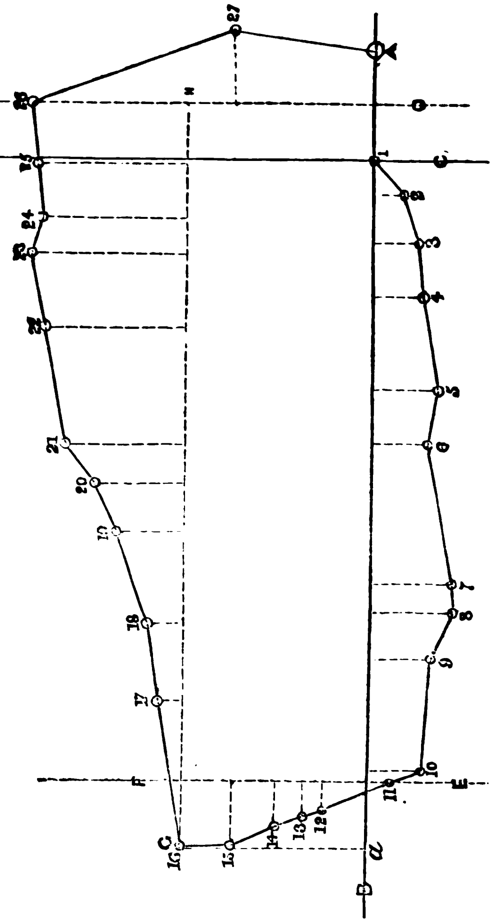
No. of hypothenuses.	Angles of direction with reference to plane of latitude.		Complements of angles of direction.	Hypothenuses × Sines of complements of angles of direction = perpendicular.	Hypothenuse × Cosine of complements of angles of direction = base.	Distance of each station with reference to plane of latitude.	Distance of each station with reference to plane of meridian.
	+	—	+	+	+	+	+
1	39° 40′	0° 0′	50° 20′	.7697710	.6383201		
				700	700		
				538.8397000	446,8240700	538.83	446.82
2	59 30	0 0	30 30	.5075384	.8616292	152.26 +	258.48 +
				300	300	691.09	705.30
				152.2615200	258.4887600	144.43 +	373.01 +
3	68 50	0 0	21 10	.3610821	.9325340	835.52	1078.31
				400	400		
				144.4328400	373.0136000	46.69 +	346.87 +
4	82 20	0 0	7 40	.1334096	.9910610	882.21	1425.18
				350	350		
				66704800	495530500	000.00	420.00 +
				4002288	29731830	882.21	1845.18
				46.6933600	346.8713500		
5	90 0	0 0	0 0	0000000	420.00000	100.35 −	228.97 +
				Hypothenuse × Sine of angle of direction = perpendicular.	Hypothenuse × Cosine of angle of direction = base.	781.86	2074.15
						94.39 −	228.57 +
	+	−	+	+	+	687.47	2190.72
6	0° 0′	23° 40′	0° 0′	.4014150	.9158963	134.63 −	268.08 +
				250	250		
				200707500	457948150	552.84	2458.80
				8028300	18317926		
				100.3537500	228.9740750	38.20 −	216.65 +
7	0 0	39 0	0 0	.6293202	.7771460		
				150	150		
				94.3980300	116·5719000	514.64	2675.45
8	0 0	26 40	0 0	.4487992	.8936326		
				300	300	29.62 −	298.53 +
				134.6397600	268.0897800		
9	0 0	10 0	0 0	.1736481	.9848078		
				220	220		
				34729620	196961560	485.02	2973.98
				3472962	19696156		
				38.2025820	216.6577160		
10	0 0	5 40	0 0	.0987401	.9951132		
				300	300		
				29.6220300	298.5339600		

495.02; draw ink lines from point to point in the perpendiculars thus formed, and they will represent a plan of the traverse required. The student will perceive that I have employed the signs + plus, and − minus, in a different sense to what they have sometimes been made to represent; thus, in the reduction of the angles by the second method the first angle = 39° 40′ is made positive, as also the quantity obtained from it by calculation; the second reduced angle = 19° 30′ is also a positive angle, and therefore to be added to the preceding one, 39° 40′ + 19° 30′ = 59° 10′. These angles, as reduced, are entered in their respective columns in Office Form No. 1, the sines and cosines corresponding to the angles are also entered in the columns five and six, and the calculation made as we proceed. Thus the perpendicular from the first angle is = 538.83 and base 446.82; that for the second angle 152.26 and 255.48; and as they are all plus, and to be added together, they are entered in columns seven and eight; thus 538.83 + 152.26 = 691.09, and 446.82 + 258.48 = 705.30, and are the lengths of the lines required to determine the stations from the plane of latitude and the meridian. In the second series, commencing at No. 6, the signs + changed to − show that all quantities calculated from the angles thus entered are to be deducted from the total lengths of the last perpendiculars in the first series; thus the angle 23° 40′ − produces 100.35 − for its perpendicular, and 882.21 − 100.35 = 781.86, the length of the next perpendicular determining the station H from the line B N, the same process to be continued until a change in the signs takes place. Thus it appears that the signs + plus and − minus mean that the data found by calculation from the angles so marked are to be added to or subtracted from the last plotted perpendicular, so as to determine the next station, when the plottings are made from the first meridian or plane of latitude.

TO SURVEY, CALCULATE, AND CONSTRUCT THE PLAN OF A CIRCUITOUS UNDERGROUND HEADING.

The survey of the heading, commencing from the shaft A, Fig. 53, and continued to the stations No. 1, 2, 3, 4, &c., to 27, is taken exactly in the same manner as described when taking that of Fig. 52. The instrument is set up at the station 1, and its plates clamped to zero; the cross hair is then made to bisect a lamp placed in centre of the shaft at A; the upper plate is then released, and the telescope turned round towards the forward lamp placed over the station 2, the cross hairs of which are made to bisect it; the angle is then read off and entered, and the instrument carried forward to the station 2; the same opera-

Fig. 53.



Plotted from the Planes and Parallels of Meridian and Latitude.

tion is then gone through at each successive station, until we arrive at the last one, No. 27; the survey will then close on the lamp in centre of the shaft, and placed in the same relative position it had at the commencement of the survey. The entries in the survey-book having been made according to that of No. 1, will have the following tabular form :—

SURVEY BOOK, No. 2.

No. of Hypothenuses.	Angles of Inclination. Elevation.	Angles of Inclination. Depression.	Measured Distance in Links.	Observed Horizontal Angles.	Remarks.
1	0 0	0 0	460	Zero.	Zero of instrument on lamp in centre of shaft.
2	...	...	200	132° 32′	
3	...	...	210	209 35	
4	...	...	230	194 40	
5	...	...	400	175 20	
6	...	...	220	193 10	
7	...	...	600	169 20	
8	...	...	110	164 45	
9	...	...	300	201 42	
10	...	...	420	206 31	
11	...	...	100	207 10	Turn suddenly to the right.
12	...	...	300	202 40	
13	...	...	100	185 40	
14	...	...	120	169 20	
15	...	...	200	186 20	
16	...	...	201	198 20	Turn to the right.
17	...	...	610	84 30	
18	...	...	350	178 20	
19	...	...	400	169 30	
20	...	...	220	174 20	
21	...	...	200	176 30	
22	...	...	500	198 20	
23	...	...	320	179 10	
24	...	...	150	169 20	
25	...	...	250	198 20	
26	...	...	250	206 30	Turn to the right.
27	...	...	900	227 30	Return to the shaft commenced at.
28	...	...	625	206 35	

There are in this survey 28 measured distances, and 27 observed angles, being always one less than the number of sides composing it. The survey was taken on an horizontal plane, consequently the measured distances require no reduction to that plane. The student will observe that when the direction of the lines in a survey takes a sudden change either right or left, it must be remarked in the proper column, and a line drawn through the column of angles, and underneath the last angle in the old direction, as at 207° 10′, turn to the right, &c. The present survey being a circuitous one, is divided into four series—the first and third are in the general direction of the meridian, and the second and fourth in that of the planes of latitude. The rules for reducing the observed horizontal angles to those planes are the same as employed for Fig. 52; the student is therefore referred to that part of the work where the process is fully explained. The following are the angles as reduced to the preceding planes from survey-book No. 2:—

No.	Angles as reduced to Planes of Meridian.	Angles as reduced to Planes of Latitude.
1	= 47° 28′ +	0° 0′ +
2	= 17 53 +	......
3	= 3 13 +	......
4	= 7 52 +	......
5	= 5 17 −	......
6	= 5 23 +	......
7	= 20 38 +	......
8	= 1 4 −	......
9	= 27 34 −	......
10	= 44 40 −	......
11	= 90° − 67 25 +	= 22 30 +
12		= 17 0 +
13		= 27 55 +
14		= 21 15 +
15		= 2 55 +
16	= 8 25 +	98 25 − 90° = 8° 25′
17	= 10 5 +	......
18	= 20 35 +	......
19	= 26 15 +	......
20	= 29 45 +	......
21	= 11 25 +	......
22	= 12 15 +	......
23	= 22 55 +	......
24	= 4 35 +	......
25	= 21 55 −	......
26	= 90° − 68 25	= 20 35 +
27	=	= 6 35 −

It will be observed that when the reduction is made to the meridian, and an angle in that reduction amounts to more than 45°, it should then be referred to the plane of latitude as at No. 11, the angle = 67° 25′ + ; this angle, deducted from 90°, will give the angle from the plane of latitude. Again, when arriving at No. 16, the angle amounts to = 98° 25′, and 90° deducted from it, will give 8° 25′ +, the angle of direction with reference to the plane of the meridian, and so on at each turn for the other series. The preceding reduced angles must now be entered in their proper columns in an office form similar to that of No. 1, with the natural sines and cosines corresponding, as also the measured lengths which are to be multiplied by the sines and cosines opposite the respective angles. After having performed the multiplication, we are then ready for another form, wherein are to be collected, classed, and entered all the data from the form No. 1. This second form is then a general sheet of reference and companion to the plan afterwards to be constructed from it. This Office Form, No. 2, is ruled into nine double and three single columns. The 1st contains the number of hypothenuses; the 2nd, the measured lengths; 3rd and 4th, the angles of inclination; the 5th, the observed horizontal angles; the 6th and 7th, the angles of direction, with reference to the first line, continued as a common meridian; the 8th and 9th, the angles of direction with reference to the plane and parallel of planes of latitude; the 10th and 11th, the distance from planes of the horizon; 12th and 13th, the distance from the planes of the meridian, in which the quantities become perpendicular and base alternately in the succeeding series; the 14th and the 15th, the distance from planes and parallels of planes of latitude, in which the quantities become base and perpendicular alternately in the succeeding series; the 16th, 17th, 18th, 19th, 20th, and 21st, the total distance from the planes of the horizon, meridian, and latitude. The columns 18 and 20 are deduced from those of 12,13, 14, and 15, by constantly adding together the bases and perpendiculars in the separate series, and entering their totals in the former.

TO CONSTRUCT THE PLAN FROM OFFICE FORM NO. II.

Draw a line on a sheet of paper representing the meridian A B, Fig. 53, and mark off from a chain-scale from A to station 1 460 links through this station, and at right angles to the meridian A B; draw the line C D, representing the first plane of latitude; apply the chamfered edge of the same scale to the line A B, with its zero division coinciding exactly with the first station 1; mark off on the paper from this scale the bases or distances in column 20, as far as No. 11, as 135.20, 335.03, 564.66, &c., to 2623.49, which will finish the bases in the first series; take the offset scale belonging to the chain-scale, and slide it along the edge of the latter fixed to the line A B, and at every pencil point on the paper representing the successive bases; mark off the perpendiculars, or distances, taken from column 18, as far as No. 11, as

OFFICE FORM, No. 2.

No. of Hypothenuses.	Reduced Measured Distances.	Angles of Inclination with the Horizon.		Observed Horizontal Angles.	Angles of Direction with reference to the Plane of Meridian.		Angles of Direction with reference to Planes of Latitude.		Distance from Planes of the Horizon.		Distance from Planes of the Meridian.		Distance from Planes of Latitude.		Total Distance from the Planes of the Horizon.		Total Distance from the Planes of the Meridian.		Total Distance from the Planes of Latitude.	
		+	−		+	−	+	−	+	−	First Series.						Perpendiculars.		Bases.	
1	460	0° 0′	0° 0′	Zero.	0° 0′	0° 0′	0° 0′	0° 0′	0° 0′	0° 0′	+	−	+	−	+	−	+	−	+	−
2	200	...	...	132°32′	47 28	...	...	...	...	...	147.37	...	135.20	...	...	...	147.27	...	135.20	...
3	210	...	...	209 35	17 53	...	...	...	...	...	64.47	...	199.83	...	...	...	211.84	...	335.03	...
4	230	...	...	194 40	3 13	...	...	...	...	...	12.90	...	229 63	...	...	...	224.74	...	564.66	...
5	400	...	...	175 20	7 52	...	...	...	...	...	54.72	...	396.20	...	...	...	279.46	...	960.86	...
6	220	...	...	193 10	...	5 17	...	...	...	...	...	20.25	219.05	...	...	...	259 21	...	1179.91	...
7	600	...	...	169 20	5 23	...	...	...	...	...	55.98	...	597.30	...	...	...	315.19	...	1777.21	...
8	110	...	...	164 45	20 38	...	...	...	...	...	38.76	...	162.94	...	...	...	353.95	...	1880.15	...
9	300	...	...	201 42	...	1 4	...	...	...	...	...	5.58	299.94	...	...	...	348.37	...	2180.09	...
10	420	...	...	206 31	...	27 34	...	...	...	...	...	194.33	372.28	...	...	...	154.05	...	2552.37	...
11	100	...	...	197 10	...	44 40	...	...	...	...	...	70.29	71.12	...	...	...	83.76	...	2623.49	...
											Second Series.						Bases.		Perpendiculars.	
12	300	...	...	202 40	90°−67° 25′=	...	22 30	...	...	...	277.14	...	114.78	...	...	...	277.14	...	114.78	...
13	100	...	...	185 34	...	...	17 0	...	...	...	95.63	...	29.23	...	...	...	372.77	...	144.01	...
14	120	...	...	169 25	...	...	27 35	...	...	...	106.35	...	54.56	...	...	...	479.12	...	198.57	...
15	200	...	...	186 20	...	...	21 15	...	...	...	186.40	...	72.48	...	...	...	665.52	...	271.05	...
16	201	...	...	198 20	...	...	2 50	...	...	...	200.73	...	10.21	...	...	...	866.25	...	281.26	...
											Third Series.						Perpendiculars.		Bases.	
17	610	...	...	84 25	8 25	...	98° 25′−90	...	...	...	89.24	...	603.41	...	...	...	89.24	...	603 41	...
18	350	...	...	178 20	10 5	...	...	...	...	...	61.25	...	342.57	...	...	...	150.45	...	945.98	...
19	400	...	...	169 30	20 35	...	...	...	...	...	140.60	...	374.40	...	...	...	291.09	...	1320.38	...
20	220	...	...	174 20	26 15	...	...	...	...	...	97.28	...	197.29	...	...	...	388.33	...	1517.67	...
21	200	...	...	176 30	29 45	...	...	...	...	...	99.24	...	173.62	...	...	...	487.57	...	1691.29	...
22	500	...	...	198 20	11 25	...	...	...	...	...	98.95	...	490.10	...	...	...	586.52	...	2181.39	...
23	320	...	...	179 10	12 15	...	...	...	...	...	67.87	...	312.70	...	...	...	654.39	...	2497.09	...
24	150	...	...	169 20	22 55	...	...	...	...	...	58.39	...	138.15	...	...	...	712.78	...	2632.24	...
25	250	...	...	198 20	4 35	...	...	...	...	...	19.97	...	249 20	...	...	...	732.75	...	2881.44	...
26	250	...	...	206 30	...	21 55	...	...	...	...	...	93.36	231.92	...	...	...	642.39	...	3113.36	...
											Fourth Series.						Bases.		Perpendiculars'	
27	900	...	...	227 30	90°−68° 25′=	...	20 35	...	...	...	842.49	...	316.35	...	...	...	842.49	...	316.35	...
28	635	...	...	206 35	...	...	...	6 0	...	...	575-03	...	...	60.40	...	...	1417.52	...	255.98	...

147.27, 211.84, &c., to 83.76, which will finish the perpendiculars in the first series; apply the parallel ruler to the line C D, and run it to the successive points, from which draw dotted perpendicular lines from the plane of the meridian; join the extreme ends of these perpendiculars by drawing lines from end to end, the junction of which with the perpendiculars will represent the stations, and the lines the measured distances in this part of the traverse. Set the parallel again to the line C D, and run it up to the last station in the first series; draw the line E F through this station, which call the parallel of latitude; apply the same scale to the line E F, with its zero to the station No. 11; mark off from it the bases in column 18, second series, as 277.14, &c., to 866.25, which will end the bases in this direction; slide the offset scale again along the edge of the chain-scale, and mark off perpendiculars from column 20, second series, as 114.78, &c., to 281.26, which will end the perpendiculars for this series, the ends of which, joined as before, will give the stations and direction of the lines composing this part of the traverse.

The meridian A B must now be brought up and drawn through the station 16 as G H, which call the parallel of the meridian. The scale must be applied to this line also, and the bases marked off from it out of column 20, third series, as 603.41, &c., to 3173.36, the end of the bases in this direction. The offset scale is again to be made pass along the edge of the previous one, and the perpendiculars marked off from it in column No. 18, third series, as 89.24, &c., to 642.39, the last; the ends joined as before will complete this part of the traverse also. Set the parallel to the first plane of latitude C D; run it up and draw the line 0 0′ through the station No. 26; apply the scale to this line with its zero division coinciding with the station; the bases and perpendiculars are then to be marked off from the chain and offset scale out of column 18 and 20, fourth series, the extreme ends of the perpendiculars joined by lines as before will complete the traverse. If the survey has been correctly taken, and the calculations accurately made, the last line in the traverse should strike exactly through the centre of the shaft at A, the point of commencement, otherwise one part or the other is at fault.

This method of plotting a traverse is vastly superior to the many others employed, as by it the several stations are plotted independent of each other; consequently an error committed in one part of the work could not possibly affect that immediately succeeding it; whereas, by the old method of plotting with protractors, the slightest error committed in one of the angles is certain to be communicated throughout all the succeeding parts of the work. A great advantage is also to be derived from the plans so constructed from Office Form No. 2, as we can at any time, by inspection, find the distances and positions of all the most important points in the survey, which can, with the greatest facility, be referred to the surface when occasion requires.

Example.—Suppose we wish to sink a shaft from the surface to the station 16 at G. By inspecting the Office Form No. 2 we are in possession of all the requisite data for calculating the direction and distance from station 1, or, in other terms, what we wish to find is only the hypothenuse, and one of the angles of a right-angled triangle. Thus, taking the total base from column 20, first series=2623.49, the distance between the parallel of latitude C D and E E, Fig. 54, to this distance add from G to the parallel E F, the last perpendicular in second series column 20=281.26, and 2623.49+281.26=2904.75=total length of base, or the distance from station 1 to *a*. Then, to find the perpendicular, take from column 18, second series, the number 866.25, deducting therefrom the last perpendicular in the first series, or 83.76, and 866.25−83.76=782.49, total length of perpendicular. The hypothenuse and angle may now be found by Problem 13th in Right-angled Trigonometry, as follows:—

To find the Angle of Direction.

Logarithm of the base 1 *a*=2904.75 .	= 3.4621088
„ „ perpendicular *a* G=782.49	= 2.8934788
„ „ radius	=10.0000000
	12.8934788
Deduct the first term	= 3.4621080
The logarithm tangent, ∠ =15° 6′ 37″	= 9.4313708

To find the Hypothenuse.

Logarithm radius	=10.0000000
„ secant=15° 6′ 37″. . . .	=10.0155695
„ of the base=2904.75 . .	= 3.4621088
Hypothenuse=3000.38	= 3.4776783

Therefore the angle of direction (of the point at surface, corresponding to the station No. 16) from station 1, with reference to the first meridian A B, is=to 15° 6′ 37″, and the distance 3000.38 links, which, if accurately set out, will find the point to the greatest degree of exactness; the chances for error are also diminished 30 times less than it would have been in case the surveyor traced all the angles, and measured the distances until he arrived at the point intended. In the former we have one angle and one line, but in the latter 15 angles and 15 lines to be measured. The surveyor has also an opportunity to correct the position as determined, by setting out the angle and distance in the first case; for if with a good instrument he ranges out the line A B, or base from station 1, until he arrive at a point determined by the distance 2904.75, and from this point set out the line *a* G at a perfect right angle to *a* 1, and also measure 782.49 links in this direction, the termination of which line should reach to and strike through the point previously determined at G. If the case proves to be otherwise (as it will frequently happen in hilly or woody districts, or from inattention to a careful measurement of the line), the three sides of the triangle must be again set out and tested with as much care as the circumstances of the case admit of, as the surveyor should rest satisfied with nothing short of perfect coincidence of the termination of the lines at this point. If any other point in the traverse was decided on, as at station 9 or 22, the bases and perpendiculars to these points are also given; consequently, the same logarithmic process will find the angle of direction and lengths.

THE NEW METHOD OF CONNECTING UNDERGROUND WORKINGS WITH THE SURFACE.

The following, Fig. 54, represents a vertical section of the shaft A (plotted traverse, Fig. 52). The first line, A to station 1, corresponds to that of A B in the section, and is required to be produced in the same direction on the surface. To perform this, we plant the transit theodolite in the centre of the shaft at A; it is then carefully levelled, and the hairs of the telescope made to bisect a small bright light placed on the peg at B; the clamp to the vertical circle is then released, and the telescope pointed up the shaft in the same vertical plane, and in the direction of the dotted line *a a*; the flame of a lamp or white peg is brought exactly into this line of sight. The surveyor should then direct the person attending to it to drive in a peg, or make any permanent mark exactly under the lamp as at *a'*; the lamp should again be placed over it, and tested with the telescope, which if found to be correct, may be revolved a little until it strike the other side of the shaft in the direction of the dotted line *b b'*, and the same operation gone through as before, we shall then have two points at surface in the same vertical plane as the line A B below ground. The surveyor may now ascend the shaft (after having carefully

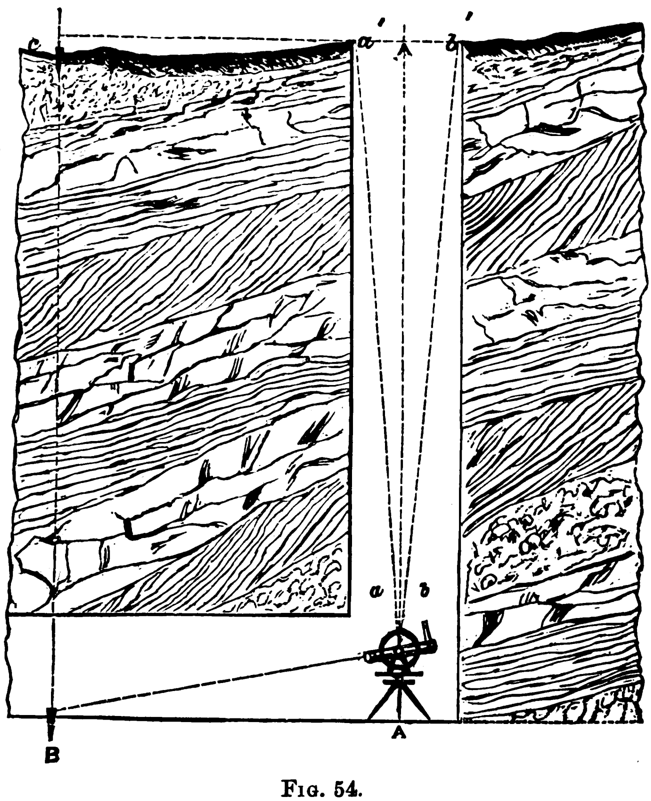


FIG. 54.

measured the line A B) to complete the operation, which will be done by stretching a strong line through the centres of the pegs or marks *b' a'*, which continued, and the measure of the line A B, measured off from A to *c*, would evidently give a point directly over the centre of the peg previously driven below at B. A strong iron peg should be driven into the ground at *c*, and its centre determined by stretching the same line through the marks or points *a b*; a small hole should then be made in its centre for future reference. The underground workings are all connected to this line, which in its turn becomes connected to the surface, and the accuracy of any distant point referred to or from this line with respect to those below, depends on the correctness with which it is set out.

If we wish to produce a line (previously marked out on the surface between two shafts) in the same relative direction below ground, so as to form a heading or tunnel from one shaft to another, it may be performed in the following manner :—Set up the transit theodolite at the bottom and in the centre of the shaft, as near as can be estimated by the eye, as at (*a*) Fig. 55, and after the instrument has been accurately levelled, and the zero of the upper made to coincide with the zero of the lower limb, sight up the shaft and make the cross hairs of the telescope bisect a mark

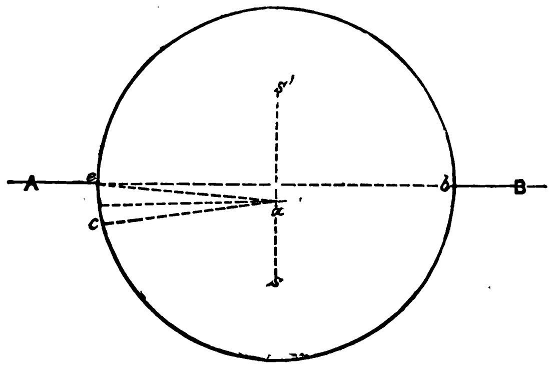


FIG. 55.

b,* Figure 55, in the line A B at surface, revolve the telescope vertically a little, until the vertical wire strike the opposite side of the shaft at (*c*) Figure 55. Measure the angle *c b e* (or what is the same thing, the angle $\frac{c\,a\,e}{2}$ for the $\angle \frac{c\,a\,e}{2} = \angle\ c\,b\,e$), and the radius of the shaft, or the distance *a e*. We may then easily find by calculation the exact deviation of the centre of the instrument from the meridian, or the vertical plane of the line A B at surface. Let the angular deviation = the $\angle\, c\ a\ e = 3^\circ\ 10'$, and the radius of the shaft = 60 inches; then the sine of $\frac{1}{2} \angle\, c\ a\ e\ \times$

* If any difficulty should be experienced in not being able to find ordinary marks, small lamps may be used instead, and these will be seen better at night than in the day-time.

radius or the distance *a e*=to the deviation in inches.* Thus the

$$\angle c\,a\,e=\frac{3^\circ\ 10'}{2}=1^\circ\ 35'=\text{sine}\ .27639\times 60=16.5 \text{ inches.}$$

The instrument may now be removed from *a* along the line *s s′*, and towards *s′*, a distance of 16.5 inches; it will then occupy its true position, or be in the same vertical plane as the line A B at surface.

The theodolite may now be properly adjusted and levelled, and the telescope pointed up the shaft, when, if the preceding operation has been accurately performed, the vertical wire will exactly thread or pass through the marks previously fixed at *e* and *b*.

It is to be observed, that ordinary marks fixed in the sides of the shaft, and in the line A B at surface, will not be distinctly seen, if the shaft is used as an occasional smoke chimney, and in that case small bright lights ought to be used instead.

It sometimes happens that shafts are to be found so badly arranged, that the surveyor will not be able to sight up them with the theodolite, in consequence of the water that is emitted from the sides of the shaft being allowed to fall down spontaneously. In such a case he may resort to the following plan for accomplishing his object. Procure two small chains, made from iron of about $\frac{3}{16}$ in., and sufficiently long to reach the bottom of the shaft. Attach them to iron bolts with screws at each end, which are to be inserted into, and screwed to a stout piece of timber, sufficiently strong to endure the weight of the chains suspended to them. This piece of timber may then be mounted on a frame erected for that purpose, and by signals from a man at the bottom of the pit the ends of the chain support (E and F) Fig. 56, may be moved until a line passing through the two chains, *a* and *b*, is found to bisect the peg A in the heading below ground. The surveyor should then measure from *c* to A, and ascend the shaft, when again sighting out a line passing through the chains at surface, and setting off the distance from *c* to A, the point B will be arrived at, which should be perpendicular to that of A below ground. After the points A and B have been fixed by this means, a theodolite should be set up over each peg separately; then after correctly adjusting the instrument, set the cross hairs on the chain

---

* This rule assumes the angle to be that of a right-angled triangle instead of an isosceles triangle, which it is. The rule depending on the former will give results sufficiently correct for small angles and short distances, and may be performed with great facility.

c, and clamp it fast; remove the chain *c* aside a little, and look through the telescope, then if the cross hair bisect the centre of the chain *d*, the point A is accurately fixed. The same operation must be performed on the surface at B to test the accuracy of that point also. It is needless to say that permanent marks should be left at A and *c* and B and *g* for future reference.

This method is much superior to that with copper wires, as the weight of the chains is sufficient of themselves to prevent any oscillation that may be occasioned by a strong current of air.

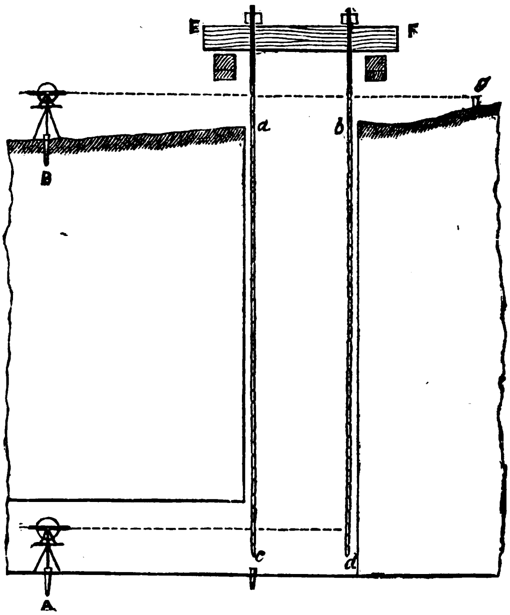


FIG. 56.

TO FIND A POINT ON THE SURFACE CORRESPONDING TO ANY ONE PREVIOUSLY FIXED ON BELOW GROUND.

The finding a point at surface corresponding to one below ground, is an operation which has often baffled the best attempts of some of the surveyors of the old school, who are so wedded to the method of plotting on the surface the bearings and lengths taken below, that it is no wonder they so seldom find the point proposed; indeed, it would be a much greater wonder if they found even a distant approximation to the truth by means of the miner's circumferentor; to perform it accurately requires much tact and care when the best instruments are employed. The surveyor or student is referred to the plotted diagram, Fig. 53, from which we will take station 16 at G as a point for an example. The length of the line from 1 to G, with the angle of direction, has already been calculated at 3000.38 links and 15° 6′ 37″; to set it out the miner's transit theodolite is placed over the station 1 (in the line A B previously connected from below); and after carefully levelling it and bisecting a distant station staff at B, the upper plate is released, and the vernier made to read the angle of direction 15° 6′ 37″, the cross hairs will then point to the station at G, Fig. 53. If this station cannot be seen from station 1 the line must be sighted out with the telescope, and station staves and pegs driven in at different distances, to mark the line so sighted out. The calculated distance 3000.38 links must be measured in this direction, the termination of which will indicate the position of a point directly above the one proposed below ground. A good caution against error will be to run out the base and perpendicular belonging to the hypothenuse just set out, and if the termination of the last line or perpendicular coincide with the position as indicated by that of the hypothenuse, the surveyor may rest satisfied his work is correct.

SURVEY OF A HEADING, TAKEN PREPARATORY TO SINKING A SHAFT INTO THE HEADING, AND DRIVING A TUNNEL FROM ONE SHAFT TO ANOTHER.

SECTION II.

The survey of the heading from the shaft at C (Fig. 1, Plate 1) to the point where the shaft is intended to be sunk down to C, is taken in a somewhat different way to that already taught in the preceding part of Section I. The surveyor plants his instrument at station 1, and levels it as usual; the cross hairs of the telescope are brought in contact with a lamp placed in centre of the shaft at *c*, the upper plate is then released, and the forward object sighted; through the telescope the horizontal and vertical angles are then read off, and entered in Survey Book No. 3; the instrument is then removed to the next station 2, when, after proper adjustment, the body of the instrument is released from its clamp screw, and turned round in the direction of a lamp placed over the back station 1,* the vernier remaining fixed at the previous forward reading, which becomes the back reading when the hairs of the telescope are made to bisect the lamp at station 1. The upper plate is then released from its clamp and turned in the direction of the next forward station 3; the horizontal and vertical angles are then read off and entered as before. The instrument is again removed, and carried forward to the station 3; the same operation is again gone through, always remembering to leave the upper plate clamped to the last forward reading, which becomes alternately the back reading. It will be obvious to the student that the 360° and 180° of the instrument are constantly

* It is of the greatest importance in traversing by this method that the supplementary or lower telescope is brought to bisect the back station before the upper telescope is released from it, and thus checking the angle by looking through the lower one to determine if any of the upper or lower works have shifted during the interval.

the meridian, and consequently parallel to the first line the telescope was set on, and the angles as read off are the horizontal angles with respect to this line, and not to the lines composing the traverse, as in the preceding method of referring the zero to the back line continually.

The survey book necessary for the entries of the observations taken in this survey is ruled into nine columns, the first four of which are common to all; the fifth and sixth contain the back and fore horizontal reading of the limb; and the seventh and eighth the horizontal angles with reference to the meridian; the ninth remarks, &c.

SURVEY BOOK, No. 3.

No. of Hypothenuses.	Angles of Inclination.		Measured Distance in Links.	Horizontal Readings.		Horizontal Angles with Meridian.		Remarks.
	Elevation.	Depression.		Back.	Fore.	+	−	
1	1 5	0 0	1000	0° 0′	185° 30′	5° 30′	...	Zero on a lamp in centre of shaft.
2	......	1 50	610	185 30	6 42	6 42	...	
3	......	2 5	820	6 42	179 35	.....	0° 25′	
4	......	1 21	960	175 35	8 2	8 2	...	
5	......	1 35	640	8 2	180 51	0 51	...	Finish at a point in the heading where the shaft must strike from the surface.
6	......	1 15	720	180 51	7 31	7 31	...	
7	......	1 21	940	7 31	191 45	11 45	...	
8	......	1 40	625	191 45	357 15	......	2 45	

It is now evident that we require an office form similar to that of Nos. 1 and 2, Section 1, in which to enter the measured distances from column four, which is to be multiplied by the sines and cosines belonging to the separate angles of elevation and depression in columns two and three; the former producing the difference of level or the distance from the planes of the horizon, and the latter the reduced horizontal measure; which last is also to be multiplied by the sines and cosines of the angles of direction with the plane of the meridian, producing the distance from the planes of the meridian in the former, and the distance from the planes of latitude in the latter.

TO DETERMINE WHEN AN ANGLE IS PLUS OR MINUS.

Rule.—In any traverse whose general direction inclines to the right of the first line in the traverse, and the first angle is more than 180°, its difference is called plus, the whole succeeding angles less than 180°, minus; also when the instrument is reversed (as it will be at every alternate station), and the vernier pass over or indicate the line to be to the right of 360°, it is called plus, and if less than 360°, its difference to be called minus. If, on the contrary, the traverse inclines to the left of the first line, and the first angle is less than 180°, its difference must be taken and called plus; the whole succeeding angles more than 180°, their difference to be called minus. These rules will be better understood by reference to Fig. 57, where it will be seen in the traverse A C that all lines diverging from the meridian D E are called plus, being in the third quadrant, and all those inclining towards it minus, being actually in or belonging to the second quadrant. Again, all lines in the traverse A B, inclining towards the meridian A E, are called minus, being in or belonging to the third quadrant; and all those diverging from it plus, being in or belonging to the second quadrant.

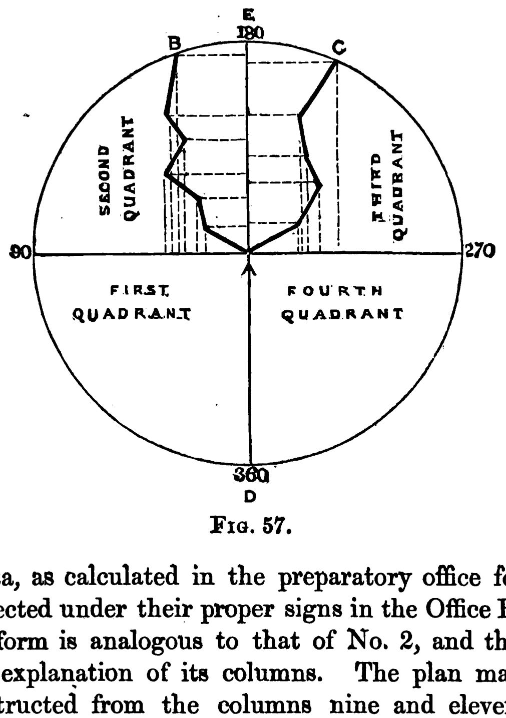


FIG. 57.

The data, as calculated in the preparatory office form, should now be collected under their proper signs in the Office Form No. 3. This office form is analogous to that of No. 2, and therefore will require no explanation of its columns. The plan may be accurately constructed from the columns nine and eleven, with the chain and offset scales. The surveyor should guard against the possibility of any of the lines in the traverse crossing the meridian. This may be avoided by drawing a datum line or meridian, A B, parallel to the first one at *a b* (Fig. 1, Plate 1), and at a fixed distance from it, as *a* A, say 1000 links. This number must be

OFFICE FORM, No. 3.

No. of Hypothenuses.	Distance from Planes of the Horizon.		Reduced Horizontal Measure.	Distance from Planes of Meridian.		Distance from Planes of Latitude.		Total Distance from					
								Planes of the Meridian.		Planes of Latitude.		Planes of the Horizon.	
	+	−		+	−	+	−	+	−	+	−	+	−
...	...	...	...	...	...	...	...	1000.0	...	...	...	...	...
1	...	31.90	999.4	95.74	...	994.70	...	1095.74	...	994.70	...	...	31.90
2	...	11.52	609.8	71.10	...	605.59	...	1166.84	...	1600.29	...	...	43.42
3	...	29.76	819.4	...	5.89	819.31	...	1160.95	...	2419.60	...	...	73.18
4	...	22.56	959.7	134.07	...	950.19	...	1295.02	...	3369.78	...	...	95.74
5	...	17.66	639.7	9.46	...	639.57	...	1304.48	...	4009.36	...	...	113.40
6	...	15.69	719.7	94.13	...	713.51	...	1398.61	...	4722.87	...	...	129.09
7	...	22.09	939.7	191.32	...	919.96	...	1589.93	...	5642.83	...	...	151.18
8	...	18.15	625.6	...	29.96	624.84	...	1559.97	...	6267.67	...	...	169.33

entered in column nine, containing the perpendiculars, each perpendicular or distance from the plane of the meridian must be added to this number, which will express the distance of each station from the datum or assumed meridian. The object of the present survey being to arrive at a conclusion whereby to determine the position of a shaft to be sunk down to the last point arrived at in the survey below ground as C, and also to connect another shaft D by means of a tunnel from C, I shall now hasten to this important part of the work, thinking the student has received sufficient insight into the preceding methods of conducting a subterraneous survey as to be enabled to undertake any work of a similar nature.

TO SINK A SHAFT SO THAT IT SHALL STRIKE A FIXED POINT IN A HEADING BELOW GROUND.

By referring to Office Form No. 3, we have given the base or distance *a b* (Fig. 1, Plate 1) = 6267.97 links, and the perpendicular *b* C = 624.84 links being the base and perpendicular of a right-angled triangle, we have therefore to find the hypothenuse and angle *b a* C; this method has already been explained in Section I., but for the sake of example the calculations will be fully gone into.

For the Angle of Direction.

Logarithm of the base *a b*=6267.97=	3.7971270
„ of perpendicular *b* C= 624.84=	2.7957688
Logarithmic radius	=10.0000000
	12.7957688
Deduct the first term	= 3.7971270
Logarithmic tangent=5° 41′ 34″ . .	= 8.9986418

For the Line a C.

Logarithmic radius	10.0000000
„ secant of angle of direction =5° 41′ 34″	=10.0022102
Logarithm of the base *a b*=6267.97	= 3.7971270
The hypothenuse *a* C=6299.95 . .	= 3.7993372

Therefore the distance from *a* to C=6299.95 links, and the angle of direction *b a* C = 5° 41′ 34″. Now if the transit instrument is set up at the station *a*, and this angle run off from the line *a b*, and 6299.95 links measured in this direction will give the position of the intended shaft. It is presumed that the line *c a* has been connected to the surface as previously explained, and as a great deal depends on the accuracy of the point C thus found, it is requisite that the surveyor should run out the base *a b* to the measure indicated in the Office Form No. 3; and when arrived there set up the theodolite and run off the perpendicular to its measure also, he will then be able to judge about the correctness of the position.

TO DETERMINE THE LEVELS, DISTANCE, AND DIRECTION OF THE TUNNEL TO BE DRIVEN FROM D TO C.

The difference of level between the tops of the two shafts D and C (Fig. 2, Plate 1) is 30 feet, the depth of D E = 450 feet, and that of C F = 320 feet; we have therefore to determine at what distance from the surface at D down the shaft towards E, or from E upwards towards D, to commence the tunnel, so as to strike the point F in the heading (Fig. 2); therefore D G = to C F − C H, or 320 feet − 30 = 290 feet = to D G, and E G = to D E + C H − C F, or 450 feet + 30 − 320 feet = 160. The distance therefore from the surface down the shaft to G and on a level with F = 290 feet, or from the bottom at E to the same point G = 160 feet. The distance C D (Fig. 1 and corresponding to C F, Fig. 2) may be found by direct measurement, if no obstacle come in the way; on the contrary, it will be best to continue the line C *b* to *d*, which being measured, and the lines set out at right angles, will be two sides of a triangle to find D C, this may be performed by the same logarithmic rule applied for ascertaining the length of C *a*; the distance between D and C, found as above, is 2234.8 links, and the angle D C *d* = 15° 50′ 23″. The surveyor will now plant his instrument at C, and measure off the previous calculated angle D C *d* = 15° 50′ 23″; this line continued will strike through the shaft at D. Two permanent marks should now be fixed in the sides of the shaft directly in this line, so sighted out. The shaft at C may now be commenced, and also a door or platform fixed in the shaft D E at G, or 290 feet from the top of the shaft. If the surveyor chooses to take the compass bearing of the line C D he may do so, and in the absence of all iron set the headers to work, driving the tunnel on this bearing from G; it must, however, be totally abandoned after the tunnel is driven a few yards, to make room for carrying on other operations. To set out this line D C accurately from G in the shaft D E (Fig. 2), so as to strike the point F, the surveyor should plant the miner's transit theodolite on the stage at G,* and move it about the centre of the shaft after calculating its deviation, as previously explained, until he finds the vertical hairs of the telescope strike exactly through the two marks previously fixed in the sides of the shaft D, and in the line C D (care being taken that the instrument is carefully levelled at the same time), he may then bring down or revolve the telescope to a horizontal position; the same vertical wire will now point from G to F (Fig. 2, Plate 1), and consequently give the correct direction for the tunnel to be driven, being in the same vertical plane as the line C D at surface. Two lines, with plumb bobs appended to their ends, must be fastened to the roof of that part of the tunnel already driven, which are placed directly in the line of sight and coinciding with the cross hairs of the telescope; these lines should be examined from time to time, and others suspended in the same line of sight as the work proceeds, the workmen will then have two points or more given by which to drive the tunnel straight; it is, however, very objectionable to depend entirely on the skill of any workmen to continue the tunnel without frequent examination, and indeed the surveyor or mining engineer should not rest satisfied with a single operation in setting out this line, and if needs be it should be traced again on the surface, and the old marks in the sides of the shaft verified. The operation of bisecting these marks, thus corrected from G with the instrument, is again to be performed, and the telescope brought down to a horizontal position; if the wires bisect the lines previously suspended it will be much ease and satisfaction to the operator. The direction may also be corrected by the following means: produce the line erected perpendicular to C *b* at *d* through the shaft, and leave marks in the sides of the shaft in this line as before. Plant the instrument again at G, and after repeated trials of levelling and sighting up the shaft, the cross hairs will be found to strike through these two marks; also bring the upper plate of the in-

* If the engineer has a counterbalancing stand for his instrument, he may set the theodolite at surface near the edge of the shaft and in the line D C, when it may be brought into such a position that the telescope will sight down the shaft; the direction of the line C D may then be produced below ground.

strument to the zero of the lower, clamp them together, and again bisect the two marks up the shaft; bring the telescope down, and release the upper plate; make the vernier point to the angle or measure between the lines D C and D *d*, or the complement of the previous calculated angle B C *d* = 74° 9′ 27″; then the vertical hair will bisect the plumb-line before suspended, if the work is correct; if it does not agree, the operations must all again be gone through, from first to last, until they do agree.

TO DRIVE THE SAME TUNNEL FROM TWO OPPOSITE POINTS AT THE SAME TIME.

If the shafts D E and C F (Fig. 2, Plate 1), are both sunk to their depths before commencing to drive the tunnel (C D, Fig. 1) between them, and it is requisite that the tunnel should be driven from these two points at the same time, it may be set out from the shafts as before explained. I have given a full explanation how the tunnel may be set out from G in the shaft D E, consequently a similar operation from the bottom of the shaft at F would bring the vertical hair of the telescope to bear on or point to G, and the tunnel so driven from the two points must meet at about I. If the surveyor desires an easy check on the direction of the tunnel as set out from F by the preceding method, he may correctly do so as follows: by referring to the Survey Book No. 3, he will find that the last horizontal angle, No. 8, was = 357° 18′, and consequently 2° 45′ − from the meridian; if to this angle 2° 45′ we add 90° + 15° 50′ 23″ = 108° 35′ 23″ or the angle of direction of the tunnel from the line passing through C and the last station, or No. 8 Station in the Survey Book; if the theodolite is planted in the centre of the shaft represented by F in the section, and C in the plan, and the telescope is brought to bisect the last station (No. 8 below ground), and the vernier made to read the angle 108° 35′ 23″, the cross hairs should then point to or bisect the plumb-line before fixed to the roof of the tunnel. It should also be remembered that the tunnel must be driven perfectly level from both sides, or it cannot be expected to meet on the same horizontal plane.

SETTING OUT UNDERGROUND CURVES.

Curves, *i.e.*, pieces of circles, are sometimes employed in mines to join headings or tunnels that have been driven in two directions and converging to a point or apex. There are many methods of running lines on the surface; but from the want of sufficient space below ground are not applicable. The following, though different, is equally reliable and well adapted to mining purposes.

To set out a Curve from One Point.

It is proposed to drive a tunnel on a curve from the point B in the heading to join that of A in the heading (Fig. 58).

It is also presumed that the surveyor has made a preparatory survey of the two headings leading from two separate shafts to the points B and A, and also to have connected the shafts in the manner before described. The survey should be reduced to a form similar to that of Office Form No. 3, and plotted to a large scale (say two inches to a chain) with a beam compass, reading to the fraction of a unit. The lines E B and F A are produced until they meet at C, and one of the sides, as B C, measured with the beam compass, we shall then have one side with the angle A C B, to find the radius necessary to draw the curve tangentially to the points A and B. The angle A C B may be calculated by the 16th Problem of Oblique-angled Trigonometry, first taking the measure of the lines A C, A B, and C B, or it may be measured direct with a circular protractor. The angle between the lines C A and C B = 105° 1′, and the measure of the line A C 505 links, to find the radius.

To find the Radius.

As the cosine of $\frac{1}{2}\angle$ A C B = 52° 30′ 30″	= 9.8994667
Is to the sine of $\angle$ A C B 105° 1′, or complement 74° 59′	= 9.9849099
So is the logarithm of the length A C = 505 links	= 2.7032914
The two last terms added	12.6882013
The first term deducted	9.8994667
Therefore the radius A D 629 links . .	= 2.7887346

Take this distance, 629 links, from a scale with the compass, and set one of its points at A, strike the arc 1 1′; set the point also at B, and strike another arc 2 2′, as at D. The point of the compass set in the intersection of these arcs, and with a sweep of the other point will describe the curve tangentially at the points A and B. The curve may then be divided into any number of equal parts, which in this case are six. Right-angled triangles should now be formed upon these divisions as hypothenuses, by drawing lines parallel to B C through the points *a, b, c, d, e*, &c., to A, and also the perpendiculars *a a′, b b′, c c′*, &c.; we shall then be enabled

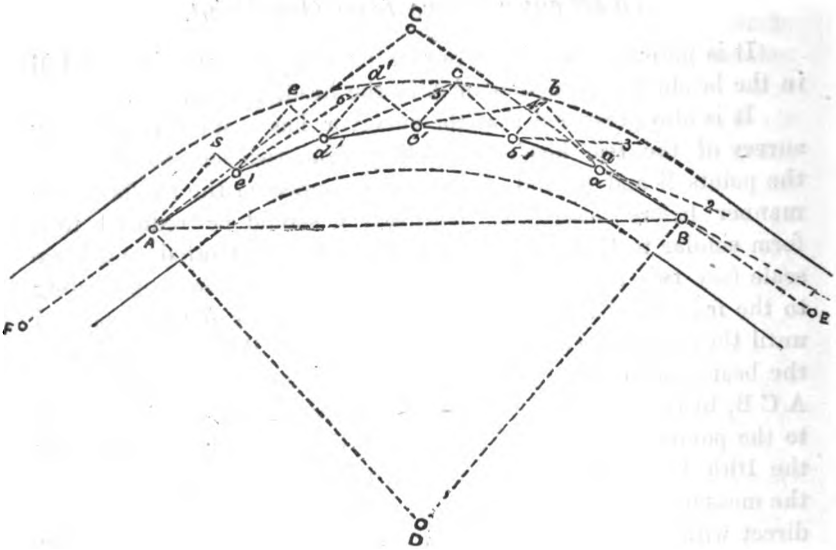


FIG. 58.

to calculate the angles,* by which to determine the direction of the lines B *a, a b, b c*, &c., to *e* A; measure the lines B *a′, a b, b c′, d d′, e e′*, and *s* A, as bases; also *a a′, b b′, c c′, c d, d′ e,′* and *e s*, as perpendiculars, and enter them in a tabular form as follows:—

FORM OF NOTE BOOK CONTAINING DATA FOR SETTING OUT THE CURVE.

No. of Stations.	Hypothenuses.	Bases.	Perpendiculars.	Angles of Direction.	Complements of Angles of Direction.	Reduced Angles for setting out the curve.	Remarks.
1	142	141	16	6° 20′ 30″	....	6° 20′ 30″	The curve to be set from one point.
2	142	135	45	18 26 30	....	12 6 0	
3	142	126	70	28 29 46	....	10 3 16	
4	142	105	101	43 58 21	....	15 28 35	
5	142	117	77	33 20 50	56° 39′ 10″	12 40 49	
6	142	131	52	21 39 10	68 20 50	11 41 40	

* Or these angles may be referred to a spare space on the drawing, and measured at once with the protractor.

The Note Book contains eight columns: the first, the number of stations; the second, the length of the chords required to set out the curve; third, the bases; and the fourth, perpendiculars of the right-angled triangle formed upon the chord as an hypothenuse; the fifth and sixth, the calculated angles of the triangles formed with the chord lines; the seventh, the reduced angles required in setting out the curve; the eighth, remarks, &c. The angles in column five are calculated by adding the logarithm of the perpendicular to radius, deducting the logarithm of the base. The remainder is the logarithm tangent of the angle. The last two calculated angles 33° 20′ 50″, and 21° 39′ 10″ are those of *d e e′* and *e* A *s* in the triangles, consequently as we are setting out the curve from one side, or from B, their complements are to be employed instead. Then the ∠ *b a b′* — the ∠ *a* B *a′*, ∠ *c b c*—*b a b*, ∠ *d c d* — ∠ *c b c*, ∠ *e d e* — ∠ *d e d*, and ∠ A *e s* — ∠ *e d e*, =18° 26′ 30″—6° 20′ 30″ ∠ 28° 29′ 46″ — 18° 26′ 30″ ∠ 43° 53′ 21″ — 28° 29′ 46″ ∠ 56° 39′ 10″—43° 58′ 21″, and ∠ 68° 20′ 50″—56° 39′ 10″=to 6° 20′ 30″, 12° 6′, 10° 3′ 16″, 15° 20′ 35″, 12° 40′ 49″, and 11° 41′ 40″, reduced angles for setting out the curve.

To set out the Curves.

Plant the transit theodolite in the heading at station B, and after adjusting it, sight back along the heading to a mark at E; release the upper plate and make the vernier read the first reduced angle 6° 20′ 30″, the cross hairs of the telescope will then point towards the station *a*; revolve the telescope vertically, and point in the direction from B to 1; at this point cause a plumb-bob to be suspended; also suspend a second line over the station B, the workman will then have two points by which to drive the length B *a*. After the line B *a* is partly driven, its direction should then be tested by setting up the instrument at B, and measure the angle 6° 20′ 30″. It is a very important matter to get this first line correct, as the curve is hinged at B, and a small error committed on it would accumulate throughout the succeeding chords, rendering it impossible for the curve to join the point A. When the point *a* is attained, or 142 links from B, the theodolite may be set up at this station also; and after being levelled, the cross hairs are made to bisect the point B; the telescope is then revolved, and the vernier made to read the angle 12° 6′; the cross hairs will then point to the next station *b′* in the curve. The telescope may then be revolved and directed towards a point at 2, at which point suspend another plumb-bob line; a second line is also to be suspended over the station *b′*; these lines will then be a guide for driving from *a* to *b′* as before. This operation must be repeated at every station, as at *b*, *c*, *d*, and *e*, which last must strike through the point A previously determined upon and tangentially to it.

To set out the same Curve from Two Points.

Divide the curve into any number of equal parts as before, draw a line through these points parallel to B C and A C (Fig. 59)

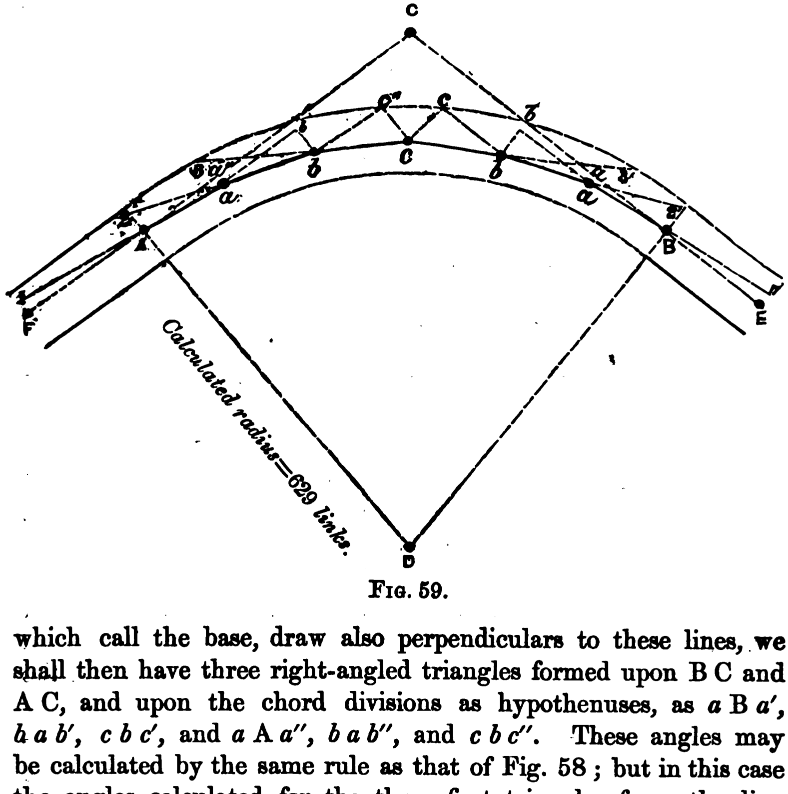


FIG. 59.

which call the base, draw also perpendiculars to these lines, we shall then have three right-angled triangles formed upon B C and A C, and upon the chord divisions as hypothenuses, as *a* B *a′*, *b a b′*, *c b c′*, and *a* A *a″*, *b a b″*, and *c b c″*. These angles may be calculated by the same rule as that of Fig. 58; but in this case the angles calculated for the three first triangles from the line B C, will be equal to those formed upon the line A C. These angles, therefore, set off from B and A alternately as previously explained, will find the point *c* in the middle of the curve, the operation being exactly the same as described when setting out Fig. 58.

TO DRIVE A TUNNEL ON A CURVE AND GRADIENT FROM TWO POINTS.

It is required to drive an underground tunnel from two points A and B, Fig. 59, on a curve and gradient. The position of these points has been previously determined by survey, and the horizontal distance between them found after plotting to a large scale equal to 562 feet. The difference of level between the points A and B = 50 feet; the length of the incline will then be found by the 13th Problem of Right-angled Plane Trigonometry, viz., by adding together the logarithm of the total rise, or 50 feet to radius, deducting the logarithm of the horizontal distance between A and B, the remainder equals the logarithm tangent of the angle of depression = 5° 17′ from A, or angle of elevation from B; secondly, add together the logarithm secant of the angle of depression to radius, deducting the logarithm of the distance 562 feet, the remainder equals the logarithm of the incline = 564.40; divide this number by six, we have 94.06 feet for the length of each chord required in setting out the curve. This distance 94.06 may be taken between the compasses and run along the curve from A towards B, which will form hypothenuses to two series of right-angled triangles formed upon it, whose bases are parallel to the lines A C and B C; the bases and perpendiculars of which triangles are to be employed in calculating the angles of direction of these chord lines, and determining points in the curve. These angles of direction may also be calculated by the forementioned problem in trigonometry, which are to be treated exactly in the same manner as those for setting out the horizontal curve (Fig. 58). The ratio of the incline may be found by dividing the length of the incline between the points A and B by the total rise, thus—564.40 feet ÷ 50 feet = 11.288, or about 1 in 11. The rise or fall per chain may be obtained by dividing the total rise by the number of chains in the incline 50.000 feet ÷ by 8.55 chains = 5.84; also to find the fall per yard, divide the number of feet in the yard by the ratio, thus—3.000 feet ÷ 11.288 = .265; therefore when the chord A *a* has been set out as previously explained, every yard forward must show a difference in level of .265, or for every chain 5.84 feet, and the termination of the chord line at *a* must be at 8.29 feet below A; on the contrary, when the chord B *b* is set out, the point *b* must be elevated 8.29 above B, in order to preserve the proper gradient; and every forward station determined by the angles of direction and the length of the chord 94.40, must show this difference in elevation or depression from B or A. The gradient may also be set out by planting the transit theodolite at A and B successively, and causing a staff to move along that part of the line A *a* and B *b* already driven the same height as the instrument, the vernier of the vertical circle pointing to the previous calculated angle of depression or elevation 5° 17′; a strong peg must then be driven into the ground until the cross hairs bisect the horizontal line on the vane of the staff; a similar process must be gone through at B, but the instrument will show an angle of elevation of 5° 17′, instead as before of depression. The best method, however, would be to mount a spirit level on a short stand and using a graduated staff, make each chain's length forward show the previous mentioned difference of level in elevation or depression.

LEVELLING UNDERGROUND WITH THE SPIRIT LEVEL.

Levelling underground may be performed to a considerable degree of correctness by the miner's transit theodolite, and with the aid of Problem 7 of Right-angled Plane Trigonometry; but when great niceties are required, it would be better to employ the spirit level.* The method of using it is as follows. Set up the level (similar to the theodolite) between the two stations whose difference of level is sought, then after bringing the bubble to the centre of its run, sight back to a graduated staff, and take the reading, say 3.42 feet; turn the telescope round to another staff placed at some distance along the road, read off again, say 3.96, the difference of these readings will then show the difference of level; the former to be called the back sight and the latter the fore sight. The surveyor may proceed to level any length of road in a similar manner.

UNDERGROUND LEVELLING BOOK.

	Rise.	Back Sight.	Fore Sight.	Fall.	Reduced Height.	Distance in Links.	Remarks.
1	0 54	3 42	3 96	......	......	120	B M bottom
2	0 42	4 78	5 20	......	......	110	and centre
3	0 20	3 90	4 10	......	... ..	140	of shaft.
4	0 16	3 82	3 98	......	......	230	
5	0 0	4 60	3 54	1 6	......	400	
	1 32	20 52	20 78	1 6			
	1 6		20 52				
	0 26		0 26				

* The 14-inch dumpy level is in most general use, and is the best for surface or underground operations.

If now we add up the columns of the back and fore sights, the difference will equal the difference of level between the first and last places arrived at, or the difference of the sums of the falls and rises will give the same figures.

The best kind of levelling staves for underground use are those painted and graduated to feet, tenths, and hundredths of a foot, and about from 3½ to 5 feet in length. When reading these graduations through the telescope, a person attending to the staff must bring the flame of two lamps to bear on its face from each side in such a manner as to illuminate it, and not obstruct the line of sight of the observer. The surveyor will then be able to read off the divisions with greater certainty. If the cross hairs of the telescope cannot be seen distinctly, the observer must hold a faint light to the object-glass of the telescope.*

In general, when surveys are taken requiring offsets to determine the width of roads, and for taking off all the workings, the Survey Book will be most convenient when begun at the bottom, and written upwards as the work proceeds. The following sketch, Fig. 60, is offered as a good form wherein to record the elements taken in a survey. The horizontal angles are written in the book in the order they were taken, with an horizontal line drawn under them; the angles of elevation or depression are written opposite, but in a direction at right-angles to the former; they are also characterized by having a line drawn under them with the letters E or D, elevation or depression; the chainage is taken and entered as in the sketch; remarks or names are written on the survey sketch as they occur without any regard to position.

When the mining surveyor or engineer is called upon to inspect and survey existing works or collieries (of which he has had no previous knowledge), for the purpose of driving or setting a tunnel or drift, to extend and connect different veins of coal one above another by that means, it is absolutely necessary that the mining-agent, or manager in charge of the works, should be able to furnish a sectional drawing or record of all particulars relative to the different strata and veins of coal through which the shaft has been sunk, as their thickness, depth from surface, or height from bottom of the shaft; and, above all things, the angle of depression as obtained to the greatest nicety;

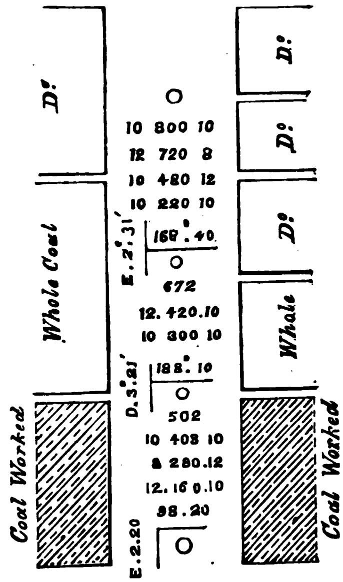
* Those persons who have constant occasion for levelling underground should have their level constructed to carry a small lantern, which illuminates the cross hairs through a perforation in the side of the telescope.

there will then be no difficulty whatever, with ordinary care, to start from any convenient selected spot in any of the underground headings, with a cutout or drift that shall have a certain length and gradient by which to arrive at another vein of coal at a remote point.

A GENERAL UNDERGROUND SURVEY BOOK.

To heading face

FIG. 60.



Of a colliery for working plan,
Commence survey at the shaft No. 1, January 20th, 1860.

It is of frequent occurrence in coal-mining that long drifts are required to connect veins of coal at a higher altitude; and it as often happens that it is necessary that such drifts should terminate in a point which shall be perpendicular to another selected or fixed mark at surface. This mark may be the boundary line defining other adjacent property—a common known drainage-gutter, an old dam or dike of water, and the like, pent up below—all of which the surveyor should avoid coming in contact with. In the absence of such a section or register as before mentioned, the surveyor will most certainly be at a loss in performing these operations accurately, for should the pitch or depression of the vein of coal be a small angle, and that depression represented to be different to what it actually is, there will be no end of anxiety, and the result will most probably be that the drift, when set out, will terminate perhaps ten or twenty yards short of distance, or further off than was at first intended; and it may be such a case would be the immediate cause of inundating the mine, or producing some other dreadful catastrophe. By these remarks I do not mean to presume that every colliery is not provided with the necessary means to enable a man to perform work accurately. I know to the contrary. The present race of colliery managers and agents, taken by the majority, are too well up to their own interest, and that of the proprietors, to allow any chance slip of bringing science to bear on their undertakings, which may account for the general success of such undertakings. At the same time, I am aware that many works are sadly neglected, and that it has been so heedlessly conducted, that if you were to inquire of them the amount of depression or thickness of a certain measure out of sight, you may get for answer, "I don't know;" or "We never troubled about it." Such a plan would no doubt involve a man in an engineering difficulty of which he may not easily get free.

For the assistance of those young men, or students, who may one day be connected with mines, I have constructed a sectional diagram (*Plate* 2), which if followed would, in my opinion, prevent perplexities and uncertainties in after years. The diagram is so plain as to require little explanation. The first column is devoted to a description, with the names of all strata as passed through in course of sinking the shaft; the second shows a section of the strata on one side of the shaft, and may be coloured or otherwise, at the option of the constructor; three, four, and five, the thickness of each stratum; six, seven, and eight, the total depths from surface; nine contains the angle of depression; ten, the number of gallons of water produced from each stratum per minute. (This is an important item to notice while sinking the shaft, as it is the usual practice to put in tubbing to keep back these springs, thereby decreasing the size and power of the pumping apparatus; but should it be thought necessary to work any of the upper veins from the same shaft by drifts, while the under ones are in progress, ample provisions should be made in the pumping apparatus in case the water so tubbed back in the shaft may again be let into the work by such drifts.) Eleven contains remarks as to the nature and solidity of the strata; and twelve, the cost per yard in course of sinking. This will also prove of service in proportioning the future cost of driving headings, &c.

through the same kinds of strata in a horizontal or oblique direction. Other columns may be added, at the discretion of the person making the section, such as the nature and quantities of all noxious gases found in particular places, all heaves or dislocations of strata, and every other particular that will be likely to prove of service in after years. If the student is at all versed in geology and chemistry, he may have special columns devoted to the geological description of the strata, and the period to which each belongs, all fossils, flora, &c., as likewise the chemical constituent parts contained in each separate rock or stratum.

TO SET OUT THE TRUE MERIDIAN BY EQUAL ALTITUDES OF ANY CELESTIAL OBJECT.

The direction of the true meridian may be found by setting up the miner's transit theodolite over the station or peg from which the meridian is intended to be set out, as at A, Fig. 61; and after carefully levelling the instrument, bring the zero of the upper to coincide with the zero of the lower limb or plate; clamp them fast; direct the telescope to any celestial object (as a planet or fixed star), when it is about two hours distant from the meridian,* and make the cross hairs cut through it by turning the body tangent, and tangent to vertical circle. The vertical circle must now be left at this reading, releasing the upper plate, and waiting until the star descends in the western horizon; attention must be given to the instrument at intervals, so as not to allow the star to descend below the line of sight before completing the second observation. When the star appears in the field of the telescope, it must be followed by moving the tangent screw of the upper plate (without moving the instrument the least in position), by which the vertical hair of the telescope should be made to cut the star continually until it descends and appears to thread the horizontal wire, at which time the vertical hair must be made to coincide with the centre of the object; the observation will then be complete. We may now take the reading of the horizontal limb, half of which angle will point out the meridian—say the reading equals $37° 18' 20'' \div 2 = 18° 39' 10''$; if, therefore, the vernier is set to this angle, the cross hairs

* This refers, of course, to observations made at night; and the student is referred to Hannay's *Astronomical Ephemeris*, price sixpence, for the elements of the planets and fixed stars, by the aid of which they may be known, and their distance from the meridian approximately determined.

will point in the direction of the true meridian; a strong peg should then be driven into the ground in the line of sight, and on opposite sides from the observer, and small nails driven into these pegs, marking the precise direction of the meridian for future reference. The meridian may also be set out by equal altitudes of the sun, but in this case there is a correction to be made for the sun's declination during the interval, amounting to several minutes. To calculate the amount of this correction, the time of each observation must be noted.

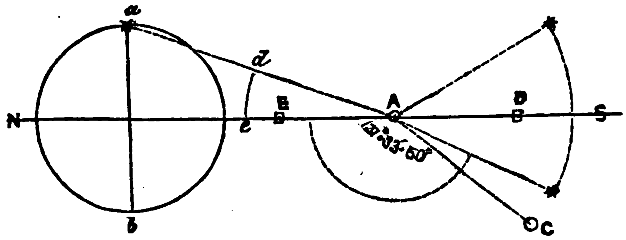


FIG. 61.

*Practical Rule.**—To the log. secant of the latitude, add the log. of half the change of declination during the interval, and the log. cosecant of half the interval of time between the observations turned into space; the total sum—20 will be the log. of the correction in seconds of space.

TO SET OUT THE MERIDIAN BY THE AZIMUTH OF THE SUN.

The azimuth of the sun is the distance of its centre from the north point or meridian at the instant of observation. But as it cannot be calculated without a knowledge of the latitude of the place of observation, I presume it will not be out of place to introduce here all the necessary elements, in order to enable the student to perform his calculations without reference to other works.†

TO FIND THE LATITUDE.

Set up the transit instrument at station A, Fig. 61, and after adjusting and putting a coloured glass on the eye-end of the telescope, direct it to the sun just before it arrives at the point D;

* Frederick William Simms on *Mathematical Instruments*.

† Those who desire to enter more fully into astronomical calculations may consult Part the Second of Chambers' *Practical Mathematics*, Woodhouse's *Astronomy*, Herschel's *Astronomy*, or Hutton's *Mathematical Dictionary*.

make the horizontal wire coincide with the lower limb, and follow it by turning the tangent screw to the body and vertical circle, until, by continually reading off the vertical circle, it appears to remain stationary, and at the same altitude; the reading on the vertical circle will then point out the sun's observed meridian altitude =say 48° 9′; then adding the semidiameter=15′ 58″, will give the altitude of the sun's centre=48° 24′ 8″, deducting 50″ for refraction* =48° 24′ 8″, and adding 6″ for parallax=48° 24′ 14″= the true altitude of the sun's centre, and 90°−48° 24′ 14″=41° 35′ 46″=the zenith distance. If the place is situated northward, and the sun's declination also to the north, add the declination corrected for the longitude to the zenith distance, the sum will express the latitude of the place of observation; thus the sun's declination=10° 13′ 10″, adding 8′ for difference in longitude west =10° 13′ 18″+41° 35′ 46″, the zenith distance=51° 49′ 4″= true latitude; but an average of several observations gives 51° 49′ 27″ 35‴, for the true latitude of Cinderford. The polar distance of any celestial object may be found by deducting its declination from 90°, when the declination and latitude are north; but when of different names add the declination to 90, the difference or sum in the first or second case will be the polar distance. The colatitude of a place is the latitude of the same place deducted from 90°.

TO CALCULATE THE AZIMUTH.

Observation.—Set up the instrument at A, Fig. 61, and as directed for finding the meridian altitude; direct the telescope to the sun after it has passed the meridian about 2 or 2½ hours, as at C, and make the horizontal wire touch the lower limb, and the vertical wire the eastern limb;† read off the altitude from vertical circle, and clear it from refraction, parallax, &c.=32° 40′ 5″; this deducted from 90′=47° 19′ 55″, the zenith distance, the polar distance is=78° 42′ 7″, and the colatitude 38° 10′ 32″; add together the polar distance, colatitude, and zenith distance, and divide them by two; call the remainder=S; from the remainder, or S, deduct the polar distance, or P; call the remainder S−P; then

* Tables of mean refraction parallax, and with others equally necessary, will be found in Chambers' *Mathematical Tables*, price 3*s*. 6*d*.

† It is to be understood that when the observation is not made to the centre of the sun, its semidiameter must be added or deducted from the computed azimuth, according to which limb of the sun was observed.

add together the log. sine of S + the log. sine S − P + log. cosecant of C + the log. cosecant of Z; half these logarithms will = log. cosine of half the azimuth from the north.

Example.

Polar distance =	78° 42′ 7″
Colatitude . =	38 10 32
Zenith distance =	47 19 55
	2)164 22 34
S =	82 11 17
P =	78 42 7
S − P =	3 29 10

Logarithm cosine of	S = 82° 11′ 17″ =	9.9959458
„ „	S − P = 3 29 10 =	8.7836048
„ cosecant of	C = 38 10 32 =	.2090459
„ „	Z = 47 19 55 =	.1336466
		2)19.1222431
Logarithm cosine ½	A = 68° 39′ 0″ =	9.5611215
	2	
	137 18 0	
	0 15 50 =	Sun's semidiameter from the north.
True azimuth* .	137 33 50	

If now the upper plate is released, and the vernier made to read this angle, or 137° 33′ 50″, the cross hairs will strike through the peg at E previously fixed in the meridian, if the operation has been accurately performed. The meridian may also be set out by equal altitudes of a circumpolar star; but this involves several hours before the observation can be made complete: it is therefore preferable to perform it by a single observation, thus. Set up the instrument at A as before; direct the telescope to the star (Alioth) in the constellation (Ursa Major), and follow it until it has attained its greatest eastern or western elongation, as at *a* or *b*; leave the instrument clamped, and make the calculation by the following rule: from the log. cosine of the star's declination increase the index by ten, deduct the log. cosine of the latitude, and the remainder will be log. sine of the azimuth, or the star's distance from the meridian = the arc *c d*. Then if the zero of the instrument was set on the star at its greatest

* If the western limb of the sun was observed, add the semidiameter; and if the eastern limb, deduct it from the azimuth.

elongation, or at $a=360°$,—the star's distance will give the angle on the limb; the vernier must be set in order for the telescope to point due north, or in the true meridian. When speaking of observations taken at night, if the instrument used has no lantern (which it should have), by which the cross hairs may be illuminated through the transit axis, the observer must hold a faint light to the object-glass in order to see the cross hairs distinctly.

TO DETERMINE THE DIFFERENCE BETWEEN THE TRUE AND MAGNETIC MERIDIAN.

Set up the miner's transit theodolite at the peg A, and set the zero of the upper and lower plate to coincide; turn the whole instrument round until the compass-needle points to its own north, or zero, which it should be made to do with the body tangent screw; release the upper plate, and bisect the peg D or E with the cross hairs; the angle may then be obtained from the horizontal limb; the minutes from the opposite vernier should also be read off, and an average of the two used; the angle as pointed out on the horizontal limb will be the difference between the true and magnetic meridian.

LAND OR SURFACE SURVEYING IN CONNEXION WITH UNDERGROUND.

TO SURVEY WITH THE CHAIN ONLY.

Chain surveying has not much pretension to accuracy, and is much more limited in its capabilities when not accompanied with an angular instrument, being in all cases confined to one figure—viz., a triangle; it will, however, serve for temporary purposes when the miner has no angular instrument at hand, and when his surface operations are not extensive. To complete a survey with any degree of precision, the student should range a line through the middle of that part of the surface he intends surveying, calling it the base line; he may then form a triangle upon it, enclosing all he possibly can of the estate in it. The whole detail of fences may then be run in by forming other triangles upon any of the sides of the original ones, in a continuous order, until complete; or he may perform it by enclosing the whole extent of surface in one large triangle, as before, and then running the base or tie-line from the apex of the triangle through the greatest extent of ground to be surveyed. In measuring lines it must be remembered that if the ground is irregular or hilly, it must be reduced to horizontal measure. The student will find no difficulty in performing this after reading the chapter on Trigonometry in this work. It may, however, be done in the field by holding one end of the chain some distance from the ground until it appears to be horizontal, suspending a plumb-bob on the end of it, which will point out the place for the chain pin. When measuring lines in any given direction, the position of all fences, houses, brooks, &c., within a chain of the line, must be determined by offsettings taken to them, and entered down in the field-book as right and left offsets; they are generally taken with a deal rod, ten links in length. The link lines in the diagrams represent the boundary fences, and the dotted lines the measured lines.

The survey of a road A *b*, &c., to B, Fig. 62, may be taken by setting up a pole at A, and ranging the line A and B, which is carefully measured, taking offsets from it to all the bends in the road, as A *a*, *b b*, &c. to *e* as left, and *f*, &c. to B, as right offsets. A survey of the woodland, Fig. 63, may be taken by ranging the lines A B, B C, and A D, with poles; continue the line

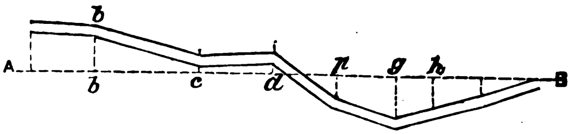


FIG. 62.

D A to *a*, say A *a*=100 links; continue B A to *b* the same distance as A *a*; measure *a b*, determining the angle D A B; measure A D and A B, taking offsets to all the irregularities in the boundary; continue the line A B to *e* 100 links, and also C B to *d* the same distance; measure *e d*, which will determine the angle A B C; also the lines B C and C D may now be measured,

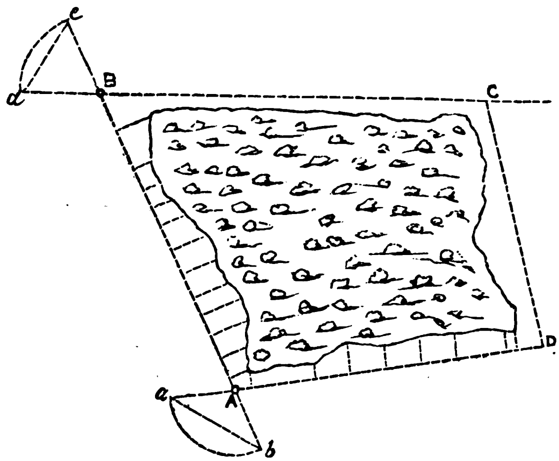


FIG. 63.

taking offsets to the boundary as before; the survey will then be complete. The method of plotting the preceding survey will be obvious to the student; he may draw the line A B at pleasure, making it the exact measure; set off from A to *b*, and B to *c*, each 100 links; take with the compasses, from the same scale, the distance *a b*; set one point at *b*, and describe an arc of a circle; describe an arc from A, with 100 links, as radius, the intersection of these two arcs will be a point in the line A D; draw the line A D through the points *a* A, and produce it to D; set off its measure, which will determine the position D; the same operation at B will also determine that of C. It is now evident that all is right if the line C D will come in: but if it is found too short or too long, an error has been committed in some part of the work. To survey Fig. 64, it will be first necessary to run a line through its greatest length at A B, which will form a base for the other lines, and divide it into two triangles; the lines A B, A C, B C, B D, and D A, being all measured, the plan may be easily constructed by drawing the line A B its exact length; then describing two arcs with the measured distances B C and A C, their intersection will determine the position of C; that of D may be found in a similar manner. If the surveyor desires to

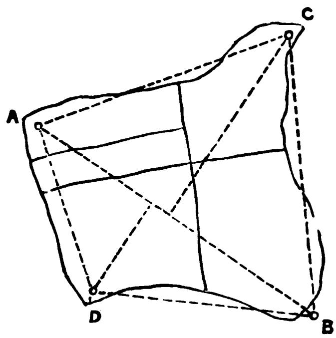


FIG. 64.

extend his survey, he may do so by taking one of the side lines D A or B C as a new base, as in Fig. 65, where B C becomes a base to the triangle C B F. E C becomes also a base to the triangle C E F; or if the point F can be seen from B, run the line B F as a base to the whole.

Before commencing a survey of the boundary and interior fences of Fig. 67, it would be advisable for the student to examine the ground, in order to run the necessary lines (forming the triangle which incloses the greater part of the estate) in the most advantageous direction. Having determined on this, we will commence running the lines. Plant a strong flagstaff at B, Fig. 66, this point being chained on from A, and as you proceed with the measurement of this line, as with all other principal lines, leave marks, or false stations, before or after crossing all fences, brooks, roads, &c., entering down in the field-book the total distance from the commencement to these points, leaving marks at *d* and *e*, as most probably they will be required in running other necessary lines at a more advanced stage of the survey; we next plant a staff at C, chaining on it also, leaving false stations at *a* and *f*, as before; erect another pole at A, the starting point, chaining on it also, leaving false stations at *b* and *g*; we shall then have enclosed a greater part of the six fields composing the estate in one large triangle A B C. The next process will be to run a line A D through the centre of the property; this line should also be accurately measured, leaving false stations at J and *k*; enter the total lengths to these points in the field-book;

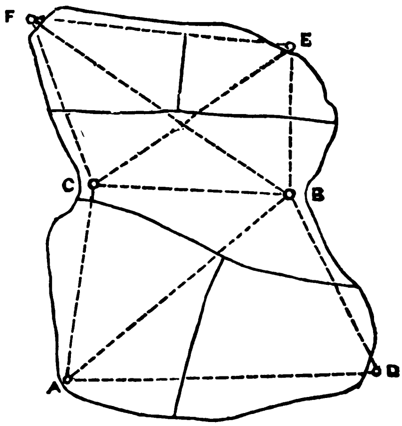


Fig. 65.

the line D E must then be ranged and measured through the false station previously fixed at *g*; from E measure to A, ranging the line E A through the false station *h*, previously fixed. We now return to the false station *b* on the line C A, ranging it through the stations left at *k* and *d*, measuring as we proceed, until arriving at *d*; the line should be continued on to *c*; we then commence again at A, ranging and measuring a line through *c* to G; and from G we range another line through the false station *e* on A B, continuing it to *a*; we must now commence at B, ranging and measuring a line to D, and from D to C, and finally from *h*, on the line E A, through the false station J, to the boundary; the survey will then be complete. It will hardly be necessary to say that, when plotting the preceding survey, the same order must be observed in plotting as in measuring the lines in the field; and that when the triangle A B C and the centre line A D are accurately laid down, and pencil marks left representing the false stations in the field, the other lines drawn through these marks cannot but come in for length and direction. In a similar manner the student may survey any number of fields by extending the triangulation; that is, other triangles formed upon the side of one of those previously employed, as A B, or C D, &c., for a new series. The student should be careful to test the accuracy of his chain by some standard every day before he commences his work, as by continual use some of the links get curved, or shortened, and others longer, by stretching, and of course finally give inaccurate results.

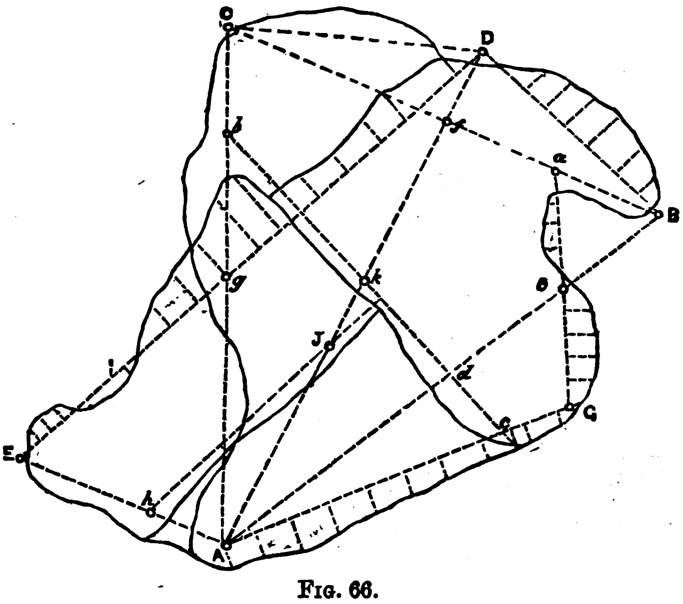


FIG. 66.

SURVEYING MINERAL LOCALITIES FOR WORKING PLANS, ETC.

Before commencing the plant at any mine, a general survey of that part of the mineral locality which is intended to be opened up should be made, and a correct plan constructed from it. The map so constructed should contain (in addition to all that is usual to be found in maps) the boundaries of the mineral property, also the position and extent of old cropping workings, where the mineral vein or load crops out, likewise that of any existing faults or dislocations, its direction, &c., the nature of the adjoining strata, &c. &c., with any other geological or mineralogical information that is likely to be useful, and may tend to assist the mining agent or engineer in setting out the winding shaft in such a position that it shall embrace as great a depth, and as long a range of level course, as may be conveniently obtained, having due regard to the proximity to existing railways, which is generally a ruling condition. If the surveyor has no reference to existing old plans of the locality about to be surveyed, he should examine the ground, and make a pencil-sketch plan of it, by which he will at once perceive the best method to be employed in pegging it out. In performing this he must exercise some judgment and care in running his lines, so that they may pass clear of all obstacles, embracing, at the same time, the greatest amount of work. He will find that, by having due regard to this point, he will save himself a vast amount of valuable time when completing the survey; much, however, depends on the facilities offered by the locality, as in some places greater difficulties occur than in others. If the property is open and free from impediments, the survey may generally be accomplished by enclosing it in two or more large triangles, which will be sufficient for obtaining the exterior boundary; the interior details may be obtained by forming other smaller triangles on the sides of the large or primary ones. If, on the contrary, the mineral property is covered with thick woodlands, such as enclosures, it will then be a difficult matter to run straight lines in any given direction without obstructions; and it would be much better to make a circuitous survey or traverse of it, going by any open roads in the general direction. The boundary marks having been previously found, may be connected to the circuitous survey (if not too far distant) by offsetting, otherwise a point in the traverse must be selected, and a new series of angles taken or traversed in the direction, and until arriving at the separate boundary marks indicating the limits of the mineral property. It will be needless to say that when the survey is plotted, lines drawn from these points will give the figure and extent of the gale or mineral property in question.

If we take Plate 3 as an example, it will be seen that the greater portion of the surface to be surveyed was enclosed by the triangle A B C and A B D, by first carefully measuring the angles B A C, B A D, and C B D, ranging and measuring the lines A B, B C, C A, A D, and B D. The interior details were then taken by ranging and measuring other lines from known false stations previously fixed in the lines forming the primary triangle, as explained in chain surveying, Fig. 66; all the boundaries, natural or artificial objects, were thus readily and correctly obtained. The student will now readily understand how the other positions of the surface shown on the plan may be obtained, by ranging other lines from the angular points D, B, and C, thus enclosing it by forming another triangle upon A C, C D, and B D, as bases. The student will do well to copy the working plan contained in Plate 3, when he may supply the requisite lines for taking off the other portion of the surface.

BEST KIND OF FIELD SURVEY BOOK.

A great difference of opinion exists among practical surveyors as to the best mode or form a survey or field-book should be kept in; one party prefers and urges that it should be kept in a tabular form; others are advocates for a hand sketch; while a third party informs us that a mixture of the two would be the best to be adopted. In some cases, the first method would possibly be employed to advantage, but when the survey is extensive, and contains many intricacies, the hand sketch is most undoubtedly to be preferred, the former requiring to be plotted immediately, whereas the latter may remain aside any length of time, and then be plotted as readily as when taken. However, it is a matter of indifference which mode is preferred, so long as the student abides by his choice, as it is a very bad practice indeed to sketch in one portion of a survey, and tabulate another; such a practice would confuse the field-book, and, of course, render it worse than useless. That mode of keeping a field-book to which I have always resorted, has been a mixture of the tabular and hand sketch, being, in my opinion, the most concise, and requiring the least space in the field-book.

The Field Book, Plate 4, by which part of the working plan, Plate 3, was constructed, was taken in this manner. It will be seen by reference to the working plan, and compared to the field notes, that the lines, boundaries, &c., are sketched in the direction in which they run, and the distances written at right angles to the direction in which they were measured. Thus we measure from A to 2480 links the first false station, which is distinguished from other numbers thus, F (2480) S, sketching every object that occurs in its proper direction; we then measure from F S 2480 to F S 2920 on the line B C; return to F S 1020, we measure to F S 1800 on the line C A; we now return, and continue the base line from 2480 to the next false station, or F S 3760; measuring from 3760 to F S 2190 on the line B C, we obtain the fences in this direction. Thus, by continuing the process, we get all the detail of fences and other objects from the base line to the right. The extreme boundaries may be better obtained when measuring the side of the triangle on the line B C. It is now a general rule, and of the greatest advantage, to begin the entries in the field-book at the bottom of the page, writing upwards; the reason is obvious, as it places the survey-book in the same relative position as the station lines with respect to the surveyor, who advances towards the distant station. The method of keeping the survey-book has been sufficiently explained by this time to enable the student to enter down any survey in a similar manner.

REDUCING THE ANGLES AND PLOTTING THE WORK.

When a survey is taken by enclosing the surface in one or more large triangles, the angles formed by the intersection of the sides of the triangles with each other require no reduction, and may therefore be plotted at once; but when the survey cannot be taken in this way, but by a circuitous route, it then becomes necessary to reduce the series of angles taken to a common meridian, to be protracted from one line by the theodolite protractor. The method of the reduction is clearly explained by example in section 1 of Subterraneous Surveying, under the head of, To Reduce Horizontal Angles to Plotting Angles from one Station; or it may be more accurately performed by preparing a form similar to Office Form No. 1, Section 1, using the natural sines and rules appended for that purpose. The working plan may be constructed by first assuming a line on the drawing as a base line A B, making it the exact length ascertained by measurement; the points C and D may then be accurately found either by protracting the observed horizontal angles formed by the lines and the base A B, or by intersection from their measure of length.

When the primary triangles are thus laid down, their measure of length should be tested by the rules of oblique-angled trigonometry, assuming the base and angles to have been correctly taken. If the process agree with the length of the lines ascertained by measurement, it is a satisfactory conclusion. The scale which the plan is intended to be drawn to should be applied to the base line A B, Plate 3, with its zero division coinciding with the commencement of the base or apex of the triangle, and all boundaries marked off from it, with the offset scale, with all false stations. The same operation to be applied to the other lines B C, C A, A D, and D B; the secondary lines should now be run in from the false stations on one line to those on another, exactly in the same order they were taken and occur in the field-book. The scale may be applied to these lines also, and the boundary fences and other objects marked off with the offset scale, until they are all run in. If other false stations occur on any of the secondary lines, as they frequently will, lines forming a third series may be run from them in the required direction, and treated with the scale as the other lines. The points left in the boundaries from the offset scale having been pencilled in, may now be permanently inked in with the drawing pen, when the plan will be complete. The next thing to be attended to, before the lines of construction are rubbed out, is the boundary stone, or marks known as Gale or Royalty marks; these should have their proper places assigned to them on the plan, as Nos. 1, 2, 3, 4, 5, and 6. Lines drawn from No. 1 to 6, 1 to 2, 2 to 3, 3 to 4, 4 to 5, and 5 to 6, define the boundaries, figure, and extent of the Gale Royalty, or mineral property under consideration.

If there are any underground workings to be connected to the surface plan thus constructed, they may be connected by first sighting out or producing the line *a b* in direction of the cutout on the surface, according to the explanation given in Figs. 54 and 56, section 1 of Mining Surveying. The angle this line makes with the true meridian previously set out, may be measured and transferred to the plan, from which all the underground cutouts, headings, and other workings may at once be plotted down.

The underground excavations should be plotted from the planes of the meridian or latitude, as explained in section No. 1 of Subterraneous Surveying; the mine agent will then be enabled to rely on the accuracy of his surface plan, and the working so connected to it.

DESCRIPTION OF SCALES FOR WORKING PLANS.

Working surface and underground plans ought, for the sake of clearness, to be plotted to as large a scale as possible, if the subterranean workings are of small extent, or if the plan is required merely for driving a heading from one place to another, a scale of 1 chain to an inch would be convenient, or a scale of 2 inches to a chain would be still better, as in the latter case the plotting could be made to a single link; but if the subterranean workings are extensive, then the plan would best suit drawn to a scale of 2 or 3 chains to an inch. In all cases the same scale should be used for the surface as for underground; plans of works required for reference only are best drawn to a scale 4, or even 6 chains to an inch.

COLOURING AND LETTERING PLANS.

The mining agent or engineer, on whom generally devolves the task of constructing maps and plans for mining purposes, cannot, from the limited time he has to devote to it, be expected to produce beautifully drawn, finished plans; neither, indeed, is it at all necessary or required, since it would be much more beneficial to devote the time required for such productions to other branches of his calling requiring immediate attention.* Colouring is optional, and if the service—that is, fields, woods, brooks, &c. &c., are to be coloured, it is much better to have the underground headings and other workings drawn in ink only; on the contrary, if the underground excavations are to be coloured, then the surface would be much better drawn in ink only. Houses are generally coloured red with carmine; brooks, rivers, or ponds of water, are coloured blue; enclosures, pleasure fields, &c., green; and all other fields, of whatever colour the draughtsman thinks most suitable, having a care to produce as much contrast as possible; underground works are generally coloured of a dull red colour.† The plan should have the name of the mine, with

* Plate 8 is given as a good specimen of conventional signs, and shows how different ground may be represented and coloured.

† Those who desire to practise colouring, mapping, lettering, &c., are referred to B. P. Wilme's *Civil Engineer's Handbook for Mapping*, where are to be seen some beautiful specimens of finished maps, plans, &c.

those of the owners, also those of the surveyors, written in plain lettering in a spare corner of the plan, and the date at which the plan was constructed, &c. The names of enclosures, fields, &c., should be written and disposed in parallel lines from west to east; those of railways, brooks, and other objects, may be written in the direction in which such objects occur. The scale by which the plan is constructed should be accurately drawn on the plan; it will then lengthen and shorten, by change of temperature, in the same proportion as the plan itself; consequently, it is oftentimes more to be depended on than the original scale by which the plan was constructed.

SETTING OUT RAILWAYS TO MINES.

Railways to mines may easily be set out when the natural features of the ground present no great irregularities; on the contrary, the least expensive, most convenient, and best line of railway, between the starting-point and the mine, is most satisfactorily determined by levelling.

The engineer may best determine on the route to be taken, if at long distance, from a correct map, showing the direction of watercourses, which is a good guide as to the inclination of the country; and as watercourses, such as rivers, brooks, &c., present great uniformity in their inclination, they materially assist the eye in judging the inclination and direction the railway should take. Levelling operations are then commenced along two or more separate directions, and trial sections made representing the valley lines along which the levelling was conducted; the engineer then selects the line represented by that section which has the slowest gradient, the least curves, and fewest engineering difficulties of construction. If the map by which the direction of the trial section was determined, was purposely constructed, and to be depended on, the straight and curved positions of the railway are laid down on the map, and are then to be transferred to the ground, and marked out roughly with strong pegs; a levelling operation is then carefully conducted along the entire line, and an accurate section made from it, by which may be determined the amount of cutting and embankment, height of roads, &c. &c.; after which the entire line, with its curves, is to be accurately set out and marked on the ground ready for execution.

The general section having been prepared, and the gradients, if any, calculated by the rule given in section 2, on Subterraneous Surveying, the pocket section may then be deduced from it. The following example, Plate 5, will illustrate the method of setting out any part of a railway from the pocket section; take Plate 5 for a cutting to be worked from both sides.

At peg 27 chains we are to have a formation height of 114.50 feet above the datum line A D, and the height of surface is 110.25; set up the levelling instrument at any convenient spot, and direct a man to hold the levelling staff on the peg 114.50 feet; read off, suppose it to be=6.20 feet; then 114.50−110.25= 4.25 feet, height of embankment, and 6.20−4.25=1.95; and if the staff is held up until the engineer can read through the level telescope 1.95 feet, it is certain that the lower part of the levelling staff will be at 4.25 feet above the surface line, or at 114.50 feet above datum, and consequently at formation height. The engineer may then direct a staff to be carried along the centre line, and in direction of the intended point of cutting until he reads through the levelling telescope 1.95 feet; he will then have found a point along the centre line on a level with the proposed formation height at peg 110.25 feet. The gradient, however, is 1 in 132, or .5 per chain; the intended formation, therefore, at this point, must be lower than 110.25 by 1 in 132, depending on the distance from the peg at 110.25; say this distance=to 50 links, or half a chain, our formation height will then be=to $110.25-\frac{.5}{2}=110.00$, or .25 lower; now, by adding .25 to 1.95, we shall have 2.20; then if the staff is brought nearer, until the reading 2.20 is found, it will give a point on the surface, and at an inclination of 1 in 132 for the cutting; a strong peg should now be driven in until reading off the staff we have 2.20, and another at 110.25, until we have 1.95; we shall then have two pegs at the required formation height 50 links asunder, and any excavators may find other points in the incline as the excavation proceeds by a process called boning, until other correcter levels are set out for his guidance. Boning is carried on with boning rods similar in formation to T squares, as follows:—Suppose *a b*, Fig. 67, are two pegs driven into the ground to a certain depth, and to any given inclination, if on each of these pegs there are placed boning rods of the same height, and held perfectly perpendicular, it is evident that the tops or heads of these rods will be parallel to the incline A B; and if any person carries a third rod along the intended slope, the top of it will be in line with the tops of the other two, if the incline is correct; on the contrary, if it is too high or too low, it must be depressed or raised until a line agrees with the tops of the boning rods. This method is, of course, only a coarse approximation, being intended only for temporary guidance to the excavator. We will now return to Plate 5, and also to the other end of the intended cutting. At formation 101.00, the surface height is=95.30, and

101.00−95,30=5.70 for embankment. Set up the level at a convenient point, and the staff on the peg at 101.00; read off, suppose=10.10 and 10.10 − 5.70=4.40; if the staff is raised up until this depth is read off, the foot of it will be again a formation height; now direct the man with the staff to move along the centre line until this 4.40 is again read off, we shall then have a point level with the intended height of embankment. The gradient being uniform, allowance must be made for it as before, thus 4.40−0.5=3.90; if now the staff is moved along the centre line until from the level we read off 3.90, we shall find the new point for formation at the proper inclination. This example has been devised* purposely for the benefit of those who may have occasion to set out branch railways to works, which generally, however, are not of any great length.

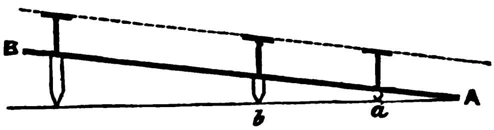


FIG. 67.

Railway curves are of frequent occurrence, and, in fact, no very long length of line can be formed without them; they, however, cannot be laid out accurately except by system, and must start from or join into straight pieces of railway at a tangent, that is, the straight portions should be tangential to the curves at the point of junction. A few gauge rods shod with iron shoes, two or more plumb-bobs, a measuring rule and pegs, are requisite in setting out curves. When the radius of the curve is given, it may be set out after calculating the tangential and deflection distance by the following rule:—When the chord is 100 links $c\ d$ in inches $= \dfrac{792}{\text{radius of the curve in chains}}$ 792 being the number of inches in a chain, or 100 links, if the curve is 20 chains radius, *i.e.* A D=20 chains, then $c\ d = \dfrac{792}{20} = 39.6$ inches, and the tangential distance $a\ b = \dfrac{39.6}{2} = 19.8$ inches. To obtain the first point in the curve, measure from A to the point of contact, 100 links

* Those who desire to enter more in detail of railway construction may consult Brees's *Railway Practice*.

TABLE OF GRADIENTS FOR UNDERGROUND RAILWAYS OR OTHER ROADS.

Of a Foot.		Of an Inch.								
.0125	or	.15 per	Chain	=	1 in.	5280	or	1	foot	per Mile.
.0250	„	.30	„	=	„	2648	„	2	„	„
.0375	„	.45	„	=	„	1760	„	3	„	„
.0500	„	.60	„	=	„	1320	„	4	„	„
.0625	„	.75	„	=	„	1056	„	5	„	„
.0750	„	.90	„	=	„	880	„	6	„	„
.0875	„	1.05	„	=	„	754.2	„	7	„	„
.1000	„	1.20	„	=	„	660.0	„	8	„	„
.1125	„	1.35	„	=	„	586.6	„	9	„	„
.1250	„	1.50	„	=	„	528.0	„	10	„	„
.1375	„	1.65	„	=	„	486.0	„	11	„	„
.1500	„	1.80	„	=	„	440.0	„	12	„	„
.1625	„	1.95	„	=	„	406.1	„	13	„	„
.1750	„	2.10	„	=	„	377.1	„	14	„	„
.1875	„	2.25	„	=	„	352.0	„	15	„	„
.2000	„	2.40	„	=	„	330.0	„	16	„	„
.2125	„	2.55	„	=	„	310.6	„	17	„	„
.2250	„	2.70	„	=	„	293.3	„	18	„	„
.2375	„	2.85	„	=	„	277.9	„	19	„	„
.2500	„	3.00	„	=	„	264.0	„	20	„	„
.2625	„	3.15	„	=	„	251.4	„	21	„	„
.2750	„	3.30	„	=	„	240.0	„	22	„	„
.2875	„	3.45	„	=	„	229.5	„	23	„	„
.3000	„	3.60	„	=	„	220.0	„	24	„	„
.3125	„	3.75	„	=	„	211.2	„	25	„	„
.3250	„	3.90	„	=	„	203.1	„	26	„	„
.3375	„	4.05	„	=	„	195.5	„	27	„	„
.3500	„	4.20	„	=	„	188.6	„	28	„	„
.3625	„	4.35	„	=	„	182.1	„	29	„	„
.3750	„	4.50	„	=	„	176.0	„	30	„	„
.3875	„	4.65	„	=	„	170.3	„	31	„	„
.4000	„	4.80	„	=	„	165.0	„	32	„	„
.4125	„	4.95	„	=	„	160.0	„	33	„	„
.4250	„	5.10	„	=	„	155.3	„	34	„	„
.4375	„	5.25	„	=	„	150.8	„	35	„	„
.4500	„	5.40	„	=	„	146.6	„	36	„	„
.4625	„	5.55	„	=	„	142.7	„	37	„	„
.4750	„	5.70	„	=	„	138.9	„	38	„	„
.4875	„	5.85	„	=	„	135.4	„	39	„	„
.5000	„	6.00	„	=	„	132.0	„	40	„	„
.5125	„	6.15	„	=	„	128.8	„	41	„	„
.5250	„	6.30	„	=	„	125.7	„	42	„	„
.5375	„	6.45	„	=	„	122.8	„	43	„	„
.5500	„	6.60	„	=	„	120.0	„	44	„	„
.5625	„	6.75	„	=	„	117.3	„	45	„	„
.5750	„	6.90	„	=	„	114.8	„	46	„	„
.5875	„	7.05	„	=	„	112.3	„	47	„	„

in the same direction as the line O A, Fig. 68; set off the perpendicular from *a*, or the tangential distance *a b*=19.8 inches, then will *b* form a point in the curve; set a pole at A, and range a line through the point *b* to any length, measure from *b* to *c* 100 links, and from *c* set off perpendicular to the line *b c* the deflection distance *c d* = 39.6 inches. Then will *d* be a point in the curve; the other points in the curve, as *s*, *h*, *j*, *l*, *n*, &c., may be found exactly in the same manner; and in order to pass from the curve A *n* to a tangent at B, use the tangential distance 19.8 instead of the deflection distance 39.6. If it is required to find the radius without construction, it may be found thus:—Set up a theodolite at *c*, and measure the ∠ A C B, and one of the sides, as A C,

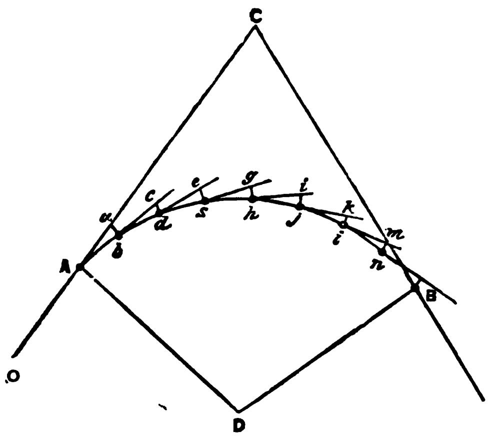


FIG. 68.

then as the cosine of half ∠ A C B is to the sine of ∠ A C B, so is the log. of the side A C to the log. of the radius A D. If we wish to set out the same curve by deflection angles, instead of deflection distances, the angles may be calculated by the following rule, thus:—Divide half the given chord by the radius of the curve in feet, the quotient will equal the natural sine of half the deflection angle. Thus: $\frac{100}{2}$=50 links=33 feet, and $\frac{33}{1320}$ = .025, the sine of the angle 1° 25′ and 1° 25′ × 2 = 2° 50′, the deflection angle. The deflection distance may also be found by multiplying double the natural sine by the chord in feet, calling the first figure feet, and the remainder inches and parts of an inch. Thus: .025 × 2=.05 × 66=3300 or=39 inches, nearly the

TABLE OF OFFSETS FOR SETTING OUT CURVES.

Radius in Chains and Feet.		Offsets in feet, inches, and parts.	Radius in Chains and Feet.		Offsets in feet, inches, and parts.
Chains.	Feet.	Feet, inches, &c.	Chains.	Feet.	Feet, inches, &c.
2	= 132	32 10 0	41	= 2706	1 7 3
3	= 198	22 0 0	42	= 2772	1 6 8
4	= 264	16 6 0	43	= 2838	1 6 4
5	= 330	13 2 4	44	= 2904	1 6 0
6	= 396	11 0 0	45	= 2970	1 5 6
7	= 462	9 5 1	46	= 3036	1 5 2
8	– 528	8 3 0	47	= 3102	1 4 7
9	= 594	7 4 0	48	= 3168	1 4 5
10	= 660	6 7 2	49	= 3234	1 4 1
11	= 726	6 0 0	50	= 3300	1 3 8
12	= 792	5 6 0	52	= 3432	1 3 2
13	= 858	5 0 9	54	= 3564	1 2 7
14	= 924	4 8 6	56	= 3696	1 2 1
15	= 990	4 4 8	58	= 3828	1 1 7
16	= 1056	4 1 5	60	= 3960	1 1 2
17	= 1122	3 10 6	64	= 4224	1 0 3
18	= 1188	3 8 0	68	= 4488	0 11 6
19	= 1254	3 5 7	70	= 4620	0 11 3
20	= 1320	3 3 6	74	= 4884	0 10 7
21	= 1386	3 1 7	78	= 5148	0 10 1
22	= 1452	3 0 0	80	= 5280	0 9 9
23	= 1518	2 10 4	84	= 5544	0 9 4
24	= 1584	2 9 0	88	= 5808	0 9 0
25	= 1650	2 7 7	90	= 5940	0 8 8
26	= 1716	2 6 5	94	= 6204	0 8 4
27	= 1782	2 5 3	98	= 6468	0 8 0
28	= 1848	2 4 3	100	= 6600	0 7 9
29	= 1914	2 3 3	105	= 6930	0 7 5
30	= 1980	2 2 4	110	= 7260	0 7 2
31	= 2046	2 1 6	120	= 7920	0 6 6
32	= 2112	2 0 8	130	= 8580	0 6 1
33	= 2178	2 0 0	140	= 9240	0 5 6
34	= 2244	1 11 3	150	= 9900	0 5 3
35	= 2310	1 10 6	160	= 10564	0 4 9
36	= 2376	1 10 0	170	= 11220	0 4 6
37	= 2442	1 9 4	180	= 11880	0 4 4
38	= 2508	1 8 8	190	= 12540	0 4 2
39	= 2574	1 8 3	200	= 13200	0 3 9
40	= 2640	1 7 8	220	= 14520	0 3 6

same as before. Set up the theodolite at A, Fig. 68, and sight back along the straight part of the railway at O, revolve the telescope vertically in the direction A *a*, set the vernier to half the deflection angle 2° 50′=1° 25′, which is the tangential angle, the cross hairs will then strike a point in the curve at a distance of 100 links from A or at *b*; remove the instrument to *b*, and sight back to A, revolve again vertically, and produce the line A *b* in the direction towards *c*, set the vernier to the deflection angle =2° 50′, and the cross hairs will again strike a point in the curve at a distance of 100 links from *b*, or at *d*. The same operation must be carried on at all the stations until arriving at *n*, when we must return to the point of contact with the tangent at B by the tangential angle, or = 1° 25′. If it is required to pass from one curve to another of a different radius, set up the theodolite at C, Fig. 69, sight back to the end of the 100 link chord at *a*, set the vernier of the instrument to the tangential angle A C *a* of the curve *n a c*, the telescope wires will then form the line A C B, the common tangent at the juncture of the two curves C, lay off the tangential angle calculated for the other curve *b m* C, making the chords C *b*=to 100 links. The curve just laid out would be what is generally termed a compound curve, and is of frequent occurrence in railway practice. If we wish to pass from one curve to another in an opposite direction, termed a reverse curve, it may be performed by setting up the theodolite at *a*, Fig. 70, sighting back to the end of the 100 link chord at *b*, laying off the tangential angle *b a e* of the curve *b d a*, then from the tangent line *e a o* set off the tangential angle *o a n* of the curve *a s n*, making the chord *a n*=100 links. In deep cutting, it is of the greatest importance to well examine the soil through which the railway is to pass, in order to give the proper and necessary slopes. Experiment proves that the following materials will stand better at one angle than another, thus:—Fine dry sand at the angle 35° 30′, loose dry shingles

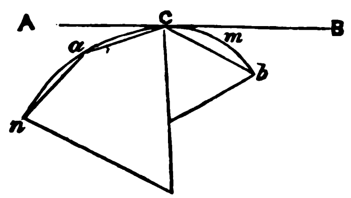


Fig. 69.

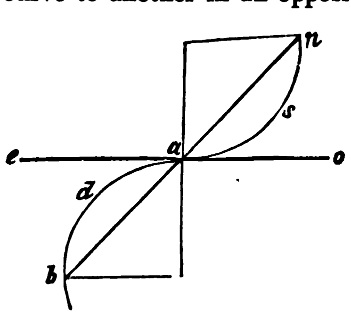


Fig. 70.

at 39°, solid damp earth 54°, common gravel about 35° 30′, wet gravel at 36°, loose gravel at 37° 30′. The slope most generally given to cuttings and embankments of the above description is 1 foot in 1½, or 1 to 1½, but this will very much depend on the nature of the soil, and therefore must be left to the judgment of the engineer. The contents of cutting, &c., may be found by direct computation, or more easily from tables published on purpose. A good table of this description is published by Bashford. Those who may wish more minute particulars in connexion with railway curves, &c., may consult those works published for that purpose.

In some cases where the height or total rise and ratio of incline are made a fixed quantity, it will be necessary to find the length of base or the horizontal distance between the termination and commencement of the incline, in order to give it the proposed ratio before commencing operations.

The following rule will be found a very useful and practical one in such a case. Suppose it is found necessary to form an incline to a fixed height or total rise = to B C, Fig. 71, of 50.50 feet, and to a ratio of 1 in 14, required the distance from the peg representing the total rise 50.50 feet at C to a point of commencement somewhere along the surface line between C and D.

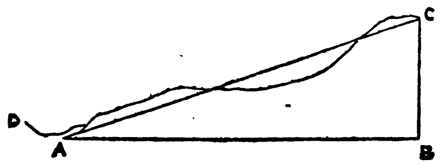


FIG. 71.

Let a = total rise and x = to required base, and b = to the fixed ratio. Then $\frac{a\ b}{x} = b$, therefore $\frac{50.50}{x} = b$, and $\frac{50.50}{x} = \frac{1 \text{ in.}}{14}$ $\therefore x \times 1 = 50.50 \times 14$ and $x = 707.0$ feet for the length of the incline A B.

LONGITUDINAL AND TRANSVERSE SECTIONS.

Longitudinal and transverse sections are of the greatest importance to the mining agent in ascertaining the depth from the surface line to any point selected in the mine; it also presents to the eye all the vertical underground workings occurring in that part of the mine across which the section is taken.

The irregularities of the surface line may be obtained by a levelling operation commencing from any point selected on the plan, and terminating at a similar one. The levelling book may be kept in the same manner—with an additional column for the reduced levels—as that in section 2 of Mine Surveying.

The levels may then be reduced, and entered in a column for that purpose, and the depth at the point of commencement used as a datum line. The section may then be plotted in the same manner as a railway section. The underground vertical workings having been previously determined may be plotted—if they are above the datum previously fixed upon—from the same datum line as the surface. Deep or land headings having elevation or depression must have their proper degree of inclination given to them; all vertical workings will then occupy their true position with respect to those headings and to the surface line. If the line assumed for the datum is at the deepest point in the mine, any number of land headings may be plotted on the same section, although they would not occupy their true position with respect to the surface line—except the surface line was perfectly level—because they would be at a distance from each other transversely, and therefore parallels, yet as regards their vertical distance or height from datum, and from each other upwards, would be perfectly true. Parts of the Field Levelling Book are given, by the aid of which that part of the section from Dean's shaft to the southern land boundary line were plotted; the datum line was taken from the bottom of Dean's shaft, 360 feet below the surface line. This number of 360 feet, therefore, is entered at the head

FIELD LEVELLING BOOK FOR SECTION.

	Bearing.	Back Sight.	Fore Sight.	Elevation.	Depression.	Distance.	Reduced Levels.	Remarks.
				+	−			
1	S. 10° 20′ E.	6.60	13.20	0.0	6.60	600	360.00 −6.60	This levelling operation was performed for a longitudinal section for an iron mine.
2	....	2.20	12.65	......	10.45	930	353.40 −10.45	
3	....	1.40	10.90	......	9.50	1240	342.95 −9.50	
4	....	2.40	12.20	......	9.80	1500	333.45 −9.80	
5	....	6.25	9.85	3.60	......	1910	323.65 +3.60	
6	....	6.50	6.30	......	0.20	2225	327.25 −0.20	
7	....	4.65	6.75	......	2.10	2520	327.05 −2.10	
8	....	5.30	12.90	......	7.61	2830	324.95 −7.61	
9	....	4.72	13.16	......	8.44	3160	317.34 −8.44	
10	....	4.30	9.36	......	5.16	3710	308.90 −5.16	
11	....	10.10	6.20	3.90	......	3940	303.74 +3.90	
12	....	10.02	5.72	4.70	......	4400	307.64 +4.70	
13	....	5.20	13.20	......	8.00	4780	312.34 −8.00	
14	....	8.60	3.20	5.40	......	4945	304.34 +5.40	
15	....	11.80	5.20	6.60	......	5280	309.74 +6.60	
16	....	12.70	4.70	8.10	......	5670	316.34 +8.10	
17	....	9.80	5.30	4.50	......	6010	324.44 +4.50	
18	....	6.70	6.20	0.20	......	6300	328.94 +0.20	
19	....	7.45	6.65	0.80	......	6610	329.14 +0.80	
20	....	10.30	6.10	4.20	......	6920	329.94 +4.20	
							334.14	

of column 8, and the numbers marked + and − in columns 5 and 6, which are the difference of the back and fore sights added to or subtracted from this number, in order to determine the distance from datum to the surface at these points.

The section may be constructed by first drawing a line A B, representing the datum line; the horizontal distances from column 7 are then marked off on the line, and perpendiculars raised from the points thus made. The distances represented by the reduced numbers, column 8, as 360.00, 353.40, 342.95, &c., to 334.14 are then marked off on the perpendiculars previously raised. A line is then drawn from the point so marked off on the first perpendicular, through all the succeeding ones, which will represent the surface line. The underground cut-outs, heading, working, &c., are then laid on the section according to their elevation from the datum line A B; as the land heading at 220½ feet above datum, and at an inclination of 1 in 600, the second land heading at 130 feet, and at an inclination of 1 in 300, &c. &c. In finishing the section, the same remarks apply as for underground working laid down on the plan, that is, if the section is uncoloured the workings would be more easily distinguished when coloured, and vice versâ.

The transverse section, Plate 7, is generally employed to show the depth at which all vertical shafts intersect the lodes, or underlie the position of all cross drifts or levels driven at right angles to the principal headings, the intersection of one lode with another, &c. &c., and may also be made to represent a geological section of the mine across which it was taken, by colouring the different strata their natural colour, &c. The transverse section may be constructed exactly in the same manner as described for the longitudinal section.

LEVELLING WITH THE TRANSIT THEODOLITE.

In levelling operations when the ground rises very abruptly, the "miner's transit theodolite" may be employed to more advantage than the "spirit level." If the latter were used for the purpose over a line whose altitude would probably amount to from 40° to 50°, much time would be lost, to say nothing of the labour that would be entailed for accomplishing the object. The following method, therefore, will render the operation less tedious, and will be found sufficiently accurate for any every-day purpose.

The proposed line of section should be ranged, and pegs driven at all the more prominent changes of the ground; the instrument is then set up at one end of the line, and the horizontal wire of the theodolite made to intersect. A levelling staff at the same height or distance as the axis of the theodolite telescope was set up above the ground. The angle of elevation or depression is then read from both verniers of the vertical circle, the mean of which are entered in the field-book.* The levelling staff is then taken along the entire length of line between the observer and the second station, and fixed at each peg previously driven. The surveyor then reads from the staff the different distances from each successive peg to the visual line passing through the axis of the telescope as it was fixed on the staff at the commencement. These distances are then entered in the field-book, and will require no reduction, as they are the actual distances required to form the section.

When the line is too long to enable the observer to read the ordinary staff, it may be exchanged for a description of staff with

---

* For convenience, the staff should be longer than those generally employed for levelling purposes—say, about 18 feet would be a good length.

a sliding vane, and when it is taken along the line the assistant must slide this vane up or down until the intersection of the telescope hairs bisects it. The measures are then noted down by the assistant, and given to the surveyor at the completion of each separate line. Take diagram Fig. 72 for example, in which A represents the position of the theodolite at the first station, and B that of the staff held at the second station. The irregularities of the ground are represented by pegs driven in as at *a, b, c, d, e,* &c., upon which the staff is successively held, while the surveyor makes the several readings or heights, as *a a,′ b b′, c c′,* &c. The theodolite is now removed from A to B, and before commencing a new line it would be well to take the reciprocal angle of elevation C, which would be a check on the accuracy of the angle as observed from A. The instrument is now turned round

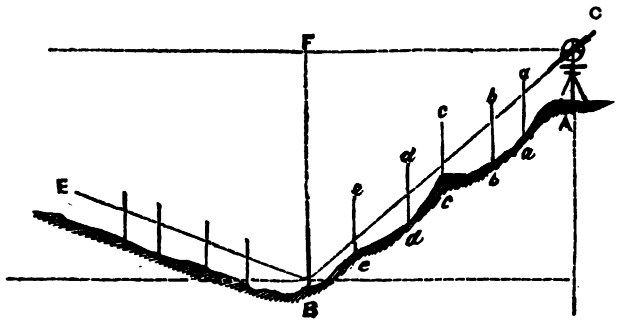


Fig. 72.

in the direction of the section to be taken to E, and the same operation of clamping the theodolite in position, and noting the readings of the staff when carried along the line between B and E as before.

The section may be plotted by first drawing a horizontal line, from which the vertical angles are marked off, and a line drawn through the angular marks representing the line of sight observed through the theodolite telescope. The measured distances are then marked off on this line from C to B, and perpendiculars to the line C F let fall through these points determined by measurement. The several distances from the field-book are then to be set off from the line C B downward, which will represent the different points in the irregularities of the ground, and by drawing a fine line through these points the surface line will be obtained. The total rise, as determined by adding the columns in the field-book, may be corrected by means of the vertical angles and measured hypothenuse, and by the rules already explained for that purpose in Trigonometry.

This mode of levelling has some objections to its general adoption, except for very precipitous places, because the surveyor has to depend on his assistant for noting the distances on the staff when the length of line is so great as to prevent the surveyor from taking the reading himself through his theodolite telescope. There is, however, this advantage—that the surveyor is not at all times obliged to take such long lines; and for my own part I do not see why the section may not be accurately taken, especially with an instrument so finely graduated as the vertical circle of the "miner's transit theodolite," which reads to 20″ of a degree. The observed vertical angles and measured distances also provide an effectual check on the heights, as determined by reading the levelling staff. And what practical man is there who would not employ the method, when by the ordinary process of levelling he had arrived at some dangerous and precipitous ravines, mountainous country, and the like, to cross which would consume much time, owing to the great difficulty in planting the levelling instrument in places from which the staff could easily be read, and from which the staff would not be removed probably more than 20 feet, and consequently require an endless number of readings in a short horizontal distance? On the contrary, the theodolite would most likely take the whole line of section at one sight as before described.

It seldom happens, when levelling with the theodolite, that the line is sufficiently long to require an allowance for curvature and refraction, and on shorter lines than half a mile it would be useless to trouble about it, as there are other disturbing causes that would amount to more than that due to curvature and refraction.

For example, the correction for curvature and refraction, taken together, amounts to—

	Curvature.		Refraction.	
For ½ mile =	.1668	−	.0238	= .1430
„ 1 „ =	.6670	−	.0953	= .5717

Allowances for curvature and refraction are seldom made in levelling operations for short distances; but should occasion require it, the following table will be found useful:—

TABLE OF CURVATURE AND REFRACTION.

Miles.	Yards.	Feet.	Curvature in Decimals of Feet.	Refraction in Decimals of Feet.	Refraction and Curvature in Decimals of Feet.
¼	440	1320	0.041	0.006	0.035
½	880	2640	0.166	0.023	0.143
¾	1320	3960	0.375	0.053	0.321
1	1760	5280	0.667	0.095	0.571
1½	2640	7920	1.500	0.214	1.286
2	3520	10560	2.668	0.380	2.286
2½	4400	13200	4.168	0.595	3.573
3	5280	15840	6.002	0.856	5.146
3½	6160	18480	8.170	1.167	7.003
4	6940	20820	10.672	1.524	9.147
4½	7820	23460	13.546	1.929	11.577
5	8800	26400	16.675	2.382	14.292
5½	9680	29040	20.176	2.882	17.294
6	10560	31680	24.012	3.430	20.581
6½	11440	34320	28.180	4.025	24.155
7	12220	36660	32.683	4.668	28.014
7½	13100	39300	37.519	5.359	32.159
8	14080	42240	42.688	6.884	36.588
8½	14960	44980	48.191	7.718	41.306
9	15840	47520	54.027	8.599	46.308
9½	16720	50160	60.197	9.528	51.596
10	17600	52800	80.707	11.529	57.170

CALCULATIONS OF AREAS.

THE contents of a field, or any number of fields, in acres, roods, and perches, may be found by the following rules:—If the fields are square or rectangular, their contents may be ascertained by multiplying the length taken in links by the breadth in links, the result will express the area in square links, which, divided by 100.000, or what is the same thing, cut off five figures from the right, the figures to the left of the decimal point will express the number of acres; the decimal part of the number, multiplied by 4, cutting off the same number of figures from the right, will be roods; the remainder, multiplied by 40, if any, cutting off five figures from the right, will represent perches. If the fields are triangular,* the area may be obtained in square links by multiplying the base or longest side of the triangle by half the perpendicular; the result will express the contents.

If we wish to compute the area of Fig. 73, it may be performed

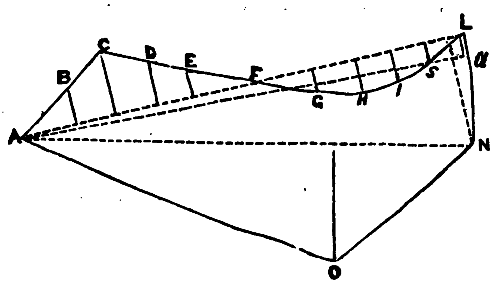


FIG. 73.

as follows: Run a line from A to L, taking offsets right and left to all the points in the irregular boundary A B C D E F, &c.,

* Any fields or number of fields may be reduced into triangles by drawing pencil lines in different directions on the map or plan representing such fields, and treated accordingly for the area.

to L, entering down the length of A L, and also that of the perpendiculars; the areas of the spaces contained in the interior of the boundary A B C D E F, and those on the exterior of the boundary F G H I S L, may be found thus:—

Interior.

$$\frac{60}{2} = 30 \times 100 - 000 = 3000$$
$$\frac{60+80}{2} = 50 \times 150 - 100 = 2500$$
$$\frac{80+60}{2} = 70 \times 250 - 150 = 7000$$
$$\frac{60+40}{2} = 50 \times 300 - 250 = 2500$$
$$\frac{40}{2} = 20 \times 400 - 300 = 2000$$

Area of A B C D E F = 17000

Exterior.

$$\frac{50}{2} = 25 \times 535 - 400 = 3375$$
$$\frac{50+90}{2} = 70 \times 650 - 530 = 8010$$
$$\frac{90+80}{2} = 85 \times 760 - 650 = 9350$$
$$\frac{80+50}{2} = 65 \times 900 - 760 = 9100$$
$$\frac{50}{2} = 25 \times 990 - 900 = 2256$$

Area of F G H I S L = 32091

Measuring from A to *o*, erecting the perpendicular *o* O, and also to *s*, erecting another perpendicular *s* L; the calculation will then be performed thus:—

A N	$=1560 + o\ O = \frac{270}{2} =$	210600
And also A N	$=1560 \times s\ L = \frac{256}{2} =$	199680
And adding the area of A B C D E F as above . . .		17000
Total area of A B C D E L N O A	=	427280
Deduct the area exterior to the boundary E F G H I S L	=	32091
Total area in square links	=	3.95189
		4
		3.80756
		40
		32.30240

Therefore the area of the field, Fig. 73, is equal to 3 acres, 3 roods, 32.3 perches.

If we wish to reduce the field into two large triangles, by running a line so as to equalize the irregular boundary, and consequently cutting off from the field as much as we take in, it may be performed thus:—

Take the area of A B C D E F . .	=17000
And the area of F G H I S L . .	=32085
Difference of the areas	=15085
	2
Twice the difference of areas . . .	=30170

$$\text{Therefore } \frac{30170}{990} = 30\tfrac{1}{2} \text{ links.}$$

Thus, by dividing twice the difference of the areas by the total length of the line A L=990, gives 30½ links; and if this 30½ links is set off perpendicular from the point L, as L *a*, it will give a point which, if a line is again set out from A, will exactly equalize the proposed irregular boundary, and reduce the field into two large triangles by the lines A *a* and A N, which may be treated as previously explained for triangles.

The surveyor wishing to discover the area of the figure A B C D E from one station, plants his theodolite at S, Fig. 74, and measuring the angles A S B, B S C, C S D, D S E, and

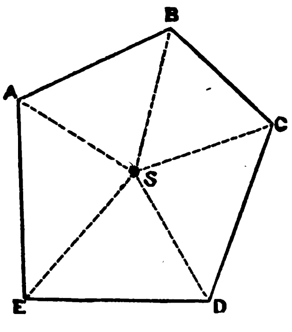


Fig. 74.

E S A=70° 20′, 64° 10′, 70° 20′, 68° 12′, and 86° 58′. The sides S A, S B, S C, S D, and S E, are then measured, and found to be=800, 790, 575, 920, and 940 links respectively.

Putting x=area of each triangle separately, the contents of the whole figure may be found by any of the following rules:—

$$\frac{A\ S,\ B\ S}{2} \times \text{sine} \angle\ A\ S\ B = x.$$

Or logarithmically thus—

$$\text{Log. } \tfrac{1}{2}\ A\ S \times \text{log. } B\ S \times \text{log. sine} \angle\ A\ S\ B - 10 = x.$$

$$\frac{A\ S,\ B\ S}{2} \times \text{sine} \angle A\ S\ B = \frac{800 \times 790}{2} \times .941666 = 297566.456$$

$$\frac{B\ S,\ C\ S}{2} \times\ ,,\ \angle B\ S\ C = \frac{790 \times 575}{2} \times .900065 = 204427.263$$

$$\frac{C\ S,\ D\ S}{2} \times\ ,,\ \angle C\ S\ D = \frac{575 \times 920}{2} \times .941666 = 249070.657$$

$$\frac{D\ S,\ E\ S}{2} \times\ ,,\ \angle D\ S\ E = \frac{920 \times 940}{2} \times .928485 = 401476.914$$

$$\frac{E\ S,\ A\ S}{2} \times\ ,,\ \angle E\ S\ A = \frac{940 \times 800}{2} \times .998598 = 375472.848$$

A=15.28014.138
4

R= 1.12056.552
40

P= 4.82262.080

Therefore the contents of the figure A B C D E=to 15 acres, 1 rood, and 4.82 perches.

To prove the First Triangle A S B *logarithmically.*

Logarithm 400	=+ 2.6020600
,, 790	=+ 2.8976271
Log. sine ∠ 70° 20′	=+ 9.9738971
	=− 10.
297566.5482=	5.4735842

This last operation gives the area .09 of a square link in excess of the first operation of the natural sines.

Given the three sides of a triangle H B C=1200, 1600, and 2000 links, to find the area.

Putting A=area, a b and c=three several sides of the triangle, and s=half sum of the three sides, we have:—

$$s=\frac{1}{2}(a+b+c)$$

$$A=\sqrt{\{s(s-a)(s-b)(s-c)\}}$$

Or logarithmically—

Logarithm $A=\frac{1}{2}\{\log. s+\log. (s-a)+\log. (s-b)+\log. (s-c).\}$

$$1200+1600+2000=\frac{4800}{2}=2400$$

2400−1200=1200
2400−1600= 800
2400−2000= 400
2400+1200+ 800+400=921600000000 links,
And $\sqrt{921600000000}$=960000.=area.

By Logarithms.

The logarithm of	2400	. . .	=	3.3802112
„ „	1200	. . .	=	3.0791812
„ „	800	. . .	=	2.9030900
„ „	400	. . .	=	2.6020600
				½)11.9645424
Arc of triangle=960000		. . .	=	5.9822712

A NEW SET OF TABLES OF DISTANCES

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PLANES OF MERIDIAN AND LATITUDE,

OR

TRAVERSE TABLES,

CALCULATED TO EVERY TWO MINUTES IN THE QUADRANT,

AND

BY DIFFERENCES TO TWENTY SECONDS,

AND

FOR ANY LENGTH OF LINES

UP TO

FIVE HUNDRED THOUSAND.

EXPLANATION TO THE TRAVERSE TABLES.

TRAVERSE Tables are those wherein are arranged, in a tabular form, the two sides of all right-angled triangles to a given hypothenuse and angle. Such a table, properly arranged, and calculated to a minute division of the circle, suitable to improved modern instruments, would be invaluable to practical men; and when we take into consideration the great amount of time and labour expended in the necessary direct calculations required in business, such a table (by the aid of which equal results may be obtained by inspection) must be considered a desideratum. Such a table I have not been able to procure—and, indeed, believe such a one does not exist in print—those that I have procured are badly arranged, and very inaccurate and incomplete, arising partly from the circumstance of their not having been calculated to a less subdivision than from 30′ to 15′ of a degree, which renders them comparatively useless for practical purposes when instruments are employed divided to single minutes, and oftentimes to 20″; and it is still more surprising that such tables, published nearly forty years since, should again be reprinted at the present date without the necessary alterations, which would render them more valuable when adapted to finely graduated instruments, for it is certain that a table calculated to every 1′ or 2′, or even to 20″, could be used, and made available for an instrument whose graduations were not less than from 30′ to 15′; but a table calculated for the latter division only could not be used (without much trouble) for observations taken with instruments graduated to the former division; and to use the words of a very distinguished author — "They are necessarily very imperfect, because, to be complete, they should be very voluminous." Under these circumstances, and for other reasons, I have therefore been induced to compute a new set of Traverse Tables, calculated to every two minutes of a degree, and by differences to twenty seconds, and by applying the decimal system of notation for any length of lines under five hundred thousand. The tables thus arranged are concise, and not very voluminous; and since they are calculated so fine, and to so great an extent, are consequently much more valuable. The proof sheets of these tables were carefully compared with the MS., corrected, and read over three separate times by different persons each time. A new proof was then taken from the press, compared with a duplicate of the preceding ones, and afterwards every number composing the table recalculated over again. They were then returned to the press for alteration, and finally stereotyped. I have, therefore, no hesitation in presenting to those of my subscribers and others (who may not find sufficient time or inclination to work from the natural sines or logarithms as taught in the body of the preceding work) a table that will not only supply nearly all that is required in practice, but will be found to be as correct and reliable as any tables of this class can possibly be made. Indeed, after all the labour and care bestowed, I cannot suppose that a single error has crept in; but after the last proof of each page was read, and all is said and done, it is quite possible that some accident might happen to the type while in press, and before stereotyping, thus introducing errors over which the author could have no possible control. However, I am not apprehensive on that account, as the work was printed by one of the best and most careful houses in London.

Nevertheless, if any of my readers should happen to discover any error either in the tables or body of the work, I should feel obliged by their communications, in order that the same may be put right in future editions.

The table is in five double or pairs of columns, and are base and perpendicular from the commencement alternately, and are carried to five decimal places for the first five degrees, and to six places all through the table afterwards. The hypothenuse, which in all cases is the measured distance, will be found at the tops and bottoms of the pages as 1, 2, 3, &c., to 5; or 10, 20, 30, &c., to 50; or 100, 200, to 500; or 1000, 2000, 3000, &c., to 5000; or 10,000, 20,000, to 50,000; or 100,000, 200,000, &c., to 500,000; and the angle in degrees and minutes in the first and last columns of every page, the first reading downwards, as 0° 2′, 4′, &c., to 60′, and the last 0° 60′, 58′, &c., to 2′ upwards. As an illustration of the use of the tables, let us proceed to find the base and perpendicular to an angle of 7° 42′, and hypothenuse or measured distance of 10,000 links. Find the angle **7**°* at the head of the first column, the minutes may be found by running the eye downwards until we find 42′, we then refer to the head of the first double column, and under 1 for measured distance, or 10,000 links. Take out of the column called distance from planes of latitude, and opposite 42′, the number 0.990983, and from that called distance from planes of meridian, and opposite 42′, the number 0.133986, which will express the length of the base and perpendicular for the proposed hypothenuse and angle; but these numbers thus found are decimals, we wish, therefore, to know the exact length of the lines expressed by them in integers and parts of an integer.

The student will observe as a rule that the decimal numbers in each column are calculated to the common integral units 1, 2, 3, 4, and 5, and when each integral unit is made to represent 10, 20, 30, 40, and 50, to find the corresponding units and parts in their respective columns the decimal point must be placed one figure to the right, and when each integral unit is made to represent 100, 1000, 10,000, or 100,000, the decimal point must be removed two, three, four, and five places to the right, the figures to the left of the decimal point so supplied will be integers, or whole numbers, and those to the right, if any, parts of an integer or decimals. Thus the base and perpendicular previously found is=9909.83, and 1345.62.

To find the Base and Perpendicular to an Angle of **7**° 58′ *and Hypothenuse* 3424 *Links.*

The angle **7**° 58′ may be found in the table as previously explained, but the measured distance, or hypothenuse, must be taken out at two or more times, thus:—

Hypothenuse.		Base.		Perpendicular.
3000	. . . =	2971.044	. . .	415.79100
400	. . . =	396.139	. . .	55.43880
20	. . . =	19.069	. . .	2.77194
4	. . . =	3.961	. . .	0.55438
3424	. . . =	3390.213	. . .	474.55612

Therefore the base and perpendicular=3390.213 and 474.55612 links respectively.

* The degrees are represented by figures larger and blacker than those for the minutes.

Take another case, when the angle=5° 20′ and hypothenuse =94243 links:—

Hypothenuse.		Base.		Perpendicular.
50000	. . .	=49783.500	. . .	4647.450
40000	. . .	=39826.800	. . .	3717.960
4000	. . .	= 3982.680	. . .	371.796
200	. . .	= 199.134	. . .	18.589
40	. . .	= 39.826	. . .	3.717
3	. . .	= 2.987	. . .	0.278
94243	. . .	=93834.927	. . .	8759.790

The required base and perpendicular is therefore=93834.927, and 8759.790 links.

To find the Base and Perpendicular to an Angle of 7° 31′ 30″ and Hypothenuse 1000 Links.

Rule.—Take out of the table the base and perpendicular corresponding to the next lesser and greater angle than the one proposed, the difference of the bases, divided by 2, and deducted from the number, expressing the base, to the larger angle, will be the required base; and the difference of the perpendicular divided by 2, and added to the number, expressing the perpendicular for the lesser angle, will be the required perpendicular.

Example.

	Base.		Perpendicular.
Next lesser angle=7° 30′	=991.444	. . . . . .	138.526
Next larger angle=7 32	=991.368	. . . . . .	131.103
Difference	= 0.076	. . difference=	0.577

One minute=half difference	=0.038	half difference	=0.288
Half minute=quarter distance	=0.019	quarter difference	=0.144
	0.057		0.432

	Base.		Perpendicular.
Next larger angle=7° 30′ 0″=	991.444	. . .	130.526
Half difference =0 1 0 =	−000.038	. .	+000.288
=7 31 0 =	991.406	. . .	130.814
Quarter difference=0 0 0 =	−000.019	. .	+000.144
7 31 30 =	991.387		130.958

Therefore the required base and perpendicular is =991.387 and 130.958.

Many of the problems proposed in the body of the work may be solved by the tables; we will, therefore, prove a few of them:—

Problem 7th in "Plane Trigonometry."

	Hypothenuse.	Base.	Perpendicular.
∠ 20° 20′ and distance =	200 .	187.5372 .	69.4962
∠ 15 40 „ „ =	300 .	288.8547 .	81.0120
∠ 24 0 „ „ =	300 .	274.0635 .	122.0208
	40 .	36.5418 .	16.2694
∠ 20 0 „ „ =	300 .	281.9076 .	102.6060
	300 .	281.9076 .	102.6060
F G, Fig. 38		=1350.8134 .	494.0104
Data as found trigonometrically		=1350.8131 .	494.0077
Difference in calculation . . .		.0003 and	.0024

Thus the base and perpendicular differs only .0003 and .0024 from the operation at page 31, showing the great accuracy and utility of the tables in performing by addition what we should otherwise be obliged to do by the tedious process of multiplication.

Problem 11*th in "Plane Trigonometry."*

∠ 40° 16′ and distance=849, to find A B and B C.

	Hypothenuse.	Base.	Perpendicular.
∠ 40° 16′	500 . . .	381.522 . . .	323.173
	300 . . .	228.913 . . .	193.903
	40 . . .	30.521 . . .	25.853
	9 . . .	6.867 . . .	5.817
	A C=849	A B=647.823 and	B C=548.746
By logarithmic process		=647.820 „ „	=584.750
Difference in calculation		= .003 „ „	= .004

Problem 15*th*, "*Oblique Trigonometry*," *by the Tables.* (*See Fig.* 46.)

	Hypothenuse.	Larger Segment of Base.		Hypothenuse.	Larger Segment of Base.
∠ 39°46′	300	=230.5965	∠ 60°34′	400	=196.5640
	300	=230.5965		50	= 24.5706
	40	= 30.7462		20	= 9.8282
	640	=491.9392		470	=230.9628

Then 491.9392 + 230.9628 = 722.9020 = A B
Data by logarithms . . = 722.9300
Difference . . . . . . = .0280

The calculation by the tables comes up to the logarithmic computation, and differs but .0280 of a unit from it. The length of the line let fall from the apex of the triangle at C perpendicular to the base could have been found at the same time by taking out the quantities opposite the bases. All the calculated data in Office Forms No. 1 and 2, may readily be found by merely inspecting the table; but it must be remembered that the work and angles must be properly stated before any reference to the table is made—that is, the observed reduced angles are all to be referred to the plane of the meridian or latitude, according as they are found with respect to these lines. Thus in the table for measured distance 330 and angle 28° 56′, we find 262.5549 and 145.1373 for the distance from planes latitude and meridian, or the base and perpendicular; but for 61° 4′, found at the bottom of the page, the same numbers become meridian and latitude; that is, for the degrees at the top of the page each pair of columns read base and perpendicular downwards; but for the degrees at the bottom the same columns read perpendicular and base upwards.

Degrees and Minutes.	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000. Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000. Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000. Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000. Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000. Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	
0° 0'	1.00000	0.00000	2.00000	0.00000	3.00000	0.00000	4.00000	0.00000	5.00000	0.00000	60'
2	1.00000	0.00058	2.00000	0.00116	3.00000	0.00174	4.00000	0.00232	5.00000	0.00290	58
4	0.99999	0.00116	1.99998	0.00232	2.99997	0.00348	3.99996	0.00464	4.99995	0.00580	56
6	0.99999	0.00174	1.99998	0.00348	2.99997	0.00522	3.99996	0.00696	4.99995	0.00870	54
8	0.99999	0.00232	1.99998	0.00464	2.99997	0.00696	3.99996	0.00928	4.99995	0.01160	52
10	0.99999	0.00290	1.99998	0.00580	2.99997	0.00870	3.99996	0.01160	4.99995	0.01450	50
12	0.99999	0.00349	1.99998	0.00698	2.99997	0.01047	3.99996	0.01396	4.99995	0.01745	48
14	0.99999	0.00407	1.99998	0.00814	2.99997	0.01221	3.99996	0.01628	4.99995	0.02035	46
16	0.99998	0.00465	1.99996	0.00930	2.99994	0.01395	3.99992	0.01860	4.99990	0.02325	44
18	0.99998	0.00523	1.99996	0.01046	2.99994	0.01569	3.99992	0.02092	4.99990	0.02615	42
20	0.99998	0.00581	1.99996	0.01162	2.99994	0.01743	3.99992	0.02324	4.99990	0.02905	40
22	0.99997	0.00639	1.99994	0.01278	2.99991	0.01917	3.99988	0.02556	4.99985	0.03195	38
24	0.99997	0.00698	1.99994	0.01396	2.99991	0.02094	3.99988	0.02792	4.99985	0.03490	36
26	0.99997	0.00756	1.99994	0.01512	2.99991	0.02268	3.99988	0.03024	4.99985	0.03780	34
28	0.99996	0.00814	1.99992	0.01628	2.99988	0.02442	3.99984	0.03256	4.99980	0.04070	32
30	0.99996	0.00872	1.99992	0.01744	2.99988	0.02616	3.99984	0.03488	4.99980	0.04360	30
32	0.99995	0.00930	1.99990	0.01860	2.99985	0.02790	3.99980	0.03720	4.99975	0.04650	28
34	0.99995	0.00989	1.99990	0.01978	2.99985	0.02967	3.99980	0.03956	4.99975	0.04945	26
36	0.99994	0.01047	1.99988	0.02094	2.99982	0.03141	3.99976	0.04188	4.99970	0.05235	24
38	0.99993	0.01105	1.99986	0.02210	2.99979	0.03315	3.99972	0.04420	4.99965	0.05525	22
40	0.99993	0.01163	1.99986	0.02326	2.99979	0.03489	3.99972	0.04652	4.99965	0.05815	20
42	0.99992	0.01221	1.99984	0.02442	2.99976	0.03663	3.99968	0.04884	4.99960	0.06105	18
44	0.99991	0.01279	1.99982	0.02558	2.99973	0.03837	3.99964	0.05116	4.99955	0.06395	16
46	0.99991	0.01338	1.99982	0.02676	2.99973	0.04014	3.99964	0.05352	4.99955	0.06690	14
48	0.99990	0.01396	1.99980	0.02792	2.99970	0.04188	3.99960	0.05584	4.99950	0.06980	12
50	0.99989	0.01454	1.99978	0.02908	2.99967	0.04362	3.99956	0.05816	4.99945	0.07270	10
52	0.99988	0.01512	1.99976	0.03024	2.99964	0.04536	3.99952	0.06048	4.99940	0.07560	8
54	0.99987	0.01570	1.99974	0.03140	2.99961	0.04710	3.99948	0.06280	4.99935	0.07850	6
56	0.99986	0·01628	1.99972	0.03256	2.99958	0.04884	3.99944	0.06512	4.99930	0.08141	4
58	0.99985	0.01687	1.99970	0.03374	2.99955	0.05061	3.99940	0.06748	4.99925	0.08435	2
60	0.99984	0.01745	1.99968	0.03490	2.99952	0.05235	3.99936	0.06980	4.99920	0.08725	89° 0'
	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Degrees and Minutes.
	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		

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Degrees and Minutes.	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		
	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	
1°	0.99984	0.01745	1.99968	0.03490	2.99952	0.05236	3.99936	0.06980	4.99920	0.08725	60′
2′	0.99983	0.01803	1.99966	0.03606	2.99949	0.05409	3.99932	0.07212	4.99915	0.09015	58
4	0.99982	0.01861	1.99964	0.03722	2.99946	0.05583	3.99928	0.07444	4.99910	0.09305	56
6	0.99981	0.01919	1.99962	0.03838	2.99943	0.05757	3.99924	0.07676	4.99905	0.09595	54
8	0.99980	0.01977	1.99960	0.03954	2.99940	0.05931	3.99920	0.07908	4.99900	0.09885	52
10	0.99979	0.02036	1.99958	0.04072	2.99937	0.06108	3.99916	0.08144	4.99895	0.10180	50
12	0.99978	0.02094	1.99956	0.04188	2.99934	0.06282	3.99912	0.08376	4.99890	0.10470	48
14	0.99976	0.02152	1.99952	0.04304	2.99928	0.06456	3.99904	0.08608	4.99880	0.10760	46
16	0.99975	0.02210	1.99950	0.04420	2.99925	0.06630	3.99900	0.08840	4.99875	0.11050	44
18	0.99974	0.02268	1.99948	0.04536	2.99922	0.06804	3.99896	0.09072	4.99870	0.11340	42
20	0.99972	0.02326	1.99944	0.04652	2.99916	0.06978	3.99888	0.09304	4.99860	0.11630	40
22	0.99971	0.02385	1.99942	0.04770	2.99913	0.07155	3.99884	0.09540	4.99855	0.11925	38
24	0 99970	0.02443	1.99940	0.04886	2.99910	0.07329	3.99880	0.09772	4.99850	0.12215	36
26	0.99968	0.02501	1.99936	0.05002	2.99904	0.07503	3.99872	0.10004	4.99840	0.12505	34
28	0.99967	0.02559	1.99934	0.05118	2.99901	0.07677	3.99868	0.10236	4.99835	0.12795	32
30	0.99966	0.02617	1.99932	0.05234	2.99898	0.07851	3.99864	0.10468	4.99830	0.13085	30
32	0.99964	0.02675	1.99928	0.05350	2.99892	0.08025	3.99856	0.10700	4.99820	0.13375	28
34	0.99962	0.02734	1.99924	0.05468	2.99886	0.08202	3.99848	0.10936	4.99810	0.13670	26
36	0 99961	0.02792	1.99922	0.05584	2.99883	0.08376	3.99844	0.11168	4.99805	0.13960	24
38	0.99959	0.02850	1.99918	0.05700	2.99877	0.08550	3.99836	0.11400	4.99795	0.14250	22
40	0.99957	0.02908	1.99914	0.05816	2.99871	0.08724	3.99828	0.11632	4.99785	0.14540	20
42	0.99955	0.02966	1.99910	0.05932	2.99865	0.08898	3.99820	0.11864	4.99775	0.14830	18
44	0.99954	0.03024	1.99908	0.06048	2.99862	0.09072	3.99816	0.12096	4.99770	0.15120	16
46	0.99952	0.03082	1.99904	0.06164	2.99856	0.09246	3.99808	0.12328	4.99760	0.15410	14
48	0.99950	0.03141	1.99900	0.06282	2.99850	0.09423	3.99800	0.12564	4.99750	0.15705	12
50	0.99948	0.03199	1.99896	0.06398	2.99844	0.09597	3.99792	0.12796	4.99740	0.15995	10
52	0.99946	0.03257	1.99892	0.06514	2.99838	0.09771	3.99784	0.13028	4.99730	0.16285	8
54	0.99945	0.03315	1.99890	0.06630	2.99835	0.09945	3.99780	0.13260	4.99725	0.16575	6
56	0.99943	0.03373	1.99886	0.06746	2.99829	0.10119	3.99772	0.13492	4.99715	0.16865	4
58	0.99941	0.03431	1.99882	0.06862	2.99823	0.10293	3.99764	0.13724	4.99705	0.17155	2
60	0.99939	0.03489	1.99878	0.06978	2.99817	0.10467	3.99756	0.13956	4.99695	0.17445	88°
	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Degrees and Minutes.
	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		

Degrees and Minutes.	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		
	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	
2°	0.99939	0.03489	1.99878	0.06978	2.99817	0.10467	3.99756	0.13956	4.99695	0.17445	60′
2′	0.99937	0.03548	1.99874	0.07096	2.99811	0.10644	3.99748	0.14192	4.99685	0.17740	58
4	0.99934	0.03606	1.99868	0.07212	2.99802	0.10818	3.99736	0.14424	4.99670	0.18030	56
6	0.99932	0.03664	1.99864	0.07328	2.99796	0.10992	3.99728	0.14656	4.99660	0.18320	54
8	0.99930	0.03722	1.99860	0.07444	2.99790	0.11166	3.99720	0.14888	4.99650	0.18610	52
10	0.99928	0.03780	1.99856	0.07560	2.99784	0.11340	3.99712	0.15120	4.99640	0.18900	50
12	0.99926	0.03838	1.99852	0.07676	2.99778	0.11514	3.99704	0.15352	4.99630	0.19190	48
14	0.99924	0.03896	1.99848	0.07792	2.99772	0.11688	3.99696	0.15584	4.99620	0.19480	46
16	0.99921	0.03955	1.99842	0.07910	2.99763	0.11865	3.99684	0.15820	4.99605	0.19775	44
18	0.99919	0.04013	1.99838	0.08026	2.99757	0.12039	3.99676	0.16052	4.99595	0.20065	42
20	0.99917	0.04071	1.99834	0.08142	2.99751	0.12213	3.99668	0.16284	4.99585	0.20355	40
22	0.99914	0.04129	1.99828	0.08258	2.99742	0.12387	3.99656	0.16516	4.99570	0.20645	38
24	0·99912	0.04187	1.99824	0.08374	2.99736	0.12561	3.99648	0.16748	4.99560	0.20935	36
26	0.99909	0.04245	1.99818	0.08490	2.99727	0.12735	3.99636	0.16980	4.99545	0.21225	34
28	0.99907	0.04303	1.99814	0.08606	2.99721	0.12909	3.99628	0.17212	4.99535	0.21515	32
30	0.99904	0.04361	1.99808	0.08722	2.99712	0.13083	3.99616	0.17444	4.99520	0.21805	30
32	0.99902	0.04420	1.99804	0·08840	2.99706	0.13260	3.99608	0.17680	4.99510	0.22100	28
34	0.99898	0.04478	1.99796	0.08956	2.99694	0.13434	3.99592	0.17912	4.99490	0.22390	26
36	0.99897	0.04536	1.99794	0.09072	2.99691	0.13608	3.99588	0.18144	4.99485	0.22680	24
38	0.99894	0.04594	1.99788	0.09188	2.99682	0.13782	3.99576	0.18376	4.99470	0.22970	22
40	0.99891	0.04652	1.99782	0.09304	2.99673	0.13956	3.99564	0.18608	4.99455	0.23260	20
42	0.99888	0.04710	1.99776	0.09420	2.99664	0.14130	3.99552	0.18840	4.99440	0.23550	18
44	0.99886	0.04768	1.99772	0.09536	2.99658	0.14304	3.99544	0.19072	4.99430	0.23840	16
46	0.99883	0.04826	1.99766	0.09652	2.99649	0.14478	3.99532	0.19304	4.99415	0.24130	14
48	0.99880	0.04884	1.99760	0.09768	2.99640	0.14652	3.99520	0.19536	4.99400	0.24420	12
50	0.99877	0.04943	1.99754	0.09886	2.99631	0.14829	3.99508	0.19772	4.99385	0.24715	10
52	0.99874	0.05001	1.99748	0.10002	2.99622	0.15003	3.99496	0.20004	4.99370	0.25005	8
54	0.99871	0.05059	1.99742	0.10118	2.99613	0.15177	3.99484	0.20236	4.99355	0.25295	6
56	0.99868	0.05117	1.99736	0.10234	2.99604	0.15351	3.99472	0.20468	4.99340	0.25585	4
58	0.99865	0.05175	1.99730	0.10350	2.99595	0.15525	3.99460	0.20700	4.99325	0.25875	2
60	0.99862	0.05233	1.99724	0.10466	2.99586	0.15699	3.99448	0.20932	4.99310	0.26165	87°
	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Degrees and Minutes.
	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		

Degrees and Minutes.	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000. Distance from Planes of Latitude, or North or South Distance.	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000. Distance from Planes of Meridian, or East or West Distance.	Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000. Distance from Planes of Latitude, or North or South Distance.	Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000. Distance from Planes of Meridian, or East or West Distance.	Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000. Distance from Planes of Latitude, or North or South Distance.	Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000. Distance from Planes of Meridian, or East or West Distance.	Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000. Distance from Planes of Latitude, or North or South Distance.	Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000. Distance from Planes of Meridian, or East or West Distance.	Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000. Distance from Planes of Latitude, or North or South Distance.	Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000. Distance from Planes of Meridian, or East or West Distance.	
3°	0.99862	0.05234	1.99724	0.10468	2.99586	0.15702	3.99448	0.20936	4.99310	0.26170	60′
2′	0.99859	0.05291	1.99718	0.10582	2.99577	0.15873	3.99436	0.21164	4.99295	0.26455	58
4	0.99856	0.05349	1.99712	0.10698	2.99568	0.16047	3.99424	0.21396	4.99280	0.26745	56
6	0.99853	0.05407	1.99706	0.10814	2.99559	0.16221	3.99412	0.21628	4.99265	0.27035	54
8	0.99850	0.05465	1.99700	0.10930	2.99550	0.16395	3.99400	0.21860	4.99250	0.27325	52
10	0.99847	0.05524	1.99694	0.11048	2.99541	0.16572	3.99388	0.22096	4.99235	0.27620	50
12	0.99844	0.05582	1.99688	0.11164	2.99532	0.16746	3.99376	0.22328	4.99220	0.27910	48
14	0.99840	0.05640	1.99680	0.11280	2.99520	0.16920	3.99360	0.22560	4.99200	0.28200	46
16	0.99837	0.05698	1.99674	0.11396	2.99511	0.17094	3.99348	0.22792	4.99185	0.28490	44
18	0.99834	0.05756	1.99668	0.11512	2.99502	0.17268	3.99336	0.23024	4.99170	0.28780	42
20	0.99830	0.05814	1.99660	0.11628	2.99490	0.17442	3.99320	0.23256	4.99150	0.29070	40
22	0.99827	0.05872	1.99654	0.11744	2.99481	0.17616	3.99308	0.23488	4.99135	0.29360	38
24	0.99823	0.05930	1.99646	0.11860	2.99469	0.17790	3.99392	0.23720	4.99115	0.29650	36
26	0.99820	0.05988	1.99640	0.11976	2.99460	0.17964	3.99280	0.23952	4.99100	0.29940	34
28	0.99817	0.06046	1.99634	0.12092	2.99451	0.18138	3.99268	0.24184	4.99085	0.30230	32
30	0.99813	0.06104	1.99626	0.12208	2.99439	0.18312	3.99252	0.24416	4.99065	0.30520	30
32	0.99809	0.06162	1.99618	0.12324	2.99427	0.18486	3.99236	0.24648	4.99045	0.30810	28
34	0.99806	0.06220	1.99612	0.12440	2 99418	0.18660	3.99224	0.24880	4.99030	0.31100	26
36	0 99802	0.06279	1.99604	0.12558	2.99406	0.18837	3.99208	0.25116	4.99010	0.31395	24
38	0.99799	0.06337	1.99598	0.12674	2.99397	0.19011	3.99196	0.25348	4.98995	0.31685	22
40	0.99795	0.06395	1.99590	0.12790	2.99385	0.19185	3.99180	0.25580	4.98975	0.31975	20
42	0.99791	0.06453	1.99582	0.12906	2.99373	0.19359	3.99164	0.25812	4.98955	0.32265	18
44	0.99787	0.06511	1.99574	0.13022	2.99361	0.19533	3.99148	0.26044	4.98935	0.32555	16
46	0.99784	0.06569	1.99568	0.13138	2.99356	0.19707	3.99136	0.26276	4.98920	0.32845	14
48	0.99780	0.06627	1.99560	0.13254	2.99340	0.19881	3.99120	0.26508	4.98900	0.33135	12
50	0.99776	0.06685	1.99552	0.13370	2.99328	0.20055	3.99104	0.26740	4.98880	0.33425	10
52	0.99772	0.06743	1.99544	0.13486	2.99316	0.20229	3.99088	0.26972	4.98860	0.33715	8
54	0.99768	0.06801	1.99536	0.13602	2.99304	0.20403	3.99072	0.27204	4.98840	0.34005	6
56	0.99764	0.06859	1.99528	0.13718	2.99292	0.20577	3.99056	0.27436	4.98820	0.34295	4
58	0.99760	0.06917	1.99520	0.13834	2.99280	0.20751	3.99040	0.27668	4.98800	0.34585	2
60	0.99756	0.06975	1.99512	0.13950	2.99268	0.20925	3.99024	0.27900	4.98780	0.34875	86°
	Distance from Planes of Meridian, or East or West Distance. Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.	Distance from Planes of Latitude, or North or South Distance. Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.	Distance from Planes of Meridian, or East or West Distance. Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.	Distance from Planes of Latitude, or North or South Distance. Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.	Distance from Planes of Meridian, or East or West Distance. Measured Distance, or Hypothonuse, 3, 30, 300, 3000, 30,000, or 300,000.	Distance from Planes of Latitude, or North or South Distance. Measured Distance, or Hypothonuse, 3, 30, 300, 3000, 30,000, or 300,000.	Distance from Planes of Meridian, or East or West Distance. Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.	Distance from Planes of Latitude, or North or South Distance. Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.	Distance from Planes of Meridian, or East or West Distance. Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.	Distance from Planes of Latitude, or North or South Distance. Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.	Degrees and Minutes.

Degrees and Minutes.	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse. 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		
	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	
4°	0.99756	0.06976	1.99512	0.13952	2.99268	0.20928	3.99024	0.27904	4.98780	0.34880	60′
2′	0.99752	0.07033	1.99504	0.14066	2.99256	0.21099	3.99008	0.28132	4.98760	0.35165	58
4	0.99748	0.07091	1.99496	0.14182	2.99244	0.21273	3.98992	0.28364	4.98740	0.35455	56
6	0.99744	0.07149	1.99488	0.14298	2.99232	0.21447	3.98976	0.28596	4.98720	0.35745	54
8	0.99739	0.07207	1.99478	0.14414	2.99217	0.21621	3.98956	0.28828	4.98695	0.36035	52
10	0.99735	0.07265	1.99470	0.14530	2.99205	0.21795	3.98940	0.29060	4.98675	0.36325	50
12	0.99731	0.07323	1.99462	0.14646	2.99193	0.21969	3.98924	0.29292	4.98655	0.36615	48
14	0.99727	0.07381	1.99454	0.14762	2.99171	0.22143	3.98908	0.29524	4.98635	0.36905	46
16	0.99722	0.07439	1.99444	0.14878	2.99166	0.22317	3.98888	0.29756	4.98610	0.37195	44
18	0.99718	0.07497	1.99436	0.14994	2.99154	0.22491	3.98872	0.29988	4.98590	0.37485	42
20	0.99714	0.07555	1.99428	0.15110	2.99142	0.22665	3.98856	0.30220	4.98570	0.37775	40
22	0.99709	0.07613	1.99418	0.15226	2.99127	0.22839	3.98836	0.30452	4.98545	0.38065	38
24	0.99705	0.07671	1.99410	0.15342	2.99115	0.23013	3.98820	0.30684	4.98525	0.38355	36
26	0.99700	0.07729	1.99400	0.15458	2.99100	0.23187	3.98800	0.30916	4.98500	0.38645	34
28	0.99696	0.07787	1.99392	0.15574	2.99088	0.23361	3.98784	0.31148	4.98480	0.38935	32
30	0.99691	0.07845	1.99382	0.15690	2.99073	0.23535	3.98764	0.31380	4.98455	0.39225	30
32	0.99687	0.07903	1.99374	0.15806	2.99061	0.23709	3.98748	0.31612	4.98435	0.39515	28
34	0.99682	0.07961	1.99364	0.15922	2.99046	0.23883	3.98728	0.31844	4.98410	0.39805	26
36	0.99677	0.08019	1.99354	0.16038	2.99031	0.24057	3.98708	0.32076	4.98385	0.40095	24
38	0.99673	0.08077	1.99346	0.16154	2.99019	0.24231	3.98692	0.32308	4.98365	0.40385	22
40	0.99668	0.08135	1.99336	0.16270	2.99004	0.24405	3.98672	0.32540	4.98340	0.40675	20
42	0.99663	0.08193	1.99326	0.16380	2.98989	0.24579	3.98652	0.32772	4.98315	0.40965	18
44	0.99658	0.08251	1.99316	0.16502	2.98974	0.24753	3.98632	0.33004	4.98290	0.41255	16
46	0.99654	0.08309	1.99308	0.16618	2.98962	0.24927	3.98616	0.33236	4.98270	0.41545	14
48	0.99649	0.08367	1.99298	0.16734	2.98947	0.25101	3.98596	0.33468	4.98245	0.41835	12
50	0.99644	0.08425	1.99288	0.16850	2.98932	0.25275	3.98576	0.33700	4.98220	0.42125	10
52	0.99639	0.08483	1.99278	0.16966	2.98917	0.25449	3.98556	0.33932	4.98195	0.42415	8
54	0.99634	0.08541	1.99268	0.17082	2.98902	0.25623	3.98536	0.34164	4.98170	0.42705	6
56	0.99629	0.08599	1.99258	0.17198	2.98887	0.25797	3.98516	0.34396	4.98145	0.42995	4
58	0.99624	0.08657	1.99248	0.17314	2.98872	0.25971	3.98496	0.34628	4.98120	0.43285	2
60	0.99619	0.08715	1.99238	0.17430	2.98857	0.26145	3.98476	0.34860	4.98095	0.43575	85°
	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Degrees and Minutes.
	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000,		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		

Degrees and Minutes.	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		
	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	
5°	0.996194	0.087155	1.992388	0.174310	2.988582	0.261465	3.984776	0.348620	4.980970	0.435775	60′
2′	0.996143	0.087735	1.992286	0.175470	2.988429	0.263205	3.984572	0.350940	4.980715	0.438675	58
4	0.996092	0.088314	1.992184	0.176628	2.988276	0.264942	3.984368	0.353256	4.980460	0.441570	56
6	0.996041	0.088894	1.992082	0.177788	2.988123	0.266682	3.984164	0.355576	4.980205	0.444470	54
8	0.995989	0.089473	1.991978	0.178946	2.987967	0.268419	3.983956	0.357892	4.979945	0.447365	52
10	0.995937	0.090053	1.991874	0.180106	2.987811	0.270159	3.983748	0.360212	4.979685	0.450265	50
12	0.995884	0.090632	1.991768	0.181264	2.987652	0.271896	3.983536	0.362528	4.979420	0.453160	48
14	0.995831	0.091211	1.991662	0.182422	2.987493	0.273633	3.983324	0.364844	4.979155	0.456055	46
16	0.995778	0.091791	1.991556	0.183582	2.987334	0.275373	3.983112	0.367164	4.978890	0.458955	44
18	0.995724	0.092370	1.991448	0.184740	2.987172	0.277110	3.982896	0.369480	4.978620	0.461850	42
20	0.995670	0.092949	1.991340	0.185898	2.987010	0.278847	3.982680	0.371796	4.978350	0.464745	40
22	0.995616	0.093529	1.991232	0.187058	2.986848	0.280587	3.982464	0.374116	4.978080	0.467645	38
24	0.995562	0.094108	1.991124	0.188216	2.986686	0.282324	3.982248	0.376432	4.977810	0.470540	36
26	0.995507	0.094687	1.991014	0.189374	2.986521	0.284061	3.982028	0.378748	4.977535	0.473435	34
28	0.995451	0.095266	1.990902	0.190532	2.986353	0.285798	3.981804	0.381064	4.977255	0.476330	32
30	0.995396	0.095845	1.990792	0.191690	2.986188	0.287535	3.981584	0.383380	4.976980	0.479225	30
32	0.995340	0.096424	1.990680	0.192848	2.986020	0.289272	3.981360	0.385696	4.976700	0.482120	28
34	0.995284	0.097003	1.990568	0.194006	2.985852	0.291009	3.981136	0.388012	4.976420	0.485015	26
36	0.995227	0.097582	1.990454	0.195164	2.985681	0.292746	3.980908	0.390328	4.976135	0.487910	24
38	0.995170	0.098161	1.990340	0.196322	2.985510	0.294483	3.980680	0.392644	4.975850	0.490805	22
40	0.995113	0.098740	1.990226	0.197480	2.985339	0.296220	3.980452	0.394960	4.975565	0.493700	20
42	0.995055	0.099319	1.990110	0.198638	2.985165	0.297957	3.980220	0.397276	4.975275	0.496595	18
44	0.994997	0.099898	1.989994	0.199796	2.984991	0.299694	3.979988	0.399592	4.974985	0.499490	16
46	0.994939	0.100477	1.989878	0.200954	2.984817	0.301431	3.979756	0.401908	4.974695	0.502385	14
48	0.994880	0.101056	1.989760	0.202112	2.984640	0.303168	3.979520	0.404224	4.974400	0.505280	12
50	0.994821	0.101635	1.989642	0.203270	2.984463	0.304905	3.979284	0.406540	4.974105	0.508175	10
52	0.994762	0.102213	1.989524	0.204426	2.984286	0.306639	3.979048	0.408852	4.973810	0.511065	8
54	0.994702	0.102792	1.989404	0.205584	2.984106	0.308376	3.978808	0.411168	4.973510	0.513960	6
56	0.994642	0.103371	1.989284	0.206742	2.983926	0.310113	3.978568	0.413484	4.973210	0.516855	4
58	0.994582	0.103949	1.989164	0.207898	2.983746	0.311847	3.978328	0.415796	4.972910	0.519745	2
60	0.994521	0.104528	1.989042	0.209056	2.983563	0.313584	3.978084	0.418112	4.972605	0.522640	84°
	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Degrees and Minutes.
	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		

Degrees and Minutes.	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		
	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	
6°	0.994521	0.104528	1.989042	0.209056	2.983563	0.313584	3.978084	0.418112	4.972605	0.522640	60′
2′	0.994460	0.105107	1.988920	0.210214	2.983380	0.315321	3.977840	0.420428	4.972300	0.525535	58
4	0.994399	0.105685	1.988798	0.211370	2.983197	0.317055	3.977596	0.422740	4.971995	0.528425	56
6	0.994337	0.106264	1.988674	0.212528	2.983011	0.318792	3.977348	0.425056	4.971685	0.531320	54
8	0.994276	0.106842	1.988552	0.213684	2.982828	0.320526	3.977104	0.427368	4.971380	0.534210	52
10	0.994213	0.107421	1.988426	0.214842	2.982639	0.322263	3.976852	0.429684	4.971065	0.537105	50
12	0.994151	0.107999	1.988302	0.215998	2.982453	0.323997	3.976604	0.431996	4.970755	0.539995	48
14	0.994088	0.108577	1.988176	0.217154	2.982264	0.325731	3.976352	0.434308	4.970440	0.542885	46
16	0.994024	0.109156	1.988048	0.218312	2.982072	0.327468	3.976096	0.436624	4.970120	0.545780	44
18	0.993961	0.109734	1.987922	0.219468	2.981883	0.329202	3.975844	0.438936	4.969805	0.548670	42
20	0.993896	0.110312	1.987792	0.220624	2.981688	0.330936	3.975584	0.441248	4.969480	0.551560	40
22	0.993832	0.110890	1.987664	0.221780	2.981496	0.332670	3.975328	0.443560	4.969160	0.554450	38
24	0.993767	0.111468	1.987534	0.222936	2.981301	0.334404	3.975068	0.445872	4.968835	0.557340	36
26	0.993702	0.112047	1.987404	0.224094	2.981106	0.336141	3.974808	0.448188	4.968510	0.560235	34
28	0.993637	0.112625	1.987274	0.225250	2.980911	0.237875	3.974548	0.450500	4.968185	0.563125	32
30	0.993571	0.113203	1.987142	0.226406	2.980713	0.339609	3.974284	0.452812	4.967855	0.566015	30
32	0.993505	0.113781	1·987010	0.227562	2.980515	0.341343	3.974020	0.455124	4.967525	0.568905	28
34	0.993439	0.114359	1.986878	0.228718	2.980317	0.343077	3.973756	0.457436	4.967195	0.571795	26
36	0.993372	0.114937	1.986744	0.229874	2.980116	0.344811	3.973488	0.459748	4.966860	0.574685	24
38	0.993305	0.115515	1.986610	0.231030	2.979915	0.346545	3.973220	0.462060	4.966525	0.577575	22
40	0.993238	0.116092	1.986476	0.232184	2.979714	0.348276	3.972952	0.464368	4.966190	0.580460	20
42	0.993170	0.116670	1.986340	0.233340	2.979510	0.350010	3.972680	0.466680	4.965850	0.583350	18
44	0.993102	0.117248	1.986204	0.234496	2.979306	0.351744	3.972408	0.468992	4.965510	0.586240	16
46	0.993034	0.117826	1.986068	0.235652	2.979102	0.353478	3.972136	0.471304	4.965170	0.589130	14
48	0.992965	0.118404	1.985930	0.236808	2.978895	0.355212	3.971860	0.473616	4.964825	0.592020	12
50	0.992896	0.118981	1.985792	0.237962	2.978688	0.356943	3.971584	0.475924	4.964480	0.594905	10
52	0.992827	0.119559	1.985654	0.239118	2.978481	0.358677	3.971308	0.478236	4.964135	0.597795	8
54	0.992757	0.120136	1.985514	0.240272	2.978271	0.360408	3.971028	0.480544	4.963785	0.600680	6
56	0.992687	0.120714	1.985374	0.241428	2.978061	0.362142	3.970748	0.482856	4.963435	0.603570	4
58	0.992616	0.121291	1.985232	0.242582	2.977848	0.363873	3.970464	0.485164	4.963080	0.606455	2
60	0.992546	0.121869	1.985092	0.243738	2.977638	0.365607	3.970184	0.487476	4.962730	0.609345	83°
	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Degrees and Minutes.
	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		

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Degrees and Minutes.	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000, — Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000. — Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000. — Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000. — Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000. — Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	
7°	0.992546	0.121869	1.985092	0.243738	2.977638	0.365607	3.970184	0.487476	4.962730	0.609345	60′
2′	0.992475	0.122446	1.984950	0.244892	2.977426	0.367338	3.969900	0.489784	4.962375	0.612230	58
4	0.992403	0.123024	1.984806	0.246048	2.977209	0.369072	3.969612	0.492096	4.962015	0.615120	56
6	0.992331	0.123601	1.984662	0.247202	2.976993	0.370803	3.969324	0.494404	4.961655	0.618005	54
8	0.992259	0.124178	1.984518	0.248356	2.976777	0.372534	3.969036	0.496712	4.961295	0.620890	52
10	0.992187	0.124756	1.984374	0.249512	2.976561	0.374268	3.968748	0.499024	4.960935	0.623780	50
12	0.992114	0.125333	1.984228	0.250666	2.976342	0.375999	3.968456	0.501332	4.960570	0.626665	48
14	0.992041	0.125910	1.984082	0.251820	2.976123	0.377730	3.968164	0.503640	4.960205	0.629550	46
16	0.991968	0.126487	1.983936	0.252974	2.975905	0.379461	3.967872	0.505948	4.959840	0.632435	44
18	0.991894	0.127064	1.983788	0.254128	2.975682	0.381192	3.967576	0.508256	4.959 70	0.635320	42
20	0.991820	0.127641	1.983640	0.255282	2.975460	0.382923	3.967280	0.510564	4.959100	0.638205	40
22	0.991745	0.128218	1.983490	0.256436	2.975235	0.384654	3.966980	0.512872	4.958725	0.641090	38
24	0.991671	0.128795	1.983342	0.257590	2.975013	0.386385	3.966684	0.515180	4.958355	0.643975	36
26	0.991596	0.129372	1.983192	0.258744	2.974788	0.388116	3.966384	0.517488	4.957980	0.646860	34
28	0.991520	0.129949	1.983040	0.259898	2.974560	0.389847	3.966080	0.519796	4.957600	0.649745	32
30	0.991444	0.130526	1.982888	0.261052	2.974332	0.391578	3.965776	0.522104	4.957220	0.652630	30
32	0.991368	0.131103	1.982736	0.262206	2.974104	0.393309	3.965472	0.524412	4.956840	0.655515	28
34	0.991292	0.131679	1.982584	0.263358	2.973876	0.395037	3.965160	0.526716	4.956460	0.658395	26
36	0.991215	0.132256	1.982430	0.264512	2.973645	0.396768	3.964860	0.529024	4.956075	0.661280	24
38	0.991138	0.132833	1.982276	0.265666	2.973414	0.398499	3.964552	0.531332	4.955690	0.664165	22
40	0.991061	0.133409	1.982122	0.266818	2.973183	0.400227	3.964242	0.533636	4.955305	0.667045	20
42	0.990983	0.133986	1.981966	0.267972	2.972949	0.401958	3.963932	0.535944	4.954915	0.669930	18
44	0.990905	0.134562	1.981810	0.269124	2.972715	0.403686	3.963620	0.538248	4.954525	0.672810	16
46	0.990826	0.135139	1.981652	0.270278	2.972478	0.405417	3.963304	0.540556	4.954130	0.675695	14
48	0.990747	0.135715	1.981494	0.271436	2.972241	0.407145	3.962988	0.542860	4.953735	0.678575	12
50	0.990668	0.136291	1.981336	0.272582	2.972004	0.408873	3.962672	0.545164	4.953340	0.681455	10
52	0.990589	0.136868	1.981178	0.273736	2.971767	0.410604	3.962356	0.547472	4.952945	0.684340	8
54	0.990509	0.137444	1.981018	0.274888	2.971527	0.412332	3.962036	0.549776	4.952545	0.687220	6
56	0.990429	0.138020	1.980858	0.276040	2.971287	0.414060	3.961716	0.552080	4.952145	0.690100	4
58	0.990348	0.138597	1.980696	0.277194	2.971044	0.415791	3.961392	0.554388	4.951740	0.692985	2
60	0.990268	0.139173	1.980536	0.278346	2.970804	0.417519	3.961072	0.556692	4.951340	0.695865	82°
	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Degrees and Minutes.
	Measured [illegible], or Hyp[illegible] 1, 10, 100, 1000, [illegible] 100,000.		[illegible]		[illegible]		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		

Degrees and Minutes.	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		
	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	
8°	0.990268	0.139173	1.980536	0.278346	2.970804	0.417519	3.961072	0.556692	4.951340	0.695865	60′
2′	0.990186	0.139749	1.980372	0.279498	2.970558	0.419247	3.960744	0.558996	4.950930	0.698745	58
4	0.990105	0.140325	1.980210	0.280650	2.970315	0.420975	3.960420	0.561300	4.950525	0.701625	56
6	0.990023	0.140901	1.980046	0.281802	2.970069	0.422703	3.960092	0.563604	4.950115	0.704505	54
8	0.989941	0.141477	1.979882	0.282954	2.969823	0.424431	3.959764	0.565908	4.949705	0.707385	52
10	0.989859	0.142053	1.979718	0.284106	2.969577	0.426159	3.959436	0.568212	4.949295	0.710265	50
12	0.989776	0.142628	1.979552	0.285256	2.969328	0.427884	3.959104	0.570512	4.948880	0.713140	48
14	0.989693	0.143204	1.979386	0.286408	2.969079	0.429612	3.958772	0.572816	4.948465	0.716020	46
16	0.989609	0.143780	1.979218	0.287560	2.968827	0.431340	3.958436	0.575120	4.948045	0.718900	44
18	0.989525	0.144356	1.979050	0.288712	2.968575	0.433068	3.958100	0.577424	4.947625	0.721780	42
20	0.989441	0.144931	1.978882	0.289862	2.968323	0.434793	3.957764	0.579724	4.947205	0.724655	40
22	0.989357	0.145507	1.978714	0.291014	2.968071	0.436521	3.957428	0.582028	4.946785	0.727535	38
24	0.989272	0.146083	1.978544	0.292166	2.967816	0.438249	3.957088	0.584332	4.946360	0.730415	36
26	0.989187	0.146658	1.978374	0.293316	2.967561	0.439974	3.956748	0.586632	4.945935	0.733290	34
28	0.989101	0.147234	1.978202	0.294468	2.967303	0.441702	3.956404	0.588936	4.945505	0.736170	32
30	0.989015	0.147809	1.978030	0.295618	2.967045	0.443427	3.956060	0.591236	4.945075	0.739045	30
32	0.988929	0.148384	1.977858	0.296768	2.966787	0.445152	3.955716	0.593536	4.944645	0.741920	28
34	0.988843	0.148960	1.977686	0.297920	2.966529	0.446880	3.955372	0.595840	4.944215	0.744800	26
36	0.988756	0.149535	1.977512	0.299070	2.966268	0.448605	3.955024	0.598140	4.943780	0.747675	24
38	0.988669	0.150110	1.977338	0.300220	2.966007	0.450330	3.954676	0.600440	4.943345	0.750550	22
40	0.988581	0.150685	1.977162	0.301370	2.965743	0.452055	3.954324	0.602740	4.942905	0.753425	20
42	0.988493	0.151260	1.976986	0.302520	2.965479	0.453780	3.953972	0.605040	4.942465	0.756300	18
44	0.988405	0.151835	1.976810	0.303670	2.965215	0.455505	3.953620	0.607340	4.942025	0.759175	16
46	0.988317	0.152410	1.976634	0.304820	2.964951	0.457230	3.953268	0.609640	4.941585	0.762050	14
48	0.988228	0.152985	1.976456	0.305970	2.964684	0.458955	3.952912	0.611940	4.941140	0.764925	12
50	0.988139	0.153560	1.976278	0.307120	2.964417	0.460680	3.952556	0.614240	4.940695	0.767800	10
52	0.988049	0.154135	1.976098	0.308270	2.964147	0.462405	3.952196	0.616540	4.940245	0.770675	8
54	0.987959	0.154710	1.975918	0.309420	2.963877	0.464130	3.951836	0.618840	4.939795	0.773550	6
56	0.987869	0.155285	1.975738	0.310570	2.963607	0.465855	3.951476	0.621140	4.939345	0.776425	4
58	0.987779	0.155859	1.975558	0.311718	2.963337	0.467577	3.951116	0.623436	4.938895	0.779295	2
60	0.987688	0.156434	1.975376	0.312868	2.963064	0.469302	3.950752	0.625736	4.938440	0.782170	81°
	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Degrees and Minutes.
	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		

Degrees and Minutes.	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		
	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	
9°	0.987688	0.156434	1.975376	0.312868	2.963064	0.469302	3.950752	0.625736	4.938440	0.782170	60′
2′	0.987597	0.157009	1.975194	0.314018	2.962791	0.471027	3.950388	0.628036	4.937985	0.785045	58
4	0.987505	0.157583	1.975010	0.315166	2.962515	0.472749	3.950020	0.630332	4.937525	0.787915	56
6	0.987413	0.158158	1.974826	0.316316	2.962239	0.474474	3.949652	0.632632	4.937065	0.790790	54
8	0.987321	0.158732	1.974642	0.317464	2.961963	0.476196	3.949284	0.634928	4.936605	0.793660	52
10	0.987229	0.159306	1.974458	0.318612	2.961687	0.477918	3.948916	0.637224	4.936145	0.796530	50
12	0.987136	0.159881	1.974272	0.319762	2.961408	0.479643	3.948544	0 639524	4.935680	0.799405	48
14	0.987043	0.160455	1.974086	0.320910	2.961129	0.481365	3.948172	0.641820	4.935215	0.802275	46
16	0.986949	0.161029	1.973898	0.322058	2.960847	0.483087	3.947796	0.644116	4.934745	0.805145	44
18	0.986855	0.161603	1.973710	0.323206	2.960565	0.484809	3.947420	0.646412	4.934275	0.808015	42
20	0.986761	0.162177	1.973522	0.324354	2.960283	0.486531	3.947044	0.648708	4.933805	0.810885	40
22	0.986667	0.162752	1.973334	0.325504	2.960001	0.488256	3.946668	0.651008	4.933335	0.813760	38
24	0.986572	0.163326	1.973144	0.326652	2.959716	0.489978	3.946288	0.653304	4.932860	0.816630	36
26	0.986477	0.163899	1.972954	0.327798	2.959431	0.491697	3.945908	0.655596	4.932385	0.819495	34
28	0.986381	0.164473	1.972762	0.328946	2.959143	0.493419	3.945524	0.657892	4.931905	0.822365	32
30	0.986285	0.165047	1.972570	0.330094	2.958855	0.495141	3.945140	0.660188	4.931425	0.825325	30
32	0.986189	0.165621	1.972378	0.331242	2.958567	0.496863	3.944756	0.662484	4.930945	0.828105	28
34	0.986092	0.166195	1.972184	0.332390	2.958276	0.498585	3.944368	0.664780	4.930460	0.830975	26
36	0.985996	0.166768	1.971992	0.333536	2.957988	0.500304	3.943984	0.667072	4.929980	0.833840	24
38	0.985898	0.167342	1.971796	0.334684	2.957694	0.502026	3.943592	0.669368	4.929490	0.836710	22
40	0.985801	0.167915	1.971602	0.335830	2.957403	0.503745	3.943204	0.671660	4.929005	0.839575	20
42	0.985703	0.168489	1.971406	0.336978	2.957109	0.505467	3.942812	0.673956	4.928515	0.842445	18
44	0.985605	0.169062	1.971210	0.338124	2.956815	0.507186	3.942420	0.676248	4.928025	0.845310	16
46	0.985506	0.169636	1.971012	0.339272	2.956518	0.508908	3.942024	0.678544	4.927530	0.848180	14
48	0.985407	0.170209	1.970814	0.340418	2.956221	0.510627	3.941628	0.680836	4.927035	0.851045	12
50	0.985308	0.170782	1.970616	0.341564	2.955924	0.512346	3.941232	0.683128	4.926540	0.853910	10
52	0.985209	0.171356	1.970418	0.342712	2.955627	0.514068	3.940836	0.685424	4.926045	0.856780	8
54	0.985109	0.171929	1.970218	0.343858	2.955327	0.515787	3.940436	0.687716	4.925545	0.859645	6
56	0.985009	0.172502	1.970018	0.345004	2.955027	0.517506	3.940036	0.690008	4.925045	0.862510	4
58	0.984908	0.173075	1.969816	0.346150	2.954724	0.519225	3.939632	0.692300	4.924540	0.865378	2
60	0.984807	0.173648	1.969614	0.347296	2.954421	0.520944	3.939228	0.694592	4.924035	0.868240	80°
	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Degrees and Minutes.
	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		

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Degrees and Minutes.	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		
	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	
10°	0.984807	0.173648	1.969614	0.347296	2·954421	0.520944	3.939228	0.694592	4.924035	0.868240	60′
2′	0.984706	0.174221	1.969412	0.348442	2.954118	0.522663	3.938824	0.696884	4.923530	0.871105	58
4	0.984605	0.174793	1.969210	0.349586	2.953815	0.524379	3.938420	0.699172	4.923025	0.873965	56
6	0.984503	0.175366	1.969006	0.350732	2.953509	0.526098	3.938012	0.701464	4.922515	0.876830	54
8	0.984401	0.175939	1.968802	0.351878	2.953203	0.527817	3.937604	0.703756	4.922005	0.879695	52
10	0.984298	0.176512	1.968596	0.353024	2.952894	0.529536	3.937192	0.706048	4.921490	0.882560	50
12	0.984195	0.177084	1.968390	0.354168	2.952585	0.531252	3.936780	0.708336	4.920975	0.885420	48
14	0.984092	0.177657	1.968184	0.355314	2.952276	0.532971	3.936368	0.710628	4.920460	0.888285	46
16	0.983988	0.178229	1.967976	0.356458	2.951964	0.534687	3.935952	0.712916	4.919940	0.891145	44
18	0.983885	0.178802	1.967770	0.357604	2.951655	0.536406	3.935540	0.715208	4.919425	0.894010	42
20	0.983780	0.179374	1.967569	0.358748	2.951340	0.538122	3.935120	0.717496	4.918900	0.896870	40
22	0.983676	0.179946	1.967352	0.359892	2.951028	0.539838	3.934704	0.719784	4.918380	0.899730	38
24	0.983571	0.180519	1.967142	0.361038	2.950713	0.541557	3.934284	0.722076	4.917855	0.902595	36
26	0.983466	0.181091	1.966932	0.362182	2.950398	0.543273	3.933864	0.724364	4.917330	0.905455	34
28	0.983360	0.181663	1.966720	0.363326	2.950080	0.544989	3.933440	0.726652	4.916800	0.908315	32
30	0.983254	0.182235	1.966508	0.364470	2.949762	0.546705	3.933016	0.728940	4.916270	0.911175	30
32	0.983148	0.182807	1.966296	0.365614	2.949444	0.548421	3.932592	0.731228	4.915740	0.914035	28
34	0.983042	0.183379	1.966084	0.366758	2.949126	0.550137	3.932168	0.733516	4.915210	0.916895	26
36	0.982935	0.183951	1.965870	0.367902	2.948805	0.551853	3.931740	0.735804	4.914675	0.919755	24
38	0.982828	0.184523	1.965656	0.369046	2.948484	0.553569	3.931312	0.738092	4.914140	0.922615	22
40	0.982720	0.185094	1.965440	0.370188	2.948160	0.555282	3.930880	0.740376	4.913600	0.925470	20
42	0.982612	0.185666	1.965224	0.371332	2.947836	0.556998	3.930448	0.742664	4.913060	0.928330	18
44	0.982504	0.186238	1.965008	0.372476	2.947512	0.558714	3.930016	0.744952	4.912520	0.931190	16
46	0.982396	0.186809	1.964792	0.373618	2.947188	0.560427	3.929584	0.747236	4.911980	0.934045	14
48	0.982287	0.187381	1.964574	0.374762	2.946861	0.562143	3.929148	0.749524	4.911435	0.936905	12
50	0.982178	0.187952	1.964356	0.375904	2.946534	0.563856	3.928712	0.751808	4.910890	0.939760	10
52	0.982068	0.188524	1.964136	0.377048	2.946204	0.565572	3.928272	0.754096	4.910340	0.942620	8
54	0.981958	0.189095	1.963916	0.378190	2.945874	0.567285	3.927832	0.756380	4.909790	0.945475	6
56	0.981848	0.189666	1.963696	0.379332	2.945544	0.568998	3.927392	0.758664	4.909240	0.948330	4
58	0.981738	0.190237	1.963476	0.380474	2.945214	0.570711	3.926952	0.760948	4.908690	0.951185	2
60	0.981627	0.190809	1.963254	0.381618	2.944881	0.572427	3.926508	0.763236	4.908135	0.954045	79°
	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Degrees and Minutes.
	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		

Degrees and Minutes.	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000. Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000. Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000. Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000. Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000. Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	
11°	0.981627	0.190809	1.963254	0.381618	2.944881	0.572427	3.926508	0.763236	4.908135	0.954045	60′
2′	0.981516	0.191380	1.963032	0.382760	2.944548	0.574140	3.926064	0.765520	4.907580	0.956900	58
4	0.981404	0.191951	1.962808	0.383902	2.944212	0.575853	3.925616	0.767804	4.907020	0.959755	56
6	0.981292	0.192522	1.962584	0.385044	2.943876	0.577566	3.925168	0.770088	4.906460	0.962610	54
8	0.981180	0.193092	1.962360	0.386184	2.943540	0.579276	3.924720	0.772368	4.905900	0.965460	52
10	0.981068	0.193663	1.962136	0.387326	2.943204	0.580989	3.924272	0.774652	4.905340	0.968315	50
12	0.980955	0.194234	1.961910	0.388468	2.942865	0.582702	3.923820	0.776936	4.904775	0.971170	48
14	0.980842	0.194805	1.961684	0.389610	2.942526	0.584415	3.923368	0.779220	4.904210	0.974025	46
16	0.980728	0.195375	1.961456	0.390750	2.942184	0.586125	3.922912	0.781500	4.903640	0.976875	44
18	0.980614	0.195946	1.961228	0.391892	2.941842	0.587838	3.922456	0.783784	4.903070	0.979730	42
20	0.980500	0.196516	1.961000	0.393032	2.941500	0.589548	3.922000	0.786064	4.902500	0.982580	40
22	0.980386	0.197087	1.960772	0.394174	2.941158	0.591261	3.921544	0.788348	4.901930	0.985435	38
24	0.980271	0.197657	1.960542	0.395314	2.940813	0.592971	3.921084	0.790628	4.901355	0.988285	36
26	0.980156	0.198227	1.960312	0.396454	2.940468	0.594681	3.920624	0.792908	4.900780	0.991135	34
28	0.980040	0.198797	1.960080	0.397594	2.940120	0.596391	3.920160	0.795188	4.900200	0.993985	32
30	0.979924	0.199367	1.959848	0.398734	2.939772	0.598101	3.919696	0.797468	4.899620	0.996835	30
32	0.979808	0.199938	1.959616	0.399876	2.939424	0.599814	3.919232	0.799752	4.899040	0.999690	28
34	0.979692	0.200508	1.959384	0.401016	2.939076	0.601524	3.918768	0.802032	4.898460	1.002540	26
36	0.979575	0.201077	1.959150	0.402154	2.938725	0.603231	3.918300	0.804308	4.897875	1.005385	24
38	0.979458	0.201647	1.958916	0.403294	2.938374	0.604941	3.917832	0.806588	4.897290	1.008235	22
40	0.979340	0.202217	1.958680	0.404434	2.938020	0.606651	3.917360	0.808868	4.896700	1.011085	20
42	0.979222	0.202787	1.958444	0.405574	2.937666	0.608361	3.916888	0.811148	4.896110	1.013935	18
44	0.979104	0.203356	1.958208	0.406712	2.937312	0.610068	3.916416	0.813424	4.895520	1.016780	16
46	0.978986	0.203926	1.957972	0.407852	2.936958	0.611778	3.915944	0.815704	4.894930	1.019630	14
48	0.978867	0.204496	1.957734	0.408992	2.936601	0.613488	3.915468	0.817984	4.894335	1.022480	12
50	0.978748	0.205065	1.957496	0.410130	2.936244	0.615195	3.914992	0.820260	4.893740	1.025325	10
52	0.978628	0.205634	1.957256	0.411268	2.935884	0.616902	3.914512	0.822536	4.893140	1.028170	8
54	0.978509	0.206204	1.957018	0.412408	2.935527	0.618612	3.914036	0.824816	4.892545	1.031020	6
56	0.978388	0.206773	1.956776	0.413546	2.935164	0.620319	3.913552	0.827092	4.891940	1.033865	4
58	0.978268	0.207342	1.956536	0.414684	2.934804	0.622026	3.913072	0.829368	4.891340	1.036710	2
60	0.978147	0.207911	1.956294	0.415822	2.934441	0.623733	3.912588	0.831644	4.890735	1.039555	78°
	Distance from Planes of Meridian, or East or West Distance. Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance. Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance. Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance. Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance. Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.	Distance from Planes of Latitude, or North or South Distance.	Degrees and Minutes.

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Degrees and Minutes.	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse. 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		
	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	
12°	0.978147	0.207911	1.956294	0.415822	2.934441	0.623733	3.912588	0.831644	4.890735	1.039555	60′
2′	0.978026	0.208480	1.956052	0.416960	2.934078	0.625440	3.912104	0.833920	4.890130	1.042400	58
4	0.977905	0.209049	1.955810	0.418098	2.933715	0.627147	3.911620	0.836196	4.889525	1.045245	56
6	0.977783	0.209618	1.955566	0.419236	2.933349	0.628854	3.911132	0.838472	4.888915	1.048090	54
8	0.977661	0.210187	1.955322	0.420374	2.932983	0.630561	3.910644	0.840748	4.888305	1.050935	52
10	0.977538	0.210756	1.955076	0.421512	2.932614	0.632268	3.910152	0.843024	4.887690	1.053780	50
12	0.977415	0.211324	1.954830	0.422648	2.932245	0.633972	3.909660	0.845296	4.887075	1.056620	48
14	0.977292	0.211893	1.954584	0.423786	2.931876	0.635679	3.909168	0.847572	4.886460	1.059465	46
16	0.977169	0.212461	1.954338	0.424922	2.931507	0.637383	3.908676	0.849844	4.885845	1.062305	44
18	0.977045	0.213030	1.954090	0.426060	2.931135	0.639090	3.908180	0.852120	4.885225	1.065150	42
20	0.976921	0.213598	1.953842	0.427196	2.930763	0.640794	3.907684	0.854392	4.884605	1.067990	40
22	0.976797	0.214167	1.953594	0.428334	2.930391	0.642501	3.907188	0.856668	4.883985	1.070835	38
24	0.976672	0.214735	1.953344	0.429470	2.930016	0.644205	3.906688	0.858940	4.883360	1.073675	36
26	0.976547	0.215303	1.953094	0.430606	2.929641	0.645909	3.906188	0.861212	4.882735	1.076515	34
28	0.976421	0.215871	1.952842	0.431742	2.929263	0.647613	3.905684	0.863484	4.882105	1.079355	32
30	0.976296	0.216439	1.952592	0.432878	2.928888	0.649317	3.905184	0.865756	4.881480	1.082195	30
32	0.976169	0.217007	1.952338	0.434014	2.928507	0.651021	3.904676	0.868028	4.880845	1.085035	28
34	0.976043	0.217575	1.952086	0.435150	2.928129	0.652725	3.904172	0.870300	4.880215	1.087875	26
36	0.975916	0.218143	1.951832	0.436286	2.927748	0.654429	3.903664	0.872572	4.879580	1.090715	24
38	0.975789	0.218711	1.951578	0.437422	2.927367	0.656133	3.903156	0.874844	4.878945	1.093555	22
40	0.975662	0.219278	1.951324	0.438556	2.926986	0.657834	3.902648	0.877112	4.878310	1.096390	20
42	0.975534	0.219846	1.951068	0.439692	2.926602	0.659538	3.902136	0.879384	4.877670	1.099230	18
44	0.975406	0.220413	1.950812	0.440826	2.926218	0.661239	3.901624	0.881652	4.877030	1.102065	16
46	0.975278	0.220981	1.950556	0.441962	2.925834	0.662943	3.901112	0.883924	4.876390	1.104905	14
48	0.975149	0.221548	1.950298	0.443096	2.925447	0.664644	3.900596	0.886192	4.875745	1.107740	12
50	0.975020	0.222115	1.950040	0.444230	2.925060	0.666345	3.900080	0.888460	4.875100	1.110575	10
52	0.974890	0.222683	1.949780	0.445366	2.924670	0.668049	3.899560	0.890732	4.874450	1.113415	8
54	0.974761	0.223250	1.949522	0.446500	2.924283	0.669750	3.899044	0.893000	4.873805	1.116250	6
56	0.974631	0.223817	1.949262	0.447634	2.923893	0.671451	3.898524	0.895268	4.873155	1.119085	4
58	0.974500	0.224384	1.949000	0.448768	2.923500	0.673152	3.898000	0.897536	4.872500	1.121920	2
60	0.974370	0.224951	1.948740	0.449902	2.923110	0.674853	3.897480	0.899804	4.871850	1.124755	77°
	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Degrees and Minutes.
	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000,		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		

Degrees and Minutes.	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		
	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance f.om Planes of Meridian, or East or West Distance.	
13°	0.974370	0.224951	1.948740	0.449902	2.923110	0.674853	3.897480	0.899804	4.871850	1.124755	60′
2′	0.974239	0.225517	1.948478	0.451034	2.922717	0.676551	3.896956	0.902068	4.871195	1.127585	58
4	0.974107	0.226084	1.948214	0.452168	2.922321	0.678252	3.896428	0.904336	4.870535	1.130420	56
6	0.973976	0.226651	1.947952	0.453302	2.921928	0.679953	3.895904	0.906604	4.869880	1.133255	54
8	0.973843	0.227217	1.947686	0.454434	2.921529	0.681651	3.895372	0.908868	4.869215	1.136085	52
10	0.973711	0.227784	1.947422	0.455568	2.921133	0.683352	3.894844	0.911136	4.868555	1.138920	50
12	0.973578	0.228350	1.947156	0.456700	2.920734	0.685050	3.894312	0.913400	4.867890	1.141750	48
14	0.973445	0.228917	1.946890	0.457834	2.920335	0.686751	3.893780	0.915668	4.867225	1.144585	46
16	0.973312	0.229483	1.946624	0.458966	2.919936	0.688449	3.893248	0.917932	4.866560	1.147415	44
18	0.973178	0.230049	1.946356	0.460098	2.919534	0.690147	3.892712	0.920196	4.865890	1.150245	42
20	0.973044	0.230615	1.946088	0.461230	2.919132	0.691845	3.892176	0.922460	4.865220	1.153075	40
22	0.972910	0.231181	1.945820	0.462362	2.918730	0.693543	3.891640	0.924724	4.864550	1.155905	38
24	0.972775	0.231747	1.945550	0.463494	2.918325	0.695241	3.891100	0.926988	4.863875	1.158735	36
26	0.972640	0.232313	1.945280	0.464626	2.917920	0.696939	3.890560	0.929252	4.863200	1.161565	34
28	0.972505	0.232879	1.945010	0.465758	2.917515	0.698637	3.890020	0.931516	4.862525	1.164395	32
30	0.972369	0.233445	1.944738	0.466890	2.917107	0.700335	3.889476	0.933780	4.861845	1.167225	30
32	0.972233	0.234011	1.944466	0.468022	2.916699	0.702033	3.888932	0.936044	4.861165	1.170055	28
34	0.972097	0.234576	1.944194	0.469152	2.916291	0.703728	3.888388	0.938304	4.860485	1.172880	26
36	0.971961	0.235142	1.943922	0.470284	2.915883	0.705426	3.887844	0.940568	4.859805	1.175710	24
38	0.971824	0.235707	1.943648	0.471414	2.915472	0.707121	3.887296	0.942828	4.859120	1.178535	22
40	0.971686	0.236272	1.943372	0.472544	2.915058	0.708816	3.886744	0.945088	4.858430	1.181360	20
42	0.971549	0.236838	1.943098	0.473676	2.914647	0.710514	3.886196	0.947352	4.857745	1.184190	18
44	0.971411	0.237403	1.942822	0.474806	2.914233	0.712209	3.885644	0.949612	4.857055	1.187015	16
46	0.971272	0.237968	1.942544	0.475936	2.913816	0.713904	3.885088	0.951872	4.856360	1.189840	14
48	0.971134	0.238533	1.942268	0.477066	2.913402	0.715599	3.884536	0.954132	4.855670	1.192665	12
50	0.970995	0.239098	1.941990	0.478196	2.912985	0.717294	3.883980	0.956392	4.854975	1.195490	10
52	0.970856	0.239663	1.941712	0.479326	2.912568	0.718989	3.883424	0.958652	4.854280	1.198315	8
54	0.970716	0.240228	1.941432	0.480456	2.912148	0.720684	3.882864	0.960912	4.853580	1.201140	6
56	0.970576	0.240792	1.941152	0.481584	2.911728	0.722376	3.882304	0.963168	4.852880	1.203960	4
58	0.970436	0.241357	1.940872	0.483714	2.911308	0.724071	3.881744	0.967428	4.852180	1.206785	2
60	0.970295	0.241921	1.940590	0.483842	2.910885	0.725763	3.881180	0.967684	4.851475	1.209605	76°
	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Degrees and Minutes.
	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		

Degrees and Minutes.	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		
	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	
14°	0.970295	0.241921	1.940590	0.483842	2.910885	0.725763	3.881180	0.967684	4.851475	1.209605	60′
2′	0.970154	0.242486	1.940308	0.484972	2.910462	0.727458	3.880616	0.969944	4.850770	1.212430	58
4	0.970018	0.243050	1.940026	0.486100	2.910039	0.729150	3.880042	0.972200	4.850065	1.215250	56
6	0.969872	0.243615	1.939744	0.487230	2.909616	0.730845	3.879488	0.974460	4.849360	1.218075	54
8	0.969730	0.244179	1.939460	0.488358	2.909190	0.732537	3.878920	0.976716	4.848650	1.220895	52
10	0.969587	0.244743	1.939174	0.489486	2.908761	0.734229	3.878348	0.978972	4.847935	1.223715	50
12	0.969445	0.245307	1.938890	0.490614	2.908335	0.735921	3.877780	0.981228	4.847225	1.226535	48
14	0.969302	0.245871	1.938604	0.491742	2.907906	0.737613	3.877208	0.983484	4.846510	1.229355	46
16	0.969159	0.246435	1.938318	0.492870	2.907477	0.739305	3.876636	0.985740	4.845795	1.232175	44
18	0.969015	0.246999	1.938030	0.493998	2.907045	0.740997	3.876060	0.987996	4.845075	1.234995	42
20	0.968871	0.247562	1.937742	0.495124	2.906613	0.742686	3.875484	0.990248	4.844355	1.237810	40
22	0.968727	0.248126	1.937454	0.496252	2.906181	0.744378	3.874908	0.992504	4.843635	1.240630	38
24	0·968583	0.248689	1.937166	0.497378	2.905749	0.746067	3.874332	0.994756	4.842915	1.243445	36
26	0.968438	0.249253	1.936876	0.498506	2.905314	0.747759	3.873752	0.997012	4.842190	1.246265	34
28	0.968293	0.249816	1.936586	0.499632	2.904879	0.749448	3.873172	0.999264	4.841465	1.249080	32
30	0.968147	0.250380	1.936294	0.500760	2.904441	0.751140	3.872588	1.001520	4.840735	1.251900	30
32	0.968001	0.250943	1.936002	0·501886	2.904003	0.752829	3.872004	1.003772	4.840005	1.254715	28
34	0.967855	0.251506	1.935710	0.503012	2.903565	0.754518	3.871420	1.006024	4.839275	1.257530	26
36	0.967709	0.252069	1.935418	0.504138	2.903127	0.756207	3.870836	1.008276	4.838545	1.260345	24
38	0.967562	0.252632	1.935124	0.505264	2.902686	0.757896	3.870248	1.010528	4.837810	1.263160	22
40	0.967415	0.253195	1.934830	0.506390	2.902245	0.759585	3.869660	1.012780	4.837075	1.265975	20
42	0.967267	0.253757	1.934534	0.507514	2.901801	0.761271	3.869068	1.015028	4.836335	1.268785	18
44	0.967120	0.254320	1.934240	0.508640	2.901360	0.762960	3.868480	1.017280	4.835600	1.271600	16
46	0.966971	0.254883	1.933942	0.509766	2.900913	0.764649	3.867884	1.019532	4.834855	1.274415	14
48	0.966823	0.255445	1.933646	0.510890	2.900469	0.766335	3.867292	1.021780	4.834115	1.277225	12
50	0.966674	0.256008	1.933348	0.512016	2.900022	0.768024	3.866696	1.024032	4.833370	1.280040	10
52	0.966525	0.256570	1.933050	0.513140	2.899575	0.769710	3.866100	1.026280	4.832625	1.282850	8
54	0.966376	0.257132	1.932752	0.514264	2.899128	0.771396	3.865504	1.028528	4.831880	1.285660	6
56	0.966226	0.257695	1.932452	0.515390	2.898678	0.773085	3.864904	1.030780	4.831130	1.288475	4
58	0.966076	0.258257	1.932152	0.516514	2.898228	0.774771	3.864304	1.033028	4.830380	1.291285	2
60	0.965925	0.258819	1.931850	0.517638	2.897775	0.776457	3.863700	1.035276	4.829625	1.294095	75°
	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Degrees and Minutes.
	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		

Degrees and Minutes.	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		
	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	
15°	0.965925	0.258819	1.931850	0.517638	2.897775	0.776457	3.863700	1.035276	4.829625	1.294095	60′
2′	0.965775	0.259381	1.931550	0.518762	2.897325	0.778143	3.863100	1.037524	4.828875	1.296905	58
4	0.965624	0.259942	1.931248	0.519884	2.896872	0.779826	3.862496	1.039768	4.828120	1.299710	56
6	0.965472	0.260504	1.930944	0.521008	2.896416	0.781512	3.861888	1.042016	4.827360	1.302520	54
8	0.965320	0.261066	1.930640	0.522132	2.895960	0.783198	3.861280	1.044264	4.826600	1.305330	52
10	0.965168	0.261627	1.930336	0.523254	2.895504	0.784881	3.860672	1.046508	4.825840	1.308135	50
12	0.965016	0.262189	1.930032	0.524378	2.895048	0.786567	3.860064	1.048756	4.825080	1.310945	48
14	0.964863	0.262750	1.929726	0.525500	2.894589	0.788250	3.859452	1.051000	4.824315	1.313750	46
16	0.964710	0.263311	1.929420	0.526622	2.894130	0.789933	3.858840	1.053244	4.823550	1.316555	44
18	0.964557	0.263873	1.929114	0.527746	2.893671	0.791619	3.858228	1.055492	4.822785	1.319365	42
20	0.964403	0.264434	1.928806	0.528868	2.893209	0.793302	3.857612	1.057736	4.822015	1.322170	40
22	0.964249	0.264995	1.928498	0.529990	2.892747	0.794985	3.856996	1.059980	4.821245	1.324975	38
24	0.964095	0.265556	1.928190	0.531112	2.892285	0.796668	3.856380	1.062224	4.820475	1.327780	36
26	0.963940	0.266117	1.927880	0.532234	2.891820	0.798351	3.855760	1.064468	4.819700	1.330585	34
28	0.963785	0.266677	1.927570	0.533354	2.891355	0.800031	3.855140	1.066708	4.818925	1.333385	32
30	0.963630	0.267238	1.927260	0.534476	2.890890	0.802714	3.854520	1.068952	4.818150	1.336190	30
32	0.963474	0.267798	1.926948	0.535596	2.890422	0.803394	3.853896	1.071192	4.817370	1.338990	28
34	0.963318	0.268359	1.926636	0.536718	2.889954	0.805077	3.853272	1.073436	4.816590	1.341795	26
36	0.963162	0.268919	1.926324	0.537838	2.889486	0.806757	3.852648	1.075676	4.815810	1.344595	24
38	0.963006	0.269480	1.926012	0.538968	2.889018	0.808440	3.852024	1.077920	4.815030	1.347400	22
40	0.962849	0.270040	1.925698	0.540080	2.888547	0.810120	3.851396	1.080160	4.814245	1.350200	20
42	0.962691	0.270600	1.925382	0.541200	2.888073	0.811800	3.850764	1.082400	4.813455	1.353000	18
44	0.962534	0.271160	1.925068	0.542320	2.887602	0.813480	3.850136	1.084640	4.812670	1.355800	16
46	0.962376	0.271720	1.924752	0.543440	2.887128	0.815160	3.849504	1.086880	4.811880	1.358600	14
48	0.962218	0.272280	1.924436	0.544560	2.886654	0.816840	3.848872	1.089120	4.811090	1.361400	12
50	0.962059	0.272840	1.924118	0.545680	2.886177	0.818520	3.848236	1.091360	4.810295	1.364200	10
52	0.961900	0.273399	1.923800	0.546798	2.885700	0.820197	3.847600	1.093596	4.809500	1.366995	8
54	0.961741	0.273959	1.923482	0.547918	2.885223	0.821877	3.846964	1.095836	4.808705	1.369795	6
56	0.961581	0.274518	1.923162	0.549036	2.884743	0.823554	3.846324	1.098072	4.807905	1.372590	4
58	0.961421	0.275078	1.922842	0.550156	2.884263	0.825234	3.845684	1.100312	4.807105	1.375390	2
60	0.961261	0.275637	1.922522	0.551274	2.883783	0.826911	3.845044	1.102548	4.806305	1.378185	74°
	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Degrees and Minutes.
	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		

Degrees and Minutes.	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		
	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	
16°	0.961261	0.275637	1.922522	0.551274	2.883783	0.826911	3.845044	1.102548	4.806305	1.378185	60′
2′	0.961101	0.276196	1.922202	0.552392	2.883303	0.828588	3.844404	1.104784	4.805505	1.380980	58
4	0.960940	0.276755	1.921880	0.553510	2.882820	0.830265	3.843760	1.107020	4.804700	1.383775	56
6	0.960779	0.277314	1.921558	0.554628	2.882337	0.831942	3.843116	1.109256	4.803895	1.386570	54
8	0.960617	0.277873	1.921234	0.555746	2.881851	0.833619	3.842468	1.111492	4.803085	1.389365	52
10	0.960455	0.278432	1.920910	0.556864	2.881365	0.835296	3.841820	1.113728	4.802275	1.392160	50
12	0.960293	0.278991	1.920586	0.557982	2.880879	0.836973	3.841172	1.115964	4.801465	1.394955	48
14	0.960131	0.279549	1.920262	0.559098	2.880393	0.838647	3.840524	1.118196	4.800655	1.397745	46
16	0.959968	0.280108	1.919936	0.560216	2.879904	0.840324	3.839872	1.120432	4.799840	1.400540	44
18	0.959805	0.280666	1.919610	0.561332	2.879415	0.841998	3.839220	1.122664	4.799025	1.403330	42
20	0.959641	0.281225	1.919282	0.562450	2.878923	0.843675	3.838564	1.124900	4.798205	1.406125	40
22	0.959478	0.281783	1.918956	0.563566	2.878434	0.845349	3.837912	1.127132	4.797390	1.408915	38
24	0.959314	0.282341	1.918628	0.564682	2.877942	0.847023	3.837256	1.129364	4.796570	1.411705	36
26	0.959149	0.282899	1.918298	0.565798	2.877447	0.848697	3.836596	1.131596	4.795745	1.414495	34
28	0.958984	0.283457	1.917968	0.566914	2.876952	0.850371	3.835936	1.133828	4.794920	1.417285	32
30	0.958819	0.284015	1.917638	0.568030	2.876457	0.852045	3.835276	1.136060	4.794095	1.420075	30
32	0.958654	0.284573	1.917308	0.569146	2.875962	0.853719	3.834616	1.138292	4.793270	1.422865	28
34	0.958488	0.285130	1.916976	0.570260	2.875464	0.855390	3.833952	1.140520	4.792440	1.425650	26
36	0.958322	0.285688	1.916644	0.571376	2.874966	0.857064	3.833288	1.142752	4.791610	1.428440	24
38	0.958156	0.286245	1.916312	0.572490	2.874468	0.858735	3.832624	1.144980	4.790780	1.431225	22
40	0.957989	0.286803	1.915978	0.573606	2.873967	0.860409	3.831956	1.147212	4.789945	1.434015	20
42	0.957822	0.287360	1.915644	0.574720	2.873466	0.862080	3.831288	1.149440	4.789110	1.436800	18
44	0.957655	0.287917	1.915310	0.575834	2.872965	0.863751	3.830620	1.151668	4.788275	1.439588	16
46	0.957487	0.288474	1.914974	0.576948	2.872461	0.865422	3.829948	1.153896	4.787435	1.442370	14
48	0.957319	0.289031	1.914638	0.578062	2.871957	0.867093	3.829276	1.156124	4.786595	1.445155	12
50	0.957151	0.289588	1.914302	0.579176	2.871453	0.868764	3.828604	1.158352	4.785755	1.447940	10
52	0.956982	0.290145	1.913964	0.580290	2.870946	0.870435	3.827928	1.160580	4.784910	1.450725	8
54	0.956813	0.290702	1.913626	0.581404	2.870439	0.872106	3.827252	1.162808	4.784065	1.453510	6
56	0.956644	0.291258	1.913288	0.582516	2.869932	0.873774	3.826576	1.165032	4.783220	1.456290	4
58	0.956477	0.291815	1.912954	0.583630	2.869431	0.875445	3.825908	1.167260	4.782385	1.459075	2
60	0.956304	0.292371	1.912608	0.584742	2.868912	0.877113	3.825216	1.169484	4.781520	1.461855	73°
	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Degrees and Minutes.
	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		

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Degrees and Minutes.	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		
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17°	0.956304	0.292371	1.912608	0.584742	2.868912	0.877113	3.825216	1.169484	4.781520	1.461855	60′
2′	0.956134	0.292928	1.912268	0.585856	2.868402	0.878784	3.824536	1.171712	4.780670	1.464640	58
4	0.955963	0.293484	1.911926	0.586968	2.867889	0.880452	3.823852	1.173936	4.779815	1.467420	56
6	0.955793	0.294040	1.911586	0.588080	2.867379	0.882120	3.823172	1.176160	4.778965	1.470200	54
8	0.955621	0.294596	1.911242	0.589192	2.866863	0.883788	3.822484	1.178384	4.778105	1.472980	52
10	0.955450	0.295152	1.910900	0.590304	2.866350	0.885456	3.821800	1.180608	4.777250	1.475760	50
12	0.955278	0.295708	1.910556	0.591416	2.865834	0.887124	3.821112	1.182832	4.776390	1.478541	48
14	0.955106	0.296263	1.910212	0.592526	2.865318	0.888789	3.820424	1.185052	4.775530	1.481315	46
16	0.954933	0.296819	1.909866	0.593638	2.864799	0.890457	3.819732	1.187276	4.774665	1.484095	44
18	0.954760	0.297374	1.909520	0.594748	2.864280	0.892122	3.819040	1.189496	4.773800	1.486870	42
20	0.954587	0.297930	1.909174	0.595860	2.863761	0.893790	3.818348	1.191720	4.772935	1.489650	40
22	0.954414	0.298485	1.908828	0.596970	2.863242	0.895455	3.817656	1.193940	4.772070	1.492425	38
24	0.954240	0.299040	1.908480	0.598081	2.862720	0.897120	3.816960	1.196162	4.771200	1.495200	36
26	0.954066	0.299595	1.908132	0.599190	2.862198	0.898785	3.816264	1.198380	4.770330	1.497975	34
28	0.953891	0.300150	1.907782	0.600300	2.861673	0.900450	3.815564	1.200600	4.769455	1.500750	32
30	0.953717	0.300705	1.907434	0.601410	2.861151	0.902115	3.814868	1.202820	4.768585	1.503525	30
32	0.953541	0.301260	1.907082	0.602520	2.860623	0.903780	3.814164	1.205040	4.767705	1.506300	28
34	0.953366	0.301815	1.906732	0.603631	2.860098	0.905445	3.813464	1.207262	4.766830	1.509075	26
36	0.953190	0.302369	1.906380	0.604738	2.859570	0.907107	3.812760	1.209476	4.765950	1.511845	24
38	0.953014	0.302924	1.906028	0.605848	2.859042	0.908772	3.812056	1.211696	4.765070	1.514620	22
40	0.952838	0.303478	1.905676	0.606956	2.858514	0.910434	3.811352	1.213912	4.764190	1.517390	20
42	0.952661	0.304033	1.905322	0.608066	2.857983	0.912099	3.810644	1.216132	4.763305	1.520165	18
44	0.952484	0.304587	1.904968	0.609174	2.857452	0.913761	3.809936	1.218348	4.762420	1.522935	16
46	0.952307	0.305141	1.904614	0.610282	2.856921	0.915423	3.809228	1.220564	4.761535	1.525705	14
48	0.952129	0.305695	1.904258	0.611390	2.856387	0.917085	3.808516	1.222780	4.760645	1.528475	12
50	0.951951	0.306249	1.903902	0.612498	2.855853	0.918747	3.807804	1.224996	4.759755	1.531245	10
52	0.951773	0.306803	1.903546	0.613606	2.855319	0.920409	3.807092	1.227212	4.758865	1.534015	8
54	0.951594	0.307356	1.903188	0.614712	2.854782	0.922068	3.806376	1.229424	4.757970	1.536780	6
56	0.951415	0.307910	1.902830	0.615820	2.854245	0.923730	3.805660	1.231640	4.757075	1.539550	4
58	0.951236	0.308463	1.902472	0.616926	2.853708	0.925389	3.804944	1.233852	4.756180	1.542315	2
60	0.951056	0.309017	1.902112	0.618034	2.853168	0.927051	3.804224	1.236068	4.755280	1.545085	72°
	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Degrees and Minutes.
	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		

Degrees and Minutes.	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000. Distance from Planes of Latitude, or North or South Distance.	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000. Distance from Planes of Meridian, or East or West Distance.	Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000. Distance from Planes of Latitude, or North or South Distance.	Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000. Distance from Planes of Meridian, or East or West Distance.	Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000. Distance from Planes of Latitude, or North or South Distance.	Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000. Distance from Planes of Meridian, or East or West Distance.	Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000. Distance from Planes of Latitude, or North or South Distance.	Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000. Distance from Planes of Meridian, or East or West Distance.	Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000. Distance from Planes of Latitude, or North or South Distance.	Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000. Distance from Planes of Meridian, or East or West Distance.	
18°	0.951056	0.309017	1.902112	0.618034	2.853168	0.927051	3.804224	1.236068	4.755280	1.545085	60′
2	0.950876	0.309570	1.901752	0.619140	2.852628	0.928710	3.803504	1.238280	4.754380	1.547850	58
4	0.950696	0.310123	1.901392	0.620246	2.852088	0.930369	3.802784	1.240492	4.753480	1.550615	56
6	0.950515	0.310676	1.901030	0.621352	2.851545	0.932018	3.802060	1.242704	4.752575	1.553380	54
8	0.950334	0.311229	1.900668	0.622458	2.851002	0.933687	3.801336	1.244916	4.751670	1.556145	52
10	0.950153	0.311782	1.900306	0.623564	2.850459	0.935346	3.800612	1.247128	4.750765	1.558910	50
12	0.949972	0.312334	1.899944	0.624668	2.849916	0.937002	3.799888	1.249336	4.749860	1.561670	48
14	0.949790	0.312887	1.899580	0.625774	2.849370	0.938661	3.799160	1.251548	4.748950	1.564435	46
16	0.949608	0.313440	1.899216	0.626880	2.848824	0.940320	3.798432	1.253760	4.748040	1.567200	44
18	0.949425	0.313992	1.898850	0.627984	2.848275	0.941976	3.797700	1.255968	4.7[illegible]125	1.569960	42
20	0.949242	0.314544	1.898484	0.629088	2.847726	0.943632	3.796968	1.258176	4.746210	1.572720	40
22	0.949059	0.315096	1.898118	0.630192	2.847177	0.945288	3.796236	1.260384	4.745295	1.575480	38
24	0.948876	0.315649	1.897752	0.631298	2.846628	0.946947	3.795504	1.262596	4.744380	1.578245	36
26	0.948692	0.316200	1.897384	0.632400	2.846076	0.948600	3.794768	1.264800	4.743460	1.581005	34
28	0.948508	0.316752	1.897016	0.633504	2.845524	0.950256	3.794032	1.267008	4.742540	1.583760	32
30	0.948323	0.317304	1.896646	0.634608	2.844969	0.951912	3.793292	1.269216	4.741615	1.586520	30
32	0.948138	0.317856	1.896276	0.635712	2.844414	0.953568	3.792552	1.271424	4.740690	1.589280	28
34	0.947953	0.318407	1.895906	0.636804	2.843859	0.955221	3.791812	1.273628	4.739765	1.592035	26
36	0.947768	0.318959	1.895536	0.637918	2.843304	0.956877	3.791072	1.275836	4.738840	1.594795	24
38	0.947582	0.319510	1.895164	0.639020	2.842746	0.958530	3.790328	1.278040	4.737910	1.597550	22
40	0 947396	0.320061	1.894792	0.640122	2.842188	0.960183	3.789584	1.280244	4.736980	1.600305	20
42	0.947210	0.320613	1.894420	0.641226	2.841630	0.961839	3.788840	1.282452	4.736050	1.603065	18
44	0.947023	0.321164	1.894046	0.642328	2.841069	0.963492	3.788092	1.284656	4.735015	1.605820	16
46	0.946836	0.321714	1.893672	0.643428	2.840508	0.965142	3.787344	1.286856	4.734180	1.608570	14
48	0.946649	0.322265	1.893298	0.644530	2.840047	0.966795	3.786596	1.289060	4.733245	1.611325	12
50	0.946461	0.322816	1.892922	0.645632	2.839383	0.968448	3.785844	1.291264	4.732305	1.614080	10
52	0.946273	0.323367	1.892546	0.646734	2.839819	0.970101	3.785092	1.293468	4.731365	1.616835	8
54	0.946085	0.323917	1.892170	0.647834	2.838255	0.971751	3.784340	1.295668	4.730425	1.619585	6
56	0.945896	0.324467	1.891792	0.648934	2.837688	0.973401	3.783584	1.297868	4.729480	1.622335	4
58	0.945707	0.325018	1.891414	0.650036	2.837121	0.975054	3.782828	1.300072	4.728535	1.625090	2
60	0.945518	0.325568	1.891036	0.651136	2.836544	0.976704	3.782072	1.302272	4.727590	1.627840	71°
	Distance from Planes of Meridian, or East or West Distance. Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.	Distance from Planes of Latitude, or North or South Distance. Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.	Distance from Planes of Meridian, or East or West Distance. Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.	Distance from Planes of Latitude, or North or South Distance. Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.	Distance from Planes of Meridian, or East or West Distance. Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.	Distance from Planes of Latitude, or North or South Distance. Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.	Distance from Planes of Meridian, or East or West Distance. Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.	Distance from Planes of Latitude, or North or South Distance. Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.	Distance from Planes of Meridian, or East or West Distance. Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.	Distance from Planes of Latitude, or North or South Distance. Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.	Degrees and Minutes.

Degrees and Minutes.	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		
	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	
19°	0.945518	0.325568	1.891036	0.651136	2.836554	0.976704	3.782072	1.302272	4.727590	1.627840	60'
2'	0.945329	0.326118	1.890658	0.652236	2.835987	0.978354	3.781316	1.304472	4.726645	1.630590	58
4	0.945139	0.326668	1.890278	0.653336	2.835417	0.980004	3.780556	1.306672	4.725695	1.633340	56
6	0.944948	0.327217	1.889896	0.654434	2.834844	0.981651	3.779792	1.308868	4.724740	1.636085	54
8	0.944758	0.327767	1.889516	0.655534	2.834274	0.983301	3.779032	1.311068	4.723790	1.638835	52
10	0.944567	0.328317	1.889134	0.656634	2.833701	0.984951	3.778268	1.313268	4.722835	1.641585	50
12	0.944876	0.328866	1.888752	0.657732	2.833128	0.986598	3.777504	1.315464	4.721880	1.644330	48
14	0.944184	0.329416	1.888368	0.658832	2.832552	0.988248	3.776736	1.317664	4.720920	1.647080	46
16	0.943993	0.329965	1.887986	0.659930	2.831979	0.989895	3.775972	1.319860	4.719965	1.649825	44
18	0.943801	0.330514	1.887602	0.661028	2.831403	0.991542	3.775204	1.322056	4.719005	1.652570	42
20	0.943608	0.331063	1.887216	0.662126	2.830824	0.993189	3.774432	1.324252	4.718040	1.655315	40
22	9.943415	0.331612	1.886830	0.663224	2.830245	0.994836	3.773660	1.326448	4.717075	1.658060	38
24	0.943222	0.332161	1.886444	0.664322	2.829666	0.996483	3.772888	1.328644	4.716110	1.660805	36
26	0.943029	0.332709	1.886058	0.665418	2.829087	0.998127	3.772116	1.330836	4.715145	1.663545	34
28	0.942835	0.333258	1.885670	0.666516	2.828505	0.999774	3.771340	1.333032	4.714175	1.666490	32
30	0.942641	0.333806	1.885282	0.667612	2.827923	1.001418	3.770564	1.335224	4.713205	1.669080	30
32	0.942447	0.334355	1·884894	0.668710	2.827341	1.003065	3.769788	1.337420	4.712235	1.671775	28
34	0.942252	0.334903	1.884504	0.669806	2.826756	1.004709	3.769008	1.339612	4.711260	1.674515	26
36	0.942057	0.335451	1.884114	0.670902	2.826171	1.006353	3.768228	1.341804	4.710285	1.677255	24
38	0.941862	0.335999	1.883724	0.671998	2.825586	1.007997	3.767448	1.343996	4.709310	1.679995	22
40	0.941666	0.336547	1.883332	0.673094	2.824998	1.009641	3.766664	1.346188	4.708330	1.682735	20
42	0.941470	0.337095	1.882940	0.674190	2.824310	1.011285	3.765880	1.348380	4.707350	1.685475	18
44	0.941274	9.337642	1.882548	9.675284	2.823822	1.012926	3.765096	1.350568	4.706370	1.688210	16
46	0.941077	0.338190	1.882154	0.676380	2.823231	1.014570	3.764308	1.352760	4.705385	1.690950	14
48	0.940880	0.338737	1.881760	0.677474	2.822640	1.016211	3.763520	1.354948	4.704400	1.693685	12
50	0.940683	0.339285	1.881366	0.678570	2.822049	1.017855	3.762732	1.357140	4.703415	1.696425	10
52	0.940486	0.339832	1.880972	0.679664	2.821458	1.019496	3.761944	1.359328	4.702430	1.699160	8
54	0.940288	0.340379	1.880576	0.680758	2.820864	1.021137	3.761152	1.361516	4.701440	1.701895	6
56	0.940089	0.340926	1.880178	0.681852	2.820267	1.022778	3.760356	1.363704	4.700445	1.704630	4
58	0.939891	0.341473	1.879782	0.682946	2.819673	1.024419	3.759564	1.365892	4.699455	1.707365	2
60	0.939692	0.342020	1.879384	0.684040	2.819076	1.026060	3.758768	1.368080	4.698460	1.710100	70°
	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Degrees and Minutes.
	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		

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Degrees and Minutes.	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse. 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		
	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	
20°	0.939692	0.342020	1.879384	0.684040	2.819076	1.026060	3.758768	1.368080	4.698460	1.710100	60′
2′	0.939493	0.342566	1.878986	0.685132	2.818479	1.027698	3.757972	1.370264	4.697465	1.712830	58
4	0.939294	0.343113	1.878588	0.686226	2.817882	1.029339	3.757176	1.372452	4.696470	1.715565	56
6	0.939094	0.343659	1.878188	0.687318	2.817282	1.030977	3.756376	1.374636	4.695470	1.718295	54
8	0.938894	0.344206	1.877788	0.688412	2.816682	1.032618	3.755576	1.376824	4.694470	1.721030	52
10	0.938693	0.344752	1.877386	0.689504	2.816079	1.034256	3.754762	1.379008	4.693465	1.723760	50
12	0.938493	0.345298	1.876986	0.690596	2.815479	1.035894	3.753972	1.381192	4.692465	1.726490	48
14	0.938292	0.345844	1.876584	0.691688	2.814876	1.037532	3.753168	1.383376	4.691460	1.729220	46
16	0.938090	0.346390	1.876180	0.692780	2.814270	1.039170	3.752360	1.385560	4.690450	1.731950	44
18	0.937888	0.346935	1.875776	0.693870	2.813664	1.040805	3.751552	1.387740	4.689440	1.734675	42
20	0.937686	0.347481	1.875372	0.694962	2.813058	1.042443	3.750744	1.389924	4.688430	1.737405	40
22	0.937484	0.348026	1.874968	0.696052	2.812452	1.044078	3.749936	1.392104	4.687420	1.740130	38
24	0.937282	0.348572	1.874564	0.697144	2.811846	1.045716	3.749128	1.394288	4.686410	1.742860	36
26	0.937079	0.349117	1.874158	0.698234	2.811237	1.047341	3.748316	1.396468	4.685395	1.745585	34
28	0.936875	0.349662	1.873750	0.699324	2.810625	1.048986	3.747500	1.398648	4.684375	1.748310	32
30	0.936672	0.350207	1.873344	0.700414	2.810016	1.050621	3.746688	1.400828	4.683360	1.751035	30
32	0.936468	0.350752	1.872936	0.701504	2.809404	1.052256	3.745872	1.403008	4.682340	1.753760	28
34	0.936264	0.351297	1.872528	0.702594	2.808792	1.053891	3.745056	1.405188	4.681320	1.756485	26
36	0.936059	0.351841	1.872118	0.703682	2.808177	1.055523	3.744236	1.407364	4.680295	1.759205	24
38	0.935854	0.352386	1.871708	0.704772	2.807562	1.057158	3.743416	1.409544	4.679270	1.761930	22
40	0.935649	0.352930	1.871298	0.705860	2.806947	1.058790	3.742596	1.411720	4.678245	1.764650	20
42	0.935444	0.353474	1.870888	0.706948	2.806332	1.060422	3.741776	1.413896	4.677220	1.767370	18
44	0.935238	0.354019	1.870476	0.708038	2.805714	1.062057	3.740952	1.416076	4.676190	1.770095	16
46	0.935032	0.354563	1.870064	0.709126	2.805096	1.063689	3.740128	1.418252	4.675160	1.772815	14
48	0.934825	0.355107	1.869650	0.710214	2.804475	1.065321	3.739300	1.420428	4.674125	1.775535	12
50	0.934618	0.355650	1.869236	0.711300	2.803854	1.066950	3.738472	1.422600	4.673090	1.778250	10
52	0.934411	0.356194	1.868822	0.712388	2.803233	1.068582	3.737644	1.424776	4.672055	1.780970	8
54	0.934204	0.356738	1.868408	0.713476	2.802612	1.070214	3.736816	1.426952	4.671020	1.783690	6
56	0.933996	0.357281	1.867992	0.714562	2.801988	1.071843	3.735984	1.429124	4.669980	1.786405	4
58	0.933788	0.357824	1.867576	0.715648	2.801364	1.073472	3.735152	1.431296	4.668940	1.789120	2
60	0.933580	0.358367	1.867160	0.716734	2.800740	1.075101	3.734320	1.433468	4.667900	1.791835	69°
	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Degrees and Minutes.
	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000,		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		

Degrees and Minutes.	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		
	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	
21°	0.933580	0.358367	1.867160	0.716734	2.800740	1.075101	3.734320	1.433468	4.667900	1.791835	60′
2′	0.933371	0.358911	1.866742	0.717822	2.800113	1.076733	3.733484	1.435644	4.666855	1.794555	58
4	0.933162	0.359454	1.866324	0.718908	2.799486	1.078362	3.732648	1.437816	4.665810	1.797270	56
6	0.932953	0.359996	1.865906	0.719992	2.798859	1.079988	3.731812	1.439984	4.664765	1.799980	54
8	0.932743	0.360539	1.865486	0.721078	2.798229	1.081617	3.730972	1.442156	4.663715	1.802695	52
10	0.932534	0.361082	1.865068	0.722164	2.797602	1.083246	3.730136	1.444328	4.662670	1.805410	50
12	0.932323	0.361624	1.864646	0.723248	2.796969	1.084872	3.729292	1.446496	4.661615	1.808120	48
14	0.932113	0.362166	1.864226	0.724332	2.796339	1.086498	3.728452	1.448664	4.660565	1.810830	46
16	0.931902	0.362709	1.863804	0.725418	2.795706	1.088127	3.727608	1.450836	4.659510	1.813545	44
18	0.931691	0.363251	1.863382	0.726502	2.795073	1.089753	3.726764	1.453004	4.658455	1.816255	42
20	0.931479	0.363793	1.862958	0.727586	2.794437	1.091379	3.725916	1.455172	4.657395	1.818965	40
22	0.931267	0.364335	1.862534	0.728670	2.793801	1.093005	3.725068	1.457340	4.656335	1.821675	38
24	0.931055	0.364876	1.862110	0.729752	2.793165	1.094628	3.724220	1.459504	4.655275	1.824380	36
26	0.930843	0.365418	1.861686	0.730836	2.792529	1.096254	3.723372	1.461672	4.654215	1.827090	34
28	0.930630	0.365959	1.861260	0.731918	2.791890	1.097877	3.722520	1.463836	4.653150	1.829795	32
30	0.930417	0.366501	1.860834	0.733002	2.791251	1.099503	3.721668	1.466004	4.652085	1.832505	30
32	0.930204	0.367042	1.860408	0.734084	2.790612	1.101126	3.720816	1.468168	4.651020	1.835210	28
34	0.929990	0.367583	1.859980	0.735166	2.789970	1.102749	3.719960	1.470332	4.649950	1.837915	26
36	0.929776	0.368124	1.859552	0.736248	2.789328	1.104372	3.719104	1.472496	4.648880	1.840620	24
38	0.929562	0.368665	1.859124	0.737330	2.788686	1.105995	3.718248	1.474660	4.647810	1.843325	22
40	0.929347	0.369206	1.858694	0.738412	2.788041	1.107618	3.717388	1.476824	4.646735	1.846030	20
42	0.929132	0.369746	1.858264	0.739492	2.787396	1.109338	3.716528	1.478984	4.645660	1.848730	18
44	0.928917	0.370287	1.857834	0.740574	2.786751	1.110861	3.715668	1.481148	4.644585	1.851435	16
46	0.928701	0.370827	1.857402	0.741654	2.786103	1.112481	3.714804	1.483308	4.643505	1.854135	14
48	0.928485	0.371367	1.856970	0.742734	2.785455	1.114101	3.713940	1.485468	4.642425	1.856835	12
50	0.928269	0.371907	1.856538	0.743814	2.784807	1.115721	3.713076	1.487628	4.641345	1.859535	10
52	0.928053	0.372447	1.856106	0.744894	2.784159	1.117341	3.712212	1.489788	4.640265	1.862235	8
54	0.927836	0.372987	1.855672	0.745974	2.782508	1.118961	3.711344	1.491948	4.639180	1.864935	6
56	0.927619	0.373527	1.855238	0.747054	2.782857	1.120581	3.710476	1.494108	4.638095	1.867635	4
58	0.927401	0.374067	1.854802	0.748134	2.782203	1.122201	3.709604	1.496268	4.637005	1.870335	2
60	0.927183	0.374606	1.854366	0.749212	2.781549	1.123818	3.708732	1.498424	4.635915	1.873030	68°
	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Degrees and Minutes.
	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		

Degrees and Minutes.	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		
	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	
22°	0.927183	0.374606	1.854366	0.749212	2.781549	1.123818	3.708732	1.498424	4.635915	1.873030	60′
2′	0.926965	0.375145	1.853930	0.750290	2.780895	1.125435	3.707860	1.500580	4.634825	1.875725	58
4	0.926747	0.375685	1.853494	0.751370	2.780241	1.127055	3.706988	1.502740	4.633735	1.878425	56
6	0.926528	0.376224	1.853056	0.752448	2.779584	1.128672	3.706112	1.504896	4.632640	1.881120	54
8	0.926309	0.376763	1.852618	0.753526	2.778927	1.130289	3.705236	1.507052	4.631545	1.883815	52
10	0.926090	0.377302	1.852180	0.754604	2.778270	1.131906	3.704360	1.509208	4.630450	1.886510	50
12	0.925870	0.377840	1.851740	0.755680	2.777610	1.133520	3.703480	1.511360	4.629350	1.889200	48
14	0.925650	0.378379	1.851300	0.756758	2.776950	1.135137	3.702600	1.513516	4.628250	1.891895	46
16	0.925430	0.378917	1.850860	0.757834	2.776290	1.136751	3.701720	1.515678	4.627150	1.894585	44
18	0.925209	0.379456	1.850418	0.758912	2.775627	1.138368	3.700836	1.517824	4.626045	1.897280	42
20	0.924988	0.379994	1.849976	0.759988	2.774964	1.139982	3.699952	1.519976	4.624940	1.899970	40
22	0.924767	0.380532	1.849534	0.761064	2.774301	1.141596	3.699068	1.522128	4.623835	1.902660	38
24	0·924546	0.381074	1.849092	0.762148	2.773638	1.143222	3.698184	1.524296	4.622730	1.905370	36
26	0.924324	0.381608	1.848648	0.763216	2.772972	1.144824	3.697296	1.526432	4.621620	1.908040	34
28	0.924102	0.382145	1.848204	0.764290	2.772306	1.146435	3.696408	1.528580	4.620510	1.910725	32
30	0.923879	0.382683	1.847758	0.765366	2.771637	1.148049	3.695516	1.530732	4.619395	1.913415	30
32	0.923656	0.383220	1.847312	0.766440	2.770968	1.149660	3.694624	1.532886	4.618280	1.916100	28
34	0.923433	0.383758	1.846866	0.767516	2.770299	1.151274	3.693732	1.535032	4.617165	1.918790	26
36	0.923210	0.384295	1.846420	0.768590	2.769630	1.152885	3.692840	1.537180	4.616050	1.921475	24
38	0.922986	0.384822	1.845972	0.769644	2.768958	1.154466	3.691944	1.539288	4.614930	1.924110	22
40	0.922762	0.385369	1.845524	0.770738	2.768286	1.156107	3.691048	1.541476	4.613810	1.926845	20
42	0.922538	0.385906	1.845076	0.771812	2.767614	1.157718	3.690152	1.543624	4.612690	1.929530	18
44	0.922313	0.386442	1.844626	0.772884	2.766939	1.159326	3.689252	1.545768	4.611565	1.932210	16
46	0.922088	0.386979	1.844176	0.773958	2.766264	1.160937	3.688352	1.547916	4.610440	1.934895	14
48	0.921863	0.387515	1.843726	0.775030	2.765589	1.162545	3.687452	1.550060	4.609315	1.937595	12
50	0.921637	0.388051	1.843274	0.776102	2.764911	1.164153	3.686548	1.552204	4.608185	1.940255	10
52	0.921411	0.388588	1.842822	0.777176	2.764233	1.165764	3.685644	1.554352	4.607055	1.942940	8
54	0.921185	0.389124	1.842370	0.778248	2.763555	1.167372	3.684740	1.556496	4.605925	1.945620	6
56	0.920958	0.389659	1.841916	0.779318	2.762874	1.168977	3.683832	1.558636	4.604790	1.948295	4
58	0.920732	0.390195	1.841464	0.780390	2.762196	1.170585	3.682928	1.560780	4.603660	1.950975	2
60	0.920504	0.390731	1.841008	0.781462	2.761512	1.172193	3.682016	1.562924	4.602520	1.953655	67°
	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Degrees and Minutes.
	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		

Degrees and Minutes.	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		
	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	
23°	0.920504	0.390731	1.841008	0.781462	2.761512	1.172193	3.682016	1.562924	4.602520	1.953655	60′
2′	0.920277	0.391266	1.840554	0.782532	2.760831	1.173798	3.681108	1.565064	4.601385	1.956330	58
4	0.920049	0.391801	1.840098	0.783602	2.760147	1.175403	3.680196	1.567204	4.600245	1.959005	56
6	0.919821	0.392337	1.839642	0.784674	2.759463	1.177011	3.679284	1.569348	4.599105	1.961685	54
8	0.919593	0.392872	1.839186	0.785744	2.758779	1.178616	3.678372	1.571488	4.597965	1.964360	52
10	0.919364	0.393407	1.838728	0.786814	2.758092	1.180221	3.677456	1.573628	4.596820	1.967035	50
12	0.919135	0.393941	1.838270	0.787882	2.757405	1.181823	3.676540	1.575764	4.595675	1.969705	48
14	0.918906	0.394476	1.837812	0.788952	2.756718	1.183428	3.675624	1.577904	4.594530	1.972380	46
16	0.918676	0.395011	1.837352	0.790022	2.756028	1.185033	3.674704	1.580044	4.593380	1.975055	44
18	0.918446	0.395545	1.836892	0.791090	2.755338	1.186635	3.673784	1.582180	4.592230	1.977725	42
20	0.918216	0.396079	1.836432	0.792158	2.754648	1.188227	3.672864	1.584316	4.591080	1.980395	40
22	0.917985	0.396613	1.835970	0.793226	2.753955	1.189839	3.671940	1.586452	4.589925	1.983065	38
24	0.917754	0.397147	1.885508	0.794294	2.753262	1.191441	3.671016	1.588588	4.588770	1.985735	36
26	0.917523	0.397681	1.835046	0.795362	2.752569	1.193043	3.670092	1.590724	4.587615	1.988405	34
28	0.917291	0.398215	1.834582	0.796430	2.751873	1.194645	3.669164	1.592866	4.586455	1.991075	32
30	0.917060	0.398749	1.834120	0.797498	2.751180	1.196247	3.668240	1.594996	4.585300	1.993745	30
32	0.916827	0.399282	1.833654	0.798564	2.750481	1.197846	3.667308	1.597128	4.584135	1.996410	28
34	0.916595	0.399815	1.833190	0.799630	2.749785	1.199445	3.666380	1.599260	4.582975	1.999075	26
36	0.916362	0.400349	1.832724	0.800698	2.749086	1.201047	3.665448	1.601396	4.581810	2.001745	24
38	0.916129	0.400882	1.832258	0.801764	2.748387	1.202646	3.664516	1.603528	4.580645	2.004410	22
40	0.915896	0.401415	1.831792	0.802830	2.747688	1.204245	3.663584	1.605660	4.579480	2.007075	20
42	0.915662	0.401947	1.831324	0.803894	2.746986	1.205841	3.662648	1.607788	4.578310	2.009735	18
44	0.915428	0.402480	1.830856	0.804960	2.746284	1.207440	3.661712	1.609920	4.577140	2.012400	16
46	0.915196	0.403012	1.830392	0.806024	2.745588	1.209036	3.660784	1.612048	4.575980	2.015060	14
48	0.914959	0.403545	1.829918	0.807090	2.744877	1.210635	3.659836	1.614180	4.574795	2.017725	12
50	0.914724	0.404077	1.829448	0.808154	2.744172	1.212231	3.658896	1.616308	4.573620	2.020385	10
52	0.914489	0.404609	1.828978	0.809218	2.743467	1.213827	3.657956	1.618436	4.572445	2.023045	8
54	0.914254	0.405141	1.828508	0.810282	2.742762	1.215423	3.657016	1.620564	4.571270	2.025705	6
56	0.914018	0.405673	1.828036	0.811346	2.742054	1.217019	3.656072	1.622692	4.570090	2.028365	4
58	0.913781	0.406205	1.827562	0.812410	2.741343	1.218615	3.655124	1.624820	4.568905	2.031025	2
60	0.913545	0.406736	1.827090	0.813472	2.740635	1.220208	3.654180	1.626944	4.567725	2.033680	66°
	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Degrees and Minutes.
	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		

Degrees and Minutes.	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		
	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	
24°	0.913545	0.406736	1.827090	0.813472	2·740635	1.220208	3.654180	1.626944	4.567725	2.033680	60′
2′	0.913308	0.407268	1.826616	0.814536	2.739924	1.221804	3.653232	1.629072	4.566540	2.036340	58
4	0.913071	0.407799	1.826142	0.815598	2.739213	1.223397	3.652284	1.631196	4.565355	2.038995	56
6	0.912834	0.408330	1.825668	0.816660	2.738502	1.224990	3.651336	1.633320	4.564170	2.041651	54
8	0.912596	0.408861	1.825192	0.817722	2.737788	1.226583	3.650384	1.635444	4.562980	2.044305	52
10	0.912358	0.409392	1.824716	0.818784	2.737074	1.228176	3.649432	1.637568	4.562790	2.046960	50
12	0.912120	0.409923	1.824240	0.819846	2.736360	1.229769	3.648480	1.639692	4.560600	2.049615	48
14	0.911881	0.410453	1.823762	0.820906	2.735643	1.231359	3.647524	1.641812	4.559405	2.052265	46
16	0.911642	0.410984	1.823284	0.821968	2.734926	1.232952	3.646568	1.643936	4.558210	2.054920	44
18	0.911403	0.411514	1.822806	0.822028	2.734209	1.234542	3.645612	1.644056	4.557015	2.057570	42
20	0.911163	0.412044	1.822326	0.824088	2.733489	1.236132	3.644652	1.648176	4.555815	2.060220	40
22	0.910923	0.412574	1.821846	0.825148	2.732769	1.237722	3.643692	1.650296	4.554615	2.062870	38
24	0.910683	0.413104	1.821366	0.826208	2.732049	1.239312	3.642732	1.652416	4.553415	2.065520	36
26	0.910443	0.413634	1.820886	0.827268	2.731329	1.240902	3.641772	1.654536	4.552215	2.068170	34
28	0.910202	0.414163	1.820404	0.828326	2.730606	1.242489	3.640808	1.656652	4.551010	2.070815	32
30	0.909961	0.414693	1.819922	0.829386	2.729883	1.244079	3.639844	1.658772	4.549805	2.073465	30
32	0.909719	0.415222	1.819438	0.830444	2.729157	1.245666	3.638876	1.660888	4.548595	2.076110	28
34	0.909478	0.415751	1.818956	0.831502	2.728434	1.247253	3.637912	1.663004	4.547390	2.078755	26
36	0.909236	0.416280	1.818472	0.832560	2.727708	1.248840	3.636944	1.665120	4.546180	2.081400	24
38	0.908993	0.416809	1.817986	0.833618	2.726979	1.250427	3.635972	1.667236	4.544965	2.084045	22
40	0.908751	0.417338	1.817502	0.834676	2.726253	1.252014	3.635004	1.669352	4.543755	2.086690	20
42	0.908508	0.417867	1.817016	0.835734	2.725524	1.253601	3.634032	1.671468	4.542540	2.089335	18
44	0.908264	0.418395	1.816528	0.836780	2.724792	1.255185	3.633056	1.673560	4.541320	2.091975	16
46	0.908021	0.418923	1.816042	0.837846	2.724063	1.256769	3.632084	1.675692	4.540105	2.094615	14
48	0.907777	0.419452	1.815554	0.838904	2.723331	1.258356	3.631108	1.677808	4.538885	2.097260	12
50	0 907533	0.419980	1.815066	0.839960	2.722599	1.259940	3.630132	1.679920	4.537665	2.099900	10
52	0.907288	0.420508	1.814576	0.841016	2.721864	1.261524	3.629152	1.682032	4.536440	2.102540	8
54	0.907044	0.421035	1.814088	0.842070	2.721133	1.263105	3.628176	1.684140	4.535220	2.105175	6
56	0.906798	0.421563	1.813596	0.843126	2.720394	1.264689	3.627192	1.686252	4.533990	2.107815	4
58	0.906553	0.422090	1.813106	0.844180	2.719659	1.266270	3.626212	1.688360	4.532765	2.110450	2
60	0.906307	0.422618	1.812614	0.845236	2.718921	1.267854	3.625228	1.690472	4.531535	2.113090	**65°**
	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Degrees and Minutes.
	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		

Degrees and Minutes.	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		
	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	
25°	0.906307	0.422618	1.812614	0.845236	2.718921	1.267854	3.625228	1.690472	4.531535	2.113090	60′
2′	0.906061	0.423145	1.812122	0.846290	2.718183	1.269435	3.624244	1.692580	4.530305	2.115725	58
4	0.905815	0.423672	1.811630	0.847344	2.717445	1.271016	3.623260	1.694688	4.529075	2.118360	56
6	0.905568	0.424199	1.811136	0.848398	2.716704	1.272597	3.622272	1.696796	4.527840	2.120995	54
8	0.905321	0.424726	1.810642	0.849452	2.715963	1.274178	3.621284	1.698904	4.526605	2.123630	52
10	0.905074	0.425252	1.810148	0.850504	2.715222	1.275756	3.620296	1.701008	4.525370	2.126260	50
12	0.904827	0.425779	1.809654	0.851558	2.714481	1.277337	3.619308	1.703116	4.524135	2.128895	48
14	0.904579	0.426305	1.809158	0.852610	2.713737	1.278915	3.618316	1.705220	4.522895	2.131525	46
16	0.904331	0.426831	1.808662	0.853662	2.712993	1.280493	3.617324	1.707324	4.521655	2.134155	44
18	0.904082	0.427357	1.808164	0.854714	2.712246	1.282071	3.616328	1.709428	4.520410	2.136785	42
20	0.903833	0.427883	1.807666	0.855766	2.711499	1.283649	3.615332	1.711532	4.519165	2.139415	40
22	0.903584	0.428409	1.807168	0.856818	2.710752	1.285227	3.614336	1.713636	4.517920	2.142045	38
24	0.903335	0.428935	1.806670	0.857870	2.710005	1.286805	3.613340	1.715740	4.516675	2.144675	36
26	0.903085	0.429460	1.806170	0.858920	2.709255	1.288380	3.612340	1.717840	4.515425	2.147300	34
28	0.902835	0.429985	1.805670	0.859970	2.708505	1.289955	3.611340	1.719940	4.514175	2.149925	32
30	0.902585	0.430511	1.805170	0.861022	2.707755	1.291533	3.610340	1.722044	4.512925	2.152555	30
32	0.902334	0.431036	1.804668	0.862072	2.707002	1.293108	3.609336	1.724144	4.511670	2.155180	28
34	0.902083	0.431561	1.804166	0.863122	2.706249	1.294683	3.608332	1.726244	4.510415	3.157805	26
36	0.901832	0.432085	1.803664	0.864170	2.705496	1.296255	3.607328	1.728340	4.509160	2.160425	24
38	0.901581	0.432610	1.803162	0.865220	2.704743	1.297830	3.606324	1.730440	4.507905	2.163050	22
40	0.901329	0.433134	1.802658	0.866268	2.713987	1.299402	3.605316	1.732536	4.506645	2.165670	20
42	0.901077	0.433659	1.802154	0.867318	2.703231	1.300977	3.604308	1.734636	4.505385	2.168295	18
44	0.900824	0.434183	1.801648	0.868366	2.702472	1.302549	3.603296	1.736732	4.504120	2.170915	16
46	0.900571	0.434707	1.801142	0.869414	2.701713	1.304121	3.602284	1.738828	4.502855	2.173535	14
48	0.900318	0.435231	1.800636	0.870462	2.700954	1.305693	3.601272	1.740924	4.501590	2.176155	12
50	0.900065	0.435754	1.800130	0.871508	2.700195	1.307262	3.600260	1.743016	4.500325	2.178770	10
52	0.899811	0.436278	1.799622	0.872556	2.699433	1.408834	3.599244	1.745112	4.499055	2.181390	8
54	0.899557	0.436801	1.799114	0.873602	2.698671	1.410403	3.598228	1.747204	4.497785	2.184005	6
56	0.899303	0.437325	1.798606	0.874650	2.697909	1.411975	3.597212	1.749300	4.496515	2.186625	4
58	0.899048	0.437848	1.798096	0.875696	2.697144	1.313544	3.596192	1.751392	4.495240	2.189240	2
60	0.898794	0.438371	1.797588	0.876742	2.696382	1.315113	3.595176	1.753484	4.493970	2.191855	64°
	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Degrees and Minutes.
	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		

Degrees and Minutes.	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		
	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	
26°	0.898794	0.438371	1.797588	0.876742	2.696382	1.315113	3.595176	1.753484	4.493970	2.191855	60′
2′	0.898538	0.438894	1.797076	0.877788	2.695614	1.316682	3.594152	1.755576	4.492690	2.194470	58
4	0.898283	0.439416	1.796566	0.878832	2.694849	1.318248	3.593132	1.757664	4.491415	2.197080	56
6	0.898027	0.439939	1.796054	0.879878	2.694081	1.319817	3.592108	1.759756	4.490135	2.199695	54
8	0.897771	0.440461	1.795542	0.880922	2.693813	1.321383	3.591084	1.761844	4.488855	2.202305	52
10	0.897515	0.440983	1.795030	0.881966	2.692545	1.322949	3.590060	1.763932	4.487575	2.204915	50
12	0.897258	0.441505	1.794516	0.883010	2.691774	1.324515	3.589032	1.766020	4.486290	2.207525	48
14	0.897001	0.442027	1.794002	0.884054	2.691003	1.326081	3.588004	1.768108	4.485005	2.210135	46
16	0.896744	0.442549	1.793488	0.885098	2.690218	1.327647	3.586976	1.770196	4.483720	2.212745	44
18	0.896486	0.443071	1.792972	0.886142	2.689458	1.329213	3.585944	1.772284	4.482430	2.215355	42
20	0.896228	0.443592	1.792456	0.887184	2.688684	1.330776	3.584912	1.774368	4.481140	2.217960	40
22	0.895970	0.444114	1.791940	0.888228	2.687910	1.332342	3.583880	1.776456	4.479850	2.220570	38
24	0.895711	0.444635	1.791422	0.889270	2.687133	1.333905	3.582844	1.778540	4.478555	2.223175	36
26	0.895452	0.445156	1.790904	0.890312	2.686356	1.335468	3.581808	1.780624	4.477260	2.225780	34
28	0.895193	0.445677	1.790386	0.891354	2.685579	1.337031	3.580772	1.782708	4.475965	2.228385	32
30	0.894934	0.446197	1.789868	0.892394	2.684802	1.338591	3.579736	1.784788	4.474670	2.230985	30
32	0.894674	0.446718	1.789348	0.893436	2.684022	1.340154	3.578696	1.786872	4.473370	2.233590	28
34	0.894414	0.447238	1.788828	0.894476	2.683242	1.341714	3.577656	1.788952	4.472070	2.236190	26
36	0.894154	0.447759	1.788308	0.895518	2.682462	1.343277	3.576616	1.791036	4.470770	2.238795	24
38	0.893893	0.448279	1.787786	0.896558	2.681679	1.344837	3.575572	1.793116	4.469465	2.241395	22
40	0.893632	0.448799	1.787264	0.897598	2.680896	1.346397	3.574528	1.795196	4.468160	2.243995	20
42	0.893371	0.449319	1.786742	0.898638	2.680113	1.347957	3.573484	1.797276	4.466855	2.246595	18
44	0.893109	0.449838	1.786218	0.899676	2.679327	1.349514	3.572436	1.799352	4.465545	2.249190	16
46	0.892848	0.450358	1.785696	0.900716	2.678544	1.351074	3.571392	1.801432	4.464240	2.251790	14
48	0.892585	0.450877	1.785170	0.901754	2.677755	1.352631	3.570340	1.803508	4.462925	2.254385	12
50	0.892323	0.451396	1.784646	0.902792	2.676969	1.354188	3.569292	1.805584	4.461615	2.256980	10
52	0.892060	0.451915	1.784120	0.903830	2.676180	1.355745	3.568240	1.807660	4.460300	2.259575	8
54	0.891797	0.452434	1.783594	0.904868	2.675391	1.357302	3.567188	1.809736	4.458985	2.262170	6
56	0.891534	0.452953	1.783068	0.905906	2.674602	1.358859	3.566136	1.801812	4.457670	2.264765	4
58	0.891270	0.453472	1.782540	0.906944	2.673810	1.360416	3.565080	1.813888	4.456350	2.267360	2
60	0.891006	0.453990	1.782012	0.907980	2.673018	1.361970	3.564024	1.815960	4.455030	2.269950	63°
	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Degrees and Minutes.
	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		

Degrees and Minutes.	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		
	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	
27°	0.891006	0.453990	1.782012	0.907980	2.673018	1.361970	3.564024	1.815960	4.455030	2.269950	60′
2′	0.890742	0.454508	1.781484	0.909016	2.672226	1.363524	3.562968	1.818032	4.453710	2.272540	58
4	0.890477	0.455026	1.780954	0.910052	2.671431	1.365078	3.561908	1.820104	4.452385	2.275130	56
6	0.890212	0.455544	1.780424	0.911088	2.670636	1.366632	3.560848	1.822176	4.451060	2.277720	54
8	0.889947	0.456062	1.779894	0.912124	2.669841	1.368186	3.559788	1.824248	4.449735	2.280310	52
10	0.889682	0.456580	1.779364	0.913160	2.669046	1.369740	3.558728	1.826320	4.448410	2.282900	50
12	0.889416	0.457097	1.778832	0.914194	2.668248	1.371291	3.557664	1.828388	4.447080	2.285485	48
14	0.889150	0.457615	1.778300	0.915230	2.667450	1.372845	3.556600	1.830460	4.445750	2.288075	46
16	0.888883	0.458132	1.777766	0.916264	2.666649	1.374396	3.555532	1.832528	4.444415	2.290660	44
18	0.888617	0.458649	1.777234	0.917298	2.665851	1.375947	3.554468	1.834596	4.443085	2.293245	42
20	0.888350	0.459166	1.776700	0.918332	2.665050	1.377498	3.553400	1.836664	4.441750	2.295830	40
22	0.888083	0.459683	1.776166	0.919366	2.664249	1.379049	3.552332	1.838732	4.440415	2.298415	38
24	0.887815	0.460199	1.775630	0.920398	2.663445	1.380597	3.551260	1.840796	4.439075	2.300995	36
26	0.887547	0.460716	1.775094	0.921432	2.662641	1.382148	3.550188	1.842864	4.437735	2.303580	34
28	0.887279	0.461232	1.774558	0.922464	2.661837	1.383696	3.549116	1.844928	4.436395	2.306160	32
30	0.887010	0.461748	1.774020	0.923496	2.661030	1.385244	3.548040	1.846992	4.435050	2.308740	30
32	0.886742	0.462264	1.773484	0.924528	2.660226	1.386792	3.546968	1.849056	4.433710	2.311320	28
34	0.886473	0.462780	1.772946	0.925560	2.659419	1.388340	3.545892	1.851120	4.432365	2.313900	26
36	0.886203	0.463296	1.772406	0.926592	2.658609	1.389888	3.544812	1.853184	4.431015	2.316480	24
38	0.885933	0.463811	1.771866	0.927622	2.657799	1.391433	3.543732	1.855244	4.429665	2.319055	22
40	0.885663	0.464326	1.771326	0.928652	2.656989	1.392978	3.542652	1.857304	4.428315	2.321630	20
42	0.885393	0.464842	1.770786	0.929684	2.656179	1.394526	3.541572	1.859368	4.426965	2.324210	18
44	0.885123	9.465357	1.770246	0.930714	2.655369	1.396171	3.540492	1.861428	4.425615	2.326785	16
46	0.884852	0.465871	1.769704	0.931742	2.654556	1.397613	3.539408	1.863184	4.424260	2.329355	14
48	0.884581	0.466386	1.769162	0.932772	2.653743	1.399158	3.538324	1.865544	4.422905	2.331930	12
50	0.884309	0.466901	1.768618	0.933802	2.652927	1.400703	3.537236	1.867604	4.421545	2.334505	10
52	0.884037	0.467415	1.768074	0.934830	2.652111	1.402245	3.536148	1.869660	4.420185	2.337075	8
54	0.883765	0.467929	1.767530	0.935858	2.651295	1.403787	3.535060	1.871716	4.418825	2.339645	6
56	0.883493	0.468443	1.766986	0.936886	2.650479	1.405329	3.533972	1.873772	4.417465	2.342215	4
58	0.883220	0.468957	1.766440	0.937914	2.649660	1.406871	3.532880	1.875828	4.416100	2.344785	2
60	0.882947	0.469471	1.765894	0.938942	2.648841	1.408413	3.531758	1.877884	4.414735	2.347355	**62°**
	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Degrees and Minutes.
	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		

Degrees and Minutes.	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		
	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	
28°	0.882947	0.469471	1.765894	0.938942	2.648841	1.408413	3.531788	1.877884	4.414735	2.347355	60′
2′	0.882674	0.469985	1.765348	0.939970	2.648022	1.409955	3.530696	1.879940	4.413370	2.349925	58
4	0.882400	0.470498	1.764800	0.940996	2.647200	1.411494	3.529600	1.881992	4.412000	2.352490	56
6	0.882126	0.471011	1.764252	0.942022	2.646378	1.413033	3.528504	1.884044	4.410630	2.355055	54
8	0.881852	0.471525	1.763704	0.943050	2.645556	1.414575	3.527408	1.886100	4.409260	2.357625	52
10	0.881578	0.472038	1.763156	0.944076	2.644734	1.416114	3.526312	1.888152	4.407890	2.360190	50
12	0.881303	0.472550	1.762606	0.945100	2.643909	1.417650	3.525212	1.890200	4.406515	2.362750	48
14	0.881028	0.473063	1.762056	0.946126	2.643084	1.419189	3.524112	1.892252	4.405140	2.365315	46
16	0.880753	0.473575	1.761506	0.947150	2.642259	1.420725	3.523012	1.894300	4.403765	2.367875	44
18	0.880477	0.474088	1.760954	0.948176	2.641431	1.422264	3.521908	1.896352	4.402385	2.370440	42
20	0.880201	0.474600	1.760402	0.949200	2.640603	1.423800	3.520804	1.898400	4.401005	2.373000	40
22	0.879925	0.475112	1.759850	0.950224	2.639775	1.425336	3.519700	1.900448	4.399625	2.375560	38
24	0.879648	0.475624	1.759296	0.951248	2.638944	1.426872	3.518592	1.902496	4.398240	2.378120	36
26	0.879371	0.476135	1.758742	0.952270	2.638113	1.428405	3.517484	1.904540	4.396855	2.380675	34
28	0.879094	0.476647	1.758188	0.953294	2.637282	1.429941	3.516376	1.906588	4.395470	2.383235	32
30	0.878817	0.477158	1.757634	0.954316	2.636451	1.431474	3.515268	1.908632	4.394085	2.385790	30
32	0.878539	0.477670	1.757078	0.955340	2.635617	1.433010	3.514156	1.910680	4.392695	2.388350	28
34	0.878261	0.478181	1.756522	0.956362	2.634783	1.434543	3.513044	1.912724	4.391305	2.390905	26
36	0.877983	0.478691	1.755966	0.957382	2.633949	1.436073	3.511932	1.914764	4.389915	2.393455	24
38	0.877704	0.479202	1.755408	0.958404	2.633112	1.437606	3.510816	1.916808	4.388520	2.396010	22
40	0.877425	0.479713	1.754850	0.959426	2.632275	1.439139	3.509700	1.918852	4.387125	2.398565	20
42	0.877146	0.480223	1.754292	0.960446	2.631438	1.440669	3.508584	1.920892	4.385730	2.401115	18
44	0.876866	0.480733	1.753732	0.961466	2.630598	1.442199	3.507464	1.922932	4.384330	2.403665	16
46	0.876586	0.481243	1.753172	0.962486	2.639758	1.443729	3.506344	1.924972	4.382930	2.406215	14
48	0.876306	0.481753	1.752612	0.963506	2.628918	1.445259	3.505224	1.927012	4.381530	2.408765	12
50	0.876026	0.482263	1.752052	0.964526	2.628078	1.446789	3.504104	1.929052	4.380130	2.411315	10
52	0.875745	0.482773	1.751490	0.965546	2.627235	1.448319	3.502980	1.931092	4.378725	2.413865	8
54	0.875464	0.483282	1.750928	0.966564	2.626392	1.449846	3.501856	1.933128	4.377320	2.416410	6
56	0.875183	0.483791	1.750366	0.967582	2.625549	1.451373	3.500732	1.935164	4.375915	2.418955	4
58	0.874901	0.484300	1.749802	0.968600	2.624703	1.452900	3.499604	1.937200	4.374505	2.421500	2
60	0.874619	0.484809	1.749238	0.969618	2.623857	1.454427	3.498476	1.939236	4.373095	2.424045	61°
	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Degrees and Minutes.
	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		

Degrees and Minutes.	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000. Distance from Planes of Latitude, or North or South Distance.	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000. Distance from Planes of Meridian, or East or West Distance.	Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000. Distance from Planes of Latitude, or North or South Distance.	Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000. Distance from Planes of Meridian, or East or West Distance.	Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000. Distance from Planes of Latitude, or North or South Distance.	Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000. Distance from Planes of Meridian, or East or West Distance.	Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000. Distance from Planes of Latitude, or North or South Distance.	Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000. Distance from Planes of Meridian, or East or West Distance.	Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000. Distance from Planes of Latitude, or North or South Distance.	Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000. Distance from Planes of Meridian, or East or West Distance.	
29°	0.874619	0.484809	1.749238	0.969618	2.623857	1.454427	3.498476	1.939236	4.373095	2.424045	60′
2′	0.874337	0.485318	1.748674	0.970636	2.623011	1.455954	3.497348	1.941272	4.371685	2.426590	58
4	0.874055	0.485827	1.748110	0.971654	2.622165	1.457481	3.496220	1.943308	4.370275	2.429135	56
6	0.873772	0.486335	1.747544	0.972670	2.621316	1.459005	3.495088	1.945340	4.368860	2.431675	54
8	0.873489	0.486843	1.746978	0.973686	2.620467	1.460529	3.493956	1.947372	4.367445	2.434215	52
10	0.873205	0.487351	1.746410	0.974702	2.619615	1.462053	3.492820	1.949404	4.366025	2.436755	50
12	0.872922	0.487859	1.745844	0.975718	2.618766	1.463577	3.491688	1.951436	4.364610	2.439295	48
14	0.872638	0.488367	1.745276	0.976734	2.617914	1.465101	3.490552	1.953468	4.363190	2.441835	46
16	0.872353	0.488875	1.744706	0.977750	2.617059	1.466625	3.489412	1.955500	4.361865	2.444375	44
18	0.872069	0.489382	1.744138	0.978764	2.616207	1.468146	3.488276	1.957528	4.360345	2.446910	42
20	0.871784	0.489889	1.743568	0.979778	2.615352	1.469667	3.487136	1.959556	4.358920	2.449445	40
22	0.871499	0.490396	1.742998	0.980792	2.614497	1.471188	3.485996	1.961584	4.357495	2.451980	38
24	0.871213	0.490903	1.742426	0.981806	2.613639	1.472709	3.484852	1.963612	4.356065	2.454515	36
26	0.870928	0.491410	1.741856	0.982820	2.612784	1.474230	3.483712	1.965640	4.354640	2.457050	34
28	0.870642	0.491917	1.741284	0.983834	2.611926	1.475751	3.482568	1.967668	4.353210	2.459585	32
30	0.870355	0.492423	1.740710	0.984846	2.611065	1.477269	3.481420	1.969692	4.351775	2.462115	30
32	0.870069	0.492929	1.740138	0.985858	2.610207	1.478787	3.480276	1.971716	4.350345	2.464645	28
34	0.869782	0.493435	1.739564	0.986870	2.609346	1.480305	3.479128	1.973740	4.348910	2.467175	26
36	0.869494	0.493941	1.738988	0.987882	2.608482	1.481823	3.477976	1.975764	4.347470	2.469705	24
38	0.869207	0.494447	1.738414	0.988894	2.607621	1.483341	3.476828	1.977788	4.346035	2.472235	22
40	0.868919	0.494953	1.737838	0.989906	2.606757	1.484859	3.475676	1.979812	4.344595	2.474765	20
42	0.868631	0.495458	1.737262	0.990916	2.605893	1.486374	3.474524	1.981832	4.343155	2.477290	18
44	0.868343	0.495963	1.736686	0.991926	2.605029	1.487889	3.473372	1.983852	4.341715	2.479815	16
46	0.868054	0.496469	1.736108	0.992938	2.604162	1.489407	3.472216	1.985876	4.340270	2.482345	14
48	0.867765	0.496974	1.735530	0.993948	2.603295	1.490922	3.471060	1.987896	4.338825	2.484870	12
50	0.867476	0.497478	1.734952	0.994956	2.602428	1.492434	3.469904	1.989912	4.337380	2.487390	10
52	0.867186	0.497983	1.734372	0.995966	2.601558	1.493949	3.468744	1.991932	4.335930	2.489915	8
54	0.866896	0.498487	1.733792	0.996974	2.600688	1.495461	3.467584	1.993948	4.334480	2.492435	6
56	0.866606	0.498992	1.733212	0.997984	2.599818	1.496976	3.466424	1.995968	4.333030	2.494960	4
58	0.866316	0.499496	1.732632	0.998992	2.598948	1.498488	3.465264	1.997984	4.331580	2.497480	2
60	0.866025	0.500000	1.732050	1.000000	2.598075	1.500000	3.464100	2.000000	4.330125	2.500000	60°
	Distance from Planes of Meridian, or East or West Distance. Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.	Distance from Planes of Latitude, or North or South Distance. Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.	Distance from Planes of Meridian, or East or West Distance. Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.	Distance from Planes of Latitude, or North or South Distance. Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.	Distance from Planes of Meridian, or East or West Distance. Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.	Distance from Planes of Latitude, or North or South Distance. Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.	Distance from Planes of Meridian, or East or West Distance. Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.	Distance from Planes of Latitude, or North or South Distance. Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.	Distance from Planes of Meridian, or East or West Distance. Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.	Distance from Planes of Latitude, or North or South Distance. Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.	Degrees and Minutes.

Degrees and Minutes.	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		
	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	
30°	0.866025	0.500000	1.732050	1.000000	2·598075	1.500000	3.464100	2.000000	4.330125	2.500000	60′
2′	0.865734	0.500503	1.731468	1.001006	2.597202	1.501509	3.462936	2.002012	4.328670	2.502515	58
4	0.865443	0.501007	1.730886	1.002014	2.596329	1.503021	3.461772	2.004028	4.327215	2.505035	56
6	0.865151	0.501510	1.730302	1.003020	2.595453	1.504530	3.460604	2.006040	4.325755	2.507550	54
8	0.864859	0.502014	1.729718	1.004028	2.594577	1.506042	3.459436	2.008056	4.324295	2.510070	52
10	0.864567	0.502517	1.729134	1.005034	2.593701	1.507551	3.458268	2.010068	4.322835	2.512585	50
12	0.864274	0.503019	1.728548	1.006038	2.592822	1.509057	3.457096	2.012076	4.321370	2.515095	48
14	0.863982	0.503522	1.727964	1.007044	2.591946	1.510566	3.455928	2.014088	4.319910	2.517610	46
16	0.863688	0.504025	1.727376	1.008050	2.591064	1.512075	3.454752	2.016100	4.318440	2.520125	44
18	0.863395	0.504527	1.726790	1.009054	2.590185	1.513581	3.453580	2.018108	4.316975	2.522635	42
20	0.863101	0.505029	1.726202	1.010058	2.589303	1.515087	3.452404	2.020116	4.315505	2.525145	40
22	0.862807	0.505531	1.725614	1.011062	2.588421	1.516593	3.451228	2.022124	4.314035	2.527655	38
24	0.862513	0.506033	1.725026	1.012066	2.587539	1.518099	3.450052	2.024132	4.312565	2.530165	36
26	0.862219	0.506535	1.724438	1.013070	2.586657	1.519605	3.448876	2.026140	4.311095	2.532675	34
28	0.861924	0.507037	1.723848	1.014074	2.585772	1.521111	3.447696	2.028148	4.309620	2.535185	32
30	0.861629	0.507538	1.723258	1.015076	2.584887	1.522614	3.446516	2.030152	4.308145	2.537690	30
32	0.861333	0.508039	1.722666	1.016078	2.583999	1.524117	3.445332	2.032156	4.306665	2.540195	28
34	0.861038	0.508540	1.722076	1.017080	2.583114	1.525620	3.444152	2.034160	4.305190	2.542700	26
36	0.860742	0.509041	1.721484	1.018082	2.582226	1.527123	3.442968	2.036164	4.303710	2.545205	24
38	0.860445	0.509542	1.720890	1.019084	2.581335	1.528626	3.441780	2.038168	4.302225	2.547710	22
40	0.860149	0.510042	1.720298	1.020084	2.580447	1.530126	3.440596	2.040168	4.300745	2.550210	20
42	0.859852	0.510542	1.719704	1.021084	2.579556	1.531626	3.439408	2.042168	4.299260	2.552710	18
44	0.859555	0.511043	1.719110	1.022086	2.578665	1.533129	3.438220	2.044172	4.297775	2.555215	16
46	0.859257	0.511543	1.718514	1.023086	2.577771	1.534629	3.437028	2.046172	4.296285	2.557715	14
48	0.858959	0.512042	1.717918	1.024084	2.576877	1.536126	3.435836	2.048168	4.294795	2.560210	12
50	0.858661	0.512542	1.717322	1.025084	2.575983	1.537626	3.434644	2.050168	4.293305	2.562710	10
52	0.858363	0.513042	1.716726	1.026084	2.575089	1.539126	3.433452	2.052168	4.291815	2.565210	8
54	0.858064	0.513541	1.716128	1.027082	2.574192	1.540623	3.432256	2.054164	4.290320	2.567705	6
56	0.857766	0.514040	1.715532	1.028080	2.573298	1.542120	3.431064	2.056160	4.288830	2.570200	4
58	0.857466	0.514539	1.714932	1.029078	2.572398	1.543617	3.429864	2.058156	4.287330	2.572695	2
60	0.857167	0.515038	1.714334	1.030076	2.571501	1.545114	3.428668	2.060152	4.285835	2.575190	59°
	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Degrees and Minutes.
	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		

Degrees and Minutes.	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000. Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000. Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000. Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000. Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000. Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	
31°	0.857167	0.515038	1.714334	1.030076	2.571501	1.545114	3.428668	2.060152	4.285835	2.575190	60′
2′	0.856867	0.515536	1.713734	1.031072	2.570601	1.546608	3.427468	2.062144	4.284335	2.577680	58
4	0.856567	0.516035	1.713134	1.032070	2.569701	1.548105	3.426268	2.064140	4.282835	2.580175	56
6	0.856267	0.516533	1.712534	1.033066	2.568801	1.549599	3.425068	2.066132	4.281335	2.582665	54
8	0.855966	0.517031	1.711932	1.034062	2.567898	1.551093	3.423864	2.068124	4.279830	2.585155	52
10	0.855665	0.517529	1.711330	1.035058	2.566995	1.552587	3.422660	2.070116	4.278325	2.587645	50
12	0.855364	0.518027	1.710728	1.036054	2.566092	1.554081	3.421456	2.072108	4.276820	2.590135	48
14	0.855062	0.518524	1.710124	1.037048	2.565186	1.555572	3.420248	2.074096	4.275310	2.592620	46
16	0.854760	0.519021	1.709520	1.038042	2.564280	1.557063	3.419040	2.076084	4.273800	2.595105	44
18	0.854458	0.519519	1.708916	1.039038	2.563374	1.558557	3.417832	2.078076	4.272290	2.597595	42
20	0.854156	0.520016	1.708312	1.040032	2.562468	1.560048	3.416624	2.080064	4.270780	2.600080	40
22	0.853853	0.520513	1.707706	1.041026	2.561559	1.561539	3.415412	2.082052	4.269265	2.602565	38
24	0.853550	0.521009	1.707100	1.042018	2.560650	1.563027	3.414200	2.084036	4.267750	2.605045	36
26	0.853247	0.521506	1.706494	1.043012	2.559741	1.564518	3.412988	2.086024	4.266235	2.607530	34
28	0.852944	0.522002	1.705888	1.044004	2.558832	1.566006	3.411776	2.088008	4.264720	2.610010	32
30	0.852640	0.522498	1.705280	1.044996	2.557920	1.567494	3.410560	2.089992	4.263200	2.612490	30
32	0.852336	0.522994	1.704672	1.045988	2.557008	1.568982	3.409344	2.091976	4.261680	2.614970	28
34	0.852031	0.523490	1.704062	1.046980	2.556093	1.570470	3.408124	2.093960	4.260155	2.617450	26
36	0.851726	0.523985	1.703452	1.047970	2.555178	1.571955	3.406904	2.095940	4.258630	2.619925	24
38	0.851421	0.524481	1.702842	1.048962	2.554263	1.573443	3.405684	2.097924	4.257105	2.622405	22
40	0.851116	0.524976	1.702232	1.049952	2.553348	1.574928	3.404464	2.099904	4.255580	2.624880	20
42	0.850811	0.525471	1.701622	1.050942	2.552433	1.576413	3.403244	2.101884	4.254055	2.627355	18
44	0.850505	0.525966	1.701010	1.051932	2.551515	1.577898	3.402020	2.103864	4.252525	2.629830	16
46	0.850199	0.526461	1.700398	1.052922	2.550597	1.579383	3.400796	2.105844	4.250995	2.632305	14
48	0.849892	0.526955	1.699784	1.053910	2.549676	1.580865	3.399568	2.107820	4.249460	2.634775	12
50	0.849586	0.527450	1.699172	1.054900	2.548758	1.582350	3.398344	2.109800	4.247930	2.637250	10
52	0.849279	0.527944	1.698558	1.055888	2.547837	1.583832	3.397116	2.111776	4.246395	2.639720	8
54	0.848971	0.528438	1.697942	1.056876	2.546913	1.585314	3.395884	2.113752	4.244855	2.642190	6
56	0.848664	0.528932	1.697328	1.057864	2.545992	1.586796	3.394656	2.115728	4.243320	2.644660	4
58	0.848356	0.529425	1.696712	1.058840	2.545068	1.588275	3.393424	2.117680	4.241780	2.647125	2
60	0.848048	0.529919	1.696096	1.059838	2.544144	1.589757	3.392192	2.119676	4.240240	2.649595	58°
	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance. Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance. Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance. Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance. Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance. Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.	Degrees and Minutes.

Degrees and Minutes.	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		
	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	
32°	0.848048	0.529919	1.696096	1.059838	2.544144	1.589757	3.392192	2.119676	4.240240	2.649595	60′
2′	0.847739	0.530412	1.695478	1.060824	2.543217	1.591236	3.390956	2.121648	4.238695	2.652060	58
4	0.847430	0.530905	1.694860	1.061810	2.542290	1.592715	3.389720	2.123620	4.237150	2.654525	56
6	0.847121	0.531398	1.694242	1.062796	2.541363	1.594194	3.388484	2.125592	4.235605	2.656990	54
8	0.846812	0.531891	1.693624	1.063782	2.540436	1.595673	3.387248	2.127564	4.234060	2.659455	52
10	0.846503	0.532383	1.693006	1.064766	2.539509	1.597149	3.386012	2.129532	4.232515	2.661915	50
12	0.846193	0.532876	1.692386	1.065752	2.538579	1.598628	3.384772	2.131504	4.230965	2.664380	48
14	0.845883	0.533368	1.691766	1.066736	2.537649	1.600104	3.383532	2.133472	4.229415	2.666840	46
16	0.845572	0.533860	1.691144	1.067720	2.536716	1.601580	3.382288	2.135440	4.227860	2.669300	44
18	0.845261	0.534352	1.690522	1.068704	2.535783	1.603056	3.381044	2.137408	4.226305	2.671760	42
20	0.844950	0.534844	1.689900	1.069688	2.534850	1.604532	3.379800	2.139376	4.224750	2.674220	40
22	0.844639	0.535335	1.689278	1.070670	2.533917	1.606005	3.378556	2.141340	4.223195	2.676675	38
24	0 844327	0.535826	1.688654	1.071652	2.532981	1.607478	3.377308	2.143304	4.221635	2.679130	36
26	0.844016	0.536317	1.688032	1.072634	2.532048	1.608951	3.376064	2.145268	4.220080	2.681585	34
28	0.843703	0.536808	1.687406	1.073616	2.531109	1.610424	3.374812	2.147232	4.218515	2.684040	32
30	0.843391	0.537299	1.686782	1.074598	2.530173	1.611897	3.373564	2.149196	4.216955	2.686495	30
32	0.843078	0.537790	1.686156	1.075580	2.529234	1.613370	3.372312	2.151160	4.215390	2.688950	28
34	0.842765	0.538280	1.685530	1.076560	2.528295	1.614840	3.371060	2.153120	4.213825	2.691400	26
36	0.842452	0.538770	1.684904	1.077540	2.527356	1.616310	3.369808	2.155080	4.212260	2.693850	24
38	0.842138	0.539260	1.684276	1.078520	2.526414	1.617780	3.368552	2.157040	4.210690	2.696300	22
40	0.841824	0.539750	1.683648	1.079500	2.525472	1.619250	3.367296	2.159000	4.209120	2.698750	20
42	0.841510	0.540240	1.683020	1.080480	2.524530	1.620720	3.366040	2.160960	4.207550	2.701200	18
44	0.841196	0.540729	1.682392	1.081458	2.523588	1.622187	3.364784	2.162916	4.205980	2.703645	16
46	0.840881	0.541219	1.681762	1.082438	2.522643	1.623657	3.363524	2.164876	4.204405	2.706095	14
48	0.840566	0.541708	1.681132	1.083416	2.521698	1.625124	3.362264	2.166832	4.202830	2.708540	12
50	0.840251	0.542197	1.680502	1.084394	2.520753	1.626591	3.361004	2.168788	4.201255	2.710985	10
52	0.839935	0.542685	1.679870	1.085370	2.519805	1.628055	3.359740	2.170740	4.199675	2.713425	8
54	0.839819	0.543174	1.679638	1.086348	2.519457	1.629522	3.359276	2.172696	4.199095	2.715870	6
56	0.839303	0.543662	1.678606	1.087324	2.517909	1.630986	3.357212	2.174648	4.196515	2.718310	4
58	0.838987	0.544151	1.677974	1.088302	2.516961	1.632453	3.355948	2.176604	4.194935	2.720755	2
60	0.838670	0.544639	1.677340	1.089278	2.516010	1.633917	3.354680	2.178556	4.193350	2.723195	57°
	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Degrees and Minutes.
	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		

Degrees and Minutes.	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		
	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	
33°	0.838670	0.544639	1.677340	1.089278	2.516010	1.633917	3.354680	2.178556	4.193350	2.723195	60′
2′	0.838353	0.545126	1.676706	1.090252	2.515059	1.635378	3.353412	2.180504	4.191765	2.725630	58
4	0.838036	0.545614	1.676072	1.091228	2.514108	1.636842	3.352144	2.182456	4.190180	2.728070	56
6	0.837718	0.546102	1.675436	1.092204	2.513154	1.638306	3.350872	2.184408	4.188590	2.730510	54
8	0.837400	0.546589	1.674800	1.093178	2.512200	1.639767	3.349600	2.186356	4.187000	2.732945	52
10	0.837082	0.547076	1.674164	1.094152	2.511246	1.641228	3.348328	2.188304	4.185410	2.735380	50
12	0.836764	0.547563	1.673528	1.095126	2.510292	1.642689	3.347056	2.190252	4.183820	2.737815	48
14	0.836445	0.548049	1.672890	1.096098	2.509335	1.644147	3.345780	2.192196	4.182225	2.740245	46
16	0.836126	0.548536	1.672252	1.097072	2.508378	1.645608	3.344504	2.194144	4.180630	2.742680	44
18	0.835807	0.549022	1.671614	1.098044	2.507421	1.647066	3.343228	2.196088	4.179035	2.745110	42
20	0.835487	0.549509	1.670974	1.099018	2.506461	1.648527	3.341948	2.198036	4.177435	2.747545	40
22	0.835168	0.549995	1.670336	1.099990	2.505504	1.649985	3.340672	2.199980	4.175840	2.749975	38
24	0.834847	0.550480	1.669694	1.100960	2.504541	1.651440	3.339388	2.201920	4.174235	2.752400	36
26	0.834527	0.550966	1.669054	1.101932	2.503581	1.652898	3.338108	2.203864	4.172635	2.754830	34
28	0.834206	0.551451	1.668412	1.102902	2.502618	1.654353	3.336824	2.205804	4.171030	2.757255	32
30	0.833885	0.551937	1.667770	1.103874	2.501655	1.655811	3.335540	2.207748	4.169425	2.759685	30
32	0.833564	0.552422	1.667128	1.104844	2.500692	1.657266	3.334256	2.209688	4.167820	2.762110	28
34	0.833243	0.552906	1.666486	1.105812	2.499729	1.658718	3.332975	2.211624	4.166215	2.764530	26
36	0.832921	0.553391	1.665842	1.106782	2.498763	1.660173	3.331684	2.213564	4.164605	2.766955	24
38	0.832599	0.553876	1.665198	1.107752	2.497797	1.661628	3.330396	2.215504	4.162995	2.769380	22
40	0.832376	0.554360	1.664752	1.108720	2.497128	1.663080	3.329504	2.217440	4.161880	2.771800	20
42	0.831954	0.554844	1.663908	1.109688	2.495862	1.664532	3.327816	2.219376	4.159770	2.774220	18
44	0.831631	0.555328	1.663262	1.110656	2.494893	1.665984	3.326524	2.221312	4.158155	2.776640	16
46	0.831308	0.555812	1.662616	1.111624	2.493924	1.667436	3.325232	2.223248	4.156540	2.779060	14
48	0.830984	0.556295	1.661968	1.112590	2.492952	1.668885	3.323936	2.225180	4.154920	2.781475	12
50	0.830660	0.556779	1.661320	1.113558	2.491980	1.670337	3.322640	2.227116	4.153300	2.783895	10
52	0.830336	0.557262	1.660672	1.114524	2.491008	1.671786	3.321344	2.229048	4.151680	2.786310	8
54	0.830012	0.557745	1.660024	1.115490	2.490036	1.673235	3.320048	2.230980	4.150060	2.788725	6
56	0.829687	0.558227	1.659374	1.116454	2.489061	1.674681	3.318748	2.232908	4.148435	2.791135	4
58	0.829362	0.558710	1.658724	1.117420	2.488086	1.676130	3.317448	2.234840	4.146810	2.793550	2
60	0.829037	0.559192	1.658074	1.118384	2.487111	1.677576	3.316148	2.236768	4.145185	2.795960	56°
	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Degrees and Minutes.
	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		

Degrees and Minutes.	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse. 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		
	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	
34°	0.829037	0.559192	1.658074	1.118384	2.487111	1.677576	3.316148	2.236768	4.145185	2.795960	60′
2′	0.828712	0.559675	1.657424	1.119350	2.486136	1.679025	3.314848	2.238700	4.143560	2.798375	58
4	0.828386	0.560157	1.656772	1.120314	2.485158	1.680471	3.313544	2.240628	4.141930	2.800785	56
6	0.828060	0.560639	1.656120	1.121278	2.484180	1.681917	3.312240	2.242556	4.140300	2.803195	54
8	0.827734	0.561120	1.655468	1.122240	2.483202	1.683360	3.310936	2.244480	4.138670	2.805600	52
10	0.827407	0.561602	1.654814	1.123204	2.482221	1.684806	3.309628	2.246408	4.137035	2.808010	50
12	0.827080	0.562083	1.654160	1.124166	2.481240	1.686249	3.308320	2.248332	4.135400	2.810415	48
14	0.826753	0.562564	1.653506	1.125128	2.480259	1.687692	3.307012	2.250256	4.133765	2.812820	46
16	0.826426	0.563045	1.652852	1.126090	2.479278	1.689135	3.305704	2.252180	4.132130	2.815225	44
18	0.826098	0.563526	1.652196	1.127052	2.478294	1.690578	3.304392	2.254104	4.130490	2.817630	42
20	0.825770	0.564006	1.651540	1.128012	2.477310	1.692018	3.303080	2.256024	4.128850	2.820030	40
22	0.825442	0.564486	1.650884	1.128972	2.476326	1.693458	3.301768	2.257944	4.127210	2.822430	38
24	0.825113	0.564967	1.650226	1.129934	2.475339	1.694901	3.300452	2.259868	4.125565	2.824835	36
26	0.824784	0.565446	1.649568	1.130892	2.474352	1.696338	3.299136	2.261784	4.123920	2.827230	34
28	0.824455	0.565926	1.648910	1.131852	2.473365	1.697778	3.297820	2.263704	4.122275	2.829630	32
30	0.824126	0.566406	1.648252	1.132812	2.472378	1.699218	3.296504	2.265624	4.120630	2.832030	30
32	0.823796	0.566885	1.647592	1.133770	2.471388	1.700655	3.295184	2.267540	4.118980	2.834425	28
34	0.823466	0.567364	1.646932	1.134728	2.470398	1.702092	3.293864	2.269456	4.117330	2.836820	26
36	0.823136	0.567843	1.646272	1.135686	2.469408	1.703529	3.292544	2.271372	4.115680	2.839215	24
38	0.822805	0.568322	1.645610	1.136644	2.468415	1.704966	3.291220	2.273288	4.114025	2.841610	22
40	0.822475	0.568801	1.644950	1.137602	2.467425	1.706403	3.289900	2.275204	4.112375	2.844005	20
42	0.822144	0.569279	1.644288	1.138558	2.466432	1.707837	3.288576	2.277116	4.110720	2.846395	18
44	0.821812	0.569757	1.643624	1.139514	2.465436	1.709271	3.287248	2.279028	4.109060	2.848785	16
46	0.821481	0.570235	1.642962	1.140470	2.464443	1.710705	3.285924	2.280940	4.107405	2.851175	14
48	0.821149	0.570713	1.642298	1.141426	2.463447	1.712139	3.284596	2.282852	4.105745	2.853565	12
50	0.820817	0.571191	1.641634	1.142382	2.462451	1.713573	3.283268	2.284764	4.104085	2.855955	10
52	0.820484	0.571668	1.640968	1.143336	2.461452	1.715004	3.281936	2.286672	4.102420	2.858340	8
54	0.820151	0.572145	1.640302	1.144290	2.460453	1.716435	3.280604	2.288580	4.100755	2.860725	6
56	0.819818	0.572622	1.639636	1.145244	2.459454	1.717866	3.279272	2.290488	4.099090	2.863110	4
58	0.819485	0.573099	1.638970	1.146198	2.458455	1.719297	3.277940	2.292396	4.097425	2.865495	2
60	0.819152	0.573576	1.638304	1.147152	2.457456	1.720728	3.276608	2.294304	4.095760	2.867880	55°
	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Degrees and Minutes.
	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		

Degrees and Minutes.	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		
	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	
35°	0.819152	0.573576	1.638304	1.147152	2.457456	1.720728	3.276608	2.294304	4.095760	2.867880	60′
2′	0.818818	0.574052	1.637636	1.148104	2.456454	1.722156	3.275272	2.296208	4.094090	2.870260	58
4	0.818484	0.574529	1.636968	1.149058	2.455452	1.723587	3.273936	2.298116	4.092420	2.872645	56
6	0.818149	0.575005	1.636298	1.150010	2.454447	1.725015	3.272596	2.300020	4.090745	2.875025	54
8	0.817815	0.575481	1.635630	1.150962	2.453445	1.726443	3.271260	2.301964	4.089075	2.877405	52
10	0.817480	0.575956	1.634960	1.151912	2.452440	1.727868	3.269920	2.303824	4.087400	2.879780	50
12	0.817144	0.576432	1.634288	1.152864	2.451432	1.729296	3.268576	2.305728	4.085720	2.882160	48
14	0.816809	0.576907	1.633618	1.153814	2.450427	1.730721	3.267236	2.307628	4.084045	2.884535	46
16	0.816473	0.577382	1.632946	1.154764	2.449419	1.732146	3.265892	2.309528	4.082365	2.886910	44
18	0.816137	0.577857	1.632274	1.155714	2.448411	1.733571	3.264548	2.311428	4.080685	2.889285	42
20	0.815801	0.578332	1.631602	1.156664	2.447403	1.734996	3.263204	2.313328	4.079005	2.891660	40
22	0.815464	0.578806	1.630928	1.157612	2.446392	1.736418	3.261856	2.315224	4.077320	2.894030	38
24	0.815127	0.579281	1.630254	1.158562	2.445381	1.737843	3.260508	2.317124	4.075635	2.896405	36
26	0.814790	0.579755	1.629580	1.159510	2.444370	1.739265	3.259160	2.319020	4.073950	2.898775	34
28	0.814453	0.580229	1.628906	1.160458	2.443359	1.740687	3.257812	2.320916	4.072265	2.901145	32
30	0.814115	0.580703	1.628230	1.161406	2.442345	1.742109	3.256460	2.322812	4.070575	2.903515	30
32	0.813777	0.581176	1.627554	1.162352	2.441331	1.743528	3.255108	2.324704	4.068885	2.905880	28
34	0.813439	0.581649	1.626878	1.163298	2.440317	1.744947	3.253756	2.326596	4.067195	2.908245	26
36	0.813100	0.582123	1.626200	1.164246	2.439300	1.746369	3.252400	2.328492	4.065500	2.910615	24
38	0.812762	0.582595	1.625524	1.165190	2.438286	1.747785	3.251048	2.330380	4.063810	2.912975	22
40	0.812422	0.583068	1.624844	1.166136	2.437266	1.749204	3.249688	2.332272	4.062110	2.915340	20
42	0.812083	0.583541	1.624166	1.167082	2.436249	1.750623	3.248332	2.334164	4.060415	2.917705	18
44	0.811743	0.584013	1.623486	1.168026	2.435229	1.752039	3.246972	2.336052	4.058715	2.920065	16
46	0.811404	0.584485	1.622808	1.168970	2.434212	1.753455	3.245616	2.337940	4.057020	2.922425	14
48	0.811063	0.584957	1.622126	1.169914	2.433189	1.754871	3.244252	2.339828	4.055315	2.924785	12
50	0.810723	0.585429	1.621446	1.170858	2.432169	1.756287	3.242892	2.341716	4.053615	2.927145	10
52	0.810382	0.585901	1.620764	1.171802	2.431146	1.757703	3.241528	2.343604	4.051910	2.929505	8
54	0.810041	0.586372	1.620082	1.172744	2.430123	1.759116	3.240164	2.345488	4.050205	2.931860	6
56	0.809700	0.586843	1.619400	1.173686	2.429100	1.760529	3.238800	2.347372	4.048500	2.934215	4
58	0.809358	0.587314	1.618716	1.174628	2.428074	1.761942	3.237432	2.349256	4.046790	2.936570	2
60	0.809017	0.587785	1.618034	1.175570	2.427051	1.763355	3.236068	2.351140	4.045085	2.938925	54°
	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Degrees and Minutes.
	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		

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Degrees and Minutes.	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		
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36°	0.809017	0.587785	1.618034	1.175570	2.427051	1.763355	3.236068	2.351140	4.045085	2.938925	60′
2′	0.808674	0.588255	1.617348	1.176510	2.426022	1.764765	3.234696	2.353020	4.043370	2.941275	58
4	0.808332	0.588726	1.616664	1.177452	2.424996	1.766178	3.233328	2.354904	4.041660	2.943630	56
6	0.807989	0.589196	1.615978	1.178392	2.423967	1.767588	3.231956	2.356784	4.039945	2.945980	54
8	0.807647	0.589666	1.615294	1.179332	2.422941	1.768998	3.230588	2.358664	4.038235	2.948330	52
10	0.807303	0.590136	1.614606	1.180272	2.421909	1.770408	3.229212	2.360544	4.036515	2.950680	50
12	0.806960	0.590605	1.613920	1.181210	2.420880	1.771815	3.227840	2.362420	4.034800	2.953025	48
14	0.806616	0.591075	1.613232	1.182150	2.419848	1.773225	3.226464	2.364300	4.033080	2.955375	46
16	0.806272	0.591544	1.612544	1.183088	2.418816	1.774632	3.225088	2.366176	4.031360	2.957720	44
18	0.805928	0.592013	1.611856	1.184026	2.417784	1.776039	3.223712	2.368052	4.029640	2.960065	42
20	0.805583	0.592481	1.611166	1.184962	2.416749	1.777443	3.222332	2.369924	4.027915	2.962405	40
22	0.805238	0.592950	1.610476	1.185900	2.415714	1.778850	3.220952	2.371800	4.026190	2.964750	38
24	0.804893	0.593418	1.609786	1.186836	2.414679	1.780254	3.219572	2.373672	4.024465	2.967090	36
26	0.804548	0.593887	1.609096	1.187774	2.413644	1.781661	3.218192	2.375548	4.022740	2.969435	34
28	0.804202	0.594355	1.608404	1.188710	2.412606	1.783065	3.216808	2.377420	4.021010	2.971775	32
30	0.803856	0.594822	1.607712	1.189644	2.411568	1.784466	3.215424	2.379288	4.019280	2.974110	30
32	0.803510	0.595290	1.607020	1.190580	2.410530	1.785870	3.214040	2.381160	4.017350	2.976450	28
34	0.803164	0.595757	1.606328	1.191514	2.409492	1.787371	3.212656	2.383028	4.015820	2.978785	26
36	0.802817	0.596224	1.605634	1.192448	2.408451	1.788672	3.211268	2.384896	4.014085	2.981120	24
38	0.802470	0.596691	1.604940	1.193382	2.407410	1.790073	3.209880	2.386764	4.012350	2.983455	22
40	0.802123	0.597158	1.604246	1.194316	2.406369	1.791474	3.208492	2.388632	4.010615	2.985790	20
42	0.801775	0.597625	1.603550	1.195250	2.405325	1.792875	3.207100	2.390500	4.008875	2.988125	18
44	0.801427	0.598091	1.602854	1.196182	2.404281	1.794273	3.205708	2.392364	4.007135	2.990455	16
46	0.801079	0.598557	1.602158	1.197114	2.403237	1.795671	3.204316	2.394228	4.005395	2.992785	14
48	0.800731	0.599023	1.601462	1.198046	2.402193	1.797069	3.202924	2.396092	4.003655	2.995115	12
50	0.800382	0.599489	1.600764	1.198978	2.401146	1.798467	3.201528	2.397956	4.001910	2.997445	10
52	0.800033	0.599954	1.600066	1.199908	2.400099	1.799862	3.200132	2.399816	4.000165	2.999770	8
54	0.799684	0.600420	1.599368	1.200840	2.399052	1.801260	3.198736	2.401680	3.998420	3.002100	6
56	0.799335	0.600885	1.598670	1.201770	2.398005	1.802655	3.197340	2.403540	3.996675	3.004425	4
58	0.798985	0.601350	1.597970	1.202700	2.396955	1.804050	3.195940	2.405400	3.994925	3.006750	2
60	0.798635	0.601815	1.597270	1.203630	2.395905	1.805445	3.194540	2.407260	3.993175	3.009075	53°
	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Degrees and Minutes.
	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		

Degrees and Minutes.	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		
	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	
37°	0.798635	0.601815	1.597270	1.203630	2.395905	1.805445	3.194540	2.407260	3.993175	3.009075	60′
2′	0.798285	0.602279	1.596570	1.204558	2.394855	1.806837	3.193140	2.409116	3.991425	3.001395	58
4	0.797934	0.602743	1.595868	1.205486	2.393802	1.808229	3.191736	2.410972	3.989670	3.013715	56
6	0.797583	0.603208	1.595166	1.206416	2.392749	1.809624	3.190332	2.412832	3.987915	3.016040	54
8	0.797232	0.603671	1.594464	1.207342	2.391696	1.811013	3.188928	2.414684	3.986160	3.018355	52
10	0.796881	0.604135	1.593762	1.208270	2.390643	1.812405	3.187524	2.416540	3.984405	3.020675	50
12	0.796529	0.604599	1.593058	1.209198	2.389587	1.813797	3.186116	2.418396	3.982645	3.022995	48
14	0.796178	0.605062	1.592356	1.210124	2.388534	1.815186	3.184712	2.420248	3.980890	3.025310	46
16	0.795825	0.605525	1.591650	1.211050	2.387475	1.816575	3.183300	2.422100	3.979125	3.027625	44
18	0.795473	0.605988	1.590946	1.211976	2.386419	1.817964	3.181892	2.423952	3.977365	3.029940	42
20	0.795121	0.606451	1.590242	1.212902	2.385363	1.819353	3.180484	2.425804	3.975605	3.032255	40
22	0.794767	0.606913	1.589534	1.213826	2.384301	1.820739	3.179068	2.427652	3.973835	3.034565	38
24	0.794414	0.607375	1.588828	1.214750	2.383242	1.822125	3.177656	2.429500	3.972070	3.036875	36
26	0.794061	0.607837	1.588122	1.215674	2.382183	1.823511	3.176244	2.431348	3.970305	3.039185	34
28	0.793707	0.608299	1.587414	1.216598	2.381121	1.824897	3.174828	2.433196	3.968535	3.041495	32
30	0.793353	0.608761	1.586706	1.217522	2.380059	1.826283	3.173412	2.435044	3.966765	3.043805	30
32	0.792999	0.609222	1.585998	1.218444	2.378997	1.827666	3.171996	2.436888	3.964995	3.046110	28
34	0.792644	0.609684	1.585288	1.219368	2.377932	1.829052	3.170576	2.438736	3.963220	3.048420	26
36	0.792289	0.610145	1.584578	1.220290	2.376867	1.830435	3.169156	2.440580	3.961445	3.050725	24
38	0.791934	0.610606	1.583868	1.221212	2.375802	1.831818	3.167736	2.442424	3.959670	3.053030	22
40	0.791579	0.611066	1.583158	1.222132	2.374737	1.833198	3.166316	2.444264	3.957895	3.055330	20
42	0.791223	0.611527	1.582446	1.223054	2.373669	1.834581	3.164892	2.446108	3.956115	3.057635	18
44	0.790867	0.611987	1.581734	1.223974	2.372601	1.835961	3.163468	2.447948	3.954335	3.059935	16
46	0.790511	0.612447	1.581022	1.224894	2.371533	1.837341	3.162044	2.449788	3.952555	3.062235	14
48	0.790155	0.612907	1.580310	1.225814	2.370465	1.838721	3.160620	2.451628	3.950775	3.064535	12
50	0.789798	0.613366	1.579596	1.226732	2.369394	1.840098	3.159192	2.453464	3.948990	3.066830	10
52	0.789441	0.613826	1.578882	1.227652	2.368323	1.841478	3.157764	2.455304	3.947205	3.069130	8
54	0.789084	0.614285	1.578168	1.228570	2.367252	1.842855	3.156336	2.457140	3.945420	3.071425	6
56	0.788726	0.614744	1.577452	1.229488	2.366178	1.844232	3.154904	2.458976	3.943630	3.073720	4
58	0.788368	0.615202	1.576736	1.230404	2.365104	1.845606	3.153472	2.460808	3.941840	3.076010	2
60	0.788010	0.615661	1.576020	1.231322	2.364030	1.846983	3.152040	2.462644	3.940050	3.078305	52°
	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Degrees and Minutes.
	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		

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Degrees and Minutes.	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000,		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		
	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	
38°	0.788010	0.615661	1.576020	1.231322	2.364030	1.846983	3.152040	2.462644	3.940050	3.078305	60′
2′	0.787652	0.616119	1.575304	1.232238	2.363956	1.848357	3.150608	2.464476	3.938260	3.080595	58
4	0.787293	0.616578	1.574586	1.233156	2.361879	1.849734	3.149172	2.466312	3.936465	3.082890	56
6	0.786935	0.617035	1.573870	1.234070	2.360805	1.851105	3.147740	2.468140	3.934675	3.085175	54
8	0.786575	0.617493	1.573150	1.234986	2.359725	1.852479	3.146300	2.469972	3.932875	3.087465	52
10	0.786216	0.617951	1.572432	1.235902	2.358648	1.853853	3.144864	2.471804	3.931080	3.089755	50
12	0.785856	0.618408	1.571712	1.236816	2.357568	1.855224	3.143424	2.473632	3.929280	3.092040	48
14	0.785497	0.618865	1.570994	1.237730	2.356491	1.856595	3.141988	2.475460	3.927485	3.094325	46
16	0.785136	0.619322	1.570272	1.238644	2.355408	1.857966	3.140544	2.477288	3.925680	3.096610	44
18	0.784776	0.619779	1.569552	1.239558	2.354328	1.859337	3.139104	2.479116	3.923880	3.098895	42
20	0.784415	0.620235	1.568830	1.240470	2.353245	1.860705	3.137660	2.480940	3.922075	3.101175	40
22	0.784054	0.620691	1.568108	1.241382	2.352162	1.862073	3.136216	2.482764	3.920270	3.103455	38
24	0.783693	0.621147	1.567386	1.242294	2.351079	1.863441	3.134772	2.484588	3.918465	3.105735	36
26	0.783332	0.621603	1.566664	1.243206	2.349996	1.864809	3.133328	2.486412	3.916660	3.108015	34
28	0.782970	0.622059	1.565940	1.244118	2.348910	1.866177	3.131880	2.488236	3.914850	3.110295	32
30	0.782608	0.622514	1.565216	1.245028	2.347824	1.867542	3.130432	2.490056	3.913040	3.112570	30
32	0.782248	0.622969	1.564496	1.245938	2.346744	1.868907	3.128992	2.491876	3.911240	3.114845	28
34	0.781883	0.623424	1.563766	1.246848	2.345649	1.870272	3.127532	2.493696	3.909415	3.117120	26
36	0.781520	0.623879	1.563040	1.247758	2.344560	1.871637	3.126080	2.495516	3.907600	3.119395	24
38	0.781157	0.624334	1.562314	1.248668	2.343471	1.873002	3.124628	2.497336	3.905785	3.121670	22
40	0.780794	0.624788	1.561588	1.249576	2.342382	1.874364	3.123176	2.499152	3.903970	3.123940	20
42	0.780430	0.625242	1.560860	1.250484	2.341290	1.875726	3.121720	2.500968	3.902150	3.126210	18
44	0.780066	0.625696	1.560132	1.251392	2.340198	1.877088	3.120264	2.502784	3.900330	3.128480	16
46	0.779702	0.626150	1.559404	1.252300	2.339106	1.878450	3.118808	2.504600	3.898510	3.130750	14
48	0.779338	0.626603	1.558676	1.253206	2.338014	1.879809	3.117352	2.506412	3.896690	3.133015	12
50	0.778973	0.627057	1.557946	1.254114	2.336919	1.881171	3.115892	2.508228	3.894865	3.135285	10
52	0.778608	0.627510	1.557216	1.255020	2.335824	1.882530	3.114432	2.510040	3.893040	3.137550	8
54	0.778243	0.627963	1.556486	1.255926	2.334729	1.883889	3.112972	2.511852	3.891215	3.139815	6
56	0.777877	0.628415	1.555754	1.256830	2.333631	1.885245	3.111508	2.513660	3.889385	3.142075	4
58	0.777512	0.628868	1.555024	1.257736	2.332536	1.886604	3.110048	2.515472	3.887560	3.144340	2
60	0.777146	0.629320	1.554292	1.258640	2.331438	1.887960	3.108584	2.517280	3.885730	3.146600	51°
	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Degrees and Minutes.
	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		

Degrees and Minutes.	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000. Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000. Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000. Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000. Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000. Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	
39°	0.777146	0.629320	1.554292	1.258640	2.331438	1.887960	3.108584	2.517280	3.885730	3.146600	60′
2′	0.776779	0.629772	1.553558	1.259544	2.330337	1.889316	3.107116	2.519088	3.883895	3.148860	58
4	0.776413	0.630224	1.552826	1.260448	2.329239	1.890672	3.105652	2.520896	3.882065	3.151120	56
6	0.776046	0.630675	1.552092	1.261350	2.328138	1.892025	3.104184	2.522700	3.880230	3.153375	54
8	0.775679	0.631127	1.551358	1.262254	2.327037	1.893381	3.102716	2.524508	3.878395	3.155635	52
10	0.775312	0.631578	1.550624	1.263156	2.325936	1.894734	3.101248	2.526312	3.876560	3.157890	50
12	0.774944	0.632029	1.549888	1.264058	2.324832	1.896087	3.099776	2.528116	3.874720	3.160145	48
14	0.774576	0.632480	1.549152	1.264960	2.323728	1.897440	3.098304	2.529920	3.872880	3.162400	46
16	0.774208	0.632930	1.548416	1.265860	2.322624	1.898790	3.096832	2.531720	3.871040	3.164650	44
18	0.773840	0.633380	1.547680	1.266760	2.321520	1.900140	3.095360	2.533520	3.869200	3.166900	42
20	0.773471	0.633831	1.546942	1·267662	2.320413	1.901493	3.093884	2.535324	3.867355	3.169155	40
22	0.773102	0.634280	1.546204	1.268560	2.319306	1.902840	3.092408	2.537120	3.865510	3.171400	38
24	0.772733	0.634730	1.545466	1.269460	2.318199	1.904190	3.090932	2.538920	3.863665	3.173650	36
26	0.772364	0.635180	1.544728	1.270360	2.317092	1.905540	3.089456	2.540720	3.861820	3.175900	34
28	0.771994	0.635629	1.543988	1.271258	2.315982	1.906887	3.087976	2.542516	3.859970	3.178145	32
30	0.771624	0.636078	1.543248	1.272156	2.314872	1.908234	3.086496	2.544312	3.858120	3.180390	30
32	0.771254	0.636527	1.542508	1.273054	2.313762	1.909581	3.085016	2.546108	3.856270	3.182635	28
34	0.770884	0.636975	1.541768	1.273950	2.312652	1.910925	3.083536	2.547900	3.854420	3.184875	26
36	0.770513	0.637424	1.541026	1.274848	2.311539	1.912272	3.082052	2.549696	3.852565	3.187120	24
38	0.770142	0.637872	1.540284	1.275744	2.310426	1.913616	3.080568	2.551488	3.850710	3.189360	22
40	0.769771	0.638320	1.539542	1.276640	2.309313	1.914960	3.079084	2.553280	3.848855	3.191600	20
42	0.769399	0.638767	1.538798	1.277534	2.308197	1.916301	3.077596	2.555068	3.846995	3.193835	18
44	0.769027	0.639215	1.538054	1.278430	2.307081	1.917645	3.076108	2.556860	3.845135	3.196075	16
46	0.768655	0.639662	1.537310	1.279324	2.305965	1.918986	3.074620	2.558648	3.843275	3.198310	14
48	0.768283	0.640109	1.536566	1.280218	2.304849	1.920327	3.073132	2.560436	3.841415	3.200545	12
50	0.767911	0.640556	1.535822	1.281112	2.303733	1.921668	3.071644	2.562224	3.839555	3.202780	10
52	0.767538	0.641003	1.535076	1.282006	2.302614	1.923009	3.070152	2.564012	3.837690	3.205015	8
54	0.767165	0.641449	1.534330	1.282898	2.301495	1.924347	3.068660	2.565796	3.835825	3.207245	6
56	0.766791	0.641895	1.533582	1.283790	2.300373	1.925685	3.067164	2.567580	3.833955	3.209475	4
58	0.766418	0.642341	1.532836	1.284682	2.299254	1.927023	3.065672	2.569364	3.832090	3.211705	2
60	0.766044	0.642787	1.532088	1.285574	2.298132	1.928361	3.064176	2.571148	3.830220	3.213935	50°
	Distance from Planes of Meridian, or East or West Distance. Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance. Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance. Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance. Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance. Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.	Distance from Planes of Latitude, or North or South Distance.	Degrees and Minutes.

Degrees and Minutes.	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		
	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	
40°	0.766044	0.642787	1.532088	1.285574	2.298132	1.928361	3.064176	2.571148	3.830220	3.213935	60′
2′	0.765670	0.643233	1.531340	1.286466	2.297010	1.929699	3.062680	2.572932	3.828350	3.216165	58
4	0.765296	0.643678	1.530592	1.287356	2.295888	1.931034	3.061184	2.574712	3.826480	3.218390	56
6	0.764921	0.644123	1.529842	1.288246	2.294763	1.932369	3.059684	2.576492	3.824605	3.220615	54
8	0.764546	0.644568	1.529092	1.289136	2.293638	1.933704	3.058184	2.578272	3.822730	3.222840	52
10	0.764171	0.645013	1.528342	1.290026	2.292513	1.935039	3.056684	2.580052	3.820855	3.225065	50
12	0.763796	0.645457	1.527592	1.290914	2.291388	1.936371	3.055184	2.581828	3.818980	3.227285	48
14	0.763420	0.645901	1.526840	1.291802	2.290260	1.937703	3.053680	2.583604	3.817100	3.229505	46
16	0.763044	0.646346	1.526088	1.292692	2.289132	1.939038	3.052176	2.585384	3.815220	3.231730	44
18	0.762668	0.646789	1.525336	1.293578	2.288004	1.940367	3.050672	2.587156	3.813340	3.233945	42
20	0.762291	0.647233	1.524582	1.294466	2.286873	1.941699	3.049164	2.588932	3.811455	3.236165	40
22	0.761915	0.647676	1.523830	1.295352	2.285745	1.943028	3.047660	2.590704	3.809575	3.238380	38
24	0.761538	0.648119	1.523076	1.296238	2.284614	1.944357	3.046152	2.592476	3.807690	3.240595	36
26	0.761161	0.648562	1.522322	1.297124	2.283483	1.945686	3.044644	2.594248	3.805805	3.242810	34
28	0.760783	0.649005	1.521566	1.298010	2.282349	1.947015	3.043132	2.596020	3.803915	3.245025	32
30	0.760406	0.649448	1.520812	1.298896	2.281218	1.948344	3.041624	2.597792	3.802030	3.247240	30
32	0.760028	0.649890	1.520056	1.299780	2.280084	1.949670	3.040112	2.599560	3.800140	3.249450	28
34	0.759649	0.650332	1.519298	1.300664	2.278947	1.950996	3.038596	2.601328	3.798245	3.251660	26
36	0.759271	0.650774	1.518542	1.301548	2.277813	1.952322	3.037084	2.603096	3.796355	3.253870	24
38	0.758892	0.651215	1.517784	1.302430	2.276676	1.953645	3.035568	2.604860	3.794460	3.256075	22
40	0.758513	0.651657	1.517026	1.303314	2.275539	1.954971	3.034052	2.606628	3.792565	3.258285	20
42	0.758134	0.652098	1.516268	1.304196	2.274402	1.956294	3.032536	2.608392	3.790670	3.260490	18
44	0.757754	0.652539	1.515508	1.305078	2.273262	1.957617	3.031016	2.610156	3.788770	3.262695	16
46	0.757375	0.652980	1.514750	1.305960	2.272125	1.958940	3.029500	2.611920	3.786875	3.264900	14
48	0.756995	0.653420	1.513990	1.306840	2.270985	1.960260	3.027980	2.613680	3.784975	3.267100	12
50	0.756614	0.653860	1.513228	1.307720	2.269842	1.961580	3.026456	2.615440	3.783070	3.269300	10
52	0.756234	0.654301	1.512468	1.308602	2.268702	1.962903	3.024936	2.617204	3.781170	3.271505	8
54	0.755853	0.654740	1.511706	1.309480	2.267559	1.964226	3.023412	2.618960	3.779265	3.273700	6
56	0.755472	0.655180	1.510944	1.310360	2.266416	1.965540	3.021888	2.620720	3.777360	3.275900	4
58	0.755091	0.655619	1.510182	1.311238	2.265273	1.966857	3.020364	2.622476	3.775455	3.278095	2
60	0.754709	0.656059	1.509418	1.312118	2.264127	1.968177	3.018836	2.624236	3.773545	3.280295	49°
	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Degrees and Minutes.
	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		

Degrees and Minutes.	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		
	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	
41°	0.754709	0.656059	1.509418	1.312118	2.264127	1.968177	3.018836	2.624236	3.773545	3.280295	60′
2′	0.754327	0.656498	1.508654	1.312996	2.262981	1.969494	3.017308	2.625992	3.771635	3.282490	58
4	0.753945	0.656936	1.507890	1.313872	2.261835	1.970808	3.015780	2.627744	3.769725	3.284680	56
6	0.753563	0.657375	1.507126	1.314750	2.260689	1.972125	3.014252	2.629500	3.767815	3.286875	54
8	0.753180	0.657813	1.506360	1.315626	2.259540	1.973439	3.012720	2.631252	3.765900	3.289065	52
10	0.752798	0.658251	1.505596	1.316502	2.258394	1.974753	3.011192	2.633004	3.763990	3.291255	50
12	0.752414	0.658689	1.504828	1.317378	2.257242	1.976067	3.009656	2.634756	3.762070	3.293445	48
14	0.752031	0.659127	1.504062	1.318254	2.256093	1.977381	3.008124	2.636508	3.760155	3.295635	46
16	0.751648	0.659564	1.503296	1.319128	2.254944	1.978692	3.006592	2.638256	3.758240	3.297820	44
18	0.751264	0.660001	1.502528	1.320002	2.253792	1.980003	3.005056	2.640004	3.756320	3.300005	42
20	0.750880	0.660438	1.501760	1.320876	2.252640	1.981314	3.003520	2.641752	3.754400	3.302190	40
22	0.750495	0.660875	1.500990	1.321750	2.252485	1.982625	3.001980	2.643500	3.752475	3.304375	38
24	0.750111	0.661311	1.500222	1.322622	2.250333	1.983933	3.000444	2.645244	3.750555	3.306555	36
26	0.749726	0.661748	1.499452	1.323496	2.249178	1.985244	2.998904	2.646992	3.748630	3.308740	34
28	0.749341	0.662184	1.498682	1.324368	2.248023	1.986552	2.997364	2.648736	3.746705	3.310920	32
30	0.748955	0.662620	1.497910	1.325240	2.246865	1.987860	2.995820	2.650480	3.744775	3.313100	30
32	0.748570	0.663055	1.497140	1.326110	2.245710	1.989165	2.994280	2.652220	3.742850	3.315275	28
34	0.748184	0.663491	1.496368	1.326982	2.244552	1.990473	2.992736	2.653964	3.740920	3.317455	26
36	0.747798	0.663926	1.495596	1.327852	2.243394	1.991778	2.991192	2.655704	3.738990	3.319630	24
38	0.747411	0.664361	1.494822	1.328722	2.242233	1.993083	2.989644	2.657444	3.737055	3.321805	22
40	0.747025	0.664795	1.494050	1.329590	2.241075	1.994385	2.988100	2.659180	3.735125	3.323975	20
42	0.746638	0.665230	1.493276	1.330460	2.239914	1.995690	2.986552	2.660920	3.733190	3.326150	18
44	0.746251	0.665664	1.492502	1.331328	2.238753	1.996992	2.985004	2.662656	3.731255	3.328320	16
46	0.745863	0.666098	1.491726	1.332196	2.237589	1.998294	2.983452	2.664392	3.729315	3.330490	14
48	0.745476	0.666532	1.490952	1.333064	2.236428	1.999596	2.981904	2.666128	3.727380	3.332660	12
50	0.745088	0.666966	1.490176	1.333932	2.235264	2.000898	2.980352	2.667864	3.725440	3.334830	10
52	0.744699	0.667399	1.489398	1.334798	2.234097	2.002197	2.978796	2.669596	3.723495	3.336995	8
54	0.744311	0.667832	1.488622	1.335664	2.232933	2.003496	2.977244	2.671328	3.721555	3.339160	6
56	0.743922	0.668265	1.487844	1.336530	2.231766	2.004795	2.975688	2.673060	3.719610	3.341325	4
58	0.743534	0.668698	1.487068	1.337396	2.230602	2.006094	2.974136	2.674792	3.717670	3.343490	2
60	0.743144	0.669130	1.486288	1.338260	2.229432	2.007390	2.972576	2.676520	3.715720	3.345650	48°
	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Degrees and Minutes.
	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		

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Degrees and Minutes.	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse. 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		
	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	
42°	0.743144	0.669130	1.486288	1.338260	2.229432	2.007390	2.972576	2.676520	3.715720	3.345650	60′
2′	0.742755	0.669562	1.485510	1.339124	2.228265	2.008686	2.971020	2.678248	3.713775	3.347810	58
4	0.742365	0.669994	1.484730	1.339988	2.227095	2.009982	2.969460	2.679976	3.711825	3.349970	56
6	0.741975	0.670426	1.483950	1.340852	2.225925	2.011278	2.967900	2.681704	3.709875	3.352130	54
8	0.741585	0.670858	1.483170	1.341716	2.224755	2.012574	2.966340	2.683432	3.707925	3.354290	52
10	0.741195	0.671289	1.482390	1.342578	2.223585	2.013867	2.964780	2.685156	3.705975	3.356445	50
12	0.740804	0.671720	1.481608	1.343440	2.222412	2.015160	2.963216	2.686880	3.704020	3.358600	48
14	0.740413	0.672151	1.480826	1.344302	2.221239	2.016453	2.961652	2.688604	3.702065	3.360755	46
16	0.740022	0.672582	1.480044	1.345164	2.220066	2.017746	2.960088	2.690328	3.700110	3.362910	44
18	0.739631	0.673012	1.479262	1.346024	2.218893	2.019036	2.958524	2.692048	3.698155	3.365060	42
20	0.739239	0.673442	1.478578	1.346884	2.217717	2.020326	2.956956	2.693768	3.696195	3.367210	40
22	0.738847	0.673872	1.477694	1.347744	2.216541	2.021616	2.955388	2.695488	3.694235	3.369360	38
24	0.738455	0.674302	1.476910	1.348604	2.215365	2.022906	2.953820	2.697208	3.692275	3.371510	36
26	0.738062	0.674731	1.476124	1.349462	2.214186	2.024193	2.952248	2.698924	3.690310	3.373655	34
28	0.737670	0.675161	1.475340	1.350322	2.213010	2.025483	2.950680	2.700644	3.688350	3.375805	32
30	0.737277	0.675590	1.474554	1.351180	2.211831	2.026770	2.949108	2.702360	3.686385	3.377950	30
32	0.736884	0.676019	1.473768	1.352038	2.210652	2.028057	2.947536	2.704076	3.684420	3.380095	28
34	0.736490	0.676447	1.472980	1.352894	2.209470	2.029341	2.945960	2.705788	3.682450	3.382235	26
36	0.736097	0.676876	1.472194	1.353752	2.208291	2.030628	2.944388	2.707504	3.680485	3.384380	24
38	0.735703	0.677304	1.471406	1.354608	2.207109	2.031912	2.942812	2.709216	3.678515	3.386520	22
40	0.735309	0.677732	1.470618	1.355464	2.205927	2.033196	2.941236	2.710928	3.676545	3.388660	20
42	0.734914	0.678159	1.469828	1.356318	2.204742	2.034477	2.939656	2.712636	3.674570	3.390795	18
44	0.734519	0.678587	1.469038	1.357174	2.203557	2.035761	2.938076	2.714348	3.672595	3.392935	16
46	0.734125	0.679014	1.468250	1.358028	2.202375	2.037042	2.936500	2.716056	3.670625	3.395070	14
48	0.733729	0.679441	1.467458	1.358882	2.201187	2.038323	2.934916	2.717764	3.668645	3.397205	12
50	0.733334	0.679868	1.466668	1.359736	2.200002	2.039604	2.933336	2.719472	3.666670	3.399340	10
52	0.732938	0.680294	1.465876	1.360588	2.198814	2.040882	2.931752	2.721176	3.664690	3.401470	8
54	0.732542	0.680720	1.465084	1.361440	2.197626	2.042160	2.930168	2.722880	3.662710	3.403600	6
56	0.732146	0.681146	1.464292	1.362292	2.196438	2.043438	2.928584	2.724584	3.660730	3.405730	4
58	0.731750	0.681572	1.463500	1.363144	2.195250	2.044716	2.927000	2.726288	3.658750	3.407860	2
60	0.731353	0.681998	1.462706	1.363996	2.194059	2.045994	2.925412	2.727992	3.656765	3.409990	47°
	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Degrees and Minutes.
	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		

Degrees and Minutes.	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		
	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	
43°	0.731353	0.681998	1.462706	1.363996	2.194059	2.045994	2.925412	2.727992	3.656765	3.409990	60′
2′	0.730956	0.682423	1.461912	1.364846	2.192868	2.047269	2.923824	2.729692	3.654780	3.412115	58
4	0.730559	0.682848	1.461118	1.365696	2.191677	2.048544	2.922236	2.731392	3.652795	3.414240	56
6	0.730162	0.683273	1.460324	1.366546	2.190486	2.049819	2.920648	2.733092	3.650810	3.416365	54
8	0.729764	0.683698	1.459528	1.367396	2.189292	2.051094	2.919056	2.734792	3.648820	3.418490	52
10	0.729366	0.684122	1.458732	1.368244	2.188098	2.052366	2.917464	2.736488	3.646830	3.420610	50
12	0.728968	0.684547	1.457936	1.369094	2.186904	2.053641	2.915872	2.738188	3.644840	3.422735	48
14	0.728570	0.684971	1.457140	1.369942	2.185710	2.054913	2.914280	2.739884	3.642850	3.424855	46
16	0.728171	0.685394	1.456342	1.370788	2.184513	2.056182	2.912684	2.741576	3.640855	3.426970	44
18	0.727772	0.685818	1.455544	1.371636	2.183316	2.057454	2.911088	2.743272	3.638860	3.429090	42
20	0.727373	0.686241	1.454746	1.372482	2.182119	2.058723	2.909492	2.744964	3.636865	3.431205	40
22	0.726974	0.686664	1.453948	1.373328	2.180912	2.059992	2.907896	2.746656	3.634870	3.433320	38
24	0.726574	0.687087	1.453148	1.374174	2.179722	2.061261	2.906296	2.748348	3.632870	3.435435	36
26	0.726174	0.687510	1.452348	1.375020	2.178522	2.062530	2.904696	2.750040	3.630870	3.437550	34
28	0.725774	0.687932	1.451548	1.375864	2.177322	2.063796	2.903096	2.751728	3.628870	3.439660	32
30	0.725374	0.688354	1.450748	1.376708	2.176122	2.065062	2.901496	2.753416	3.626870	3.441770	30
32	0.724973	0.688776	1.449946	1.377552	2.174919	2.066328	2.899892	2.755104	3.624865	3.443880	28
34	0.724572	0.689198	1.449144	1.378396	2.173716	2.067594	2.898288	2.756792	3.622860	3.445990	26
36	0.724171	0.689619	1.448342	1.379238	2.172513	2.068857	2.896684	2.758476	3.620855	3.448095	24
38	0.723770	0.690040	1.447540	1.380080	2.171310	2.070120	2.895080	2.760160	3.618850	3.450200	22
40	0.723369	0.690461	1.446738	1.380922	2.170107	2.071383	2.893476	2.761844	3.616845	3.452305	20
42	0.722967	0.690882	1.445934	1.381764	2.168901	2.072646	2.891868	2.763528	3.614835	3.454410	18
44	0.722565	0.691302	1.445130	1.382604	2.167695	2.073906	2.890260	2.765208	3.612825	3.456510	16
46	0.722162	0.691723	1.444324	1.383446	2.166486	2.075169	2.888648	2.766892	3.610810	3.458615	14
48	0.721760	0.692143	1.443520	1.384286	2.165280	2.076429	2.887040	2.768572	3.608800	3.460715	12
50	0.721357	0.692563	1.442714	1.385126	2.164071	2.077689	2.885428	2.770252	3.606785	3.462815	10
52	0.720954	0.692982	1.441908	1.385964	2.162862	2.078946	2.883816	2.771928	3.604770	3.464910	8
54	0.720551	0.693401	1.441102	1.386802	2.161653	2.080203	2.882204	2.773604	3.602755	3.467005	6
56	0.720147	0.693820	1.440294	1.387640	2.160441	2.081460	2.880588	2.775280	3.600735	3.469100	4
58	0.719743	0.694239	1.439486	1.388478	2.159229	2.082717	2.878972	2.776956	3.598715	3.471195	2
60	0.719339	0.694658	1.438678	1.389316	2.158017	2.083974	2.877356	2.778632	3.596695	3.473290	46°
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Degrees and Minutes.	Measured Distance, or Hypothenuse, 1, 10, 100, 1000, 10,000, or 100,000.		Measured Distance, or Hypothenuse, 2, 20, 200, 2000, 20,000, or 200,000.		Measured Distance, or Hypothenuse, 3, 30, 300, 3000, 30,000, or 300,000.		Measured Distance, or Hypothenuse, 4, 40, 400, 4000, 40,000, or 400,000.		Measured Distance, or Hypothenuse, 5, 50, 500, 5000, 50,000, or 500,000.		
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44°	0.719339	0.694658	1.438678	1.389316	2.158017	2.083974	2.877356	2.778632	3.596695	3.473290	60′
2′	0.718935	0.695076	1.437870	1.390152	2.156805	2.085228	2.875740	2.780304	3.594675	3.475380	58
4	0.718531	0.695494	1.437062	1.390988	2.155593	2.086482	2.874124	2.781976	3.592655	3.477470	56
6	0.718126	0.695912	1.436252	1.391824	2.154378	2.087736	2.872504	2.783648	3.590630	3.479560	54
8	0.717721	0.696330	1.435442	1.392660	2.153163	2.088990	2.870884	2.785320	3.588605	3.481650	52
10	0.717316	0.696747	1.434632	1.393494	2.151948	2.090241	2.869264	2.786988	3.586580	3.483735	50
12	0.716910	0.697165	1.433820	1.394330	2.150730	2.091495	2.867640	2.788660	3.584550	3.485825	48
14	0.716504	0.697582	1.433008	1.395164	2.149512	2.092746	2.866016	2.790328	3.582520	3.487910	46
16	0.716098	0.697998	1.432196	1.395996	2.148294	2.093994	2.864392	2.791992	3.580490	3.489990	44
18	0.715692	0.698415	1.431384	1.396830	2.147076	2.095245	2.862768	2.793660	3.578460	3.492075	42
20	0.715286	0.698831	1.430572	1.397662	2.145858	2.096493	2.861144	2.795324	3.576430	3.494155	40
22	0.714879	0.699247	1.429758	1.398494	2.144637	2.097741	2.859516	2.796988	3.574395	3.496235	38
24	0.714472	0.699663	1.428944	1.399326	2.143416	2.098989	2.857888	2.798652	3.572360	3.498315	36
26	0.714065	0.700078	1.428130	1.400156	2.142195	2.100234	2.856260	2.800312	3.570325	3.500390	34
28	0.713658	0.700494	1.427316	1.400988	2.140974	2.101482	2.854632	2.801976	3.568290	3.502470	32
30	0.713250	0.700909	1.426500	1.401818	2.139750	2.102727	2.853000	2.803636	3.566250	3.504545	30
32	0.712842	0.701324	1.425684	1.402648	2.138526	2.103972	2.851368	2.805296	3.564210	3.506620	28
34	0.712434	0.701738	1.424868	1.403476	2.137302	2.105214	2.849736	2.806952	3.562170	3.508690	26
36	0.712026	0.702153	1.424052	1.404306	2.136078	2.106459	2.848104	2.808612	3.560130	3.510765	24
38	0.711617	0.702567	1.423234	1.405134	2.134851	2.107701	2.846468	2.810268	3.558085	3.512835	22
40	0.711208	0.702981	1.422416	1.405962	2.133624	2.108943	2.844832	2.811924	3.556040	3.514905	20
42	0.710799	0.703394	1.421598	1.406788	2.132397	2.110182	2.843196	2.813576	3.553995	3.516970	18
44	0.710390	0.703808	1.420780	1.407616	2.131170	2.111424	2.841560	2.815232	3.551950	3.519040	16
46	0.709980	0.704221	1.419960	1.408442	2.129940	2.112663	2.839920	2.816884	3.549900	3.521105	14
48	0.709570	0.704634	1.419140	1.409268	2.128710	2.113902	2.838280	2.818536	3.547850	3.523170	12
50	0.709160	0.705046	1.418320	1.410092	2.127480	2.115138	2.836640	2.820184	3.545800	3.525230	10
52	0.708750	0.705459	1.417500	1.410918	2.126250	2.116377	2.835000	2.821836	3.543750	3.527295	8
54	0.708339	0.705871	1.416678	1.411742	2.125017	2.117613	2.833356	2.823484	3.541695	3.529355	6
56	0.707929	0.706283	1.415858	1.412566	2.123787	2.118849	2.831716	2.825132	3.539645	3.531415	4
58	0.707518	0.706695	1.415036	1.413390	2.122554	2.120085	2.830072	2.826780	3.537590	3.533475	2
60	0.707106	0.707106	1.414212	1.414212	2.121318	2.121318	2.828424	2.828424	3.535530	3.535530	45°
	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Distance from Planes of Meridian, or East or West Distance.	Distance from Planes of Latitude, or North or South Distance.	Degrees and Minutes.
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INTRODUCTION

TO THE

TABLES OF NATURAL SINES, SECANTS, TANGENTS, ETC.

The method of computing with sines, cosines, &c., is due to the invention of the Arabians, who were the first to improve on the ancient practice of calculating trigonometrical quantities by means of chords, in which state it was received by them from the Greeks. The science of trigonometry came to us from the Arabians, and has, since that period, received important alterations and improvements from many eminent European mathematicians, among whom may be mentioned "Purbech," and his friend "Regiomontanus," whose tables are little inferior to those we possess in these times.

Lines drawn in and about a circle whose radius is = unity, have been taken by these mathematicians as a standard measurement for triangles, and there may be any number of such triangles formed upon the radius, depending on the minuteness to which the circumference of the circle is conceived to be divided to. The length of a series of these lines, called or denominated sines, cosines, secants, tangents, &c., have at different times been determined to every minute of arc of the circle, arranged and tabulated ready for use. Such a table I have prepared to six decimal places (for the present work), and in their compilation much care has been bestowed in order to render the table as accurate as possible; for which purpose they have not only been compared with Dr. Hutton's best edition, but with those of others equally reliable. The number answering to any degree or minute may be taken out of the table by inspection at sight, by finding the number of degrees at the top or bottom of each page, and the single minutes down every first or up every last column.

If the sine, cosine, &c., answering to degrees, minutes, and seconds are wanted, they may be found in the following manner by differences:—

Suppose the sine of 10° 21′ 20″ is required:—

Natural sine . . .	10° 21′ 0″ =	.179661	
Next less natural sine	10 20 0 =	.179375	
$\frac{1}{3}$)	0 1 0 =	$\frac{1}{3}$).000286	difference for 1′
	0 0 20 =	+.000095	„ „ 20″

Therefore .179661 + .000095 = .179756 = ∠ 10° 21′ 20″

Required the Cosine of 10° 21′ 20″.

Natural cosine of . .	10° 20′ 0″ =	.983781	
„ „ next less	10 21 0 =	.983729	
$\frac{1}{3}$)	0 1 0 =	$\frac{1}{3}$).000052	
	0 0 20 =	−.000017	difference for 20″

Therefore .983729 − .000017 = .983712 = ∠ 10° 21′ 20″.

To find the Sine of 40° 10′ 10″.

Next higher natural sine	=40° 11′ 0″ =	.645236	
Nearest given „ „	=40 10 0 =	.645013	
$\frac{1}{6}$)	0 1 0 =	$\frac{1}{6}$).000223	diff. for 1′ 0″
	0 0 10 =	.000037	„ „ 0 10

Therefore .645013 + .000037 = .645050 = ∠ 40° 10′ 10″.

The proportional part found in this manner for any number of odd seconds must be added for sines, secants, and tangents, but subtracted for cosines, cosecants, and cotangents.

The tables of natural sines may be computed in the following manner:—

1. If we take A B C as a quadrant, or fourth part of the circle A B D E, and call the radius C B unity or = to 1, and conceive it to be divided into an indefinite number of decimal parts, as 1000000, &c.; and if we take the chord B F = to the radius, the arc subtended by it will be = to 60°, because in every circle the radius is equal to the chord of 60°. Now, if we draw the

line G F, the sine of the arc at right angles, to C B, and also the cosine F H at right angles to C F, bisect B F in I, then will I S be the sine, and I N the cosine of the arc of 30°=B I; bisect the chord of 30° or B I in O, then M O will be=to the sine and T O the cosine of the arc of 15°=B O. Now if we continue the process until we have made 12 bisections, we should determine the arc of 0° 0′ 52″ 44‴ 3⁗ 45′′′′′, the cosine of which would approximate so closely to the radius C B, that it may be

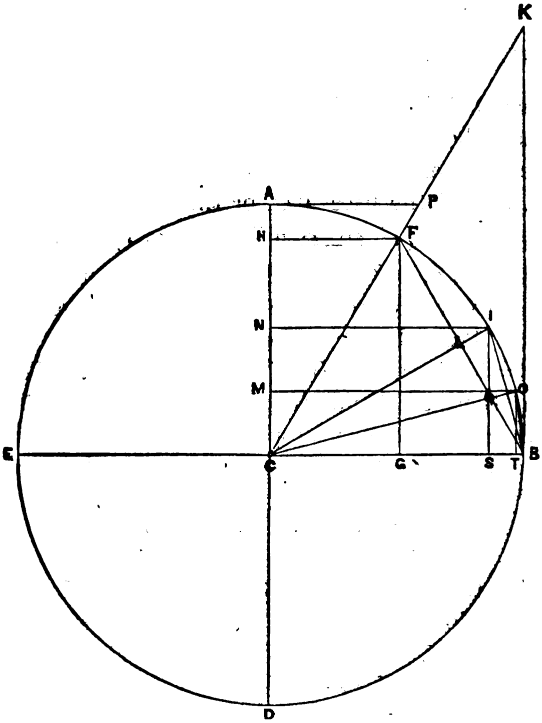

FIG. 75.

taken, without sensible error, as of equal value, and the numerical measured value of this arc may be obtained by calculation as follows:—

Euclid's corollary to the 15 Prop. of his 4 Book, teaches that the chord line B F, Fig. 75, is the side of a hexagon, inscribed in a circle, being the subtense of 60°, and consequently, as before stated,=to the radius C B. Now, if we take half the radius, or B L, it will be equal to the sine of 30°=I S, which, consequently, must be=5000000. The sine of 30°, having been thus found, its cosine may also be deduced from it by the 47 Prop. of the 1 Book of Euclid; for in the right-angled triangle I C S the hypothenuse 1 C = 100000, and the perpendicular I S = .500000, to find the base C S = the cosine I N.

$\therefore \sqrt{\text{C S} \times \text{C I} - \text{I S} \times \text{I S} = \text{C N}}$ .8660254 = I N, consequently the sine of 30° = .5000000, and its cosine .8660254.

2nd. The perpendicular I S in the triangle I S B is = .5000000, and the base C B − C S = S B .1339745, to find the hypothenuse B I.

Therefore $\sqrt{\text{I S} \times \text{I S} + \text{S B} \times \text{S B}} = \text{B I} = \frac{.51763809}{2} = \text{T Q} =$ .25881904, or O T, its equal the sine of 15°, the cosine belonging may now easily be found from it, for in the triangle O C T the hypothenuse and perpendicular are given = 100000 and .25881904 respectively, to find the base T C, or the cosine O M.

Therefore $\sqrt{\text{O C} \times \text{O C} - \text{O T} \times \text{O T}} = \text{T C} =$ .96592582, consequently the sine of 15° is = .25881904, and cosine = .96592582.

Now, if we were to continue the same process until we had attained the 12th bisection, we should arrive at the sine .0002556634 = to the arc 0° 0′ 5″ 44‴ 3⁗ 45′′′′′. This arc only differs from that of 1 minute by 0° 0′ 7″ 15‴ 56⁗ 15′′′′′, and as small arcs are nearly proportional to their corresponding sines, the measure of 1′ of arc may be deduced from the small arc previously found.

To find the Sine of 1′.

Rule.—As the arc 52″ 44‴ 3⁗ 45′′′′′ is to the arc of 1′, so is the sine—previously found—to the sine of an arc of 1′.

Example.—As 52″ 44‴ 3⁗ 45′′′′′ : 1′ : : .00025566 : .00029088, which is therefore = to the sine of 1′, and the cosine answering to this is nearly equal to radius.

To find the Sine of 2′.

Example.—As radius (1) : 2 : : .00029088 : .0005817 − 0 = .0005817.

To find the Sine of 3′.

Example.—As radius (1) : 2 : : .0005817 : .0011635 and .0011635 − .0002908 = .0008726 − the sine of three minutes. By the same kind of operation the sines may be found to 30° or 60°, and the tables computed to the end by addition only.

The tangents, cotangents, secants, and cosecants may also be found from the sines and cosines as follows. When referring to Fig. 75, the roman large letters represent lines, and the small ones—as *a*, *b*, and *e*—the arc of any circle to radius 1.

$$(\text{Sine } a)^2 + (\text{cosecant } a)^2 = 1. \quad (\text{Secant } a)^2 - (\text{tangent } a)^2 = 1.$$
$$(\text{Cosecant } a)^2 - (\text{cotangent } a)^2 = 1.$$

For in Fig. 75, in the right-angled triangle P A C, F H C, and O K B, we have:—

$$\text{F H}^2 + \text{H C}^2 = \text{F C}^2 \therefore (\text{sine } a)^2 + (\text{cosecant } a)^2 = 1.$$
$$\text{C P}^2 - \text{A P}^2 = \text{A C}^2 \therefore (\text{secant } a)^2 - (\text{tangent } a)^2 = 1.$$
$$\text{O K}^2 - \text{B K}^2 = \text{C B}^2 \therefore (\text{cosecant } a)^2 - (\text{cotangent } a)^2 = 1.$$

Again, for $a = \dfrac{\text{sine } a}{\text{cosine } a}$; cotangent $a = \dfrac{\text{cosine } a}{\text{sine } a}$; tangent $a = \dfrac{1}{\text{cotangent } a}$.

$$\text{For } \frac{.3420201}{.9396926} = .3639702 = \text{tangent of } 20°.$$

$$\text{And } \frac{.9396926}{.3420201} = .27474774 = \text{cotangent of } 20°.$$

For, by similar triangles in the same figure we have:—

$$\frac{\text{A P}}{\text{A C}} = \frac{\text{P H}}{\text{H C}} \therefore \text{ tangent } a = \frac{\text{sine } a}{\text{cosine } a}.$$

$$\frac{\text{B K}}{\text{C B}} = \frac{\text{H C}}{\text{F H}} \therefore \text{ cotangent } a = \frac{\text{cosine } a}{\text{sine } a}.$$

$$\frac{\text{A B}}{\text{C B}} = \frac{\text{C B}}{\text{B K}} \therefore \text{ tangent } a = \frac{1}{\text{cotangent } a}.$$

$$\text{For } \frac{100000000}{.27474774} = .3639702 = \text{tangent of } 20°.$$

Also to prove the secants and cosecants as follows:—

$$\text{Secant } a = \frac{1}{\text{cosine } a}; \text{ cosine } a = \frac{1}{\text{sine } a}.$$

For we have $\frac{C\,P}{C\,A} = \frac{C\,F}{C\,H}$ $\therefore$ secant $a = \frac{1}{\text{sine } a}$.

$\frac{C\,K}{C\,B} = \frac{O\,F}{F\,H}$ $\therefore$ cosecant $a = \frac{1}{\text{cosine } a}$.

For $\frac{1.000000}{.9396926} = 1.0641778 =$ secant of 20°.

And $\frac{1000000}{.3420201} = 2.9238044 =$ cosecant of 20°.

New tables may be thus constructed, or the accuracy of those already calculated proved, from the commencement to the end of the quadrant.

0°	Sines.	Cosines.	Secants.	Cosecants.	Tangents.	Cotangents.	
0′	0.000000	1.000000	1.000000	Infinite.	0.000000	Infinite.	60′
1	0.000291	1.000000	1.000000	3437.7468	0.000291	3437.7467	59
2	0.000582	1.000000	1.000000	1718.8735	0.000582	1718.8732	58
3	0.000873	1.000000	1.000000	1145.9157	0.000873	1145.9153	57
4	0.001164	0.999999	1.000001	859.43689	0.001164	859.43630	56
5	0.001454	0.999999	1.000001	687.54960	0.001454	687.54887	55
6	0.001745	0.999999	1.000002	572.95809	0.001745	572.95721	54
7	0.002036	0.999998	1.000002	491.10702	0.002036	491.10600	53
8	0.002327	0.999997	1.000003	429.71873	0.002327	429.71757	52
9	0.002618	0.999997	1.000003	381.97230	0.002618	381.79099	51
10	0.002909	0.999996	1.000004	343.77516	0.002909	343.77371	50
11	0.003200	0.999995	1.000005	312.52297	0.003200	312.52137	49
12	0.003491	0.999994	1.000006	286.47948	0.003491	286.47773	48
13	0.003782	0.999993	1.000007	264.44269	0.003782	264.44080	47
14	0.004072	0.999992	1.000008	245.55402	0.004073	245.55198	46
15	0.004363	0.999991	1.000010	229.18385	0.004363	229.18166	45
16	0.004654	0.999989	1.000011	214.85995	0.004654	214.85762	44
17	0.004945	0.999988	1.000012	202.22122	0.004945	202.21875	43
18	0.005286	0.999986	1.000014	190.98680	0.005236	190.98419	42
19	0.005527	0.999985	1.000015	180.93496	0.005527	180.93220	41
20	0.005818	0.999983	1.000017	171.88831	0.005818	171.88540	40
21	0.006109	0.999981	1.000019	163.70325	0.006109	163.70019	39
22	0.006400	0.999980	1.000021	156.26228	0.006400	156.25908	38
23	0.006690	0.999978	1.000022	149.46837	0.006691	149.46502	37
24	0.006981	0.999976	1.000024	143.24061	0.006981	143.23712	36
25	0.007272	0.999974	1.000026	137.51108	0.007272	137.50745	35
26	0.007563	0.999971	1.000029	132.22229	0.007563	132.21851	34
27	0.007854	0.999969	1.000031	127.32526	0.007854	127.32134	33
28	0.008145	0.999967	1.000033	122.77803	0.008145	122.77396	32
29	0.008436	0.999964	1.000036	118.54440	0.008436	118.54018	31
30	0.008727	0.999962	1.000039	114.59301	0.008727	114.58865	30
31	0.009017	0.999959	1.000041	110.89656	0.009018	110.89205	29
32	0.009308	0.999957	1.000044	107.43114	0.009309	107.42648	28
33	0.009599	0.999954	1.000046	104.17574	0.009600	104.17094	27
34	0.009890	0.999951	1.000049	101.11185	0.009890	101.10690	26
35	0.010181	0.999948	1.000052	98.223033	0.010181	98.217943	25
36	0.010472	0.999945	1.000055	95.494711	0.010472	95.489475	24
37	0.010763	0.999942	1.000058	92.913869	0.010763	92.908487	23
38	0.011054	0.999939	1.000061	90.468863	0.011054	90.463336	22
39	0.011344	0.999936	1.000064	88.149244	0.011345	88.143572	21
40	0.011635	0.999932	1.000068	85.945609	0.011636	85.939791	20
41	0.011926	0.999929	1.000071	83.849470	0.011927	83.843507	19
42	0.012217	0.999925	1.000075	81.853150	0.012218	81.847041	18
43	0.012508	0.999922	1.000078	79.949484	0.012509	79.943430	17
44	0.012799	0.999918	1.000082	78.132742	0.012800	78.126342	16
45	0.013090	0.999914	1.000086	76.396554	0.013091	76.390009	15
46	0.013381	0.999911	1.000090	74.735856	0.013382	74.729165	14
47	0.013671	0.999907	1.000094	73.145827	0.013673	73.138991	13
48	0.013962	0.999903	1.000096	71.622852	0.013964	71.615070	12
49	0.014253	0.999898	1.000102	70.160474	0.014256	70.153346	11
50	0.014544	0.999894	1.000106	68.757360	0.014545	68.750087	10
51	0.014835	0.999890	1.000110	67.409272	0.014336	67.401854	9
52	0.015126	0.999886	1.000114	66.113036	0.015127	66.105473	8
53	0.015417	0.999881	1.000119	64.865716	0.015418	64.858008	7
54	0.015707	0.999877	1.000123	63.664595	0.015709	63.656741	6
55	0.015998	0.999872	1.000128	62.507153	0.016000	62.499154	5
56	0.016289	0.999867	1.000133	61.391050	0.016291	61.382905	4
57	0.016580	0.999863	1.000138	60.314110	0.016582	60.305820	3
58	0.016871	0.999858	1.000142	59.274308	0.016873	59.265872	2
59	0.017162	0.999853	1.000147	58.269755	0.017164	58.261174	1
60	0.017452	0.999848	1.000152	57.298688	0.017455	57.289962	0
	Cosines.	Sines.	Cosecants.	Secants.	Cotangents.	Tangents.	89°

1°	Sines.	Cosines.	Secants.	Cosecants.	Tangents.	Cotangents.	
0′	0.017452	0.999848	1.000152	57.298688	0.017455	57.289962	60′
1	0.017743	0.999843	1.000157	56.359462	0.017746	56.350590	59
2	0.018034	0.999837	1.000163	55.450534	0.018037	55.441517	58
3	0.018325	0.999832	1.000168	54.570464	0.018328	54.561300	57
4	0.018616	0.999827	1.000174	53.717896	0.018619	53.708587	56
5	0.018907	0.999821	1.000179	52.891564	0.018910	52.882109	55
6	0.019197	0.999816	1.000184	52.090272	0.019201	52.080673	54
7	0.019489	0.999810	1.000190	51.312902	0.019492	51.303157	53
8	0.019779	0.999804	1.000196	50.558396	0.019783	50.548506	52
9	0.020070	0.999799	1.000202	49.825762	0.020074	49.815726	51
10	0.020361	0.999793	1.000207	49.114062	0.020365	49.103881	50
11	0.020652	0.999787	1.000213	48.422411	0.020656	48.412084	49
12	0.020942	0.999781	1.000219	47.749974	0.020947	47.739501	48
13	0.021233	0.999775	1.000226	47.095961	0.021238	47.085343	47
14	0.021524	0.999768	1.000232	46.459625	0.021529	46.448862	46
15	0.021815	0.999762	1.000238	45.840260	0.021820	45.829351	45
16	0.022106	0.999756	1.000244	45.237195	0.022111	45.226141	44
17	0.022397	0.999749	1.000251	44.649795	0.022402	44.638596	43
18	0.022687	0.999743	1.000258	44.077458	0.022693	44.066113	42
19	0.022978	0.999736	1.000264	43.519612	0.022984	43.508122	41
20	0.023269	0.999729	1.000271	42.975713	0.023275	42.964077	40
21	0.023560	0.999722	1.000278	42.445245	0.023566	42.433464	39
22	0.023851	0.999716	1.000285	41.927717	0.023857	41.915790	38
23	0.024141	0.999709	1.000292	41.422660	0.024148	41.410588	37
24	0.024432	0.999702	1.000299	40.929630	0.024440	40.917412	36
25	0.024723	0.999694	1.000306	40.448201	0.024731	40.435837	35
26	0.025014	0.999687	1.000313	39.977969	0.025022	39.965460	34
27	0.025305	0.999680	1.000320	39.518549	0.025313	39.505895	33
28	0.025595	0.999672	1.000328	39.069571	0.025604	39.056771	32
29	0.025886	0.999665	1.000335	38.630683	0.025895	38.617738	31
30	0.026177	0.999657	1.000343	38.201550	0.026186	38.188459	30
31	0.026468	0.999650	1.000351	37.781849	0.026477	37.768613	29
32	0.026759	0.999642	1.000358	37.371273	0.026768	37.357892	28
33	0.027049	0.999634	1.000366	36.969528	0.027059	36.956001	27
34	0.027340	0.999626	1.000374	36.576332	0.027350	36.562659	26
35	0.027631	0.999618	1.000382	36.191414	0.027641	36.177596	25
36	0.027922	0.999610	1.000390	35.814517	0.027933	35.800553	24
37	0.028212	0.999602	1.000398	35.445391	0.028224	35.431282	23
38	0.028503	0.999594	1.000407	35.803800	0.028515	35.069546	22
39	0.028794	0.999585	1.000415	34.729515	0.028806	34.715115	21
40	0.029085	0.999577	1.000423	34.382316	0.029097	34.367771	20
41	0.029376	0.999568	1.000432	34.041994	0.029388	34.027303	19
42	0.029666	0.999560	1.000441	33.708345	0.029679	33.693509	18
43	0.029957	0.999551	1.000449	33.381976	0.029971	33.366194	17
44	0.030248	0.999542	1.000458	33.060300	0.030262	33.045173	16
45	0.030539	0.999534	1.000467	32.745537	0.030553	32.730264	15
46	0.030829	0.999525	1.000476	32.436713	0.030844	32.421295	14
47	0.031120	0.999516	1.000485	32.133663	0.031135	32.118099	13
48	0.031411	0.999507	1.000494	31.836225	0.031426	31.820516	12
49	0.031702	0.999497	1.000503	31.544246	0.031717	31.528392	11
50	0.031992	0.999488	1.000512	31.257577	0.032009	31.241577	10
51	0.032283	0.999479	1.000522	30.976074	0.032300	30.959928	9
52	0.032574	0.999469	1.000531	30.699598	0.032591	30.683307	8
53	0.032864	0.999460	1.000541	30.428077	0.032882	30.411580	7
54	0.033155	0.999450	1.000550	30.161201	0.033174	30.144619	6
55	0.033446	0.999441	1.000560	29.899026	0.033465	29.882299	5
56	0.033737	0.999431	1.000570	29.641373	0.033756	29.624499	4
57	0.034027	0.999421	1.000579	29.388124	0.034047	29.371106	3
58	0.034318	0.999411	1.000589	29.139169	0.034338	29.122005	2
59	0.034609	0.999401	1.000599	28.894398	0.034630	28.877089	1
60	0.034900	0.999391	1.000610	28.653708	0.034921	28.636253	0
	Cosines.	Sines.	Cosecants.	Secants.	Cotangents.	Tangents.	88°

2°	Sines.	Cosines.	Secants.	Cosecants.	Tangents.	Cotangents.	
0′	0.034900	0.999391	1.000610	28.653708	0.034921	28.636253	60′
1	0.035190	0.999381	1.000620	28.416997	0.035213	28.399397	59
2	0.035481	0.999370	1.000630	28.184168	0.035503	28.166422	58
3	0.035772	0.999360	1.000640	27.955125	0.035795	27.937233	57
4	0·036062	0.999350	1.000651	27.729777	0.036086	27.711740	56
5	0.036353	0.999339	1.000661	27.508035	0.036377	27.489853	55
6	0.036644	0.999328	1.000672	27.289814	0.036668	27.271486	54
7	0.036934	0.999318	1.000683	27.075030	0.036960	27.056557	53
8	0.037225	0.999307	1.000694	26.863603	0.037251	26.844984	52
9	0.037516	0.999296	1.000705	26.655455	0.037542	26.636690	51
10	0.037807	0.999285	1.000715	26.450510	0.037834	26.431600	50
11	0.038097	0.999274	1.000727	26.248694	0.038125	26.229638	49
12	0.038388	0.999263	1.000738	26.049937	0.038416	26.030736	48
13	0.038679	0.999252	1.000749	25.854169	0.038707	25.834823	47
14	0.038969	0.999240	1.000760	25.661324	0.038999	25.641832	46
15	0.039260	0.999229	1.000772	25.471337	0.039290	25.451700	45
16	0.039551	0.999218	1.000783	25.284144	0.039581	25.264361	44
17	0.039841	0.999206	1.000795	25.099685	0.039873	25.079757	43
18	0.040132	0.999194	1.000806	24.917900	0.040164	24.897826	42
19	0.040422	0.999183	1.000818	24.738731	0.040456	24.718512	41
20	0.040713	0.999171	1.000830	24.562123	0.040747	24.541758	40
21	0.041004	0.999159	1.000842	24.388020	0.041038	24.367509	39
22	0.041294	0.999147	1.000854	24.216370	0.041330	24.195714	38
23	0.041585	0.999135	1.000866	24.047121	0.041621	24.026320	37
24	0.041876	0.999123	1.000878	23.880224	0.041912	23.859277	36
25	0.042166	0.999111	1.000890	23.715630	0.042204	23.694537	35
26	0.042457	0.999098	1.000903	23.553291	0.042495	23.532052	34
27	0.042748	0.999086	1.000915	23.393161	0.042787	23.371777	33
28	0.043038	0.999073	1.000927	23.235196	0.043078	23.213666	32
29	0.043329	0.999061	1.000940	23.079351	0.043370	23.057677	31
30	0.043619	0.999048	1.000953	22.925586	0.043661	22.903766	30
31	0.043910	0.999036	1.000965	22.773857	0.043952	22.751892	29
32	0.044201	0.999023	1.000978	22.624126	0.044244	22.602015	28
33	0.044491	0.999010	1.000991	22.476352	0 044535	22.454096	27
34	0.044782	0.998997	1.001004	22.330492	0.044827	22.308097	26
35	0.045072	0.998984	1.001017	22.186528	0.045118	22.163980	25
36	0.045363	0.998971	1.001031	22.044403	0.045410	22.021710	24
37	0.045654	0.998957	1.001044	21.904090	0.045701	21.881251	23
38	0.045944	0.998944	1.001057	21.765550	0.045993	21.742569	22
39	0.046235	0.998931	1.001071	21.628759	0.046284	21.605630	21
40	0.046525	0.998917	1.001084	21.493676	0.046576	21.470401	20
41	0.046816	0.998904	1.001098	21.360272	0.046867	21.336851	19
42	0.047107	0.998890	1.001111	21.228515	0.047159	21.204949	18
43	0.047397	0.998876	1.001125	21.098376	0.047450	21.074664	17
44	0.047688	0.998862	1.001139	20.969824	0.047742	20.945966	16
45	0.047978	0.998848	1.001153	20.842830	0.048033	20.818828	15
46	0.048269	0.998834	1.001167	20.717368	0.048325	20.693220	14
47	0.048559	0.998820	1.001181	20.593409	0.048617	20.569115	13
48	0.048850	0.998806	1.001195	20.470926	0.048908	20.446486	12
49	0.049141	0.998792	1.001210	20.349893	0.049200	20.325308	11
50	0.049431	0.998778	1.001224	20.230284	0.049491	20.205553	10
51	0.049721	0.998763	1.001238	20.112075	0.049783	20.087199	9
52	0.050012	0.998749	1.001253	19.995241	0.050075	19.970219	8
53	0.050302	0.998734	1.001268	19.879758	0.050366	19.854951	7
54	0.050593	0.998719	1.001282	19.765604	0.050655	19.740291	6
55	0.050884	0.998705	1.001297	19.652754	0.050950	19.627296	5
56	0.051174	0.998690	1.001312	19.541187	0.051241	19.518584	4
57	0.051465	0.998675	1.001327	19.430882	0.051533	19.405133	3
58	0.051755	0.998660	1.001342	19.321816	0.051824	19.295922	2
59	0.052046	0.998645	1.001357	19.213970	0.052116	19.187930	1
60	0.052336	0.998630	1.001372	19.107322	0.052408	19.081137	0
	Cosines.	Sines.	Cosecants.	Secants.	Cotangents.	Tangents.	87°

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3°	Sines.	Cosines.	Secants.	Cosecants.	Tangents.	Cotangents.	
0'	0.052336	0.998630	1.001372	19.107323	0.052408	19.081137	60'
1	0.052626	0.998614	1.001388	19.101854	0.052700	18.975523	59
2	0.052917	0.998599	1.001403	18.897545	0.052991	18.871068	58
3	0.053207	0.998584	1.001419	18.794377	0.053283	18.767754	57
4	0.053498	0.998568	1.001434	18.692330	0.053575	18.665562	56
5	0.053788	0.998552	1.001450	18.591387	0.053866	18.564473	55
6	0.054079	0.998537	1.001466	18.491530	0.054158	18.464471	54
7	0.054369	0.998521	1.001481	18.392742	0.054450	18.365537	53
8	0.054660	0.998505	1.001497	18.295005	0.054742	18.267654	52
9	0.054950	0.998489	1.001513	18.198303	0.055033	18.170807	51
10	0.055240	0.998473	1.001529	18.102619	0.055325	18.074977	50
11	0.055531	0.998457	1.001545	18.007937	0.055617	17.980150	49
12	0.055822	0.998441	1.001562	17.914243	0.055909	17.886310	48
13	0.056112	0.998425	1.001578	17.821520	0.056201	17.793442	47
14	0.056402	0.998408	1.001594	17.729753	0.056492	17.701529	46
15	0.056693	0.998392	1.001611	17.638928	0.056784	17.610559	45
16	0.056983	0.998375	1.001628	17.549030	0.057076	17.520516	44
17	0.057274	0.998359	1.001644	17.460046	0.057368	17.431385	43
18	0.057564	0.998342	1.001661	17.371960	0.057660	17.343155	42
19	0.057854	0.998325	1.001678	17.284761	0.057952	17.255809	41
20	0.058145	0.998308	1.001695	17.198434	0.058243	17.169337	40
21	0.058435	0.998291	1.001712	17.112966	0.058535	17.083724	39
22	0.058726	0.998274	1.001729	17.028346	0.058827	16.998957	38
23	0.059016	0.998257	1.001746	16.944559	0.059119	16.915025	37
24	0.059306	0.998240	1.001763	16.861594	0.059411	16.831915	36
25	0.059597	0.998223	1.001781	16.779439	0.059703	16.749614	35
26	0.059887	0.998205	1.001798	16.698082	0.059995	16.668112	34
27	0.060178	0.998188	1.001816	16.617512	0.060287	16.587396	33
28	0.060468	0.998170	1.001833	16.537717	0.060579	16.507456	32
29	0.060758	0.998153	1.001851	16.458686	0.060871	16.428279	31
30	0.061049	0.998135	1.001869	16.380408	0.061163	16.349855	30
31	0.061339	0.998117	1.001887	16.302873	0.061455	16.272174	29
32	0.061629	0.998099	1.001905	16.226069	0.061747	16.195225	28
33	0.061920	0.998081	1.001923	16.149987	0.062039	16.118998	27
34	0.062210	0.998063	1.001941	16.074617	0.062331	16.043482	26
35	0.062500	0.998045	1.001959	15.999948	0.062623	15.968667	25
36	0.062791	0.998027	1.001977	15.925971	0.062915	15.894545	24
37	0.063081	0.998008	1.001996	15.852676	0.063207	15.821105	23
38	0.063371	0.997990	1.002014	15.780050	0.063499	15.748337	22
39	0.063661	0.997972	1.002033	15.708096	0,063791	15.676233	21
40	0.063952	0.997953	1.002051	15.636798	0.064083	15.604784	20
41	0.064242	0.997934	1.002070	15.566135	0.064375	15.533981	19
42	0.064532	0.997916	1.002089	15.496114	0.064667	15.463814	18
43	0.064823	0.997897	1.002108	15.426721	0.064959	15.394276	17
44	0.065113	0.997878	1.002127	15.357949	0.065251	15.325358	16
45	0.065403	0.997859	1.002146	15.289789	0.065544	15.257052	15
46	0.065693	0.997840	1.002165	15.222231	0.065836	15.189349	14
47	0.065984	0.997821	1.002184	15.155270	0.066128	15.122242	13
48	0.066274	0.997802	1.002203	15.088896	0.066420	15.055723	12
49	0.066564	0.997782	1.002223	15.023103	0.066712	14.989784	11
50	0.066854	0.997763	1.002243	14.957882	0.067004	14.924417	10
51	0.067145	0.997743	1.002262	14.893226	0.067297	14.859616	9
52	0.067435	0.997724	1.002282	14.829128	0.067589	14.795372	8
53	0.067725	0.997704	1.002301	14.765580	0.067881	14.731679	7
54	0.068015	0.997684	1.002321	14.702576	0.068173	14.668529	6
55	0.068306	0.997665	1.002341	14.640109	0.068465	14.605916	5
56	0.068596	0.997645	1.002361	14.578172	0.068758	14.543833	4
57	0.068886	0.997625	1.002381	14.516756	0.069050	14.482273	3
58	0.069176	0.997605	1.002401	14.455859	0.069342	14.421230	2
59	0.069466	0.997584	1.002422	14.395471	0.069635	14.360696	1
60	0.069757	0.997564	1.002442	14.335587	0.069927	14.300666	0
	Cosines.	Sines.	Cosecants.	Secants.	Cotangents.	Tangents.	86°

4°	Sines.	Cosines.	Secants.	Cosecants.	Tangents.	Cotangents.	
0′	0.069757	0.997564	1.002442	14.335587	0.069927	14.300666	60′
1	0.070047	0.997544	1.002462	14.276200	0.070219	14.241134	59
2	0.070339	0.997523	1.002483	14.217304	0.070512	14.182092	58
3	0.070627	0.997503	1.002504	14.158894	0.070804	14.123536	57
4	0.070917	0.997482	1.002524	14.100963	0.071096	14.065459	56
5	0.071207	0.997462	1.002545	14.043504	0.071389	14.007856	55
6	0.071497	0.997441	1.002566	13.986514	0.071681	13.950719	54
7	0.071788	0.997420	1.002587	13.929985	0.071973	13.894045	53
8	0.072078	0.997399	1.002608	13.873913	0.072266	13.837827	52
9	0.072368	0.997378	1.002629	13.818291	0.072558	13.782060	51
10	0.072658	0.997357	1.002650	13.763115	0.072851	13.726738	50
11	0.072948	0.997336	1.002671	13.708379	0.073143	13.671856	49
12	0.073238	0.997315	1.002693	13.654077	0.073435	13.617409	48
13	0.073528	0.997293	1.002714	13.600205	0.073728	13.563391	47
14	0.073818	0.997272	1.002736	13.546758	0.074020	13.509799	46
15	0.074109	0.997250	1.002757	13.493731	0.074313	13.456625	45
16	0.074399	0.997229	1.002779	13.441118	0.074605	13.403867	44
17	0.074689	0.997207	1.002801	13.388914	0.074898	13.351518	43
18	0.074979	0.997185	1.002823	13.337116	0.075190	13.299574	42
19	0.075269	0.997163	1.002845	13.285719	0.075483	13.248031	41
20	0.075559	0.997141	1.002867	13.234717	0.075776	13.196883	40
21	0.075849	0.997119	1.002889	13.184106	0.076068	13.146127	39
22	0.076139	0.997097	1.002911	13.133882	0.076361	13.095757	38
23	0.076429	0.997075	1.002934	13.080404	0.076653	13.045769	37
24	0.076719	0.997053	1.002956	13.034576	0.076946	12.996160	36
25	0.077009	0.997030	1.002979	12.985486	0.077238	12.946924	35
26	0.077299	0.997008	1.003001	12.936765	0.077531	12.898058	34
27	0.077589	0.996985	1.003024	12.888410	0.077824	12.849557	33
28	0.077879	0.996963	1.003046	12.840416	0.078116	12.801417	32
29	0.078169	0.996940	1.003069	12.792779	0.078409	12.753634	31
30	0.078459	0.996918	1.003092	12.745495	0.078702	12.706205	30
31	0.078749	0.996895	1.003115	12.698560	0.078994	12.659125	29
32	0.079039	0.996872	1.003138	12.651971	0.079287	12.612390	28
33	0.079329	0.996849	1.003162	12.605724	0.079580	12.565997	27
34	0.079619	0.996825	1.003185	12.559815	0.079873	12.519942	26
35	0.079909	0.996802	1.003208	12.514240	0.080165	12.474221	25
36	0.080199	0.996779	1.003232	12.468995	0.080458	12.428881	24
37	0.080489	0.996756	1.003255	12.424078	0.080751	12.383768	23
38	0.080779	0.996732	1.003279	12.379484	0.081044	12.339028	22
39	0.081069	0.996709	1.003302	12.335210	0.081337	12.294609	21
40	0.081359	0.996685	1.003326	12.291252	0.081629	12.250505	20
41	0.081649	0.996661	1.003350	12.247608	0.081922	12.206716	19
42	0.081939	0.996637	1.003374	12.204274	0.082215	12.163236	18
43	0.082228	0.996614	1.003398	12.161246	0.082508	12.120062	17
44	0.082518	0.996590	1.003422	12.118522	0.082801	12.077192	16
45	0.082808	0.996566	1.003446	12.076098	0.083094	12.034622	15
46	0.083098	0.996541	1.003471	12.033970	0.083387	11.992349	14
47	0.083388	0.996517	1.003495	11.992137	0.083679	11.950370	13
48	0.083678	0.996493	1.003520	11.950595	0.083972	11.908682	12
49	0.083968	0.996469	1.003544	11.909340	0.084265	11.867282	11
50	0.084258	0.996444	1.003569	11.868370	0.084558	11.826167	10
51	0.084547	0.996420	1.003593	11.827683	0.084851	11.785333	9
52	0.084837	0.996395	1.003618	11.784274	0.085144	11.744779	8
53	0.085127	0.996370	1.003643	11.747141	0.085437	11.704500	7
54	0.085417	0.996345	1.003668	11.707282	0.085730	11.664495	6
55	0.085707	0.996320	1.003693	11.667693	0.086023	11.624761	5
56	0.085997	0.996295	1.003718	11.628372	0.086316	11.585294	4
57	0.086286	0.996270	1.003744	11.589316	0.086609	11.546093	3
58	0.086576	0.996245	1.003769	11.550523	0.086903	11.507154	2
59	0.086866	0.996220	1.003794	11.511590	0.087196	11.468474	1
60	0.087156	0.996195	1.003820	11.473713	0.087489	11.430052	0
	Cosines.	Sines.	Cosecants.	Secants.	Cotangents.	Tangents.	85°

5°	Sines.	Cosines.	Secants.	Cosecants.	Tangents.	Cotangents.	
0′	0.087156	0.996195	1.003820	11.473713	0.087489	11.430052	60′
1	0.087446	0.996169	1.003845	11.435692	0.087782	11.391885	59
2	0.087735	0.996144	1.003871	11.397922	0.088075	11.353970	58
3	0.088025	0.996118	1.003897	11.360402	0.088368	11.316304	57
4	0.088315	0.996093	1.003923	11.323129	0.088661	11.278885	56
5	0.088605	0.996067	1.003949	11.286101	0.088954	11.241712	55
6	0.088894	0.996041	1.003975	11.249316	0.089248	11.204780	54
7	0.089184	0.996015	1.004001	11.212770	0.089541	11.168089	53
8	0.089474	0.995989	1.004027	11.176462	0.089834	11.131638	52
9	0.089764	0.995963	1.004053	11.140389	0.090127	11.095416	51
10	0.090053	0.995937	1.004080	11.104549	0.090421	11.059431	50
11	0.090343	0.995911	1.004106	11.068940	0.090714	11.023676	49
12	0.090633	0.995884	1.004133	11.033560	0.091007	10.988150	48
13	0.090922	0.995858	1.004159	10.998406	0.091300	10.952850	47
14	0.091212	0.995832	1.004186	10.963476	0.091594	10.917775	46
15	0.091502	0.995805	1.004213	10.928768	0.091887	10.882921	45
16	0.091791	0.995778	1.004240	10.894281	0.092180	10.848288	44
17	0.092081	0.995752	1.004267	10.860011	0.092474	10.813872	43
18	0.092371	0.995725	1.004294	10.825957	0.092767	10.779673	42
19	0.092660	0.995698	1.004321	10.792117	0.093061	10.745687	41
20	0.092950	0.995671	1.004348	10.758488	0.093354	10.711913	40
21	0.093240	0.995644	1.004375	10.725070	0.093647	10.678348	39
22	0.093529	0.995617	1.004403	10.691859	0.093941	10.644992	38
23	0.093819	0.995589	1.004430	10.658854	0.094234	10.611841	37
24	0.094108	0.995562	1.004458	10.626054	0.094528	10.578895	36
25	0.094398	0.995535	1.004486	10.593455	0.094821	10.546151	35
26	0.094688	0.995507	1.004513	10.561057	0.095115	10.513607	34
27	0.094977	0.995480	1.004541	10.528857	0.095408	10.481261	33
28	0.095267	0.995452	1.004569	10.496854	0.095702	10.449112	32
29	0.095556	0.995424	1.004597	10.465046	0.095996	10.417158	31
30	0.095846	0.995396	1.004625	10.433431	0.096289	10.385397	30
31	0.096135	0.995368	1.004653	10.402007	0.096583	10.353827	29
32	0.096425	0.995340	1.004682	10.370772	0.096876	10.322447	28
33	0.096714	0.995312	1.004710	10.339726	0.097170	10.291255	27
34	0.097004	0.995284	1.004738	10.308866	0.097464	10.260249	26
35	0.097293	0.995256	1.004767	10.278190	0.097757	10.229428	25
36	0.097583	0.995227	1.004796	10.247697	0.098051	10.198789	24
37	0.097872	0.995199	1.004824	10.217386	0.098345	10.168332	23
38	0.098162	0.995177	1.004853	10.187254	0.098638	10.138054	22
39	0.098451	0.995142	1.004882	10.157300	0.098932	10.107954	21
40	0.098741	0.995113	1.004911	10.127522	0.099226	10.078031	20
41	0.099030	0.995084	1.004940	10.097920	0.099519	10.048283	19
42	0.099320	0.995056	1.004969	10.068491	0.099813	10.018708	18
43	0.099609	0.995027	1.004998	10.039234	0.100107	9.989305	17
44	0.099899	0.994998	1.005028	10.010147	0.100401	9.960072	16
45	0.100188	0.994969	1.005057	9.981229	0.100695	9.931009	15
46	0.100478	0.994939	1.005086	9.952479	0.100989	9.902113	14
47	0.100767	0.994910	1.005116	9.923894	0.101282	9.873382	13
48	0.101056	0.994881	1.005146	9.895474	0.101576	9.844817	12
49	0.101346	0.994851	1.005175	9.867218	0.101870	9.816414	11
50	0.101635	0.994822	1.005205	9.839123	0.102164	9.788173	10
51	0.101925	0.994792	1.005235	9.811188	0.102458	9.760893	9
52	0.102214	0.994763	1.005265	9.783412	0.102572	9.732171	8
53	0.102503	0.994733	1.005295	9.755794	0.103046	9.704408	7
54	0.102793	0.994703	1.005325	9.728333	0.103340	9.676800	6
55	0.103082	0.994673	1.005356	9.701026	0.103634	9.649348	5
56	0.103371	0.994643	1.005386	9.673873	0.103928	9.622049	4
57	0.103661	0.994613	1.005416	9.646872	0.104222	9.594902	3
58	0.103950	0.994583	1.005447	9.620023	0.104516	9.567907	2
59	0.104239	0.994552	1.005478	9.593323	0.104810	9.541061	1
60	0.104529	0.994522	1.005508	9.566772	0.105104	9.514365	0
	Cosines.	Sines.	Cosecants.	Secants.	Cotangents.	Tangents.	84°

6°	Sines.	Cosines.	Secants.	Cosecants.	Tangents.	Cotangents.	
0′	0.104529	0.994522	1.005508	9.566772	0·105104	9.514365	60′
1	0.104818	0.994491	1.005539	9.540368	0.105398	9.487815	59
2	0.105107	0.994461	1.005570	9.514111	0.105693	9.461412	58
3	0.105396	0.994430	1.005601	9.487998	0.105987	9.435153	57
4	0.105686	0.994400	1.005632	9.462030	0.106281	9.409038	56
5	0.105975	0.994369	1.005663	9.436203	0.106575	9.383066	55
6	0.106264	0.994338	1.005694	9.410518	0.106869	9.357236	54
7	0.106553	0.994307	1.005726	9.384974	0.107163	9.331545	53
8	0.106843	0.994276	1.005757	9.359568	0.107458	9.305994	52
9	0.107132	0.994245	1.005789	9.334301	0.107752	9.280580	51
10	0.107421	0.994214	1.005820	9.309170	0.108046	9.255304	50
11	0.107710	0.994182	1.005852	9.284175	0.108341	9.230163	49
12	0.107999	0.994151	1.005883	9.259315	0.108635	9.205156	48
13	0.108289	0.994120	1.005915	9.234588	0.108929	9.180284	47
14	0.108578	0.994088	1.005947	9.209993	0.109223	9.155544	46
15	0.108867	0.994056	1.005979	9.185531	0.109518	9.130935	45
16	0.109156	0.994025	1.006011	9.161198	0.109812	9.106456	44
17	0.109445	0.993993	1.006044	9.136995	0.110107	9.082107	43
18	0.109734	0.993961	1.006076	9.112920	0.110401	9.057887	42
19	0.110023	0.993929	1.006108	9.088973	0.110696	9.033793	41
20	0.110313	0.993897	1.006141	9.065151	0.110990	9.009826	40
21	0.110602	0.993865	1.006173	9.041455	0.111284	8.985984	39
22	0.110891	0.993833	1.006206	9.017884	0.111579	8.962267	38
23	0.111180	0.993800	1.006238	8.994435	0.111873	8.938672	37
24	0.111469	0.993768	1.006271	8.971110	0.112168	8.915201	36
25	0.111758	0.993736	1.006304	8.947905	0.112463	8.891851	35
26	0.112047	0.993703	1.006337	8.924821	0.112757	8.868621	34
27	0.112336	0.993670	1.006370	8.901857	0.113052	8.845510	33
28	0.112625	0.993638	1.006403	8.879010	0.113346	8.822519	32
29	0.112914	0.993605	1.006436	8.856283	0.113641	8.799645	31
30	0.113203	0.993572	1.006470	8.833672	0.113936	8.776887	30
31	0.113492	0.993539	1.006503	8.811176	0.114230	8.754246	29
32	0.113781	0.993506	1.006537	8.788796	0.114525	8.731720	28
33	0.114070	0.993473	1.006570	8.766530	0.114820	8.709308	27
34	0.114359	0.993440	1.006604	8.744377	0.115114	8.687009	26
35	0.114648	0.993406	1.006638	8.722336	0.115409	8.664822	25
36	0.114937	0.993373	1.006671	8.700407	0.115704	8.642748	24
37	0.115226	0.993339	1.006705	8.678589	0.115999	8.620783	23
38	0.115515	0.993306	1.006739	8.656881	0.116294	8.598929	22
39	0.115804	0.993272	1.006774	8.635281	0.116588	8.577184	21
40	0.116093	0.993238	1.006808	8.613790	0.116883	8.555547	20
41	0.116382	0.993205	1.006842	8.592406	0.117178	8.534017	19
42	0.116671	0.993171	1.006876	8.571130	0.117473	8.512594	18
43	0.116960	0.993137	1.006911	8.549958	0.117768	8.491277	17
44	0.117249	0.993103	1.006945	8.528892	0.118063	8.470065	16
45	0.117537	0.993069	1.006980	8.507930	0.118358	8.448957	15
46	0.117826	0.993034	1.007015	8.487072	0.118652	8.427953	14
47	0.118115	0.993000	1.007049	8.466317	0.118948	8.407052	13
48	0.118404	0.992966	1.007084	8.445663	0.119243	8.386252	12
49	0.118693	0.992931	1.007119	8.425111	0.119538	8.365554	11
50	0.118982	0.992897	1.007154	8.404659	0.119833	8.344956	10
51	0.119270	0.992862	1.007190	8.384307	0.120128	8.324458	9
52	0.119559	0.992827	1.007225	8.364053	0.120423	8.304059	8
53	9.119848	0.992792	1.007260	8.343899	0.120718	8.283758	7
54	0.120137	0.992757	1.007296	8.323842	0.121013	8.263555	6
55	0.120426	0.992722	1.007331	8.303881	0.121309	8.243449	5
56	0.120714	0.992687	1.007367	8.284017	0.121604	8.223438	4
57	0.121003	0.992652	1.007402	8.264249	0.121899	8.203524	3
58	0.121292	0.992617	1.007438	8.244575	0.122194	8.183704	2
59	0.121581	0.992582	1.007474	8.224995	0.122489	8.163979	1
60	0.121869	0.992546	1.007510	8.205509	0.122785	8.144346	0
	Cosines.	Sines.	Cosecants.	Secants.	Cotangents.	Tangents.	83°

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7°	Sines.	Cosines.	Secants.	Cosecants.	Tangents.	Cotangents.	
0′	0.121869	0.992546	1.007510	8.205509	0.122785	8.144346	60′
1	0.122158	0.992511	1.007546	8.186116	0.123080	8.124807	59
2	0.122447	0.992475	1.007582	8.166815	0.123375	8.105360	58
3	0.122736	0.992439	1.007618	8.147605	0.123671	8.086004	57
4	0.123024	0.992404	1.007655	8.128486	0.123966	8.066739	56
5	0.123313	0.992368	1.007691	8.109457	0.124261	8.047565	55
6	0.123602	0.992332	1.007727	8.090518	0.124557	8.028480	54
7	0.123890	0.992296	1.007764	8.071668	0.124852	8.009484	53
8	0.124179	0.992260	1.007801	8.052906	0.125147	7.990576	52
9	0.124467	0.992224	1.007837	8.034232	0.125443	7.971756	51
10	0.124756	0.992187	1.007874	8.015645	0.125738	7.953022	50
11	0.125044	0.992151	1.007911	7.997145	0.126034	7.934376	49
12	0.125333	0.992115	1.007948	7.978730	0.126329	7.915815	48
13	0.125622	0.992078	1.007985	7.960400	0.126625	7.897340	47
14	0.125910	0.992042	1.008022	7.942156	0.126921	7.878949	46
15	0.126199	0.992005	1.008060	7.923995	0.127216	7.860642	45
16	0.126488	0.991968	1.008097	7.905918	0.127512	7.842419	44
17	0.126776	0.991931	1.008134	7.887924	0.127807	7.824279	43
18	0.127065	0.991894	1.008172	7.870012	0.128103	7.806221	42
19	0.127353	0.991857	1.008209	7.852182	0.128399	7.788245	41
20	0.127642	0.991820	1.008247	7.834434	0.128694	7.770351	40
21	0.127930	0.991783	1.008285	7.816766	0.128990	7.752537	39
22	0.128219	0.991746	1.008323	7.799178	0.129286	7.734803	38
23	0.128507	0.991709	1.008361	7.781670	0.129582	7.717149	37
24	0.128796	0.991671	1.008399	7.764241	0.129877	7.699574	36
25	0.129084	0.991634	1.008437	7.746890	0.130173	7.682077	35
26	0.129373	0.991596	1.008475	7.729618	0.130469	7.664658	34
27	0.129661	0.991558	1.008514	7.712423	0.130765	7.647317	33
28	0.129949	0.991521	1.008552	7.695305	0.131061	7.630053	32
29	0.130238	0.991483	1.008590	7.678263	0.131357	7.612866	31
30	0.130526	0.991445	1.008629	7.661298	0.131653	7.595754	30
31	0.130815	0.991407	1.008668	7.644408	0.131948	7.578718	29
32	0.131103	0.991369	1.008706	7.627592	0.132244	7.561757	28
33	0.131391	0.991331	1.008745	7.610852	0.132540	7.544870	27
34	0.131680	0.991292	1.008784	7.594185	0.132836	7.528057	26
35	0.131968	0.991254	1.008823	7.577592	0.133132	7.511318	25
36	0.132256	0.991216	1.008862	7.561071	0.133429	7.494651	24
37	0.132545	0.991177	1.008902	7.544624	0.133725	7.478058	23
38	0.132833	0.991138	1.008941	7.528248	0.134021	7.461536	22
39	0.133121	0.991100	1.008980	7.511944	0.134317	7.445086	21
40	0.133410	0.991061	1.009020	7.495711	0.134613	7.428706	20
41	0.133698	0.991022	1.009059	7.479548	0.134909	7.412398	19
42	0.133986	0.990983	1.009099	7.463456	0.135205	7.396160	18
43	0.134274	0.990944	1.009139	7.447434	0.135502	7.379991	17
44	0.134563	0.990905	1.009178	7.431480	0.135798	7.363892	16
45	0.134851	0.990866	1.009218	7.415596	0.136094	7.347861	15
46	0.135139	0.990827	1.009258	7.399780	0.136390	7.331899	14
47	0.135427	0.990787	1.009298	7.384032	0.136687	7.316005	13
48	0.135716	0.990748	1.009339	7.368351	0.136983	7.300178	12
49	0.136004	0.990708	1.009379	7.352738	0.137279	7.284418	11
50	0.136292	0.990669	1.009419	7.337191	0.137576	7.268726	10
51	0.136580	0.990629	1.009460	7.321710	0.137872	7.253099	9
52	0.136868	0.990589	1.009500	7.306295	0.138169	7.237538	8
53	0.137156	0.990549	1.009541	7.290946	0.138465	7.222042	7
54	0.137445	0.990510	1.009582	7.275662	0.138762	7.206612	6
55	0.137733	0.990469	1.009622	7.260442	0.139058	7.191246	5
56	0.138021	0.990429	1.009663	7.245286	0.139355	7.175944	4
57	0.138319	0.990389	1.009704	7.230194	0.139651	7.160706	3
58	0.138597	0.990349	1.009745	7.215165	0.139948	7.145531	2
59	0.138885	0.990309	1.009786	7.200200	0.140244	7.130419	1
60	0.139173	0.990268	1.009828	7.185297	0.140541	7.115370	0
	Cosines.	Sines.	Cosecants.	Secants.	Cotangents.	Tangents.	82°

8°	Sines.	Cosines.	Secants.	Cosecants.	Tangents.	Cotangents.	
0′	0.139173	0.990268	1.009828	7.185297	0.140541	7.115370	60′
1	0.139461	0.990228	1.009869	7.170456	0.140838	7.100383	59
2	0.139749	0.990187	1.009910	7.155676	0.141134	7.085457	58
3	0.140037	0.990146	1.009952	7.140959	0.141431	7.070593	57
4	0.140325	0.990106	1.009993	7.126302	0.141728	7.055791	56
5	0.140613	0.990065	1.010035	7.111706	0.142024	7.041048	55
6	0.140901	0.990024	1.010077	7.097170	0.142321	7.026366	54
7	0.141189	0.989983	1.010119	7.082694	0.142618	7.011744	53
8	0.141477	0.989942	1.010161	7.068278	0.142915	6.997181	52
9	0.141765	0.989900	1.010203	7.053921	0.143212	6.982678	51
10	0.142053	0.989859	1.010245	7.039622	0.143508	6.968234	50
11	0.142341	0.989818	1.010287	7.025382	0.143805	6.953847	49
12	0.142629	0.989776	1.010329	7.011200	0.144102	6.939519	48
13	0.142917	0.989735	1.010372	6.997076	0.144399	6.925249	47
14	0.143205	0.989693	1.010414	6.983009	0.144696	6.911036	46
15	0.143493	0.989651	1.010457	6.968999	0.144993	6.896880	45
16	0.143781	0.989610	1.010500	6.955046	0.145290	6.882781	44
17	0.144068	0.989568	1.010542	6.941150	0.145587	6.868738	43
18	0.144356	0.989526	1.010585	6.927309	0.145884	6.854751	42
19	0.144644	0.989484	1.010628	6.913524	0.146181	6.840820	41
20	0.144932	0.989442	1.010671	6.899794	0.146478	6.826944	40
21	0.145220	0.989399	1.010714	6.886120	0.146776	6.813123	39
22	0.145508	0.989357	1.010757	6.872500	0.147073	6.799357	38
23	0.145795	0.989315	1.010801	6.858934	0.147370	6.785645	37
24	0.146083	0.989272	1.010844	6.845422	0.147667	6.791987	36
25	0.146371	0.989230	1.010888	6.831964	0.147964	6.758383	35
26	0.146659	0.989187	1.010931	6.818560	0.148262	6.744832	34
27	0.146946	0.989145	1.010975	6.805208	0.148559	6.731334	33
28	0.147234	0.989102	1.011018	6.791910	0.148856	6.717889	32
29	0.147522	0.989059	1.011062	6.778663	0.149154	6.704497	31
30	0.147809	0.989016	1.011106	6.765469	0.149451	6.691156	30
31	0.148097	0.988973	1.011150	6.752327	0.149748	6.677868	29
32	0.148384	0.988930	1.011194	6.739236	0.150046	6.664631	28
33	0.148672	0.988887	1.011238	6.726197	0.150343	6.651445	27
34	0.148960	0.988843	1.011283	6.713208	0.150641	6.638310	26
35	0.149248	0.988800	1.011327	6.700270	0.150938	6.625226	25
36	0.149534	0.988756	1.011372	6.687382	0.151236	6.612192	24
37	0.149823	0.988713	1.011416	6.674545	0.151533	6.599205	23
38	0.150111	0.988669	1.011461	6.661757	0.151831	6.586274	22
39	0.150398	0.988626	1.011505	6.649018	0.152129	6.573389	21
40	0.150686	0.988582	1.011550	6.636329	0.152426	6.560554	20
41	0.150973	0.988538	1.011595	6.623689	0.152724	6.547767	19
42	0.151261	0.988494	1.011640	6.611097	0.153022	6.535029	18
43	0.151548	0.988450	1.011685	6.598554	0.153319	6.522340	17
44	0.151836	0.988406	1.011730	6.586059	0.153617	6.509698	16
45	0.152123	0.988362	1.011776	6.573611	0.153915	6.497104	15
46	0.152411	0.988317	1.011821	6.561211	0.154213	6.484558	14
47	0.152698	0.988273	1.011866	6.548859	0.154510	6.472059	13
48	0.152986	0 988228	1.011912	6.536553	0.154808	6.459607	12
49	0.153273	0.988184	1.011958	6.524294	0.155106	6.447202	11
50	0.153561	0.988139	1.012003	6.512081	0.155404	6.434843	10
51	0.153848	0.988095	1.012049	6.499915	0.155702	6.422530	9
52	0.154136	0.988050	1.012095	6.487794	0.156000	6.410263	8
53	0.154423	0.988005	1.012141	6.475720	0.156298	6.398042	7
54	0.154710	0.987969	1.012187	6.463690	0.156596	6.385867	6
55	0.154998	0.987915	1.012233	6.451706	0.156894	6.373736	5
56	0.155286	0.987870	1.012279	6.439767	0.157192	6.361650	4
57	0.155573	0.987825	1.012326	6.427872	0.157490	6.349609	3
58	0.155860	0.987779	1.012372	6.416022	0.157788	6.337613	2
59	0.156147	0.987734	1.012419	6.404215	0.158086	6.325660	1
60	0.156434	0.987688	1.012465	6.392453	0.158384	6.323752	0
	Cosines.	Sines.	Cosecants.	Secants.	Cotangents.	Tangents.	81°

9°	Sines.	Cosines.	Secants.	Cosecants.	Tangents.	Cotangents.	
0′	0.156435	0.987688	1.012465	6.392453	0.158384	6.313752	60′
1	0.156722	0.987643	1.012512	6.380735	0.158683	6.301887	59
2	0.157009	0.987597	1.012559	6.369060	0.158981	6.290065	58
3	0.157296	0.987551	1.012606	6.357428	0.159279	6.278287	57
4	0.157584	0.987506	1.012652	6.345839	0.159577	6.266552	56
5	0.157871	0.987460	1.012700	6.334292	0.159876	6.254859	55
6	0.158158	0.987414	1.012747	6.322788	0.160174	6.243209	54
7	0.158445	0.987368	1.012794	6.311327	0.160472	6.231601	53
8	0.158733	0.987323	1.012841	6.299907	0.160771	6.220035	52
9	0.159020	0.987275	1.012889	6.288530	0.161069	6.208511	51
10	0.159307	0.987229	1.012936	6.277193	0.161368	6.197028	50
11	0.159594	0.987183	1.012984	6.265898	0.161666	6.185587	49
12	0.159881	0.987136	1.013031	6.254645	0.161965	6.174187	48
13	0.160168	0.987090	1.013079	6.243432	0.162263	6.162827	47
14	0.160456	0.987403	1.013127	6.232259	0.162562	6.151509	46
15	0.160743	0.986996	1.013175	6.221128	0.162860	6.140230	45
16	0.161030	0.986950	1.013223	6.210036	0.163159	6.128992	44
17	0.161317	0.986903	1.013271	6.198984	0.163458	6.117794	43
18	0.161604	0.986856	1.013319	6.187973	0.163756	6.106636	42
19	0.161891	0.986809	1.013368	6.177000	0.164055	6.095517	41
20	0.162178	0.986762	1.013416	6.166067	0.164354	6.084438	40
21	0.162465	0.986714	1.013465	6.155174	0.164653	6.073398	39
22	0.162752	0.986667	1.013513	6.144319	0.164951	6.062397	38
23	0.163039	0.986620	1.013562	6.133503	0.165250	6.051434	37
24	0.163326	0.986572	1.013611	6.122725	0.165549	6.040510	36
25	0.163613	0.986525	1.013660	6.111986	0.165848	6.029625	35
26	0.163900	0.986477	1.013708	6.101285	0.166147	6.018777	34
27	0.164187	0.986429	1.013757	6.090622	0.166446	6.007968	33
28	0.164474	0.986382	1.013807	6.079996	0.166745	5.997196	32
29	0.164761	0.986334	1.013856	6.069409	0.167044	5.986461	31
30	0.165048	0.986286	1.013905	6.058858	0.167343	5.975764	30
31	0.165335	0.986238	1.013955	6.048345	0.167642	5.965105	29
32	0.165621	0.986189	1.014004	6.037868	0.167941	5.954482	28
33	0.165908	0.986141	1.014054	6.027428	0.168240	5.943895	27
34	0.166195	0.986093	1.014103	6.017025	0.168539	5.933346	26
35	0.166482	0.986046	1.014153	6.006658	0.168838	5.922832	25
36	0.166769	0.985996	1.014203	5.996327	0.169137	5.912355	24
37	0.167057	0.985948	1.014253	5.986033	0.169437	5.901914	23
38	0.167343	0.985899	1.014303	5.975774	0.169736	5.891508	22
39	0.167629	0.985850	1.014353	5.965550	0.170035	5.881139	21
40	0.167916	0.985801	1.014403	5.955363	0.170334	5.870804	20
41	0.168203	0.985752	1.014454	5.945210	0.170634	5.860505	19
42	0.168489	0.985704	1.014504	5.935092	0.170933	5.850241	18
43	0.168776	0.985654	1.014554	5.925010	0.171233	5.840012	17
44	0.169063	0.985605	1.014605	5.914961	0.171532	5.829817	16
45	0.169350	0.985556	1.014656	5.904948	0.171831	5.819657	15
46	0.169636	0.985507	1.014706	5.894969	0.172131	5.809532	14
47	0.169923	0.985457	1.014757	5.885024	0.172430	5.799440	13
48	0.170210	0.985408	1.014808	5.875113	0.172730	5.789383	12
49	0.170496	0.985358	1.014859	5.865236	0.173030	5.779359	11
50	0.170783	0.985309	1.014910	5.855392	0.173329	5.769369	10
51	0.171069	0.985259	1.014962	5.845582	0.173629	5.759412	9
52	0.171356	0.985209	1.015013	5.835805	0.173929	5.749469	8
53	0.171643	0.985159	1.015064	5.826062	0.174228	5.739599	7
54	0.171929	0.985109	1.015116	5.816351	0.174528	5.729742	6
55	0.172216	0.985059	1.015167	5.806673	0.174828	5.719917	5
56	0.172502	0.985009	1.015219	5.797028	0.175128	5.710126	4
57	0.172789	0.984959	1.015271	5.787415	0.175427	5.700366	3
58	0.173075	0.984909	1.015323	5.777835	0.175727	5.690639	2
59	0.173362	0.984858	1.015375	5.768287	0.176027	5.680945	1
60	0.173648	0.984808	1.015427	5.758771	0.176327	5.671282	0
	Cosines.	Sines.	Cosecants.	Secants.	Cotangents.	Tangents.	80°

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10°	Sines.	Cosines.	Secants.	Cosecants.	Tangents.	Cotangents.	
0′	0.173648	0.984808	1.015427	5.758771	0.176327	5.671282	60′
1	0.173935	0.984757	1.015479	5.749286	0.176627	5.661651	59
2	0.174221	0.984707	1.015531	5.739833	0.176927	5.652052	58
3	0.174508	0.984656	1.015583	5.730412	0.177227	5.642484	57
4	0.174794	0.984605	1.015636	5.721022	0.177527	5.632947	56
5	0.175080	0.984554	1.015688	5.711664	0.177827	5.623442	55
6	0.175367	0.984503	1.015741	5.702336	0.178127	5.613968	54
7	0.175653	0.984452	1.015793	5.693039	0.178427	5.604525	53
8	0.175940	0.984401	1.015846	5.683773	0.178727	5.595112	52
9	0.176226	0.984350	1.015899	5.674538	0.179028	5.585730	51
10	0.176512	0.984299	1.015952	5.665333	0.179328	5.576379	50
11	0.176798	0.984247	1.016005	5.656158	0.179628	5.567057	49
12	0.177085	0.984196	1.016058	5.647014	0.179928	5.557766	48
13	0.177371	0.984144	1.016111	5.637900	0.180229	5.548505	47
14	0.177657	0.984092	1.016165	5.628815	0.180529	5.539274	46
15	0.177944	0.984041	1.016218	5.619760	0.180830	5.530072	45
16	0.178230	0.983989	1.016272	5.610735	0.181130	5.520901	44
17	0.178516	0.983937	1.016325	5.601739	0.181430	5.511758	43
18	0.178802	0.983885	1.016379	5.592772	0.181731	5.502645	42
19	0.179088	0.983833	1.016433	5.583834	0.182031	5.493560	41
20	0.179375	0.983781	1.016487	5.574926	0.182332	5.484505	40
21	0.179661	0.983729	1.016541	5.566046	0.182632	5.475479	39
22	0.179947	0.983676	1.016595	5.557195	0.182933	5.466481	38
23	0.180233	0.983624	1.016649	5.548373	0.183234	5.457512	37
24	0.180519	0.983572	1.016703	5.539579	0.183534	5.448572	36
25	0.180805	0.983519	1.016757	5.530813	0.183835	5.439659	35
26	0.181091	0.983466	1.016812	5.522075	0.184136	5.430775	34
27	0.181377	0.983414	1.016866	5.513366	0.184437	5.421919	33
28	0.181664	0.983361	1.016921	5.504684	0.184737	5.413091	32
29	0.181950	0.983308	1.016976	5.496031	0.185038	5.404290	31
30	0.182236	0.983255	1.017030	5.487404	0.185339	5.395517	30
31	0.182522	0.983202	1.017085	5.478806	0.185640	5.386772	29
32	0.182808	0.983149	1.017140	5.470234	0.185941	5.378054	28
33	0.183094	0.983096	1.017195	5.461690	0.186242	5.369363	27
34	0.183380	0.983042	1.017250	5.453173	0.186543	5.360699	26
35	0.183665	0.982989	1.017306	5.444683	0.186844	5.352063	25
36	0.183951	0.982935	1.017361	5.436220	0.187145	5.343453	24
37	0.184237	0.982882	1.017416	5.427784	0.187446	5.334870	23
38	0.184523	0.982828	1.017472	5.419374	0.187747	5.326313	22
39	0.184809	0.982774	1.017528	5.410990	0.188048	5.317783	21
40	0.185095	0.982721	1.017583	5.402633	0.188350	5.309279	20
41	0.185381	0.982667	1.017639	5.394303	0.188651	5.300802	19
42	0.185667	0.982613	1.017695	5.385998	0.188952	5.292351	18
43	0.185952	0.982559	1.017751	5.377719	0.189253	5.283925	17
44	0.186238	0.982505	1.017807	5.369466	0.189555	5.275526	16
45	0.186524	0.982450	1.017863	5.361239	0.189856	5.267152	15
46	0.186810	0.982396	1.017919	5.353038	0.190157	5.258804	14
47	0.187096	0.982342	1.017976	5.344862	0.190459	5.250481	13
48	0.187381	0.982287	1.018032	5.336711	0.190760	5.242184	12
49	0.187667	0.982233	1.018089	5.328586	0.191062	5.233919	11
50	0.187953	0.982178	1.018145	5.320486	0.191363	5.225665	10
51	0.188239	0.982123	1.018202	5.312411	0.191665	5.217443	9
52	0.188524	0.982069	1.018259	5.304361	0.191966	5.209246	8
53	0.188810	0.982014	1.018316	5.296335	0.192268	5.201074	7
54	0.189095	0.981959	1.018373	5.288335	0.192570	5.192926	6
55	0.189381	0.981904	1.018430	5.280359	0.192871	5.184804	5
56	0.189667	0.981849	1.018487	5.272407	0.193173	5.176705	4
57	0.189952	0.981793	1.018544	5.264480	0.193475	5.168631	3
58	0.190238	0.981738	1.018602	5.256577	0.193777	5.160581	2
59	0.190523	0.981683	1.018659	5.248698	0.194078	5.152556	1
60	0.190809	0.981627	1.018717	5.240843	0.194380	5.144554	0
	Cosines.	Sines.	Cosecants.	Secants.	Cotangents.	Tangents.	79°

11°	Sines.	Cosines.	Secants.	Cosecants.	Tangents.	Cotangents.	
0′	0.190809	0.981627	1.018717	5.240843	0.194380	5.144554	60′
1	0.191095	0.981572	1.018774	5.233012	0.194682	5.136576	59
2	0.191380	0.981516	1.018832	5.225205	0.194984	5.128622	58
3	0.191666	0.981460	1.018890	5.217422	0.195286	5.120692	57
4	0.191951	0.981405	1.018948	5.209662	0.195588	5.112786	56
5	0.192237	0.981349	1.019006	5.201925	0.195890	5.104902	55
6	0.192522	0.981293	1.019064	5.194213	0.196192	5.097043	54
7	0.192807	0.981237	1.019122	5.186523	0.196494	5.089206	53
8	0.193093	0.981181	1.019181	5.178856	0.196796	5.081393	52
9	0.193378	0.981124	1.019239	5.171213	0.197099	5.073603	51
10	0.193664	0.981068	1.019297	5.163592	0.197401	5.065835	50
11	0.193949	0.981012	1.019356	5.155995	0.197703	5.058091	49
12	0.194234	0.980955	1.019415	5.148420	0.198005	5.050369	48
13	0.194520	0.980899	1.019473	5.140868	0.198308	5.042670	47
14	0.194805	0.980842	1.019532	5.133338	0.198610	5.034994	46
15	0.195090	0.980785	1.019591	5.125831	0.198912	5.027340	45
16	0.195376	0.980729	1.019650	5.118346	0.199215	5.019708	44
17	0.195661	0.980672	1.019709	5.110884	0.199517	5.012098	43
18	0.195946	0.980615	1.019769	5.103443	0 199820	5.004511	42
19	0.196231	0.980558	1.019828	5.096025	0.200122	4.996946	41
20	0.196517	0.980501	1.019887	5.088628	0.200425	4.989403	40
21	0.196802	0.980443	1.019947	5.081254	0.200727	4.981881	39
22	0.197087	0.980386	1.020006	5.073901	0.201030	4.974382	38
23	0.197372	0.980329	1.020066	5.066570	0.201333	4.966904	37
24	0.197657	0.980271	1.020126	5.059261	0.201635	4.959447	36
25	0.197943	0.980214	1.020186	5.051973	0.201938	4.952013	35
26	0.198228	0.980156	1.020246	5.044706	0.202241	4.944599	34
27	0.198513	0.980098	1.020306	5.037461	0.202544	4.937207	33
28	0.198798	0.980041	1.020366	5.030237	0.202847	4.929836	32
29	0.199083	0.979983	1.020426	5.023034	0.203149	4.922486	31
30	0.199368	0.979924	1.020487	5.015852	0.203452	4.915157	30
31	0.199653	0.979867	1.020547	5.008691	0.203755	4.907849	29
32	0.199938	0.979809	1.020608	5.001551	0.204058	4.900562	28
33	0.200223	0.979750	1.020668	4.994431	0.204361	4.893296	27
34	0.200508	0.979692	1.020729	4.987332	0.204664	4.886050	26
35	0.200793	0.979634	1.020790	4.980254	0.204967	4.878825	25
36	0.201078	0.979575	1.020851	4.973196	0.205271	4.871620	24
37	0.201363	0.979517	1.020912	4.966159	0.205574	4.864436	23
38	0.201648	0.979458	1.021973	4.959142	0.205877	4.857272	22
39	0.201933	0.979399	1.021034	4.952145	0.206180	4.850128	21
40	0.202218	0.979341	1.021095	4.945169	0.206483	4.843005	20
41	0.202502	0.979282	1.021157	4.938212	0.206787	4.835901	19
42	0.202787	0.979223	1.021218	4.931275	0.207090	4.828817	18
43	0.203072	0.979164	1.021280	4.924359	0.207393	4.821754	17
44	0.203357	0.979105	1.021341	4.917462	0.207697	4.814710	16
45	0.203642	0.979046	1.021403	4.910584	0.208000	4.807685	15
46	0.203927	0.978986	1.021465	4.903727	0.208304	4.800681	14
47	0.204211	0.978927	1.021527	4.896889	0.208607	4.793696	13
48	0.204496	0.978867	1.021589	4.890070	0.208911	4.786730	12
49	0.204781	0.978808	1.021651	4.883271	0.209215	4.779784	11
50	0.205066	0.978748	1.021713	4.876491	0.209518	4.772857	10
51	0.205350	0.978689	1.021776	4.869730	0.209822	4.765950	9
52	0.205635	0.978629	1.021838	4.862988	0.210126	4.759060	8
53	0.205920	0.978569	1.021900	4.856266	0.210429	4.752191	7
54	0.206204	0.978509	1.021963	4.849562	0.210733	4.745340	6
55	0.206489	0.978449	1.022026	4.842877	0.211037	4.738508	5
56	0.206773	0.978389	1.022089	4.836211	0.211341	4.731695	4
57	0.207058	0.978329	1.022151	4.829564	0.211645	4.724901	3
58	0.207343	0.978268	1.022214	4.822936	0.211949	4.718126	2
59	0.207627	0.978208	1.022277	4.816326	0.212253	4.711369	1
60	0.207912	0.978148	1.022341	4.809734	0.212557	4.704630	0
	Cosines.	Sines.	Cosecants.	Secants.	Cotangents.	Tangents.	78°

12°	Sines.	Cosines.	Secants.	Cosecants.	Tangents.	Cotangents.	
0′	0.207912	0.978148	1.022341	4.809734	0.212557	4.704630	60′
1	0.208196	0.978087	1.022404	4.803161	0.212861	4.697910	59
2	0.208481	0.978027	1.022467	4.796607	0.213165	4.691208	58
3	0.208765	0.977966	1.022531	4.790070	0.213469	4.684525	57
4	0.209050	0.977905	1.022594	4.783552	0.213773	4.677860	56
5	0.209334	0.977844	1.022658	4.777052	0.214077	4.671212	55
6	0.209619	0.977783	1.022722	4.770570	0.214381	4.664583	54
7	0.209903	0.977722	1.022785	4.764106	0.214686	4.657972	53
8	0.210187	0.977661	1.022849	4.757660	0.214990	4.651379	52
9	0.210472	0.977600	1.022913	4.751231	0.215294	4.644803	51
10	0.210756	0.977539	1.022977	4.744821	0.215599	4.638246	50
11	0.211041	0.977177	1.023047	4.738428	0.215903	4.631706	49
12	0.211325	0.977416	1.023106	4.732052	0.216208	4.625183	48
13	0.211609	0.977354	1.023170	4.725695	0.216512	4.618678	47
14	0.211893	0.977293	1.023235	4.719354	0.216817	4.612191	46
15	0.212178	0.977231	1.023299	4.713031	0.217121	4.605721	45
16	0.212462	0.977169	1.023364	4.706726	0.217426	4.599268	44
17	0.212746	0.977108	1.023429	4.700437	0.217731	4.592833	43
18	0.213030	0.977046	1.023494	4.694166	0.218035	4.586414	42
19	0.213315	0.976984	1.023559	4.687912	0.218340	4.580013	41
20	0.213599	0.976922	1.023624	4.681675	0.218645	4.573629	40
21	0.213883	0.976859	1.023689	4.675455	0.218950	4.567262	39
22	0.214167	0.976797	1.023754	4.669252	0.219254	4.560911	38
23	0.214451	0.976735	1.023820	4.663065	0.219559	4.554578	37
24	0.214735	0.976672	1.023885	4.656896	0.219864	4.548261	36
25	0.215019	0.976610	1.023950	4.650743	0.220169	4.541961	35
26	0.215306	0.976547	1.024016	4.644606	0.220474	4.535677	34
27	0.215588	0.976485	1.024082	4.638487	0.220779	4.529411	33
28	0.215872	0.976422	1.024148	4.632384	0.221084	4.523160	32
29	0.216156	0.976359	1.024214	4.626297	0.221390	4.516926	31
30	0.216440	0.976296	1.024280	4.620226	0.221695	4.510709	30
31	0.216724	0.976233	1.024346	4.614172	0.222000	4.504507	29
32	0.217008	0.976170	1.024412	4.608134	0.222305	4.498322	28
33	0.217292	0.976107	1.024478	4.602113	0.222610	4.492153	27
34	0.217575	0.976044	1.024545	4.596107	0.222916	4.486000	26
35	0.217859	0.975980	1.024611	4.590117	0.223221	4.479864	25
36	0.218143	0.975917	1.024678	4.584144	0.223527	4.473743	24
37	0.218427	0.975853	1.024744	4.578186	0.223832	4.467638	23
38	0.218711	0.975790	1.024811	4.572244	0.224137	4.461549	22
39	0.218995	0.975726	1.024878	4.566318	0.224443	4.455476	21
40	0.219279	0.975662	1.024945	4.560408	0.224749	4.449418	20
41	0.219562	0.975599	1.025012	4.554513	0.225054	4.443376	19
42	0.219846	0.975535	1.025079	4.548634	0.225360	4.437350	18
43	0.220130	0.975471	1.025146	4.542771	0.225665	4.431339	17
44	0.220414	0.975407	1.025214	4.536923	0.225971	4.425344	16
45	0.220697	0.975342	1.025281	4.531090	0.226277	4.419364	15
46	0.220981	0.975278	1.025349	4.525273	0.226583	4.413400	14
47	0.221265	0.975214	1.025416	4.519471	0.226889	4.407450	13
48	0.221549	0.975149	1.025484	4.513684	0.227194	4.401516	12
49	0.221832	0.975085	1.025552	4.507913	0.227500	4.395598	11
50	0.222116	0.975020	1.025620	4.502157	0.227806	4.389694	10
51	0.222399	0.974956	1.025688	4.496415	0.228112	4.383805	9
52	0.222683	0.974891	1.025756	4.490689	0.228418	4.377932	8
53	0.222967	0.974826	1.025824	4.484978	0.228724	4.372073	7
54	0.223250	0.974761	1.025892	4.479281	0.229031	4.366229	6
55	0.223534	0.974696	1.025961	4.473599	0.229337	4.360400	5
56	0.223817	0.974631	1.026029	4.467932	0.229643	4.354586	4
57	0.224101	0.974566	1.026098	4.462280	0.229950	4.348787	3
58	0.224384	0.974501	1.026167	4.456643	0.230256	4.343002	2
59	0.224668	0.974436	1.026235	4.451020	0.230562	4.337232	1
60	0.224951	0.974370	1.026304	4.445412	0.230868	4.331476	0
	Cosines.	Sines.	Cosecants.	Secants.	Cotangents.	Tangents.	77°

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13°	Sines.	Cosines.	Secants.	Cosecants.	Tangents.	Cotangents.	
0′	0.224951	0.974370	1.026304	4.445412	0.230868	4.331476	60′
1	0.225235	0.974305	1.026373	4.439818	0.231175	4.325735	59
2	0.225518	0.974239	1.026442	4.434238	0.231481	4.320008	58
3	0.225801	0.974173	1.026511	4.428673	0.231788	4.314296	57
4	0.226085	0.974108	1.026581	4.423123	0.232094	4.308597	56
5	0.226368	0.974042	1.026650	4.417586	0.232401	4.302914	55
6	0.226651	0.974976	1.026719	4.412064	0.232707	4.297244	54
7	0.226935	0.973910	1.026789	4.406556	0.233014	4.291589	53
8	0.227218	0.973844	1.026859	4.401062	0.233321	4.285947	52
9	0.227501	0.973778	1.026928	4.395582	0.233627	4.280320	51
10	0.227784	0.973712	1.026998	4.390116	0.233934	4.274707	50
11	0.228068	0.973645	1.027068	4.384664	0.234241	4.269107	49
12	0.228351	0.973579	1.027138	4.379226	0.234548	4.263522	48
13	0.228634	0.973512	1.027208	4.373802	0.234855	4.257950	47
14	0.228917	0.973446	1.027279	4.368391	0.235162	4.252392	46
15	0.229200	0.973379	1.027344	4.362994	0.235469	4.246848	45
16	0.229484	0.973313	1.027419	4.357611	0.235776	4.241318	44
17	0.229767	0.973246	1.027490	4.352242	0.236083	4.235801	43
18	0.230050	0.973179	1.027560	4.346886	0.236390	4.230298	42
19	0.230333	0.973112	1.027631	4.341544	0.236697	4.224808	41
20	0.230616	0.973045	1.027702	4.336215	0.237004	4.219332	40
21	0.230899	0.972978	1.027773	4.330900	0.237312	4.213869	39
22	0.231182	0.972911	1.027845	4.325598	0.237619	4.208420	38
23	0.231465	0.972843	1.027915	4.320309	0.237926	4.202984	37
24	0.231748	0.972776	1.027986	4.315034	0.238234	4.197561	36
25	0.232031	0.972708	1.028057	4.309772	0.238541	4.192151	35
26	0.232314	0.972641	1.028129	4.304523	0.238849	4.186755	34
27	0.232597	0.972573	1.028200	4.299287	0.239156	4.181371	33
28	0.232880	0.972506	1.028272	4.294064	0.239464	4.176001	32
29	0.233163	0.972438	1.028343	4.288854	0.239771	4.170644	31
30	0.233445	0.972370	1.028415	4.283658	0.240079	4.165300	30
31	0.233728	0.972302	1.028487	4.278474	0.240386	4.159969	29
32	0.234011	0.972234	1.028559	4.273303	0.240694	4.154650	28
33	0.234294	0.972166	1.028631	4.268145	0.241002	4.149345	27
34	0.234577	0.972098	1.028703	4.263000	0.241310	4.144052	26
35	0.234859	0.972029	1.028776	4.257867	0.241618	4.138772	25
36	0.235142	0.971961	1.028848	4.252747	0.241926	4.133505	24
37	0.235425	0.971893	1.028920	4.247640	0.242233	4.128250	23
38	0.235708	0.971824	1.028993	4.242546	0.242541	4.123008	22
39	0.235990	0.971755	1.029066	4.237464	0.242849	4.117778	21
40	0.236273	0.971687	1.029138	4.232394	0.243158	4.112561	20
41	0.236556	0.971618	1.029211	4.227337	0.243466	4.107357	19
42	0.236838	0.971549	1.029284	4.222293	0.243774	4.102165	18
43	0.237121	0.971480	1.029357	4.217261	0.244082	4.096985	17
44	0.237403	0.971411	1.029430	4.212241	0.244390	4.091818	16
45	0.237686	0.971342	1.029503	4.207233	0.244698	4.086663	15
46	0.237968	0.971273	1.029577	4.202238	0.245007	4.081520	14
47	0.238251	0.971204	1.029650	4.197255	0.245315	4.076389	13
48	0.238534	0.971134	1.029724	4.192284	0.245624	4.071271	12
49	0.238816	0.971065	1.029797	4.187325	0.245932	4.066164	11
50	0.239098	0.970998	1.029871	4.182379	0.246241	4.061070	10
51	0.239381	0.970926	1.029945	4.177444	0.246549	4.055988	9
52	0.239663	0.970856	1.030019	4.172521	0.246858	4.050917	8
53	0.239946	0.970786	1.030093	4.167610	0.247166	4.045859	7
54	0.240228	0.970717	1.030167	4.162711	0.247475	4.040813	6
55	0.240510	0.970647	1.030241	4.157824	0.247784	4.035778	5
56	0.240793	0.970577	1.030315	4.152949	0.248093	4.030755	4
57	0.240175	0.970506	1.030390	4.148086	0.248401	4.025744	3
58	0.241357	0.970436	1.030464	4.143234	0.248710	4.020745	2
59	0.241640	0.970366	1.030539	4.138394	0.249019	4.015757	1
60	0.241922	0.970296	1.030614	4.133566	0.249328	4.010781	0
	Cosines.	Sines.	Cosecants.	Secants.	Cotangents.	Tangents.	76°

14°	Sines.	Cosines.	Secants.	Cosecants.	Tangents.	Cotangents.	
0′	0.241922	0.970296	1.030614	4.133566	0.249328	4.010781	60′
1	0.242204	0.970225	1.030688	4.128749	0.249637	4.005817	59
2	0.242486	0.970155	1.030763	4.123944	0.249946	4.000864	58
3	0.242769	0.970084	1.030838	4.119150	0.250255	3.995922	57
4	0.243051	0.970014	1.030913	4.114368	0.250564	3.990992	56
5	0.243333	0.969943	1.030989	4.109597	0.250873	3.986074	55
6	0.243615	0.969872	1.031064	4.104837	0.251183	3.981167	54
7	0.243897	0.969801	1.031139	4.100089	0.251492	3.976271	53
8	0.244179	0.969730	1.031215	4.095353	0.251801	3.971387	52
9	0.244461	0.969659	1.031290	4.090627	0.252111	3.966514	51
10	0.244743	0.969588	1.031366	4.085913	0.252420	3.961652	50
11	0.245025	0.969517	1.031442	4.081210	0.252729	3.956801	49
12	0.245307	0.969445	1.031518	4.076518	0.253039	3.951962	48
13	0.245589	0.969374	1.031594	4.071837	0.253348	3.947133	47
14	0.245871	0.969305	1.031670	4.067168	0.253658	3.942316	46
15	0.246153	0.969231	1.031746	4.062509	0.253968	3.937509	45
16	0.246435	0.969159	1.031822	4.057862	0.254277	3.932716	44
17	0.246717	0.969088	1.031899	4.053225	0.254587	3.927930	43
18	0.246999	0.969016	1.031975	4.048599	0.254897	3.923156	42
19	0.247281	0.968944	1.032052	4.043984	0.255207	3.918394	41
20	0.247563	0.968872	1.032128	4.039380	0.255517	3.913642	40
21	0.247845	0.968800	1.032205	4.034787	0.255826	3.908901	39
22	0.248126	0.968728	1.032282	4.030205	0.256136	3.904171	38
23	0.248408	0.968656	1.032359	4.025633	0.256446	3.899452	37
24	0.248690	0.968583	1.032436	4.021072	0.256756	3.894743	36
25	0.248972	0.968511	1.032513	4.016522	0.257066	3.890045	35
26	0.249253	0.968438	1.032590	4.011982	0.257377	3.885357	34
27	0.249535	0.968366	1.032668	4.007453	0.257687	3.880681	33
28	0.249817	0.968293	1.032745	4.002935	0.257997	3.876014	32
29	0.250098	0.968221	1.032823	3.998427	0.258307	3.871358	31
30	0.250380	0.968148	1.032900	3.993929	0.258618	3.866713	30
31	0.250662	0.968075	1.032978	3.989442	0.258928	3.862078	29
32	0.250943	0.968002	1.033056	3.984965	0.259238	3.857454	28
33	0.251225	0.967929	1.033134	3.980499	0.259549	3.852840	27
34	0.251506	0.967856	1.033212	3.976043	0.259859	3.848236	26
35	0.251788	0.967783	1.033290	3.971598	0.260170	3.843642	25
36	0.252069	0.967709	1.033368	3.967162	0.260481	3.839059	24
37	0.252351	0.967636	1.033447	3.962737	0.260791	3.834486	23
38	0.252632	0.967562	1.033525	3.958322	0.261102	3.829923	22
39	0.252914	0.967489	1.033604	3.953917	0.261413	3.825371	21
40	0.253105	0.967415	1.033682	3.949522	0.261723	3.820828	20
41	0.253477	0.967342	1.033761	3.945138	0.262034	3.816296	19
42	0.253758	0.967268	1.033840	3.940763	0.262345	3.811773	18
43	0.254039	0.967194	1.033919	3.936399	0.262656	3.807261	17
44	0.254321	0.967120	1.033998	3.932044	0.262967	3.802759	16
45	0.254602	0.967046	1.034077	3.927700	0.263278	3.798266	15
46	0.254883	0.966972	1.034156	3.923365	0.263589	3.793784	14
47	0.255165	0.966898	1.034236	3.919040	0.263900	3.789311	13
48	0.255446	0.966823	1.034315	3.914725	0.264211	3.784848	12
49	0.255727	0.966749	1.034395	3.910420	0.264523	3.780395	11
50	0.256008	0.966675	1.034474	3.906125	0.264834	3.775952	10
51	0.256289	0.966600	1.034554	3.901840	0.265145	3.771519	9
52	0.256571	0.966526	1.034634	3.897564	0.265457	3.767095	8
53	0.256852	0.966451	1.034714	3.893298	0.265768	3.762681	7
54	0.257133	0.966376	1.034794	3.889041	0.266079	3.758276	6
55	0.257414	0.966301	1.034874	3.884794	0.266391	3.753882	5
56	0.257695	0.966226	1.034954	3.880557	0.266703	3.749496	4
57	0.257976	0.966151	1.035034	3.876329	0.267014	3.745121	3
58	0.258257	0.966076	1.035115	3.872111	0.267326	3.740755	2
59	0.258538	0.966001	1.035196	3.867903	0.267637	3.736398	1
60	0.258819	0.965926	1.035276	3.863703	0.267949	3.732051	0
	Cosines.	Sines	Cosecants.	Secants.	Cotangents.	Tangents.	75°

15°	Sines.	Cosines.	Secants.*	Cosecants.	Tangents.	Cotangents.	
0′	0.258819	0.965926	1.035276	3.863703	0.267949	3.732051	60′
1	0.259100	0.965851	1.035357	3.859514	0.268261	3.727713	59
2	0.259381	0.965775	1.035438	3.855333	0.268573	3.723385	58
3	0.259662	0.965700	1.035519	3.851162	0.268885	3.719066	57
4	0.259943	0.965624	1.035600	3.847001	0.269197	3.714756	56
5	0.260224	0.965548	1.035681	3.842848	0.269509	3.710456	55
6	0.260505	0.961473	1.035762	3.838705	0.269821	3.706165	54
7	0.260785	0.965397	1.035844	3.834571	0.270133	3.701883	53
8	0.261066	0.965321	1.035925	3.830447	0.270445	3.697610	52
9	0.261347	0.965245	1.036007	3.826331	0.270757	3.693347	51
10	0.261628	0.965169	1.036088	3.822225	0.271069	3.689093	50
11	0.261909	0.965093	1.036170	3.818128	0.271382	3.684848	49
12	0.262189	0.965017	1.036252	3.814040	0.271694	3.680612	48
13	0.262470	0.964940	1.036334	3.809961	0.272006	3.676385	47
14	0.262751	0.964864	1.036416	3.805891	0.272319	3.672167	46
15	0.263031	0.964787	1.036498	3.801830	0.272631	3.667958	45
16	0.263312	0.964711	1.036580	3.797778	0.272944	3.663758	44
17	0.263593	0.964634	1.036663	3.793735	0.273256	3.659567	43
18	0.263873	0.964557	1.036745	3.789701	0.273569	3.655384	42
19	0.264154	0.964481	1.036828	3.785676	0.273882	3.651211	41
20	0.264434	0.964404	1.036910	3.781660	0.274195	3.647047	40
21	0.264715	0.964327	1.036993	3.777652	0.274507	3.642891	39
22	0.264995	0.964250	1.037076	3.773654	0.274820	3.638744	38
23	0.265276	0.964173	1.037159	3.769664	0.275133	3.634606	37
24	0.265556	0.964095	1.037242	3.765682	0.275446	3.630477	36
25	0.265837	0.964018	1.037325	3.761710	0.275759	3.626357	35
26	0.266117	0.963941	1.037408	3.757746	0.276072	3.622245	34
27	0.266397	0.963863	1.037492	3.753791	0.276385	3.618142	33
28	0.266678	0.963786	1.037575	3.749845	0.276698	3.614047	32
29	0.266958	0.963708	1.037659	3.745907	0.277011	3.609961	31
30	0.267238	0.963631	1.037742	3.741978	0.277325	3.605884	30
31	0.267519	0.963553	1.037826	3.738057	0.277638	3.601815	29
32	0.267799	0.963475	1.037910	3.734145	0.277951	3.597754	28
33	0.268079	0.963397	1.037994	3.730241	0.278265	3.593702	27
34	0.268359	0.963319	1.038078	3.726346	0.278578	3.589659	26
35	0.268640	0.963241	1.038162	3.722454	0.278892	3.585624	25
36	0.268920	0.963163	1.038246	3.718581	0.279205	3.581598	24
37	0.269200	0.963084	1.038331	3.714711	0.279519	3.577579	23
38	0.269480	0.963006	1.038415	3.710849	0.279832	3.573570	22
39	0.269760	0.962928	1.038500	3.706996	0.280146	3.569568	21
40	0.270040	0.962849	1.038584	3.703151	0.280460	3.565575	20
41	0.270320	0.962770	1.038669	3.699314	0.280774	3.561590	19
42	0.270600	0.962692	1.038754	3.695485	0.281087	3.557613	18
43	0.270881	0.962613	1.038839	3.691665	0.281401	3.553645	17
44	0.271161	0.962534	1.038924	3.687853	0.281715	3.549685	16
45	0.271440	0.962455	1.039009	3.684049	0.282029	3.545733	15
46	0.271720	0.962376	1.039095	3.680254	0.282343	3.541789	14
47	0.272000	0.962297	1.039180	3.676466	0.282657	3.537853	13
48	0.272280	0.962218	1.039266	3.672687	0.282972	3.533925	12
49	0.272560	0.962139	1.039351	3.668915	0.283286	3.530005	11
50	0.272840	0.962059	1.039437	3.665152	0.283600	3.526094	10
51	0.273120	0.961980	1.039523	3.661396	0.283914	3.522190	9
52	0.273400	0.961901	1.039609	3.657649	0.284229	3.518295	8
53	0.273679	0.961821	1.039695	3.653910	0.284543	3.514407	7
54	0.273959	0.961741	1.039781	3.650178	0.284858	3.510527	6
55	0.274239	0.961662	1.039867	3.646455	0.285172	3.506656	5
56	0.274519	0.961582	1.039953	3.642739	0.285487	3.502792	4
57	0.274798	0.961502	1.040040	3.639032	0.285801	3.498936	3
58	0.275078	0.961422	1.040126	3.635332	0.286116	3.495087	2
59	0.275358	0.961342	1.040213	3.631640	0.286431	3.491247	1
60	0.275637	0.961262	1.040299	3.627955	0.286745	3.487414	0
	Cosines.	Sines.	Cosecants.	Secants.	Cotangents.	Tangents.	74°

16°	Sines.	Cosines.	Secants.	Cosecants.	Tangents.	Cotangents.	
0'	0.275637	0.961262	1.040299	3.627955	0.286745	3.487414	60'
1	0.275917	0.961182	1.040386	3.624279	0.287060	3.483590	59
2	0.276196	0.961101	1.040473	3.620610	0.287375	3.479773	58
3	0.276476	0.961021	1.040560	3.616949	0.287690	3.475963	57
4	0.276756	0.960940	1.040647	3.613294	0.288005	3.472162	56
5	0.277035	0.960860	1.040735	3.609650	0.288320	3.468368	55
6	0.277315	0.960779	1.040822	3.606012	0.288635	3.464581	54
7	0.277594	0.960698	1.040909	3.602382	0.288950	3.460803	53
8	0.277874	0.960618	1.040997	3.598759	0.289266	3.457032	52
9	0.278153	0.960537	1.041085	3.595144	0.289581	3.453268	51
10	0.278432	0.960456	1.041172	3.591536	0.289896	3.449512	50
11	0.278712	0.960375	1.041260	3.587936	0.290211	3.445764	49
12	0.278991	0.960294	1.041348	3.584344	0.290527	3.442023	48
13	0.279270	0.960213	1.041436	3.580759	0.290842	3.438289	47
14	0.279550	0.960131	1.041524	3.577181	0.291158	3.434563	46
15	0.279829	0.960050	1.041613	3.573611	0.291473	3.430845	45
16	0.280108	0.959968	1.041701	3.570048	0.291789	3.427133	44
17	0.280388	0.959887	1.041789	3.566493	0.292105	3.423430	43
18	0.280667	0.959805	1.041878	3.562945	0.292421	3.419733	42
19	0.280946	0.959724	1.041967	3.559404	0.292736	3.416044	41
20	0.281225	0.959642	1.042055	3.555871	0.293052	3.412363	40
21	0.281504	0.959560	1.042144	3.552345	0.293368	3.408688	39
22	0.281783	0.959478	1.042233	3.548826	0.293684	3.405021	38
23	0.282062	0.959396	1.042322	3.545315	0.294000	3.401361	37
24	0.282342	0.959314	1.042412	3.541811	0.294316	3.397709	36
25	0.282621	0.959232	1.042501	3.538314	0.294632	3.394063	35
26	0.282900	0.959150	1.042590	3.534824	0.294948	3.390425	34
27	0.283179	0.959067	1.042680	3.531341	0.295265	3.386794	33
28	0.283458	0.958985	1.042769	3.527866	0.295581	3.383170	32
29	0.283736	0.958902	1.042859	3.524398	0.295897	3.379553	31
30	0.284015	0.958820	1.042949	3.520937	0.296214	3.375943	30
31	0.284294	0.958737	1.043039	3.517482	0.296530	3.372341	29
32	0.284573	0.958654	1.043129	3.514035	0.296846	3.368745	28
33	0.284852	0.958372	1.043219	3.510595	0.297163	3.365157	27
34	0.285131	0.958489	1.043309	3.507163	0.297480	3.361575	26
35	0.285410	0.958406	1.043400	3.503737	0.297796	3.358001	25
36	0.285688	0.958323	1.043490	3.500318	0.298113	3.354433	24
37	0.285967	0.958239	1.043581	3.496906	0.298430	3.350873	23
38	0.286246	0.958156	1.043671	3.493500	0.298747	3.347319	22
39	0.286525	0.958073	1.043762	3.490102	0.299063	3.343772	21
40	0.286803	0.957990	1.043853	3.486711	0.299380	3.340233	20
41	0.287082	0.957906	1.043944	3.483327	0.299697	3.336700	19
42	0.287361	0.957823	1.044035	3.479949	0.300014	3.333174	18
43	0.287639	0.957739	1.044126	3.476579	0.300332	3.329654	17
44	0.287918	0.957655	1.044217	3.473215	0.300649	3.326142	16
45	0.288196	0.957571	1.044309	3.469858	0.300966	3.322636	15
46	0.288475	0.957488	1.044400	3.466507	0.301283	3.319137	14
47	0.288753	0.957404	1.044492	3.463164	0.301600	3.315645	13
48	0.288032	0 957320	1.044583	3.459827	0.301918	3.312160	12
49	0.289310	0.957235	1.044675	3.456497	0.302235	3.308681	11
50	0.289589	0.957151	1.044767	3.453174	0.302553	3.305209	10
51	0.289867	0.957067	1.044859	3.449857	0.302870	3.301744	9
52	0.290146	0.956983	1.044951	3.446547	0.303188	3.298285	8
53	0.290424	0.956898	1.045043	3.443243	0.303506	3.294833	7
54	0.290702	0.956814	1.045136	3.439947	0.303823	3.291388	6
55	0.290981	0.956729	1.045228	3.436656	0.304141	3.287949	5
56	0.291259	0.956644	1.045321	3.433373	0.304459	3.284516	4
57	0.291537	0.956560	1.045413	3.430096	0.304777	3.281091	3
58	0.291815	0.956475	1.045506	3.426825	0.305095	3.277672	2
59	0.292094	0.956390	1.045599	3.423561	0.305413	3.274259	1
60	0.292372	0.956305	1.045692	3.420304	0.305731	3.270853	0
	Cosines.	Sines.	Cosecants.	Secants.	Cotangents.	Tangents.	73°

17°	Sines.	Cosines.	Secants.	Cosecants.	Tangents.	Cotangents.	
0'	0.292372	0.956305	1.045692	3.420304	0.305731	3.270853	60'
1	0.292650	0.956220	1.045785	3.417053	0.306049	3.267453	59
2	0.292928	0.956135	1.045878	3.413808	0.306367	3.264060	58
3	0.293206	0.956049	1.045971	3.410570	0.306685	3.260673	57
4	0.293484	0.955964	1.046065	3.407338	0.307003	3.257292	56
5	0.293762	0.955879	1.046158	3.404113	0.307322	3.253918	55
6	0.294040	0.955793	1.046252	3.400894	0.307640	3.250551	54
7	0.294318	0.955707	1.046345	3.397682	0.307959	3.247190	53
8	0.294596	0.955622	1.046439	3.394475	0.308277	3.243835	52
9	0.294874	0.955536	1.046533	3.391276	0.308596	3.240486	51
10	0.295152	0.955450	1.046627	3.388082	0.308914	3.237144	50
11	0.295430	0.955364	1.046721	3.384895	0.309233	3.233808	49
12	0.295708	0.955278	1.046815	3.381714	0.309552	3.230478	48
13	0.295986	0.955192	1.046910	3.378539	0.309871	3.227155	47
14	0.296264	0.955106	1.047004	3.375371	0.310189	3.223837	46
15	0.296542	0.955020	1.047099	3.372208	0.310508	3.220526	45
16	0.296819	0.954934	1.047193	3.369052	0.310827	3.217222	44
17	0.297097	0.954847	1.047288	3.365903	0.311146	3.213923	43
18	0.297375	0.954761	1.047383	3.362759	0.311465	3.210630	42
19	0.297653	0.954674	1.047478	3.359621	0.311785	3.207344	41
20	0.297930	0.954588	1.047573	3.356490	0.312104	3.204064	40
21	0.298208	0.954501	1.047668	3.353365	0.312423	3.200790	39
22	0.298486	0.954414	1.047763	3.350246	0.312742	3.197522	38
23	0.298763	0.954327	1.047859	3.347132	0.313062	3.194260	37
24	0.299041	0.954240	1.047954	3.344025	0.313381	3.191004	36
25	0.299318	0.954153	1.048050	3.340924	0.313701	3.187754	35
26	0.299596	0.954066	1.048145	3.337829	0.314020	3.184510	34
27	0.299873	0.953979	1.048241	3.334741	0.314340	3.181272	33
28	0.300151	0.953892	1.048337	3.331658	0.314659	3.178041	32
29	0.300428	0.953806	1.048433	3.328581	0.314979	3.174815	31
30	0.300706	0.953717	1.048529	3.325510	0.315299	3.171595	30
31	0.300983	0.953629	1.048625	3.322444	0.315619	3.168381	29
32	0.301261	0.953542	1.048722	3.319385	0.315939	3.165173	28
33	0.301538	0.953454	1.048818	3.316332	0 316259	3.161971	27
34	0.301815	0.953366	1.048915	3.313285	0.316579	3.158774	26
35	0.302093	0.953279	1.049011	3.310243	0.316899	3.155584	25
36	0.302370	0.953191	1.049108	3.307208	0.317219	3.152399	24
37	0.302647	0.953103	1.049205	3.304178	0.317539	3.149221	23
38	0.302924	0.953015	1.049302	3.301154	0.317859	3.146048	22
39	0.303202	0.952926	1.049399	3.298136	0.318179	3.142881	21
40	0.303479	0.952838	1.049496	3.295123	0.318500	3.139719	20
41	0.303756	0.952750	1.049593	3.292117	0.318820	3.136564	19
42	0.304033	0.952662	1.049691	3.289116	0.319141	3.133414	18
43	0.304310	0.952573	1.049788	3.286121	0.319461	3.130270	17
44	0.304587	0.952484	1.049886	3.283132	0.319782	3.127132	16
45	0.304864	0.952396	1.049984	3.280148	0.320103	3.123999	15
46	0.305141	0.952307	1.050082	3.277170	0.320423	3.120872	14
47	0.305418	0.952218	1.050179	3.274198	0.320744	3.117751	13
48	0.305695	0.952129	1.050277	3.271231	0.321065	3.114635	12
49	0.305972	0.952040	1.050376	3.268270	0.321386	3.111525	11
50	0.306249	0.951951	1.050474	3.265315	0.321707	3.108421	10
51	0.306526	0.951862	1.050572	3.262365	0.322028	3.105322	9
52	0.306803	0.951773	1.050671	3.259421	0.322349	3.102229	8
53	0.307080	0.951684	1.050769	3.256483	0.322670	3.099142	7
54	0.307357	0.951594	1.050868	3.253550	0.322991	3.096060	6
55	0.307633	0.951505	1.050967	3.250622	0.323313	3.092983	5
56	0.307910	0.951415	1.051066	3.247700	0.323634	3.089912	4
57	0.308187	0.951326	1.051165	3.244784	0.323955	3.086847	3
58	0.308464	0.951236	1.051264	3.241873	0.324277	3.083787	2
59	0.308740	0.951146	1.051363	3.238968	0.324598	3.080733	1
60	0.309017	0.951057	1.051462	3.236068	0.324920	3.077684	0
	Cosines.	Sines.	Cosecants.	Secants.	Cotangents.	Tangents.	72°

18°	Sines.	Cosines.	Secants.	Cosecants.	Tangents.	Cotangents.	
0′	0.309017	0.951057	1.051462	3.236068	0.324920	3.077684	60′
1	0.309294	0.950967	1.051562	3.233174	0.325241	3.074640	59
2	0.309570	0.950877	1.051661	3.230285	0.325563	3.071602	58
3	0.309847	0.950787	1.051761	3.227401	0.325885	3.068569	57
4	0.310123	0.950696	1.051861	3.224523	0.326207	3.065542	56
5	0.310400	0.950606	1.051961	3.221650	0.326528	3.062520	55
6	0.310676	0.950516	1.052060	3.218783	0.326850	3.059504	54
7	0.310953	0.950425	1.052161	3.215921	0.327172	3.056493	53
8	0.311229	0.950335	1.052261	3.213064	0.327494	3.053487	52
9	0.311506	0.950244	1.052361	3.210213	0.327817	3.050487	51
10	0.311782	0.950154	1.052461	3.207367	0.328139	3.047492	50
11	0.312059	0.950063	1.052562	3.204527	0.328461	3.044502	49
12	0.312335	0.949972	1.052663	3.201691	0.328783	3.041517	48
13	0.312611	0.949881	1.052763	3.198861	0.329106	3.038538	47
14	0.312888	0.949790	1.052864	3.196037	0.329428	3.035564	46
15	0.313164	0.949699	1.052965	3.193217	0.329751	3.032595	45
16	0.313440	0.949608	1.053066	3.190403	0.330073	3.029632	44
17	0.313716	0.949517	1.053167	3.187594	0.330396	3.026674	43
18	0.313993	0.949426	1.053269	3.184790	0.330718	3.023721	42
19	0.314269	0.949334	1.053370	3.181991	0.331041	3.020773	41
20	0.314545	0.949242	1.053471	3.179198	0.331364	3.017830	40
21	0.314821	0.949151	1.053573	3.176410	0.331687	3.014893	39
22	0.315097	0.949060	1.053675	3.173626	0.332010	3.011960	38
23	0.315373	0.948968	1.053777	3.170848	0.332333	3.009033	37
24	0.315649	0.948876	1.053879	3.168076	0.332656	3.006111	36
25	0.315925	0.948784	1.053981	3.165308	0.332979	3.003194	35
26	0.316201	0.948692	1.054083	3.162545	0.333302	3.000282	34
27	0.316477	0.948600	1.054185	3.159788	0.333625	2.997375	33
28	0.316753	0.948508	1.054287	3.157035	0.333949	2.994473	32
29	0.317029	0.948416	1.054390	3.154288	0.334272	2.991577	31
30	0.317305	0.948324	1.054492	3.151545	0.334595	2.988685	30
31	0.317581	0.948231	1.054595	3.148808	0.334919	2.985798	29
32	0.317856	0.948139	1.054698	3.146076	0.335242	2.982917	28
33	0.318132	0.948046	1.054801	3.143318	0.335566	2.980040	27
34	0.318408	0.947954	1.054904	3.140626	0.335890	2.977168	26
35	0.318684	0.947861	1.055007	3.137909	0.336213	2.974302	25
36	0.318959	0.947768	1.055110	3.135196	0.336537	2.971440	24
37	0.319235	0.947675	1.055213	3.132489	0.336861	2.968583	23
38	0.319511	0.947582	1.055317	3.129786	0.337185	2.965731	22
39	0.319786	0.947490	1.055420	3.127089	0.337509	2.962884	21
40	0.320062	0.947397	1.055524	3.124396	0.337833	2.960042	20
41	0.320337	0.947304	1.055628	3.121708	0.338157	2.957205	19
42	0.320613	0.947210	1.055732	3.119025	0.338481	2.954373	18
43	0.320889	0.947117	1.055836	3.116347	0.338806	2.951545	17
44	0.321164	0.947024	1.055940	3.113674	0.339130	2.948723	16
45	0.321440	0.946930	1.056044	3.111006	0.339454	2.945905	15
46	0.321715	0.946837	1.056149	3.108342	0.339779	2.943092	14
47	0.321990	0.946743	1.056253	3.105684	0.340103	2.940284	13
48	0.322266	0.946649	1.056358	3.103030	0.340428	2.937481	12
49	0.322541	0.946556	1.056462	3.100381	0.340752	2.934682	11
50	0.322816	0.946462	1.056567	3.097736	0.341077	2.931889	10
51	0.323092	0.946368	1.056672	3.095097	0.341402	2.929100	9
52	0.323367	0.946274	1.056777	3.092462	0.341727	2.926315	8
53	0.323642	0.946180	1.056882	3.089832	0.342052	2.923536	7
54	0.323917	0.946085	1.056987	3.087207	0.342377	2.920761	6
55	0.324192	0.945991	1.057092	3.084586	0.342702	2.917991	5
56	0.324468	0.945897	1.057198	3.081970	0.343027	2.915226	4
57	0.324743	0.945802	1.057303	3.079359	0.343352	2.912465	3
58	0.325018	0.945708	1.057409	3.076753	0.343677	2.909709	2
59	0.325293	0.945613	1.057515	3.074151	0.344002	2.906958	1
60	0.325568	0.945519	1.057621	3.071554	0.344328	2.904211	0
	Cosines.	Sines.	Cosecants.	Secants.	Cotangents.	Tangents.	71°

19°	Sines.	Cosines.	Secants.	Cosecants.	Tangents.	Cotangents.	
0′	0.325568	0.945519	1.057621	3.071554	0.344328	2.904211	60′
1	0.325843	0.945424	1.057727	3.068961	0.344653	2.901469	59
2	0.326118	0.945329	1.057833	3.066373	0.344979	2.898731	58
3	0.326393	0.945234	1.057939	3.063790	0.345304	2.895999	57
4	0.326668	0.945139	1.058045	3.061211	0.345630	2.893270	56
5	0.326943	0.945044	1.058152	3.058637	0.345955	2.890547	55
6	0.327218	0.944949	1.058258	3.056068	0.346281	2.887828	54
7	0.327493	0.944854	1.058365	3.053503	0.346607	2.885113	53
8	0.327768	0.944758	1.058472	3.050942	0.346933	2.882403	52
9	0.328042	0.944663	1.058579	3.048386	0.347259	2.879698	51
10	0.328317	0.944568	1.058686	3.045835	0.347585	2.876997	50
11	0.328592	0.944472	1.058793	3.043288	0.347911	2.874301	49
12	0.328867	0.944376	1.058900	3.040746	0.348237	2.871609	48
13	0.329141	0.944281	1.059007	3.038208	0.348563	2.868922	47
14	0.329416	0.944184	1.059115	3.035675	0.348889	2.866239	46
15	0.329691	0.944089	1.059222	3.033146	0.349216	2.863560	45
16	0.329965	0.943993	1.059330	3.030622	0.349542	2.860886	44
17	0.330240	0.943897	1.059438	3.028102	0.349869	2.858217	43
18	0.330514	0.943801	1.059545	3.025587	0.350195	2.855552	42
19	0.330789	0.943705	1.059653	3.023076	0.350522	2.852891	41
20	0.331063	0.943609	1.059762	3.020569	0.350848	2.850235	40
21	0.331338	0.943512	1.059870	3.018067	0.351175	2.847583	39
22	0.331612	0.943416	1.059978	3.015569	0.351502	2.844936	38
23	0.331887	0.943319	1.060087	3.013076	0.351829	2.842293	37
24	0.332161	0.943223	1.060195	3.010587	0.352156	2.839654	36
25	0.332436	0.943126	1.060304	3.008102	0.352483	2.837020	35
26	0.332710	0.943029	1.060413	3.005622	0.352810	2.834390	34
27	0.332984	0.942932	1.060521	3.003146	0.353137	2.831764	33
28	0.333258	0.942836	1.060630	3.000675	0.353464	2.829143	32
29	0.333533	0.942739	1.060740	2.998207	0.353791	2.826526	31
30	0.333807	0.942642	1.060849	2.995744	0.354119	2.823913	30
31	0.334081	0.942544	1.060958	2.993286	0.354446	2.821305	29
32	0.334355	0.942447	1.061068	2.990831	0.354773	2.818700	28
33	0.334629	0.942350	1.061177	2.988381	0.355101	2.816100	27
34	0.334903	0.942253	1.061287	2.985935	0.355429	2.813505	26
35	0.335178	0.942155	1.061397	2.983494	0.355756	2.810913	25
36	0.335452	0.942058	1.061506	2.981056	0.356084	2.808326	24
37	0.335726	0.941960	1.061616	2.978623	0.356412	2.805743	23
38	0.336000	0.941862	1.061727	2.976194	0.356740	2.803165	22
39	0.336274	0.941764	1.061837	2.973770	0.357068	2.800590	21
40	0.336548	0.941667	1.061947	2.971349	0.357396	2.798020	20
41	0.336821	0.941569	1.062058	2.968933	0.357724	2.795454	19
42	0.337095	0.941471	1.062168	2.966521	0.358052	2.792892	18
43	0.337369	0.941372	1.062279	2.964113	0.358380	2.790334	17
44	0.337643	0.941274	1.062390	2.961709	0.358708	2.787780	16
45	0.337917	0.941176	1.062501	2.959309	0.359037	2.785231	15
46	0.338191	0.941078	1.062612	2.956414	0.359365	2.782685	14
47	0.338464	0.940979	1.062723	2.954522	0.359694	2.780144	13
48	0.338738	0.940881	1.062834	2.952135	0.360022	2.777607	12
49	0.339012	0.940782	1.062945	2.949752	0.360351	2.775074	11
50	0.339285	0.940684	1.063057	2.947373	0.360680	2.772545	10
51	0.339559	0.940585	1.063168	2.944998	0.361008	2.770020	9
52	0.339833	0.940486	1.063280	2.942627	0.361337	2.767499	8
53	0.340106	0.940387	1.063392	2.940260	0.361666	2.764982	7
54	0.340380	0.940288	1.063504	2.937897	0.361995	2.762470	6
55	0.340653	0.940189	1.063616	2.935538	0.362324	2.759961	5
56	0.340927	0.940091	1.063728	2.933183	0.362653	2.757456	4
57	0.341200	0.939991	1.063840	2.930833	0.362982	2.754955	3
58	0.341473	0.939891	1.063953	2.928486	0.363312	2.752459	2
59	0.341747	0.939792	1.064065	2.926143	0.363641	2.749966	1
60	0.342020	0.939693	1.064178	2.923804	0.363970	2.747477	0
	Cosines.	Sines.	Cosecants.	Secants.	Cotangents.	Tangents.	70°

20°	Sines.	Cosines.	Secants.	Cosecants.	Tangents.	Cotangents.	
0′	0.342020	0.939693	1.064178	2.923804	0.363970	2.747477	60′
1	0.342294	0.939595	1.064291	2.921470	0.364300	2.744993	59
2	0.342567	0.939494	1.064403	2.919139	0.364629	2.742512	58
3	0.342840	0.939394	1.064516	2.916812	0.364959	2.740035	57
4	0.343113	0.939294	1.064629	2.914489	0.365289	2.737562	56
5	0.343387	0.939194	1.064743	2.912170	0.365618	2.735093	55
6	0.343660	0.939094	1.064856	2.909855	0.365948	2.732628	54
7	0.343933	0.938994	1.064969	2.907544	0.366278	2.730167	53
8	0.344206	0.938894	1.065083	2.905237	0.366608	2.727710	52
9	0.344479	0.938794	1.065196	2.902934	0.366938	2.725257	51
10	0.344752	0.938694	1.065310	2.900635	0.367268	2.722808	50
11	0.345025	0.938594	1.065424	2.898339	0.367598	2.720362	49
12	0.345298	0.938493	1.065538	2.896048	0.367928	2.717920	48
13	0.345571	0.938393	1.065652	2.893760	0.368259	2.715483	47
14	0.345844	0.938292	1.065766	2.891476	0.368589	2.713049	46
15	0.346117	0.938191	1.065881	2.889196	0.368920	2.710619	45
16	0.346390	0.938091	1.065995	2.886920	0.369250	2.708192	44
17	0.346663	0.937990	1.066110	2.884647	0.369581	2.705770	43
18	0.346936	0.937889	1.066224	2.882379	0.369911	2.703351	42
19	0.347209	0.937788	1.066339	2.880114	0.370242	2.700936	41
20	0.347481	0.937687	1.066454	2.877853	0.370573	2.698525	40
21	0.347754	0.937586	1.066569	2.875596	0.370904	2.696118	39
22	0.348026	0.937485	1.066684	2.873343	0.371235	2.693715	38
23	0.348299	0.937383	1.066799	2.871093	0.371566	2.691315	37
24	0.348572	0.937282	1.066915	2.868847	0.371897	2.688919	36
25	0.348845	0.937181	1.067030	2.866605	0.372228	2.686527	35
26	0.349117	0 937079	1.067146	2.864367	0.372559	2.684138	34
27	0.349390	0.936977	1.067262	2.862132	0.372890	2.681754	33
28	0.349662	0.936876	1.067377	2.859902	0.373222	2.679373	32
29	0 349935	0.936774	1.067493	2.857674	0.373553	2.676995	31
30	0.350207	0.936672	1.067609	2.855451	0.373885	2.674622	30
31	0.350480	0.936570	1.067726	2.853231	0.374216	2.672252	29
32	0.350752	0.936468	1.067842	2.851015	0.374548	2.669885	28
33	0.351025	0.936366	1.067958	2.848803	0.374880	2.667523	27
34	0.351297	0.936264	1.068075	2.846594	0.375212	2.665164	26
35	0.351569	0.936162	1.068191	2.844389	0.375543	2.662809	25
36	0.351842	0.936060	1.068308	2.842188	0.375875	2.660457	24
37	0.352114	0.935957	1.068425	2.839990	0.376207	2.658109	23
38	0.352386	0.935855	1.068542	2.837796	0.376539	2.655765	22
39	0.352658	0.935752	1.068659	2.835605	0.376872	2.653424	21
40	0.352931	0.935650	1.068776	2.833419	0.377204	2.651087	20
41	0.353203	0.935547	1.068894	2.831235	0.377536	2.648753	19
42	0.353475	0.935444	1.069011	2.829056	0.377869	2.646423	18
43	0.353747	0.935341	1.069129	2.826880	0.378201	2.644097	17
44	0.354019	0.935238	1.069246	2.824707	0.378534	2.641774	16
45	0.354291	0.935135	1.069364	2.822538	0.378866	2.639455	15
46	0.354563	0.935032	1.069482	2.820373	0.379199	2.637139	14
47	0.354835	0.934929	1.069600	2.818211	0.379532	2.634827	13
48	0.355107	0.934826	1.069718	2.816053	0.379864	2.632519	12
49	0.355379	0.934722	1.069836	2.813898	0.380197	2.630214	11
50	0.355651	0.934619	1.069955	2.811747	0.380530	2.627912	10
51	0.355923	0.934515	1.070073	2.809600	0.380863	2.625614	9
52	0.356194	0.934412	1.070192	2.807455	0.381196	2.623320	8
53	0.356466	0.934308	1.070311	2.805315	0.381530	2.621029	7
54	0.356738	0.934205	1.070430	2.803178	0.381863	2.618741	6
55	0.357010	0.934101	1.070548	2.801044	0.382196	2.616457	5
56	0.357281	0.933997	1.070668	2.798914	0.382530	2.614177	4
57	0.357553	0.933893	1.070787	2.796787	0.382863	2.611900	3
58	0.357825	0.933789	1.070906	2.794664	0.383197	2.609626	2
59	0.358096	0.933685	1.071025	2.792544	0.383530	2.607356	1
60	0.358368	0.933580	1.071145	2.790428	0.383864	2.605089	0
	Cosines.	Sines.	Cosecants.	Secants.	Cotangents.	Tangents.	69°

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21°	Sines.	Cosines.	Secants.	Cosecants.	Tangents.	Cotangents.	
0′	0.358368	0.933580	1.071145	2.790428	0.383864	2.605089	60′
1	0.358640	0.933476	1.071265	2.788315	0.384198	2.602826	59
2	0.358911	0.933372	1.071384	2.786206	0.384532	2.600566	58
3	0.359183	0.933267	1.071504	2.784100	0.384866	2.598310	57
4	0.359454	0.933163	1.071624	2.781997	0.385200	2.596056	56
5	0.359725	0.933508	1.071745	2.779898	0.385534	2.593807	55
6	0.359997	0.932954	1.071865	2.777802	0.385868	2.591561	54
7	0.360268	0.932849	1.071985	2.775710	0.386202	2.589318	53
8	0.360540	0.932744	1.072106	2.773621	0.386536	2.587078	52
9	0.360811	0.932639	1.072226	2.771536	0.386871	2.584842	51
10	0.361082	0.932534	1.072347	2.769453	0.387205	2.582609	50
11	0.361353	0.932429	1.072468	2.767374	0.387540	2.580380	49
12	0.361625	0.932324	1.072589	2.765299	0.387874	2.578154	48
13	0.361896	0.932219	1.072710	2.763227	0.388209	2.575931	47
14	0.362167	0.932113	1.072831	2.761158	0.388544	2.573712	46
15	0.362438	0.932008	1.072952	2.759092	0.388879	2.571496	45
16	0.362709	0.931902	1.073074	2.757030	0.389214	2.569283	44
17	0.362980	0.931797	1.073195	2.754971	0.389549	2.567074	43
18	0.363251	0.931691	1.073317	2.752916	0.389884	2.564867	42
19	0.363522	0.931586	1.073439	2.750863	0.390219	2.562665	41
20	0.363793	0.931480	1.073561	2.748814	0.390554	2.560465	40
21	0.364064	0.931374	1.073683	2.746769	0.390889	2.558269	39
22	0.364335	0.931268	1.073805	2.744726	0.391225	2.556076	38
23	0.364606	0.931162	1.073927	2.742687	0.391560	2.553886	37
24	0.364877	0.931056	1.074050	2.740651	0.391896	2.551699	36
25	0.365148	0.930950	1.074172	2.738619	0.392231	2.549516	35
26	0.365418	0.930843	1.074295	2.736589	0.392567	2.547336	34
27	0.365689	0.930737	1.074417	2.734563	0.392903	2.545159	33
28	0.365960	0.930631	1.074540	2.732540	0.393239	2.542986	32
29	0.366231	0.930524	1.074663	2.730520	0.393575	2.540815	31
30	0.366501	0.930418	1.074786	2.728504	0.393911	2.538648	30
31	0.366772	0.930311	1.074910	2.726491	0.394247	2.536484	29
32	0.367043	0.930204	1.075033	2.724480	0.394583	2.534323	28
33	0.367313	0.930097	1.075156	2.722474	0.394919	2.532166	27
34	0.367584	0.929995	1.075280	2.720469	0.395255	2.530011	26
35	0.367854	0.929884	1.075404	2.718469	0.395592	2.527860	25
36	0.368125	0.929777	1.075527	2.716472	0.395928	2.525712	24
37	0.368395	0.929669	1.075651	2.714478	0.396268	2.523567	23
38	0.368665	0.929562	1.075775	2.712487	0.396601	2.521425	22
39	0.368936	0.929455	1.075900	2.710499	0.396938	2.519286	21
40	0.369206	0.929348	1.076024	2.708514	0.397275	2.517151	20
41	0.369477	0.929240	1.076148	2.706532	0.397611	2.515018	19
42	0.369747	0.929133	1.076273	2.704554	0.397948	2.512889	18
43	0.370017	0.929025	1.076397	2.702578	0.398285	2.510763	17
44	0.370287	0.928917	1.076522	2.700606	0.398622	2.508640	16
45	0.370557	0.928810	1.076647	2.698637	0.398960	2.506520	15
46	0.370828	0.928702	1.076772	2.696671	0.399297	2.504403	14
47	0.371098	0.928594	1.076897	2.694708	0.399634	2.502289	13
48	0.371368	0.928486	1.077022	2.692748	0.399972	2.500178	12
49	0.371638	0.928379	1.077148	2.690791	0.400309	2.498071	11
50	0.371908	0.928270	1.077273	2.688837	0.400647	2.495966	10
51	0.372178	0.928161	1.077399	2.686887	0.400984	2.493865	9
52	0.372448	0.928053	1.077525	2.684939	0.401322	2.491766	8
53	0.372718	0.927945	1.077650	2.682995	0.401660	2.489671	7
54	0.372988	0.927836	1.077776	2.681053	0.401997	2.487578	6
55	0.373258	0.927728	1.077903	2.679115	0.402335	2.485489	5
56	0.373528	0.927619	1.078029	2.677179	0.402673	2.483402	4
57	0.373797	0.927510	1.078155	2.675247	0.403012	2.481319	3
58	0.374067	0.927402	1.078282	2.673317	0.403350	2.479239	2
59	0.374337	0.927293	1.078408	2.671391	0.403688	2.477161	1
60	0.374607	0.927184	1.078535	2.669467	0.404026	2.475087	0
	Cosines.	Sines.	Cosecants.	Secants.	Cotangents.	Tangents.	68°

22°	Sines.	Cosines.	Secants.	Cosecants.	Tangents.	Cotangents.	
0′	0.374607	0.927184	1.078535	2.669467	0.404026	2.475087	60′
1	0.374876	0.927075	1.078662	2.667547	0.404365	2.473016	59
2	0.375146	0.926966	1.078789	2.665629	0.404703	2.470947	58
3	0.375416	0.926857	1.078916	2.663715	0.405042	2.468882	57
4	0.375685	0.926747	1.079043	2.661803	0.405380	2.466819	56
5	0.375955	0.926638	1.079170	2.659895	0.405719	2.464760	55
6	0.376224	0.926529	1.079298	2.657989	0.406058	2.462703	54
7	0.376494	0.926419	1.079425	2.656087	0.406397	2.460649	53
8	0.376763	0.926310	1.079553	2.654187	0.406736	2.458599	52
9	0.377032	0.926200	1.079681	2.652290	0.407075	2.456551	51
10	0.377302	0.926090	1.079808	2.650396	0.407414	2.454506	50
11	0.377571	0.925981	1.079936	2.648505	0.407753	2.452464	49
12	0.377841	0.925871	1.080065	2.646617	0.408092	2.450425	48
13	0.378110	0.925761	1.080193	2.644732	0.408432	2.448389	47
14	0.378379	0.925651	1.080321	2.642850	0.408771	2.446356	46
15	0.378649	0.925541	1.080450	2.640971	0.409111	2.444326	45
16	0.378918	0.925430	1.080578	2.639095	0.409450	2.442298	44
17	0.379187	0.925320	1.080707	2.637221	0.409790	2.440274	43
18	0.379456	0.925210	1.080836	2.635351	0.410130	2.438252	42
19	0.379725	0.925099	1.080965	2.633483	0.410470	2.436233	41
20	0.379994	0.924989	1.081094	2.631618	0.410810	2.434217	40
21	0.380263	0.924878	1.081223	2.629756	0.411150	2.432204	39
22	0.380532	0.924768	1.081353	2.627897	0.411490	2.430194	38
23	0.380801	0.924657	1.081482	2.626041	0.411830	2.428186	37
24	0.381070	0.924546	1.081612	2.624187	0.412170	2.426182	36
25	0.381339	0.924435	1.081742	2.622337	0.412511	2.424180	35
26	0.381608	0.924324	1.081872	2.620489	0.412851	2.422181	34
27	0.381877	0.924213	1.082002	2.618644	0.413192	2.420185	33
28	0.382146	0.924102	1.082132	2.616802	0.413532	2.418192	32
29	0.382415	0.923991	1.082262	2.614962	0.413873	2.416201	31
30	0.382683	0.923880	1.082392	2.613126	0.414214	2.414214	30
31	0.382952	0.923768	1.082523	2.611292	0.414554	2.412229	29
32	0.383221	0.923657	1.082653	2.609461	0.414895	2.410247	28
33	0.383490	0.923545	1.082784	2.607633	0.415236	2.408267	27
34	0.383758	0.923434	1.082915	2.605808	0.415577	2.406291	26
35	0.384027	0.923322	1.083046	2.603985	0.415919	2.404317	25
36	0.384295	0.923210	1.083177	2.602165	0.416260	2.402346	24
37	0.384564	0.923098	1.083308	2.600348	0.416601	2.400377	23
38	0.384832	0.922987	1.083440	2.598534	0.416943	2.398412	22
39	0.385101	0.922875	1.083571	2.596723	0.417284	2.396449	21
40	0.385369	0.922762	1.083703	2.594914	0.417626	2.394489	20
41	0.385638	0.922650	1.083834	2.593108	0.417967	2.392532	19
42	0.385906	0.922538	1.083966	2.591304	0.418309	2.390577	18
43	0.386174	0.922426	1.084098	2.589504	0.418651	2.388625	17
44	0.386443	0.922313	1.084230	2.587706	0.418993	2.386676	16
45	0.386711	0.922201	1.084362	2.585911	0.419335	2.384729	15
46	0.386979	0.922088	1.084495	2.584118	0.419677	2.382786	14
47	0.387247	0.921976	1.084627	2.582328	0.420019	2.380844	13
48	0.387516	0.921863	1.084760	2.580541	0.420361	2.378906	12
49	0.387784	0.921750	1.084892	2.578757	0.420704	2.376970	11
50	0.388052	0.921638	1.085025	2.576975	0.421046	2.375037	10
51	0.388320	0.921525	1.085158	2.575196	0.421389	2.373107	9
52	0.388589	0.921412	1.085291	2.573420	0.421731	2.371179	8
53	0.388856	0.921299	1.085425	2.571646	0.422074	2.369254	7
54	0.389124	0.921185	1.085558	2.569875	0.422417	2.367332	6
55	0.389392	0.921072	1.085691	2.568107	0.422759	2.365412	5
56	0.389660	0.920959	1.085825	2.566341	0.423102	2.363495	4
57	0.389928	0.920846	1.085959	2.564578	0.423445	2.361580	3
58	0.390196	0.920732	1.086092	2.562818	0.423788	2.359668	2
59	0.390463	0.920619	1.086226	2.561060	0.424132	2.357759	1
60	0.390731	0.920505	1.086360	2.559305	0.424475	2.355852	0
	Cosines.	Sines.	Cosecants.	Secants.	Cotangents.	Tangents.	67°

23°	Sines.	Cosines.	Secants.	Cosecants.	Tangents.	Cotangents.	
0′	0.390731	0.920505	1.086360	2.559305	0.424474	2.355852	60′
1	0.390999	0.920391	1.086495	2.557552	0.424818	2.353948	59
2	0.391267	0.920277	1.086629	2.555802	0.425162	2.352047	58
3	0.391534	0.920164	1.086763	2.554055	0.425505	2.350148	57
4	0.391801	0.920050	1.086898	2.552310	0.425849	2.348252	56
5	0.392070	0.919936	1.087033	2.550568	0.426192	2.346358	55
6	0.392337	0.919822	1.087168	2.548828	0.426536	2.344467	54
7	0.392604	0.919707	1.087302	2.547092	0.426880	2.342579	53
8	0.392872	0.919593	1.087438	2.545357	0.427224	2.340693	52
9	0.393140	0.919479	1.087573	2.543625	0.427568	2.338810	51
10	0.393407	0.919364	1.087708	2.541896	0.427912	2.336929	50
11	0.393675	0.919250	1.087844	2.540169	0.428256	2.335051	49
12	0.393942	0.919135	1.087979	2.538445	0.428601	2.333175	48
13	0.394209	0.919021	1.088115	2.536724	0.428945	2.331302	47
14	0.394477	0.918906	1.088251	2.535005	0.429289	2.329431	46
15	0.394744	0.918791	1.088387	2.533288	0.429634	2.327563	45
16	0.395011	0.918676	1.088523	2.531574	0.429979	2.325698	44
17	0.395278	0.918561	1.088659	2.529863	0.430323	2.323835	43
18	0.395546	0.918446	1.088795	2.528154	0.430668	2.321974	42
19	0.395813	0.918331	1.088932	2.526448	0.431013	2.320116	41
20	0.396080	0.918216	1.089068	2.524744	0.431358	2.318261	40
21	0.396347	0.918101	1.089205	2.523043	0.431703	2.316408	39
22	0.396614	0.917986	1.089342	2.521344	0.432048	2.314557	38
23	0.396881	0.917870	1.089479	2.519648	0.432393	2.312709	37
24	0.397148	0.917755	1.089616	2.517954	0.432739	2.310846	36
25	0.397415	0.917639	1.089753	2.516262	0.433084	2.309021	35
26	0.397682	0.917523	1.089890	2.514574	0.433430	2.307180	34
27	0.397949	0.917408	1.090028	2.512887	0.433775	2.305342	33
28	0.398216	0.917292	1.090166	2.511203	0.434121	2.303506	32
29	0.398482	0.917176	1.090303	2.509522	0.434467	2.301673	31
30	0.398749	0.917060	1.090441	2.507843	0.434812	2.299843	30
31	0.399016	0.916944	1.090579	2.506166	0.435158	2.298014	29
32	0.399286	0.916828	1.090717	2.504492	0.435504	2.296189	28
33	0.399549	0.916712	1.090855	2.502821	0.435850	2.294365	27
34	0.399816	0.916596	1.090994	2.501152	0.436197	2.292544	26
35	0.400083	0.916479	1.091132	2.499485	0.436543	2.290726	25
36	0.400349	0.916363	1.091271	2.497820	0.436889	2.288910	24
37	0.400616	0.916246	1.091410	2.496159	0.437236	2.287096	23
38	0.400882	0.916130	1.091549	2.494499	0.437582	2.285285	22
39	0.401149	0.916013	1.091688	2.492842	0.437929	2.283476	21
40	0.401415	0.915896	1.091827	2.491187	0.438276	2.281669	20
41	0.401681	0.915780	1.091966	2.489535	0.438622	2.279865	19
42	0.401948	0.915663	1.092105	2.487885	0.438969	2.278064	18
43	0.402214	0.915546	1.092245	2.486238	0.439316	2.276264	17
44	0.402480	0.915429	1.092385	2.484593	0.439663	2.274467	16
45	0.402747	0.915312	1.092524	2.482950	0.440011	2.272673	15
46	0.403013	0.915194	1.092664	2.481310	0.440358	2.270881	14
47	0.403279	0.915077	1.092804	2.479672	0.440705	2.269091	13
48	0.403545	0.914960	1.092944	2.478037	0.441053	2.267304	12
49	0.403811	0.914842	1.093085	2.476406	0.441400	2.265518	11
50	0.404078	0.914725	1.093225	2.474773	0.441748	2.263736	10
51	0.404344	0.914607	1.093366	2.473144	0.442095	2.261955	9
52	0.404610	0.914490	1.093506	2.471518	0.442443	2.260177	8
53	0.404876	0.914372	1.093647	2.469894	0.442791	2.258402	7
54	0.405142	0.914254	1.093788	2.468273	0.443139	2.256628	6
55	0.405408	0.914136	1.093929	2.466654	0.443487	2.254857	5
56	0.405673	0.914018	1.094070	2.465037	0.443835	2.253089	4
57	0.405939	0.913900	1.094212	2.463423	0.444183	2.251322	3
58	0.406205	0.913782	1.094353	2.461811	0.444532	2.249558	2
59	0.406471	0.913664	1.094495	2.460201	0.444880	2.247796	1
60	0.406737	0.913546	1.094636	2.458593	0.445229	2.246037	0
	Cosines.	Sines.	Cosecants.	Secants.	Cotangents.	Tangents.	66°

24°	Sines.	Cosines.	Secants.	Cosecants.	Tangents.	Cotangents.	
0′	0.406737	0.913546	1 094636	2.458593	0.445229	2.246037	60′
1	0.407002	0.913427	1.094778	2.456988	0.445577	2.244280	59
2	0.407268	0.913309	1.094920	2.455385	0.445926	2.242525	58
3	0.407534	0.913190	1.095062	2.453785	0.446275	2.240772	57
4	0.407799	0.913072	1.095204	2.452187	0.446624	2.239022	56
5	0.408065	0.912953	1.095347	2.450591	0.446973	2.237274	55
6	0.408331	0.912834	1.095489	2.448997	0.447322	2.235528	54
7	0.408596	0.912715	1.095632	2.447405	0.447671	2.233785	53
8	0.408862	0.912597	1.095775	2.445816	0.448020	2.232043	52
9	0.409127	0.912478	1.095917	2.444229	0.448369	2.230304	51
10	0.409392	0.912358	1.096060	2.442645	0.448719	2.228568	50
11	0.409658	0.912239	1.096204	2.441062	0.449068	2.226833	49
12	0.409923	0.912120	1.096347	2.439482	0.449418	2.225108	48
13	0.410188	0.912001	1.096490	2.437905	0.449768	2.223371	47
14	0.410454	0.911882	1.096634	2.436329	0.450117	2.221643	46
15	0.410719	0.911762	1.096777	2.434756	0.450467	2.219918	45
16	0.410984	0.911643	1.096921	2.433184	0.450817	2.218194	44
17	0.411249	0.911523	1.097065	2.431616	0.451167	2·216473	43
18	0.411514	0.911403	1.097209	2.430049	0.451517	2.214755	42
19	0.411780	0.911284	1.097353	2.428484	0.451868	2.213038	41
20	0.412045	0.911164	1.097498	2.426922	0.452218	2.211323	40
21	0.412310	0.911044	1.097642	2.425362	0.452568	2.209611	39
22	0.412575	0.910924	1.097787	2.423804	0.452919	2.207901	38
23	0.412840	0.910804	1.097931	2.422249	0.453269	2.206193	37
24	0.413104	0.910684	1.098076	2.420695	0.453620	2.204488	36
25	0.413369	0.910564	1.098221	2.419144	0.453971	2.202784	35
26	0.413634	0.910443	1.098366	2.417595	0.454322	2.201083	34
27	0 413899	0.910323	1.098511	2.416048	0.454673	2.199384	33
28	0.414164	0.910202	1.098657	2.414504	0.455024	2.197687	32
29	0.414429	0.910082	1.098802	2.412961	0.455375	2.195992	31
30	0.414693	0.909961	1.098948	2.411421	0.455726	2.194300	30
31	0.414958	0.909841	1.099094	2.409883	0.456078	2.192609	29
32	0.415223	0.909720	1.099240	2.408347	0.456429	2.190921	28
33	0.415487	0.909599	1.099386	2.406813	0.456781	2.189235	27
34	0.415752	0.909478	1.099532	2.405282	0.457132	2.187551	26
35	0.416016	0.909357	1.099678	2.403752	0.457484	2.185869	25
36	0.416281	0.909236	1.099824	2.402225	0.457836	2.184189	24
37	0.416545	0.909115	1.099971	2.400700	0.458188	2.182512	23
38	0.416810	0.908994	1.100118	2.399176	0.458540	2.180836	22
39	0.417074	0.908873	1.100264	2.397656	0.458892	2.179163	21
40	0.417339	0.908751	1.100411	2.396137	0.459244	2.177492	20
41	0.417603	0.908630	1.100558	2.394620	0.459596	2.175823	19
42	0.417867	0.908508	1.100706	2.393106	0.459949	2.174156	18
43	0.418131	0.908387	1.100853	2.391593	0.460301	2.172491	17
44	0.418396	0.908265	1.101000	2.390083	0.460654	2.170828	16
45	0.418660	0.908143	1.101148	2.388575	0.461006	2.169168	15
46	0.418924	0.908021	1.101296	2.387069	0.461359	2.167509	14
47	0.419188	0.907900	1.101444	2.385565	0.461712	2.165853	13
48	0.419452	0.907778	1.101592	2.384063	0.462065	2 164198	12
49	0.419716	0.907655	1.101740	2.382563	0.462418	2.162546	11
50	0.419980	0.907533	1.101888	2.381065	0.462771	2.160896	10
51	0.420244	0.907411	1.102036	2.379569	0.463124	2.159248	9
52	0.420508	0.907289	1.102185	2.378076	0.463478	2.157602	8
53	0.420772	0.907167	1.102334	2.376584	0.463831	2.155958	7
54	0.421036	0.907044	1.102482	2.375095	0.464185	2.154316	6
55	0.421300	0.906922	1.102631	2.373608	0.464538	2.152676	5
56	0.421563	0.906799	1.102780	2.372122	0.464892	2.151038	4
57	0.421827	0.906676	1.102930	2.370639	0.465246	2.149402	3
58	0.422091	0.906554	1.103079	2.369158	0.465600	2.147768	2
59	0.422355	0.906431	1.103228	2.367679	0.465954	2.446137	1
60	0.422618	0.906308	1.103378	2.366202	0.466308	2.144507	0
	Cosines.	Sines.	Cosecants.	Secants.	Cotangents.	Tangents.	65°

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25°	Sines.	Cosines.	Secants.	Cosecants.	Tangents.	Cotangents.	
0′	0.422618	0.906308	1.103378	2.366202	0.466308	2.144507	60′
1	0.422882	0.906185	1.103528	2.364727	0.466662	2.142879	59
2	0.423146	0.906062	1.103678	2.363254	0.467016	2.141254	58
3	0.423409	0.905939	1.103828	2.361783	0.467371	2.139630	57
4	0.423673	0.905815	1.103978	2.360314	0.467725	2.138009	56
5	0.423936	0.905692	1.104128	2.358847	0.468080	2.136389	55
6	0.424199	0.905569	1.104278	2.357382	0.468434	2.134771	54
7	0.424463	0.905445	1.104429	2.355919	0.468789	2.133156	53
8	0.424726	0.905322	1.104580	2.354458	0.469144	2.131542	52
9	0.424990	0.905198	1.104730	2.352999	0.469499	2.129931	51
10	0.425253	0.905075	1.104881	2.351542	0.469854	2.128321	50
11	0.425516	0.904951	1.105032	2.350088	0.470209	2.126714	49
12	0.425779	0.904827	1.105184	2.348635	0.470564	2.125108	48
13	0.426043	0.904703	1.105335	2.347184	0.470920	2.123505	47
14	0.426306	0.904579	1.105486	2.345735	0.471275	2.121903	46
15	0.426569	0.904455	1.105638	2.344288	0.471631	2.120303	45
16	0.426832	0.904331	1.105790	2.342843	0.471986	2.118706	44
17	0.427095	0.904207	1.105942	2.341400	0.472342	2.117110	43
18	0.427358	0.904083	1.106094	2.339959	0.472698	2.115516	42
19	0.427621	0.903958	1.106246	2.338520	0.473054	2.113925	41
20	0.427884	0.903834	1.106398	2.337083	0.473410	2.112335	40
21	0.428147	0.903709	1.106551	2.335648	0.473766	2.110747	39
22	0.428410	0.903585	1.106703	2.334215	0.474122	2.109161	38
23	0.428672	0.903460	1.106856	2.332784	0.474479	2.107577	37
24	0.428935	0.903335	1.107009	2.331355	0.474835	2.105995	36
25	0.429198	0.903211	1.107162	2.329928	0.475191	2.104415	35
26	0.429461	0.903086	1.107315	2.328502	0.475548	2.102837	34
27	0.429723	0.902961	1.107468	2.327079	0·475905	2.101261	33
28	0.429986	0.902836	1.107621	2.325658	0.476262	2.099686	32
29	0.430249	0.902711	1.107775	2.324238	0.476619	2.098114	31
30	0.430511	0.902585	1.107929	2.322821	0.476976	2.096544	30
31	0.430774	0.902460	1.108082	2.321405	0.477333	2.094975	29
32	0.431036	0.902335	1.108236	2.319991	0.477690	2.093409	28
33	0.431299	0.902209	1.108390	2.318579	0.478047	2.091844	27
34	0.431561	0.902084	1.108545	2.317170	0.478405	2.090281	26
35	0.431823	0.901958	1.108699	2.315762	0.478762	2.088720	25
36	0.432086	0.901833	1.108853	2.314355	0.479120	2.087161	24
37	0.432348	0.901707	1.109008	2.312951	0.479477	2.085604	23
38	0.432610	0.901581	1.109163	2.311549	0.479835	2.084049	22
39	0.432873	0.901455	1.109318	2.310149	0.480193	2.082495	21
40	0.433135	0.901329	1.109473	2.308750	0.480551	2.080944	20
41	0.433397	0.901203	1.109628	2.307354	0.480909	2.079394	19
42	0.433659	0.901077	1.109783	2.305959	0.481268	2.077847	18
43	0.433921	0.900951	1.109939	2.304566	0.481626	2.076301	17
44	0.434183	0.900825	1.110094	2.303175	0.481984	2.074755	16
45	0.434445	0.900698	1.110250	2.301786	0.482343	2.073215	15
46	0.434707	0.900572	1.110406	2.300399	0.482701	2.071674	14
47	0.434969	0.900445	1.110562	2.299013	0.483060	2.070136	13
48	0.435231	0.900319	1.110718	2.297630	0.483419	2.068599	12
49	0.435493	0.900192	1.110874	2.296248	0.483778	2.067065	11
50	0.435755	0.900065	1.111030	2.294869	0.484137	2.065532	10
51	0.436017	0.899939	1.111187	2.293491	0.484496	2.064001	9
52	0.436278	0.899812	1.111344	2.292115	0.484855	2.062472	8
53	0.436540	0.899685	1.111500	2.290740	0.485215	2.060944	7
54	0.436802	0.899558	1.111657	2.289368	0.485574	2.059419	6
55	0.437063	0.899431	1.111814	2.287997	0.485933	2.057895	5
56	0.437325	0.899304	1.111972	2.286629	0.486293	2.056373	4
57	0.437587	0.899176	1.112129	2.285262	0.486653	2.054853	3
58	0.437848	0.899049	1.112287	2.283897	0.487013	2.053335	2
59	0.438110	0.898922	1.112444	2.282534	0.487373	2.051819	1
60	0.438371	0.898794	1.112602	2.281172	0.487733	2.050304	0
	Cosines.	Sines.	Cosecants.	Secants.	Cotangents.	Tangents.	64°

26°	Sines.	Cosines.	Secants.	Cosecants.	Tangents.	Cotangents.	
0′	0.438371	0.898794	1.112602	2.281172	0.487733	2.050304	60′
1	0.438633	0.898667	1.112760	2.279812	0.488093	2.048791	59
2	0.438894	0.898539	1.112918	2.278455	0.488453	2.047280	58
3	0.439155	0.898411	1.113076	2.277099	0.488813	2.045771	57
4	0.439417	0.898283	1.113235	2.275745	0.489174	2.044263	56
5	0.439678	0.898156	1.113393	2.274392	0.489534	2.042758	55
6	0.439939	0.898028	1.113552	2.273042	0.489895	2.041254	54
7	0.440200	0.897900	1.113710	2.271693	0.490256	2.039752	53
8	0.440462	0.897772	1.113869	2.270346	0.490617	2.038252	52
9	0.440723	0.897643	1.114028	2.269001	0.490978	2.036753	51
10	0.440984	0.897515	1.114187	2.267657	0.491339	2.035257	50
11	0.441245	0.897387	1.114347	2.266316	0.491700	2.033762	49
12	0.441506	0.897258	1.114506	2.264976	0.492061	2.032268	48
13	0.441767	0.897130	1.114666	2.263638	0.492422	2.030777	47
14	0.442028	0.897001	1.114826	2.262301	0.492784	2.029287	46
15	0.442289	0.896873	1.114985	2.260967	0.493145	2.027799	45
16	0.442550	0.896744	1.115145	2.259634	0.493507	2.026313	44
17	0.442810	0.896615	1.115306	2.258303	0.493869	2.024829	43
18	0.443071	0.896486	1.115466	2.256974	0.494231	2.023346	42
19	0.443332	0.896358	1.115626	2.255646	0.494593	2.021865	41
20	0.443592	0.896229	1.115787	2.254320	0.494955	2.020386	40
21	0.443853	0.896099	1.115948	2.252996	0.495317	2.018909	39
22	0.444114	0.895970	1.116108	2.251674	0.495679	2.017433	38
23	0.444375	0.895841	1.116269	2.250354	0.496042	2.015959	37
24	0.444635	0.895712	1.116431	2.249035	0.496404	2.014487	36
25	0.444896	0.895582	1.116592	2.247718	0.496767	2.013016	35
26	0.445156	0.895453	1.116753	2.246403	0.497130	2.011548	34
27	0.445417	0.895323	1.116915	2.245089	0.497493	2.010081	33
28	0.445677	0.895194	1.117077	2.243777	0.497855	2.008615	32
29	0.445938	0.895064	1.117238	2.242467	0.498219	2.007152	31
30	0.446198	0.894934	1.117400	2.241159	0.498582	2.005690	30
31	0.446458	0.894805	1.117563	2.239852	0.498945	2.004230	29
32	0.446718	0.894675	1.117725	2.238547	0.499308	2 002771	28
33	0.446979	0.894545	1.117887	2.237244	0.499672	2.001314	27
34	0.447239	0.894415	1.118050	2.235942	0.500035	1.999859	26
35	0.447499	0.894284	1.118212	2.234642	0.500399	1.998406	25
36	0.447759	0.894154	1.118375	2.233344	0.500763	1.996954	24
37	0.448019	0.894025	1.118538	2.232047	0.501127	1.995504	23
38	0.448279	0.893894	1.118701	2 230753	0.501491	1.994055	22
39	0.448539	0.893763	1.118865	2.229460	0.501855	1.992609	21
40	0.448799	0.893633	1.119028	2.228168	0.502219	1.991164	20
41	0.449059	0.893502	1.119192	2.226878	0.502583	1.989720	19
42	0.449319	0.893371	1.119355	2.225590	0.502948	1.988279	18
43	0.449579	0.893241	1.119519	2.224304	0.503312	1.986839	17
44	0.449839	0.893110	1.119683	2.223019	0.503677	1.985400	16
45	0.450098	0.892979	1.119847	2.221736	0.504042	1.983964	15
46	0.450358	0.892848	1.120012	2.220455	0.504406	1.982529	14
47	0.450618	0.892717	1.120176	2.219175	0.504771	1.981095	13
48	0.450878	0.892586	1.120341	2.217897	0.505136	1.979664	12
49	0.451137	0.892455	1.120505	2.216621	0.505502	1.978233	11
50	0.451397	0.892323	1.120670	2.215346	0.505867	1.976805	10
51	0.451656	0.892192	1.120835	2.214073	0.506232	1.975378	9
52	0.451916	0.892061	1.121000	2.212802	0.506598	1.973953	8
53	0.452175	0.891929	1.121165	2.211532	0.506963	1.972530	7
54	0.452435	0.891798	1.121331	2.210262	0.507329	1.971108	6
55	0.452694	0.891666	1.121496	2.208997	0.507695	1.969687	5
56	0.452954	0.891534	1.121662	2.207732	0.508061	1.968269	4
57	0.453213	0.891402	1.121828	2.206469	0.508427	1.966852	3
58	0.453472	0.891271	1.121994	2.205208	0.508793	1.965436	2
59	0.453731	0.891139	1.122160	2.203948	0.509159	1.964023	1
60	0.453991	0.891007	1.122326	2.202689	0.509225	1.962611	0
	Cosines.	Sines.	Cosecants.	Secants.	Cotangents.	Tangents.	63°

27°	Sines.	Cosines.	Secants.	Cosecants.	Tangents.	Cotangents.	
0′	0.453991	0.891007	1.122326	2.202689	0.509525	1.962611	60′
1	0.454249	0.890874	1.122493	2.201433	0.509892	1.961200	59
2	0.454509	0.890742	1.122659	2.200178	0.510259	1.959791	58
3	0.454767	0.890610	1.122826	2.198924	0.510625	1,958384	57
4	0.455027	0.890478	1.122993	2.197672	0.510992	1.956978	56
5	0.455286	0.890345	1.123160	2.196422	0.511359	1.955574	55
6	0.455545	0.890213	1.123327	2.195173	0.511726	1.954171	54
7	0.455804	0.890080	1.123494	2.193926	0.512093	1.952770	53
8	0.456063	0.889948	1.123662	2.192681	0.512460	1.951371	52
9	0.456323	0.889815	1.123829	2.191437	0.512828	1.949973	51
10	0.456580	0.889682	1.123997	2.190195	0.513195	1.948577	50
11	0.456839	0.889549	1.124165	2.188954	0.513563	1.947183	49
12	0.457098	0.889416	1.124333	2.187715	0.513930	1.945790	48
13	0.457356	0.889283	1.124501	2.186478	0.514298	1.944398	47
14	0.457615	0.889150	1.124669	2.185242	0.514666	1.943008	46
15	0.457874	0.889017	1.124838	2.184007	0.515034	1.941620	45
16	0.458133	0.888884	1.125006	2.182775	0.515402	1.940233	44
17	0.458391	0.888751	1.125175	2.181544	0.515770	1.938848	43
18	0.458650	0.888617	1.125344	2.180314	0.516139	1.937465	42
19	0.458908	0.888484	1.125113	2.179086	0.516507	1.936083	41
20	0.459167	0.888350	1.125682	2.177860	0.516876	1.934702	40
21	0.459425	0.888217	1.125851	2.176635	0.517244	1.933323	39
22	0.459683	0.888083	1.126021	2.175411	0.517613	1.931948	38
23	0.459942	0.887949	1.126191	2.174190	0.517982	1.930570	37
24	0.460200	0.887815	1.126360	2.172969	0.518351	1.929196	36
25	0.460458	0.887682	1.126530	2.171751	0.518720	1.927823	35
26	0.460716	0.887548	1.126700	2.170734	0.519089	1.926451	34
27	0.460974	0.887413	1.126871	2.169318	0.519458	1.925082	33
28	0.461233	0.887279	1.127041	2.168104	0.519828	1.923714	32
29	0.461491	0.887145	1.127211	2.166895	0.520197	1.922347	31
30	0.461749	0.887011	1.127382	2.165681	0.520567	1.920982	30
31	0.462007	0.886877	1.127553	2.164471	0.520937	1.919619	29
32	0.462265	0.886742	1.127724	2.163263	0.521307	1.918256	28
33	0.462523	0.886608	1.127895	2.162057	0.521677	1.916896	27
34	0.462780	0.886473	1.128066	2.160852	0.522047	1.915537	26
35	0.463038	0.886338	1.128237	2.159649	0.522417	1.914180	25
36	0.463296	0.886204	1.128409	2.158447	0.522787	1.912824	24
37	0.463554	0.886069	1.128581	2.157247	0.523158	1.911469	23
38	0.463811	0.885934	1.128752	2.156048	0.523528	1.910116	22
39	0.464069	0.885799	1.128924	2.154851	0.523899	1.908765	21
40	0.464327	0.885664	1.129097	2.153655	0.524270	1.907415	20
41	0.464585	0.885529	1.129269	2.152461	0.524641	1.906066	19
42	0.464842	0.885394	1.129441	2.151268	0.525012	1.904719	18
43	0.465100	0.885258	1.129614	2.150077	0.525383	1.903374	17
44	0.465357	0.885123	1.129786	2.148888	0.525754	1.902030	16
45	0.465615	0.884988	1.129959	2.147699	0.526126	1.900687	15
46	0.465872	0.884852	1.130132	2.146613	0.526497	1.899346	14
47	0.466129	0.884717	1.130306	2.145328	0.526869	1.898007	13
48	0.466387	0.884581	1.130479	2.144144	0.527240	1.896669	12
49	0.466644	0.884445	1.130652	2.142062	0.527612	1.895332	11
50	0.466901	0.884310	1.130826	2.141781	0.527984	1.893997	10
51	0.467158	0.884174	1.131000	2.140602	0.528356	1.892664	9
52	0.467416	0.884038	1.131174	2.139424	0.528728	1.891331	8
53	0.467672	0.883902	1.131348	2.138248	0.529100	1.890001	7
54	0.467930	0.883766	1.131522	2.137073	0.529473	1.888671	6
55	0.468187	0.883630	1.131696	2.135899	0.529845	1.887344	5
56	0.468444	0.883493	1.131871	2.134727	0.530218	1.886017	4
57	0.468701	0.883357	1.132045	2.133557	0.530591	1.884692	3
58	0.468958	0.883221	1.132220	2.132388	0.530963	1.883369	2
59	0.469215	0.883084	1.132395	2.131221	0.531336	1 882047	1
60	0.469472	0.882947	1.132570	2.130055	0.531709	1.880727	0
	Cosines.	Sines.	Cosecants.	Secants.	Cotangents.	Tangents.	62°

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28°	Sines.	Cosines.	Secants.	Cosecants.	Tangents.	Cotangents.	
0′	0.469472	0.882947	1.132570	2.130055	0.531709	1.880727	60′
1	0.469728	0.882811	1.132745	2.128890	0.532083	1.879407	59
2	0.469985	0.882674	1.132921	2.127726	0.532456	1.878090	58
3	0.470242	0.882538	1.133096	2.126565	0.532829	1.876774	57
4	0.470499	0.882401	1.133272	2.125405	0.533203	1.875459	56
5	0.470755	0.882264	1.133448	2.124246	0.533577	1.874146	55
6	0.471012	0.882127	1.133624	2.123089	0.533950	1.872834	54
7	0.471269	0.881990	1.133800	2.121933	0.534324	1.871523	53
8	0.471525	0.881853	1.133976	2.120778	0.534698	1.870214	52
9	0.471782	0.881716	1.134153	2.119625	0.535072	1.868907	51
10	0.472038	0.881578	1.134329	2.118474	0.535447	1.867600	50
11	0.472294	0.881441	1.134506	2.117324	0.535821	1.866296	49
12	0.472551	0.881304	1.134683	2.116175	0.536195	1.864992	48
13	0.472807	0.881166	1.134860	2.115027	0.536570	1.863690	47
14	0.473063	0.881028	1.135037	2.113882	0.536944	1.862390	46
15	0.473320	0.880891	1.135215	2.112737	0.537319	1.861091	45
16	0.473576	0.880753	1.135392	2.111594	0.537694	1.859793	44
17	0.473832	0.880615	1.135570	2.110452	0.538069	1.858497	43
18	0.474088	0.880477	1.135748	2.109312	0.538444	1.857202	42
19	0.474344	0.880339	1.135926	2.108173	0.538820	1.855908	41
20	0.474600	0.880201	1.136104	2.107036	0.539195	1.854616	40
21	0.474856	0.880063	1.136282	2.105900	0.539571	1.853325	39
22	0.475112	0.879925	1.136460	2.104765	0.539546	1.852856	38
23	0.475368	0.879787	1.136639	2.103632	0·540322	1.850748	37
24	0.475624	0.879649	1.136818	2.102500	0.540698	1.849461	36
25	0.475880	0.879518	1.136997	2.101370	0.541074	1.848176	35
26	0.476136	0.879372	1.137176	2.100241	0.541450	1.846892	34
27	0.476392	0.879233	1.137355	2.099113	0.541826	1.845610	33
28	0.476647	0.879095	1.137534	2.097987	0.542203	1.844329	32
29	0.476901	0.878956	1.137714	2.096862	0.542579	1.843049	31
30	0.477159	0.878817	1.137893	2.095739	0.542956	1.841771	30
31	0.477414	0.878678	1.138073	2.094616	0.543332	1.840494	29
32	0.477670	0.878539	1.138253	2.093496	0.543709	1.839218	28
33	0.477926	0.878400	1.138434	2.092376	0.544086	1.837944	27
34	0.478181	0.878261	1.138613	2.091258	0.544463	1.836671	26
35	0.478436	0.878122	1.138794	2.090142	0.544840	1.835400	25
36	0.478692	0.877983	1.138974	2.089027	0.545218	1.834130	24
37	0.478947	0.877844	1.139155	2.087913	0.545595	1.832861	23
38	0.479202	0.877704	1.139336	2.086800	0.545973	1.831594	22
39	0.479458	0.877565	1.139517	2.085689	0.546350	1.830328	21
40	0.479713	0.877425	1.139698	2.084579	0.546728	1.829063	20
41	0.479968	0.877286	1.139879	2.083471	0.547106	1.827799	19
42	0.480224	0.877146	1.140061	2.082364	0.547484	1.826537	18
43	0.480479	0.877006	1.140243	2.081258	0.547862	1.825277	17
44	0.480734	0.876867	1.140424	2.080154	0.548240	1.824017	16
45	0.480989	0.876727	1.140606	2.079051	0.548619	1.822759	15
46	0.481244	0.876587	1.140788	2.077949	0.548997	1.821503	14
47	0.481499	0.876447	1.140971	2.076849	0.549376	1.820247	13
48	0.481754	0.876307	1.141153	2.075750	0.549755	1.818993	12
49	0.482009	0.876167	1.141336	2.074652	0.550134	1.817741	11
50	0.482263	0.876026	1.141518	2.073556	0.550513	1.816489	10
51	0.482518	0.875886	1.141701	2.072461	0.550892	1.815239	9
52	0.482773	0.875746	1.141884	2.071367	0.551271	1.813990	8
53	0.483028	0.875605	1.142067	2.070275	0.551650	1.812743	7
54	0.483282	0.875465	1.142251	2.069184	0.552030	1.811496	6
55	0.483537	0.875324	1.142434	2.068094	0.552409	1.810252	5
56	0.483792	0.875183	1.142618	2.067006	0.552789	1.809009	4
57	0.484046	0.875043	1.142802	2.065919	0.553169	1.807766	3
58	0.484300	0.874902	1.142986	2.064833	0.553549	1.806526	2
59	0.484555	0.874761	1.143170	2.063748	0.553929	1.805286	1
60	0.484810	0.874620	1.143354	2.062665	0.554309	1.804048	0
	Cosines.	Sines.	Cosecants.	Secants.	Cotangents.	Tangents.	61°

29°	Sines.	Cosines.	Secants.	Cosecants.	Tangents.	Cotangents.	
0′	0.484810	0.874620	1.143354	2.062665	0.554309	1.804048	60′
1	0.485064	0.874479	1.143539	2.061584	0.554689	1.802811	59
2	0.485318	0.874338	1.143723	2.060503	0.555070	1·801575	58
3	0.485573	0.874196	1.143908	2.059424	0.555450	1.800341	57
4	0.485827	0.874055	1.144093	2.058346	0.555831	1.799108	56
5	0.486081	0.873914	1.144278	2.057270	0.556212	1.797876	55
6	0.486335	0.873772	1.144463	2.056194	0.556592	1.796645	54
7	0.486590	0.873631	1.144648	2.055120	0.556974	1.795416	53
8	0.486894	0.873489	1.144834	2.054048	0.557355	1.794188	52
9	0.487098	0.873348	1.145020	2.052976	0.557736	1.792962	51
10	0.487352	0.873206	1.145206	2.051906	0.558118	1.791736	50
11	0.487606	0.873064	1.145392	2.050837	0.558499	1.790512	49
12	0.487860	0.872922	1.145578	2.049770	0.558881	1.789289	48
13	0.488114	0.872780	1.145764	2.048704	0.559263	1.788068	47
14	0.488367	0.872638	1.145950	2.047639	0.559645	1.786848	46
15	0.488621	0.872496	1.146137	2.046575	0.560027	1.785629	45
16	0.488875	0.872354	1.146324	2.045513	0.560409	1.784411	44
17	0.489129	0.872212	1.146511	2.044452	0 560791	1.783194	43
18	0.489383	0.872069	1.146698	2.043392	0.561174	1.781979	42
19	0.489636	0.871927	1.146885	2.042333	0.561556	1.780765	41
20	0.489890	0.871784	1.147073	2.041276	0.561939	1.779552	40
21	0.490143	0.871642	1.147260	2.040220	0.562322	1.778341	39
22	0.490397	0.871499	1.147448	2.039165	0.562705	1.777131	38
23	0.490650	0.871357	1.147636	2.038111	0.563088	1.775922	37
24	0.490904	0.871214	1.147824	2.037059	0.563471	1.774716	36
25	0.491157	0.871071	1.148012	2.036008	0.563854	1.773508	35
26	0.491411	0.870928	1.148201	2.034959	0.564238	1.772302	34
27	0.491664	0.870785	1.148389	2.033910	0.564621	1.771099	33
28	0.491917	0.870642	1.148578	2.032863	0.565005	1.769896	32
29	0.492170	0.870499	1.148767	2.031817	0.565389	1.768694	31
30	0.492424	0.870356	1.148956	2.030772	0.565773	1.767494	30
31	0.492677	0.870212	1.149145	2.029729	0.566157	1 766295	29
32	0.492930	0.870069	1.149334	2.028686	0.566541	1.765097	28
33	0.493183	0.869926	1.149524	2.027645	0.566925	1.763901	27
34	0.493436	0.869782	1.149713	2.026606	0.567310	1.762705	26
35	0.493689	0.869639	1.149903	2.025567	0.567694	1.761511	25
36	0.493942	0.869495	1.150093	2.024530	0.568079	1.760318	24
37	0.494195	0.869351	1.150283	2.023494	0.568464	1.759127	23
38	0.494448	0.869207	1.150473	2.022459	0.568849	1.757936	22
39	0.494701	0.869064	1.150664	2.021425	0.569234	1.756747	21
40	0.494953	0.868920	1.150854	2.020393	0.569619	1.755559	20
41	0.495206	0.868776	1.151045	2.019362	0.570005	1.754372	19
42	0.495459	0.868632	1.151236	2.018332	0.570390	1.753187	18
43	0.495711	0.868487	1.151427	2.017303	0.570776	1.752002	17
44	0.495964	0 868343	1.151619	2.016276	0.571161	1.750819	16
45	0.496217	0.868199	1.151810	2.015249	0.571547	1.749637	15
46	0.496469	0.868054	1.152002	2.014224	0.571933	1.748456	14
47	0.496722	0.867910	1.152193	2.013201	0.572319	1.747277	13
48	0.496974	0.867766	1.152385	2.012178	0.572705	1.746098	12
49	0.497226	0.867621	1.152577	2.011156	0.573092	1.744921	11
50	0.497479	0.867476	1.152769	2.010136	0.573478	1.743745	10
51	0.497731	0.867331	1.152962	2.009117	0.573865	1.742571	9
52	0.497983	0.867187	1.153154	2.008099	0.574252	1.741397	8
53	0.498236	0.867042	1.153347	2.007083	0.574639	1.740225	7
54	0.498488	0.866897	1.153540	2.006067	0.575026	1.739053	6
55	0.498740	0.866752	1.153733	2.005053	0.575413	1.737883	5
56	0.498992	0.866607	1.153926	2.004040	0.575800	1.736714	4
57	0.499244	0.866461	1.154120	2.003028	0.576187	1.735547	3
58	0.499496	0.866316	1.154313	2.002018	0.576575	1.734380	2
59	0.499748	0.866171	1.154507	2.001008	0.576963	1.733215	1
60	0.500000	0.866025	1.154701	2.000000	0.577350	1.732051	0
	Cosines.	Sines.	Cosecants.	Secants.	Cotangents.	Tangents.	60°

30°	Sines.	Cosines.	Secants.	Cosecants.	Tangents.	Cotangents.	
0′	0.500000	0.866025	1.154701	2.000000	0.577350	1.732051	60′
1	0.500225	0.865880	1.154895	1.998993	0.577738	1.730888	59
2	0.500504	0.865734	1.155089	1.997987	0.578126	1.729726	58
3	0.500756	0.865589	1.155283	1.996982	0.578514	1.728565	57
4	0.501007	0.865443	1.155478	1.995979	0.578903	1.727406	56
5	0.501259	0.865297	1.155672	1.994976	0.579291	1.726248	55
6	0.501511	0.865151	1.155867	1.993975	0.579680	1.725091	54
7	0.501762	0.865006	1.156062	1.992975	0.580068	1.723935	53
8	0.502014	0.864860	1.156257	1.991976	0.580457	1.722780	52
9	0.502266	0.864713	1.156453	1.990979	0.580846	1.721626	51
10	0.502517	0.864567	1.156648	1.989982	0.581235	1.720474	50
11	0.502769	0.864421	1.156844	1.988987	0.581625	1.719322	49
12	0.503020	0.864275	1.157039	1.987993	0.582014	1.718172	48
13	0.503271	0.864128	1.157235	1.987000	0.582403	1.717023	47
14	0.503523	0.863982	1.157432	1.986008	0.582793	1.715875	46
15	0.503774	0.863836	1.157628	1.985017	0.583183	1.714728	45
16	0.504025	0.863689	1.157824	1.984028	0.583573	1.713583	44
17	0.504277	0.863542	1.158021	1.983039	0.583963	1.712438	43
18	0.504528	0.863396	1.158218	1.982052	0.584353	1.711295	42
19	0.504779	0.863249	1.158415	1.981066	0.584743	1.710153	41
20	0.505030	0.863102	1.158612	1.980081	0.585134	1.709012	40
21	0.505281	0.862955	1.158809	1.979097	0.585524	1.707872	39
22	0.505532	0.862808	1.159007	1.978115	0.585915	1.706733	38
23	0.505783	0.862661	1.159204	1.977133	0.586306	1.705595	37
24	0.506034	0.862514	1.159402	1.976153	0.586697	1.704459	36
25	0.506285	0.862366	1.159600	1.975174	0.587088	1.703323	35
26	0.506536	0.862219	1.159798	1.974195	0.587479	1.702189	34
27	0.506786	0.862072	1.159996	1.973219	0.587870	1.701056	33
28	0.507037	0.861924	1.160195	1.972243	0.588262	1.699924	32
29	0.507288	0.861777	1.160393	1.971268	0.588653	1.698793	31
30	0.507538	0.861629	1.160592	1.970294	0.589045	1.697663	30
31	0.507789	0.861482	1.160791	1.969322	0.589437	1.696534	29
32	0.508049	0.861334	1.160990	1.968351	0.589829	1.695407	28
33	0.508290	0.861186	1.161189	1.967381	0.590221	1.694280	27
34	0.508541	0.861038	1.161589	1.966411	0.590613	1.693155	26
35	0.508791	0.860990	1.161589	1.965444	0.591006	1.692031	25
36	0.509041	0.860742	1.161788	1.964477	0.591398	1.690908	24
37	0.509292	0.860594	1.161988	1.963511	0.591791	1.689786	23
38	0.509542	0.860446	1.162188	1.962546	0.592184	1.688665	22
39	0.509792	0.860298	1.162389	1.961583	0.592577	1.687545	21
40	0.510043	0.860149	1.162589	1.960621	0.592970	1.686426	20
41	0.510293	0.860001	1.162790	1.959659	0.593363	1.685309	19
42	0.510543	0.859852	1.162991	1.958699	0.593757	1.684192	18
43	0.510793	0.859704	1.163191	1.957740	0.594150	1.683077	17
44	0.511043	0.859555	1.163393	1.956782	0.594544	1.681962	16
45	0.511293	0.859406	1.163594	1·955825	0.594938	1.680849	15
46	0.511543	0.859258	1.163795	1.954870	0.595331	1.679737	14
47	0.510793	0.859109	1.163997	1.953915	0.595726	1.678626	13
48	0.512043	0.858960	1.164199	1.952962	0.596120	1.677516	12
49	0.512293	0.858811	1.164401	1.952000	0.596514	1.676407	11
50	0.512543	0.858662	1.164603	1.951058	0.596908	1.675299	10
51	0.512792	0.858513	1.164805	1.950108	0.597308	1.674192	9
52	0.513042	0.858364	1.165008	1.949158	0.597698	1.673086	8
53	0.513292	0.858214	1.165210	1.948210	0.598093	1.671982	7
54	0.513541	0.858065	1.165413	1.947263	0.598488	1.670878	6
55	0.513791	0.857916	1.165616	1.946317	0.598883	1.669776	5
56	0.514040	0.857766	1.165819	1.945373	0.599278	1.668674	4
57	0.514290	0.857616	1.166022	1.944429	0.599674	1.667574	3
58	0.514539	0.857467	1.166226	1.943486	0.600069	1.666475	2
59	0.514789	0.857317	1.166430	1.942545	0.600465	1.665377	1
60	0.515038	0.857167	1.166633	1.941604	0.600861	1.664280	0
	Cosines.	Sines.	Cosecants.	Secants.	Cotangents.	Tangents.	59°

31°	Sines.	Cosines.	Secants.	Cosecants.	Tangents.	Cotangents.	
0′	0.515038	0.857167	1.166633	1.941604	0.600861	1.664280	60′
1	0.515287	0.857017	1.166837	1.940665	0.601257	1.663183	59
2	0.515537	0.856868	1.167042	1.939726	0.601653	1.662088	58
3	0.515786	0.856718	1.167246	1.938789	0.602049	1.660995	57
4	0.516035	0.856567	1.167450	1.937853	0.602445	1.659902	56
5	0.516284	0.856417	1.167655	1.936918	0.602842	1.658810	55
6	0.516533	0.856267	1.167860	1.935984	0.603239	1.657719	54
7	0.516782	0.856117	1.168065	1.935051	0.603635	1.656629	53
8	0.517031	0.855966	1.168270	1.934119	0.604032	1.655541	52
9	0.517280	0.855816	1.168476	1.933188	0.604429	1.654453	51
10	0.517529	0.855666	1.168681	1.932258	0.604827	1.653366	50
11	0.517778	0.855515	1.168887	1.931329	0.605224	1.652281	49
12	0.518027	0.855364	1.169093	1.930401	0.605622	1.651196	48
13	0.518276	0.855214	1.169299	1.929475	0.606019	1.650113	47
14	0.518526	0.855063	1.169505	1.928549	0.606417	1.649030	46
15	0.518773	0.854912	1.169711	1.927624	0.606815	1.647949	45
16	0.519022	0.854761	1.169918	1.926701	0.607213	1.646869	44
17	0.519271	0.854610	1.170125	1.925778	0.607611	1.645789	43
18	0.519519	0.854459	1.170331	1.924857	0.608010	1.644711	42
19	0.519768	0.854308	1.170539	1.923937	0.608408	1.643634	41
20	0.520016	0.854156	1.170746	1.923017	0.608807	1.642558	40
21	0.520265	0.854005	1.170953	1.922099	0.609205	1.641482	39
22	0.520513	0.853854	1.171161	1.921182	0.609604	1.640408	38
23	0.520761	0.853702	1.171369	1.920266	0.610003	1.639335	37
24	0.521010	0.853551	1.171576	1.919350	0.610403	1.638263	36
25	0.521258	0.853399	1.171785	1.918436	0.610802	1.637192	35
26	0.521506	0.853248	1.171993	1.917523	0.611201	1.636122	34
27	0.521754	0.853096	1.172201	1.916611	0.611601	1.635053	33
28	0.522002	0.852944	1.172410	1.915700	0.612001	1.633985	32
29	0.522251	0.852792	1.172619	1.914790	0.612401	1.632918	31
30	0.522499	0.852640	1.172828	1.913881	0.612801	1.631852	30
31	0.522747	0.852488	1.173037	1.912973	0.613201	1.630787	29
32	0.522995	0.852336	1.173246	1.912066	0.613601	1.629723	28
33	0.523242	0.852184	1.173456	1.911160	0.614002	1.628660	27
34	0.523490	0.852032	1.173665	1.910255	0.614402	1.627598	26
35	0.523738	0.851879	1.173875	1.909351	0.614803	1.626537	25
36	0.523986	0.851727	1.174085	1.908448	0.615204	1.625477	24
37	0.524233	0.851575	1.174295	1.907546	0.615605	1.624418	23
38	0.524481	0.851422	1.174506	1.906646	0.616006	1.623360	22
39	0.524729	0.851269	1.174716	1.905746	0.616408	1.622303	21
40	0.524977	0.851117	1.174927	1.904847	0.616809	1.621247	20
41	0.525224	0.850964	1.175138	1.903949	0.617211	1.620192	19
42	0.525472	0.850811	1.175349	1.903052	0.617613	1.619138	18
43	0.525719	0.850658	1.175560	1.902156	0.618015	1.618085	17
44	0.525967	0.850505	1.175772	1.901262	0.618417	1.617033	16
45	0.526214	0.850352	1.175983	1.900368	0.618819	1.615982	15
46	0.526461	0.850199	1.176195	1.899475	0.619221	1.614932	14
47	0.526709	0.850046	1.176407	1.898583	0.619624	1.613883	13
48	0.526956	0.849893	1.176619	1.897692	0.620026	1.612835	12
49	0.527203	0.849799	1.176831	1.896803	0.620429	1.611788	11
50	0.527450	0.849586	1.177044	1.895914	0.620832	1.610742	10
51	0.527697	0.849433	1.177257	1.895026	0.621235	1.609697	9
52	0.527944	0.849279	1.177469	1.894139	0.621638	1.608653	8
53	0.528191	0.849125	1.177682	1.893253	0.622042	1.607609	7
54	0.528438	0.848972	1.177896	1.892368	0.022445	1.606567	6
55	0.528685	0.848818	1.178109	1.891485	0.622849	1.605526	5
56	0.528932	0.848664	1.178323	1.890602	0.623253	1.604486	4
57	0.529179	0.848510	1.178536	1.889720	0.623657	1.603447	3
58	0.529426	0.848356	1.178750	1.888839	0.624061	1.602408	2
59	0.529673	0.848202	1.178964	1.887959	0.624465	1.601371	1
60	0.529919	0.848048	1.178978	1.887080	0.624869	1.600335	0
	Cosines.	Sines.	Cosecants.	Secants.	Cotangents.	Tangents.	58°

32°	Sines.	Cosines.	Secants.	Cosecants.	Tangents.	Cotangents.	
0′	0.529919	0.848048	1.179178	1.887080	0.624869	1.600335	60′
1	0.530166	0.847894	1.179393	1.886203	0.625274	1.599299	59
2	0.530413	0.847740	1.179607	1.885325	0.625679	1.598265	58
3	0.530659	0.847585	1.179822	1.884449	0.626083	1.597231	57
4	0 530906	0.847431	1.180037	1.883574	0.626488	1.596199	56
5	0.531152	0.847277	1.180252	1.882700	0.626894	1.595167	55
6	0.531399	0.847122	1.180468	1.881827	0.627299	1.594137	54
7	0.531645	0.846967	1.180683	1.880955	0.627704	1.593109	53
8	0.531891	0.846813	1.180899	1.880083	0.628110	1.592078	52
9	0.532138	0.846658	1.181115	1.879213	0.628516	1.591051	51
10	0.532384	0.846503	1.181331	1.878344	0.628921	1.590024	50
11	0.532630	0.846348	1.181547	1.877476	0.629327	1.588998	49
12	0.532876	0.846193	1.181763	1.876608	0.629734	1.587973	48
13	0.533122	0.846038	1.181980	1.875742	0.630140	1.586949	47
14	0.533369	0.845883	1.182197	1.874876	0.630546	1.585926	46
15	0.633614	0.845728	1.182414	1.874012	0.630953	1.584904	45
16	0.533861	0.845573	1.182631	1.873149	0.631360	1.583883	44
17	0.534107	0.845417	1.182848	1.872286	0.631767	1.582863	43
18	0.534352	0.845262	1.183065	1.871424	0.632174	1.581844	42
19	0.534598	0.845106	1.183283	1.870564	0.632581	1.580825	41
20	0.534844	0.844951	1.183501	1.869904	0.632988	1.579808	40
21	0.535090	0.844795	1.183719	1.868845	0.633396	1.578792	39
22	0.535336	0.844640	1.183937	1.867988	0.633804	1.577776	38
23	0 535581	0.844484	1.184155	1.867131	0.634211	1.576762	37
24	0.535826	0.844328	1.184374	1.866275	0.634619	1.575748	36
25	0.536072	0.844172	1.184593	1.865420	0.635027	1.574735	35
26	0.536318	0.844016	1.184812	1.864566	0.635436	1.573723	34
27	0.536563	0.843860	1.185031	1.863713	0.635844	1.572713	33
28	0.536809	0.843704	1.185250	1.862861	0.636253	1.571703	32
29	0.537054	0.843548	1.185469	1.862009	0.636661	1.570694	31
30	0 537300	0.843391	1.185689	1.861159	0.637070	1.569686	30
31	0.537545	0.843235	1.185909	1.860310	0.637479	1.568678	29
32	0.537790	0.843079	1.186129	1.859461	0.637889	1.567672	28
33	0.538035	0.842922	1.186349	1.858614	0.638298	1.566667	27
34	0.538281	0.842766	1.186569	1.857767	0.638707	1.565663	26
35	0.538526	0.842609	1.186790	1.856922	0.639117	1.564659	25
36	0.538771	0.842452	1.187011	1.856077	0.639527	1.563656	24
37	0.539016	0.842296	1.187232	1.855233	0.639937	1.562655	23
38	0.539261	0.842139	1.187453	1.854390	0.640347	1.561654	22
39	0.539506	0.841982	1.187674	1.853548	0.640757	1.560654	21
40	0.539751	0.841825	1.187895	1.852707	0.641167	1.559655	20
41	0.539996	0.841668	1.188117	1.851867	0.641578	1.558657	19
42	0.540240	0.841511	1.188339	1.851028	0.641989	1.557660	18
43	0.540485	0.841354	1.188561	1.850190	0.642399	1.556664	17
44	0.540730	0.841196	1.188783	1.849353	0.642811	1.555669	16
45	0.540975	0.841039	1.189006	1.848516	0.643222	1.554674	15
46	0.541219	0.840882	1.189228	1.847681	0.643633	1.553681	14
47	0.541464	0.840724	1.189451	1.846846	0.644044	1.552688	13
48	0.541708	0.840567	1.189674	1.846012	0.644456	1.551696	12
49	0.541953	0.840409	1.189897	1.845180	0.644868	1.550705	11
50	0.542197	0.840251	1.190120	1.844348	0.645280	1.549716	10
51	0.542442	0.840094	1.190344	1.843517	0.645692	1.548726	9
52	0.542686	0 839936	1.190567	1.842687	0.646104	1.547738	8
53	0.542930	0.839778	1.190791	1.841857	0.646517	1.546751	7
54	0.543174	0.839620	1.191015	1.841029	0.646929	1.545765	6
55	0.543419	0.839462	1.191239	1.840202	0.647342	1.544779	5
56	0.543663	0.839304	1.191464	1.839375	0.647755	1.543795	4
57	0.543907	0.839146	1.191688	1.838550	0.648168	1.542811	3
58	0.544151	0.838987	1.191913	1.837725	0.648581	1.541828	2
59	0.544395	0.838829	1.192138	1.836901	0.648994	1.540846	1
60	0.544639	0.838671	1.192363	1.836079	0.649408	1.539865	0
	Cosines.	Sines.	Cosecants.	Secants.	Cotangents.	Tangents.	57°

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33°	Sines.	Cosines.	Secants.	Cosecants.	Tangents.	Cotangents.	
0′	0.544639	0.838671	1.192363	1.836079	0.649408	1.539865	60′
1	0.544883	0.838512	1.192589	1.835257	0.649821	1.538885	59
2	0.545127	0.838354	1.192814	1.834435	0.650235	1.537905	58
3	0.545371	0.838195	1.193040	1.833615	0.650640	1.536927	57
4	0.545615	0.838036	1.193266	1.832796	0.651063	1.535949	56
5	0.545858	0.837878	1.193492	1.831977	0.651477	1.534973	55
6	0.546102	0.837719	1.193718	1.831160	0.651892	1.533997	54
7	0.546346	0.837560	1.193945	1.830343	0.652306	1.533022	53
8	0.546589	0.837401	1.194171	1.829527	0.652721	1.532048	52
9	0.546833	0.837242	1.194398	1.828713	0.653136	1.531075	51
10	0.547076	0.837083	1.194625	1.827899	0.653551	1.530102	50
11	0.547320	0.836924	1.194852	1.827085	0.653966	1.529131	49
12	0.547563	0.836764	1.195080	1.826273	0.654382	1.528160	48
13	0.547807	0.836605	1.195307	1.825462	0.654797	1.527190	47
14	0.548050	0.836446	1.195535	1.824651	0.655213	1.526222	46
15	0.548293	0.836286	1.195763	1.823842	0.655629	1.525254	45
16	0.548537	0.836127	1.195991	1.823033	0.656045	1.524286	44
17	0.548780	0.835967	1.196219	1.822225	0.656461	1.523320	43
18	0.549023	0.835807	1.196448	1.821418	0.656877	1.522355	42
19	0.549267	0.835648	1.196677	1.820612	0.657294	1.521390	41
20	0.549509	0.835488	1.196906	1.819807	0.657710	1.520426	40
21	0.549752	0.835328	1.197135	1.819002	0.658127	1.519463	39
22	0.549995	0.835168	1.197364	1.818199	0.658544	1.518501	38
23	0.550238	0.835008	1.197593	1.817396	0.658961	1.517540	37
24	0.550481	0.834848	1.197823	1.816594	0.659379	1.516580	36
25	0.550724	0.834688	1.198053	1.815793	0.659796	1.515620	35
26	0.550966	0.834528	1.198283	1.814993	0.660214	1.514661	34
27	0.551209	0.834367	1.198513	1.814194	0.660631	1.513704	33
28	0.551452	0.834207	1.198744	1.813395	0.661049	1.512747	32
29	0.551694	0.834046	1.198974	1.812598	0.661467	1.511791	31
30	0.551937	0.833886	1.199205	1.811801	0.661886	1.510835	30
31	0.552180	0.833725	1.199436	1.811005	0.662304	1.509881	29
32	0.552422	0.833565	1.199667	1.810210	0.662723	1.508927	28
33	0.552665	0.833404	1.199899	1.809416	0.663141	1.507974	27
34	0.552907	0.833243	1.200130	1.808623	0.663560	1.507022	26
35	0.553149	0.833082	1.200362	1.807830	0.663979	1.506071	25
36	0.553392	0.832921	1.200594	1.807039	0.664398	1.505121	24
37	0.553634	0.832760	1.200826	1.806248	0.664818	1.504172	23
38	0.553876	0.832599	1.201058	1.805458	0.665237	1.503223	22
39	0.554118	0.832438	1.201291	1.804669	0.665657	1.502275	21
40	0.554360	0.832277	1.201523	1.803881	0.666077	1.501328	20
41	0.554602	0.832116	1.201756	1.803094	0.666497	1.500382	19
42	0.554844	0.831954	1.201989	1.802307	0.666917	1.499437	18
43	0.555086	0.831793	1.202223	1.801521	0.667337	1.498492	17
44	0.555328	0.831631	1.202456	1.800737	0.667758	1.497549	16
45	0.555570	0.831470	1.202690	1.799952	0.668179	1.496606	15
46	0.555812	0.831308	1.202924	1.799169	0.668600	1.495664	14
47	0.556054	0.831146	1.203158	1.798387	0.669021	1.494723	13
48	0.556296	0.830985	1.203392	1.797605	0.669442	1.493782	12
49	0.556537	0.830823	1.203626	1.796825	0.669863	1.492843	11
50	0.556779	0.830661	1.203861	1.796045	0.670285	1.491904	10
51	0.557021	0.830499	1.204096	1.795266	0.670706	1.490966	9
52	0.557262	0.830337	1.204331	1.794488	0.671128	1.490029	8
53	0.557504	0.830175	1.204566	1.793710	0.671550	1.489093	7
54	0.557745	0.830012	1.204801	1.792934	0.671972	1.488157	6
55	0.557987	0.829850	1.205037	1.792158	0.672394	1.487222	5
56	0.558225	0.829688	1.205273	1.791383	0.672817	1.486288	4
57	0.558469	0.829525	1.205509	1.790609	0.673240	1.485355	3
58	0.558711	0.829363	1.205745	1.789836	0.673662	1.484423	2
59	0.558952	0.829200	1.205981	1.789063	0.674085	1.483492	1
60	0.559193	0.829038	1.206218	1.788292	0.674509	1.482561	0
	Cosines.	Sines.	Cosecants.	Secants.	Cotangents.	Tangents.	56°

34°	Sines.	Cosines.	Secants.	Cosecants.	Tangents.	Cotangents.	
0′	0.559193	0.829038	1.206218	1.788292	0.674509	1.482561	60′
1	0.559434	0.828875	1.206455	1.787521	0.674932	1.481631	59
2	0.559675	0.828712	1.206692	1.786751	0.675355	1.480702	58
3	0.559916	0.828549	1.206929	1.785982	0.675779	1.479774	57
4	0.560157	0.828386	1.207166	1.785213	0.676203	1.478846	56
5	0.560398	0.828223	1.207404	1.784446	0.676627	1.477920	55
6	0.560639	0.828060	1.207642	1.783679	0.677051	1.476994	54
7	0.560880	0.827897	1.207879	1.782913	0.677475	1.476069	53
8	0.561121	0.827734	1.208118	1.782148	0.677900	1.475145	52
9	0.561361	0.827571	1.208356	1.781384	0.678324	1.474221	51
10	0.561602	0.827407	1.208594	1.780620	0.678749	1.473298	50
11	0.561843	0.827244	1.208833	1.779857	0.679174	1.472376	49
12	0.562083	0.827081	1.209072	1.779096	0.679599	1.471455	48
13	0.562324	0.826917	1.209311	1.778334	0.680025	1.470535	47
14	0.562565	0.826753	1.209551	1.777574	0.680450	1.469616	46
15	0.562805	0.826590	1.209790	1.776815	0.680876	1.468697	45
16	0.563045	0.826426	1.210030	1.776056	0.681302	1.467779	44
17	0.563286	0.826262	1.210270	1.775298	0.681728	1.466862	43
18	0.563526	0.826098	1.210510	1.774541	0.682154	1.465945	42
19	0.563766	0.825934	1.210750	1.773785	0.682580	1.465030	41
20	0.564007	0.825770	1.210991	1.773029	0.683007	1.464115	40
21	0.564247	0.825606	1.211231	1.772274	0.683433	1.463201	39
22	0.564487	0.825442	1.211472	1.771520	0.683860	1.462287	38
23	0.564727	0.825278	1.211713	1.770767	0.684287	1.461375	37
24	0.564967	0.825114	1.211955	1.770015	0.684714	1.460463	36
25	0.565208	0.824949	1.212196	1.769263	0.685142	1.459552	35
26	0.565447	0.824785	1.212438	1.768513	0.685569	1.458642	34
27	0.565687	0.824620	1.212680	1.767763	0.685997	1.457733	33
28	0.565927	0.824456	1.212922	1.767013	0.686425	1.456824	32
29	0.566167	0.824291	1.213164	1.766265	0.686853	1.455916	31
30	0.566406	0.824126	1.213406	1.765517	0.687281	1.455009	30
31	0.566646	0.823961	1.213649	1.764770	0.687709	1.454103	29
32	0.566886	0.823797	1.213892	1.764024	0.688138	1.453197	28
33	0.567125	0.823632	1.214135	1.763279	0.688567	1.452292	27
34	0.567365	0.823467	1.214378	1.762535	0.688996	1.451388	26
35	0.567604	0.823302	1.214622	1.761791	0.689425	1.450485	25
36	0.567844	0.823136	1.214866	1.761048	0.689854	1.449583	24
37	0.568083	0.822971	1.215109	1.760306	0.690283	1.448681	23
38	0.568323	0.822806	1.215354	1.759564	0.690713	1.447780	22
39	0.568562	0.822641	1.215598	1.758824	0.691143	1.446880	21
40	0.568801	0.822475	1.215842	1.758084	0.691573	1.445980	20
41	0.569040	0.822310	1.216087	1.757345	0.692003	1.445081	19
42	0.569280	0.822144	1.216332	1.756606	0.692433	1.444183	18
43	0.569519	0.821978	1.216577	1.755869	0.692863	1.443286	17
44	0.569758	0.821813	1.216822	1.755132	0.693294	1.442390	16
45	0.569997	0.821647	1.217068	1.754396	0.693725	1.441494	15
46	0.570236	0.821481	1.217314	1.753661	0.694156	1.440599	14
47	0.570475	0.821315	1.217559	1.752926	0.694587	1.439705	13
48	0.570714	0.821149	1.217806	1.752192	0.695018	1.438811	12
49	0.570952	0.820983	1.218052	1.751460	0.695450	1.437919	11
50	0.571191	0.820817	1.218298	1.750727	0.695881	1.437027	10
51	0.571430	0.820651	1.218545	1.749996	0.696313	1.436136	9
52	0.571669	0.820485	1.218792	1.749265	0.696745	1.435245	8
53	0.571907	0.820318	1.219039	1.748535	0.697177	1.434355	7
54	0.572146	0.820152	1.219286	1.747806	0.697610	1.433466	6
55	0.572385	0.819985	1.219534	1.747078	0.698042	1.432578	5
56	0.572623	0.819819	1.219782	1.746350	0.698475	1.431691	4
57	0.572861	0.819652	1.220030	1.745623	0 698908	1.430804	3
58	0.573100	0.819486	1.220278	1.744897	0.999341	1.429918	2
59	0.573338	0.819319	1.220526	1.744172	0.699774	1.429033	1
60	0.573576	0.819152	1.220775	1.743447	0.700208	1.428148	0
	Cosines.	Sines.	Cosecants.	Secants.	Cotangents.	Tangents.	55°

35°	Sines.	Cosines.	Secants.	Cosecants.	Tangents.	Cotangents.	
0′	0.573576	0.819152	1.220775	1.743447	0.700208	1.428148	60′
1	0.573815	0.818985	1.221023	1.742723	0.700641	1.427264	59
2	0.574054	0.818818	1.221272	1.742000	0.701075	1.426381	58
3	0.574291	0.818651	1.221522	1.741277	0.701509	1.425499	57
4	0.574529	0.818484	1.221771	1.740556	0.701943	1.424617	56
5	0.574767	0.818317	1.222020	1.739835	0.702377	1.423736	55
6	0.575005	0.818150	1.222270	1.739115	0.702812	1.422856	54
7	0.575243	0.817982	1.222520	1.738395	0.703246	1.421977	53
8	0.575481	0.817815	1.222770	1.737676	0.703681	1.421098	52
9	0.575719	0.817648	1.223021	1.736959	0.704116	1.420220	51
10	0.575957	0.817480	1.223271	1.736241	0.704552	1.419343	50
11	0.576195	0.817313	1.223522	1.735525	0.704987	1.418466	49
12	0.576432	0.817145	1.223773	1.734809	0 705422	1.417590	48
13	0.576670	0.816977	1.224024	1.734094	0.705858	1.416715	47
14	0.576908	0.816809	1.224276	1.733380	0.706294	1.415841	46
15	0.577145	0.816642	1.224527	1.732666	0.706730	1.414967	45
16	0.577383	0.816474	1.224779	1.731954	0.707166	1.414094	44
17	0.577620	0.816306	1.225031	1.731241	0.707603	1.413222	43
18	0.577858	0.816138	1.225284	1.730530	0.708040	1.412351	42
19	0.578095	0.815970	1.225536	1.729820	0.708476	1.411480	41
20	0.578332	0.815801	1.225789	1.729110	0.708913	1.410610	40
21	0.578570	0.815633	1.226042	1.728401	0.709350	1.409741	39
22	0.578808	0.815465	1.226295	1.727692	0.709788	1.408872	38
23	0.579044	0.815296	1.226548	1.726984	0.710225	1.408004	37
24	0.579281	0.815128	1.226802	1.726277	0.710663	1.407137	36
25	0.579518	0.814959	1.227055	1.725571	0.711101	1.406270	35
26	0.579755	0.814791	1.227309	1.724866	0.711539	1.405404	34
27	0.579992	0.814622	1.227563	1.724161	0.711977	1.404539	33
28	0.580229	0.814453	1.227818	1.723457	0.712416	1.403675	32
29	0.580466	0.814284	1.228072	1.722753	0.712854	1.402811	31
30	0.580703	0.814116	1.228327	1.722051	0.713293	1.401948	30
31	0.580940	0.813947	1.228582	1.721349	0.713732	1.401086	29
32	0.581177	0.813778	1.228837	1.720648	0.714171	1.400225	28
33	0.581413	0.813608	1.229092	1.719947	0.714611	1.399364	27
34	0.581650	0.813439	1.229348	1.719248	0.715050	1.398503	26
35	0.581886	0.813270	1.229604	1.718548	0.715490	1.397644	25
36	0.582123	0.813101	1.229860	1.717850	0.715930	1.396785	24
37	0.582360	0.812931	1.230116	1.717153	0.716370	1.395927	23
38	0.582596	0.812762	1.230373	1.716456	0.716810	1.395070	22
39	0.582832	0.812593	1.230629	1.715759	0.717251	1.394213	21
40	0.583069	0.812423	1.230886	1.715064	0.717691	1.393357	20
41	0.583305	0.812253	1.231143	1.714369	0.718132	1.392502	19
42	0.583541	0.812084	1.231400	1.713675	0.718573	1.391647	18
43	0.583777	0.811914	1.231658	1.712982	0.719014	1.390793	17
44	0.584014	0.811744	1.231916	1.712289	0.719455	1.389940	16
45	0.584250	0.811574	1.232174	1.711597	0.719897	1.389088	15
46	0.584486	0.811404	1.232432	1.710906	0.720339	1.388236	14
47	0.584722	0.811234	1.232690	1.710215	0.720781	1.387385	13
48	0.584958	0.811064	1.232949	1.709525	0.721223	1.386534	12
49	0.585194	0.811894	1.233207	1.708836	0.721665	1.385684	11
50	0.585429	0.810723	1.233466	1.708148	0.722108	1.384835	10
51	0.585665	0.810553	1.233726	1.707460	0.722550	1.383987	9
52	0.585901	0.810383	1.233985	1.706773	0.722993	1.383139	8
53	0.586137	0.810212	1.234245	1.706087	0.723436	1.382292	7
54	0.586372	0.810042	1.234504	1.705401	0.723879	1.381446	6
55	0.586608	0.809871	1.234765	1.704716	0.724323	1.380600	5
56	0.586844	0.809700	1.235025	1.704032	0.724766	1.379755	4
57	0.587079	0.809530	1.235285	1.703348	0.725210	1.378911	3
58	0.587315	0.809359	1.235546	1.702665	0.725654	1.378067	2
59	0.587550	0.809188	1.235807	1.701983	0.726098	1.377224	1
60	0.587785	0.809117	1.236068	1.701302	0.726543	1.376382	0
	Cosines.	Sines.	Cosecants.	Secants.	Cotangents.	Tangents.	54°

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36°	Sines.	Cosines.	Secants.	Cosecants.	Tangents.	Cotangents.	
0′	0.587785	0.809017	1.236068	1.701302	0.726543	1.376381	60′
1	0.588021	0.808846	1.236329	1.700621	0.726987	1.375540	59
2	0.588256	0.808675	1.236591	1.699941	0.727432	1.374699	58
3	0.588491	0.808504	1.236853	1.699261	0.727877	1.373859	57
4	0.588726	0.808333	1.237115	1.698583	0.728322	1.373019	56
5	0.588961	0.808161	1.237377	1.697904	0.728767	1.372180	55
6	0.589196	0.807990	1.237639	1.697227	0.729213	1.371342	54
7	0.589431	0.807819	1.237902	1.696550	0.729658	1.370504	53
8	0.589666	0.807647	1.238165	1.695874	0.730104	1.369667	52
9	0.589901	0.807475	1.238428	1.695199	0.730550	1.368831	51
10	0.590136	0.807304	1.238691	1.694524	0.730996	1.367995	50
11	0.590371	0.807132	1.238955	1.693850	0.731443	1.367161	49
12	0.590606	0.806960	1.239218	1.693177	0.731889	1.366326	48
13	0.590840	0.806789	1.239482	1.692505	0.732336	1.365493	47
14	0.591075	0.806617	1.239746	1.691833	0.732783	1.364660	46
15	0.591310	0.806445	1.240011	1.691161	0.733230	1.363827	45
16	0.591544	0.806273	1.240275	1.690491	0.733678	1.362996	44
17	0.591779	0.806101	1.240540	1.689821	0.734125	1.362165	43
18	0.592013	0.805928	1.240805	1.689152	0.734573	1.361335	42
19	0.592248	0.805756	1.241070	1.688483	0.735021	1.360505	41
20	0.592482	0.805584	1.241336	1.687815	0.735469	1.359676	40
21	0.592716	0.805411	1.241602	1.687148	0.735917	1.358848	39
22	0.592951	0.805239	1.241868	1.686481	0.736366	1.358020	38
23	0.593185	0.805066	1.242134	1.685816	0.736815	1.357193	37
24	0.593419	0.804894	1.242400	1.685150	0.737264	1.356367	36
25	0.593653	0.804721	1.242667	1.684486	0.737713	1.355541	35
26	0.593887	0 804548	1.242933	1.683822	0.738162	1.354716	34
27	0.594121	0.804376	1.243200	1.683159	0.738612	1.353892	33
28	0.594355	0.804203	1.243468	1.682496	0.739061	1.353068	32
29	0.594589	0.804038	1.243735	1.681834	0.739511	1.352244	31
30	0.594822	0.803857	1.244003	1.681173	0.739961	1.351422	30
31	0.595057	0.803684	1.244270	1.680512	0.740411	1.350601	29
32	0.595290	0.803511	1.244539	1.679853	0.740861	1.349779	28
33	0.595524	0.803338	1.244807	1.679193	0 741312	1.348958	27
34	0.595758	0.803164	1.245075	1.678535	0.741763	1.348139	26
35	0.595991	0.802991	1.245344	1.677877	0.742214	1.347320	25
36	0.596225	0.802818	1.245613	1.677220	0.742666	1.346501	24
37	0.596458	0.802644	1.245882	1.676563	0.743117	1.345683	23
38	0.596692	0.802471	1.246152	1.675907	0.743569	1.344866	22
39	0.596925	0.802297	1.246421	1.675252	0.744020	1.344049	21
40	0.597159	0.802123	1.246691	1.674597	0.744472	1.343233	20
41	0.597392	0.801950	1.246961	1.673943	0.744925	1.342417	19
42	0.597625	0.801776	1.247232	1.673290	0.745377	1.341602	18
43	0.597858	0.801602	1.247502	1.672637	0.745830	1.340788	17
44	0.598092	0.801428	1.247773	1.671985	0.746282	1.339975	16
45	0.598324	0.801254	1.248044	1.671334	0.746735	1.339162	15
46	0.598558	0.801080	1.248315	1.670683	0.747189	1.338350	14
47	0.598791	0.800906	1.248587	1.670033	0.747642	1.337538	13
48	0.599024	0.800731	1.248858	1.669383	0.748096	1.336728	12
49	0.599257	0.800557	1.249130	1.668735	0.748549	1.335917	11
50	0.599489	0.800383	1.249402	1.668086	0.749003	1.335107	10
51	0.599722	0.800208	1.249675	1.667439	0.749458	1.334298	9
52	0.599955	0.800034	1.249947	1.666792	0.749912	1.333490	8
53	0.600188	0.799859	1.250220	1.666146	0.750367	1.332682	7
54	0.600420	0.799685	1.250493	1.665500	0.750821	1.331875	6
55	0.600653	0.799510	1.250766	1.664855	0.751276	1.331068	5
56	0.600885	0.799335	1.251040	1.664211	0.751731	1.330262	4
57	0.601118	0.799160	1.251313	1.663567	0.752187	1.329457	3
58	0.601350	0.798986	1.251587	1.662924	0.752642	1.328652	2
59	0.601583	0.798811	1.251861	1.662282	0.753098	1.327848	1
60	0.601815	0.798636	1.252136	1.661640	0.753554	1.327044	0
	Cosines.	Sines.	Cosecants.	Secants.	Cotangents.	Tangents.	53°

37°	Sines.	Cosines.	Secants.	Cosecants.	Tangents.	Cotangents.	
0′	0.601815	0.798636	1.252136	1.661640	0.753554	1.327045	60′
1	0.602847	0.798460	1.252410	1.660999	0.754010	1.326242	59
2	0.602280	0.798285	1.252685	1.660359	0.754467	1.325440	58
3	0.602512	0.798110	1.252960	1.659719	0.754923	1.324638	57
4	0.602744	0.797935	1.253235	1.659080	0.755380	1.323837	56
5	0.602976	0.797759	1.253511	1.658441	0.755837	1.323037	55
6	0.603208	0.797584	1.253787	1.657803	0.756294	1.322237	54
7	0.603440	0.797408	1.254063	1.657166	0.756751	1.321438	53
8	0.603672	0.797233	1.254339	1.656529	0.757209	1.320639	52
9	0.603904	0.797057	1.254615	1.655893	0.757667	1.319841	51
10	0.604136	0.796882	1.254892	1.655258	0.758125	1.319044	50
11	0.604367	0.796706	1.255169	1.654623	0.758583	1.318247	49
12	0.604599	0.796530	1.255446	1.653989	0.759041	1.317451	48
13	0.604831	0.796354	1.255723	1.653355	0.759500	1.316656	47
14	0.605062	0.796178	1.256001	1.652722	0.759959	1.315861	46
15	0.605294	0.796002	1.256278	1.652090	0.760418	1.315067	45
16	0.605526	0.795826	1.256556	1.651458	0.760877	1.314273	44
17	0.605757	0.795650	1.256835	1.650827	0.761336	1.313480	43
18	0.605988	0.795474	1.257113	1.650197	0.761796	1.312688	42
19	0.606220	0.795297	1.257392	1.649567	0.762256	1.311896	41
20	0.606451	0.795121	1.257671	1.648938	0.762716	1.311105	40
21	0.606682	0.794944	1.257950	1.648309	0.763176	1.310314	39
22	0.606914	0.794768	1.258229	1.647681	0.763636	1.309524	38
23	0.607145	0.794591	1.258509	1.647054	0.764097	1.308735	37
24	0.607376	0.794415	1.258789	1.646427	0.764558	1.307946	36
25	0.607607	0.791238	1.259069	1.645801	0.765019	1.307158	35
26	0.607838	0.794061	1.259349	1.645175	0.765480	1.306370	34
27	0.608069	0.793884	1.259629	1.644551	0.765941	1.305583	33
28	0.608300	0.793707	1.259910	1.643926	0.766403	1.304796	32
29	0.608531	0.793530	1.260191	1.643303	0.766865	1.304011	31
30	0.608761	0.793353	1.260472	1.642680	0.767327	1.303225	30
31	0.608992	0.793176	1.260754	1.642057	0.767789	1.302441	29
32	0.609223	0.792999	1.261036	1.641435	0.768252	1.301657	28
33	0.609454	0.792822	1.261318	1.640814	0.768714	1.300873	27
34	0.609684	0.792645	1.261600	1.640194	0.769177	1.300090	26
35	0.609915	0.792467	1.261882	1.639574	0.769640	1.299308	25
36	0.610145	0.792290	1.262165	1.638954	0.770104	1.298527	24
37	0.610376	0.792112	1.262448	1.638336	0.770567	1.297745	23
38	0.610606	0.791935	1.262731	1.637717	0.771031	1.296965	22
39	0.610836	0.791757	1.263014	1.637100	0.771495	1.296185	21
40	0.611067	0.791579	1.263298	1.636483	0.771959	1.295406	20
41	0.611297	0.791401	1.263581	1.635866	0.772423	1.294627	19
42	0.611527	0.791224	1.263865	1.635251	0.772888	1.293849	18
43	0.611757	0.791046	1.264150	1.634636	0.773353	1.293071	17
44	0.611987	0.790868	1.264434	1.634021	0.773818	1.292294	16
45	0.612217	0.790690	1.264719	1.633407	0.774283	1.291518	15
46	0.612447	0.790512	1.265004	1.632794	0.774748	1.290742	14
47	0.612677	0.790333	1.265289	1.632181	0.775214	1.289967	13
48	0.612907	0.790155	1.265575	1.631569	0.775680	1.289192	12
49	0.613137	0.789977	1.265860	1.630957	0.776146	1.288418	11
50	0.613367	0.789798	1.266146	1.630346	0.776612	1.287645	10
51	0.613596	0.789620	1.266432	1.629736	0.777078	1.286872	9
52	0.613826	0.789441	1.266719	1.629126	0.777545	1.286100	8
53	0.614056	0.789263	1.267005	1.628517	0.778012	1.285328	7
54	0.614285	0.789884	1.267292	1.627908	0.778479	1.284557	6
55	0.614514	0.788905	1.267579	1.627300	0.778946	1.283786	5
56	0.614744	0.788727	1.267867	1.626693	0.779414	1.283016	4
57	0.614974	0.788548	1.268154	1.626086	0.779881	1.282247	3
58	0.615203	0.788369	1.268442	1.625480	0.780349	1.281478	2
59	0.615432	0.788190	1.268730	1.624874	0.780817	1.280709	1
60	0.615662	0.788011	1.269018	1.624269	0.781286	1.279942	0
	Cosines.	Sines.	Cosecants.	Secants.	Cotangents.	Tangents.	52°

38°	Sines.	Cosines.	Secants.	Cosecants.	Tangents.	Cotangents.	
0′	0.615662	0.788011	1.269018	1.624269	0.781286	1.279942	60′
1	0.615891	0.787832	1.269307	1.623665	0.781754	1.279175	59
2	0.616120	0.787652	1.269596	1.623061	0.782223	1.278408	58
3	0.616349	0.787473	1.269885	1.622458	0.782692	1.277642	57
4	0.616578	0.787294	1.270174	1.621855	0.783161	1.276877	56
5	0.616807	0.787115	1.270463	1.621253	0.783631	1.276112	55
6	0.617036	0.786935	1.270753	1.620651	0.784100	1.275347	54
7	0.617265	0.786756	1.271043	1.620050	0.784570	1.274584	53
8	0.617494	0.786574	1.271333	1.619450	0.785040	1.273820	52
9	0.617722	0.786396	1.271624	1.618850	0.785510	1.273058	51
10	0.617951	0.786217	1.271914	1.618251	0.785981	1.272296	50
11	0.618180	0.786037	1.272205	1.617652	0.786452	1.271534	49
12	0.618408	0.785857	1.272496	1.617054	0.786922	1.270773	48
13	0.618637	0.785677	1.272788	1.616457	0.787394	1.270013	47
14	0.618866	0.785497	1.273079	1.615860	0.787865	1.269253	46
15	0.619094	0.785317	1.273371	1.615264	0.788336	1.268494	45
16	0.619322	0.785137	1.273663	1.614668	0.788808	1.267735	44
17	0.619551	0.784951	1.273956	1.614073	0.789280	1.266977	43
18	0.619779	0.784776	1.274248	1.613478	0.789752	1.266220	42
19	0.620007	0.784596	1.274541	1.612884	0.790225	1.265463	41
20	0.620236	0.784416	1.274834	1.612291	0.790698	1.264706	40
21	0.620464	0.784235	1.275128	1.611698	0.791170	1.263950	39
22	0.620692	0.784055	1.275421	1.611106	0.791643	1.263195	38
23	0.620920	0.783874	1.275715	1.610514	0.792117	1.262440	37
24	0.621148	0.783694	1.276009	1.609923	0.792590	1.261686	36
25	0.621376	0.783513	1.276303	1.609332	0.793064	1.260932	35
26	0.621604	0.783332	1.276598	1.608742	0.793538	1.260179	34
27	0.621831	0.783151	1.276893	1.608153	0.794012	1.259427	33
28	0.622059	0.782970	1.277188	1.607564	0.794487	1.258675	32
29	0.622287	0.782789	1.277483	1.606976	0.794961	1.257923	31
30	0.622515	0.782608	1.277779	1.606388	0.795436	1.257172	30
31	0.622742	0.782427	1.278074	1.605801	0.795911	1.256422	29
32	0.622970	0.782246	1.278371	1.605214	0.796386	1.255672	28
33	0.623197	0.782065	1.278667	1.604628	0.796862	1.254923	27
34	0.623425	0.781883	1.278963	1.604043	0.797337	1.254174	26
35	0.623652	0.781702	1.279260	1.603458	0.797813	1.253426	25
36	0.623880	0.781521	1.279557	1.602873	0.798290	1.252678	24
37	0.624107	0.781339	1.279854	1.602290	0.798766	1.251931	23
38	0.624334	0.781157	1.280152	1.601706	0.799243	1.251185	22
39	0.624561	0.780976	1.280450	1.601124	0.799719	1.250439	21
40	0.624789	0.780794	1.280748	1.600542	0.800196	1.249693	20
41	0.625016	0.780612	1.281046	1.599960	0.800674	1.248948	19
42	0.625243	0.780430	1.281344	1.599379	0.801151	1.248204	18
43	0.625470	0.780249	1.281643	1.598799	0.801629	1.247460	17
44	0.625697	0.780067	1.281942	1.598219	0.802107	1.246717	16
45	0.625924	0.779885	1.282241	1.597639	0.802585	1.245974	15
46	0.626150	0.779702	1.282541	1.597061	0.803063	1.245232	14
47	0.626377	0.779520	1.282840	1.596482	0.803542	1.244490	13
48	0.626604	0.779338	1.283140	1.595905	0.804021	1.243749	12
49	0.626831	0.779156	1.283441	1.595328	0.804500	1.243009	11
50	0.627057	0.778973	1.283741	1.594751	0.804979	1.242269	10
51	0.627284	0.778791	1.284042	1.594175	0.805458	1.241529	9
52	0.627510	0.778608	1.284343	1.593600	0.805938	1.240790	8
53	0.627737	0.778426	1.284644	1.593025	0.806418	1.240052	7
54	0.627963	0.778243	1.284946	1.592450	0.806898	1.239314	6
55	0.628189	0.778060	1.285247	1.591877	0.807379	1.238576	5
56	0.628416	0.777878	1.285549	1.591303	0.807859	1.237839	4
57	0.628642	0.777695	1.285851	1.590731	0.808340	1.237103	3
58	0.628868	0.777512	1.286154	1.590158	0.808821	1.236367	2
59	0.629094	0.777329	1.286457	1.589587	0.809303	1.235632	1
60	0.629320	0.777146	1.286760	1.589016	0.809784	1.234897	0
	Cosine s.	Sines.	Cosecants.	Secants.	Cotangents.	Tangents.	51°

39°	Sines.	Cosines.	Secants.	Cosecants.	Tangents.	Cotangents.	
0′	0.629320	0.777146	1.286760	1.589016	0.809784	1.234897	60′
1	0.629546	0.776963	1.287063	1.588445	0.810266	1.234163	59
2	0.629772	0.776780	1.287366	1.587875	0.810748	1.233429	58
3	0.629998	0.776597	1.287670	1.587306	0.811230	1.232696	57
4	0.630224	0.776413	1.287974	1.586737	0.811712	1.231963	56
5	0.630450	0.776230	1.288278	1.586169	0.812195	1.231231	55
6	0.630676	0.776046	1.288583	1.585601	0.812678	1.230500	54
7	0.630902	0.775863	1.288888	1.585033	0.813161	1.229769	53
8	0.631127	0.775679	1.289193	1.584467	0.813644	1.229038	52
9	0.631353	0.775496	1.289498	1.583901	0.814128	1.228308	51
10	0.631578	0.775312	1.289803	1.583335	0.814612	1.227579	50
11	0.631804	0.775128	1.290109	1.582770	0.815096	1.226850	49
12	0.632029	0.774945	1.290415	1.582205	0.815580	1.226121	48
13	0.632255	0.774761	1.290721	1.581641	0.816065	1.225393	47
14	0.632480	0.774577	1.291028	1.581078	0.816549	1.224666	46
15	0.632705	0.774393	1.291335	1.580515	0.817034	1.223939	45
16	0.632931	0.774209	1.291642	1.579952	0.817520	1.223213	44
17	0.633156	0.774024	1.291949	1.579390	0.818005	1.222487	43
18	0.633381	0.773840	1.292256	1.578829	0.818491	1.221761	42
19	0.633606	0.773656	1.292564	1.578268	0.818976	1.221036	41
20	0.633831	0.773472	1.292872	1.577708	0.819463	1.220312	40
21	0.634056	0.773287	1.293181	1.577148	0.819949	1.219588	39
22	0.634281	0.773103	1.293489	1.576589	0.820435	1.218865	38
23	0.634506	0.772918	1.293798	1.576030	0.820922	1.218142	37
24	0.634731	0.772734	1.294107	1.575472	0.821409	1.217420	36
25	0.634955	0.772549	1.294416	1.574914	0.821897	1.216698	35
26	0.635180	0.772364	1.294726	1.574357	0.822384	1.215977	34
27	0.635405	0.772179	1.295036	1.573800	0.822872	1.215256	33
28	0.635629	0.771995	1.295346	1.573244	0.823360	1.214536	32
29	0.633854	0.771810	1.295656	1.572689	0.823848	1.213816	31
30	0.636078	0.771625	1.295967	1.572134	0.824336	1.213097	30
31	0.636303	0.771440	1.296278	1.571579	0.824825	1.212378	29
32	0.636527	0.771254	1.296589	1.571025	0.825314	1.211660	28
33	0.636751	0.771069	1.296900	1.570472	0.825803	1.210942	27
34	0.636976	0.770884	1.297212	1.569919	0.826293	1.210225	26
35	0.637200	0.770699	1.297524	1.569366	0.826782	1.209509	25
36	0.637424	0.770513	1.297836	1.568815	0.827272	1.208792	24
37	0.637648	0.770328	1.298149	1.568263	0.827762	1.208077	23
38	0.637872	0.770142	1.298461	1.567712	0 828252	1.207362	22
39	0.638096	0.769957	1.298774	1.567162	0.828743	1.206647	21
40	0.638320	0.769771	1.299088	1.566612	0.829234	1.205933	20
41	0.638544	0.769585	1.299401	1.566063	0.829725	1.205219	19
42	0.638768	0.769400	1.299715	1.565514	0.830216	1.204506	18
43	0.638992	0.769214	1.300029	1.564966	0.830708	1.203793	17
44	0.639215	0.769028	1.300343	1.564418	0.831199	1.203081	16
45	0.639439	0.768842	1.300658	1.563871	0.831691	1.202369	15
46	0.639663	0.768656	1.300972	1.563324	0.832183	1.201658	14
47	0.639886	0.768470	1.301288	1.562778	0.832676	1.200948	13
48	0.640110	0.768284	1.301603	1.562232	0.833169	1.200237	12
49	0.640333	0.768097	1.301918	1.561687	0.833662	1.199528	11
50	0.640557	0.767911	1.302234	1.561142	0.834155	1.198818	10
51	0.640780	0.767725	1.302550	1.560598	0.834648	1.198110	9
52	0.641003	0.767538	1.302867	1.560055	0.835142	1.197402	8
53	0.641226	0.767352	1.303183	1.559512	0.835636	1.196694	7
54	0.641450	0.767165	1.303500	1.558969	0.836130	1.195987	6
55	0.641673	0.766979	1.303818	1.558427	0.836624	1.195280	5
56	0.641896	0.766792	1.304135	1.557885	0.837119	1.194574	4
57	0.642119	0.766605	1.304453	1.557344	0.837614	1.193868	3
58	0.642342	0.766418	1.304771	1.556804	0.838109	1.193163	2
59	0.642565	0.766231	1.305089	1.556263	0.838604	1.192458	1
60	0.642788	0.766044	1.305407	1.555724	0.839100	1.191753	0
	Cosines.	Sines.	Cosecants.	Secants.	Cotangents.	Tangents.	50°

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40°	Sines.	Cosines.	Secants.	Cosecants.	Tangents.	Cotangents.	
0′	0.642788	0.766044	1.305407	1.555724	0.839100	1.191754	60′
1	0.643010	0.765857	1.305726	1.555185	0.839596	1.191050	59
2	0.643233	0.765670	1.306045	1.554646	0.840092	1.190347	58
3	0.643456	0.765483	1.306364	1.554108	0.840588	1.189644	57
4	0.643679	0.765296	1.306684	1.553571	0.841084	1.188941	56
5	0.643901	0.765109	1.307004	1.553034	0.841581	1.188240	55
6	0.644124	0.764921	1.307324	1.552497	0.842078	1.187538	54
7	0.644346	0.764734	1.307644	1.551961	0.842576	1.186837	53
8	0.644569	0.764547	1.307965	1.551425	0.843073	1.186137	52
9	0.644791	0.764359	1.308286	1.550890	0.843571	1.185437	51
10	0.645013	0.764171	1.308607	1.550356	0.844069	1.184738	50
11	0.645236	0.763984	1.308928	1.549822	0.844567	1.184039	49
12	0.645458	0.763796	1.309250	1.549288	0.845066	1.183340	48
13	0.645680	0.763608	1.309572	1.548755	0.845564	1.182642	47
14	0.645902	0.763420	1.309894	1.548223	0.846063	1.181945	46
15	0.646124	0.763233	1.310217	1.547691	0.846563	1.181248	45
16	0.646346	0.763045	1.310540	1.547159	0.847062	1.180551	44
17	0.646568	0.762856	1.310863	1.546628	0.847562	1.179855	43
18	0.646790	0.762668	1.311186	1.546097	0.848062	1.179160	42
19	0.647012	0.762480	1.311510	1.545567	0.848562	1.178464	41
20	0.647233	0.762292	1.311833	1.545038	0.849062	1.177770	40
21	0.647455	0.762104	1.312158	1.544509	0.849563	1.177076	39
22	0.647677	0.761915	1.312482	1.543980	0.850064	1.176382	38
23	0.647898	0.761727	1.312807	1.543452	0.850565	1.175689	37
24	0.648120	0.761538	1.313132	1.542924	0.851067	1.174996	36
25	0.648341	0.761350	1.313457	1.542397	0.851568	1.174304	35
26	0.648563	0.761161	1.313782	1.541871	0.852070	1.173612	34
27	0.648784	0.760972	1.314108	1.541345	0.852573	1.172921	33
28	0.649006	0.760784	1.314434	1.540819	0.853075	1.172230	32
29	0.649227	0.760595	1.314760	1.540294	0.853578	1.171540	31
30	0.649448	0.760406	1.315087	1.539769	0.854081	1.170850	30
31	0.649669	0.760217	1.315414	1.539245	0.854584	1 170160	29
32	0.649890	0.760028	1.315741	1.538721	0.855087	1.169471	28
33	0.650111	0.759839	1.316068	1.538198	0.855591	1.168783	27
34	0.650332	0.759650	1.316396	1.537675	0.856095	1.168095	26
35	0.650553	0.759461	1.316724	1.537153	0.856599	1.167407	25
36	0.650774	0.759271	1.317052	1.536631	0.857104	1.166720	24
37	0.650995	0.759082	1.317381	1.536110	0.857608	1.166033	23
38	0.651216	0.758893	1.317710	1.535589	0.858113	1.165347	22
39	0.651437	0.758703	1.318039	1.535069	0.858619	1.164662	21
40	0.651657	0.758514	1.318368	1.534549	0.859124	1.163976	20
41	0.651879	0.758324	1.318698	1.534030	0.859630	1.163292	19
42	0.652098	0.758134	1.319027	1.533511	0.860136	1.162607	18
43	0.652319	0.757945	1.319358	1.532993	0.860642	1.161923	17
44	0.652539	0 757755	1.319688	1.532475	0.861148	1.161240	16
45	0.652760	0.757565	1.320019	1.531957	0.861655	1.160557	15
46	0.652980	0.757375	1.320350	1.531440	0.862162	1.159875	14
47	0.653200	0.757185	1.320681	1.530924	0.862669	1.159193	13
48	0.653421	0.756995	1.321013	1.530408	0.863177	1.158511	12
49	0.653641	0.756805	1.321344	1.529892	0.863685	1.157830	11
50	0.653861	0.756615	1 321677	1.529377	0.864193	1.157150	10
51	0.654081	0.756425	1.322009	1.528863	0.864701	1.156469	9
52	0.654301	0.756234	1.322342	1.528349	0.865209	1.155790	8
53	0.654521	0.756044	1.322675	1.527835	0.865718	1.155110	7
54	0.654741	0.755854	1.323008	1.527322	0.866227	1.154432	6
55	0.654961	0.755663	1.323341	1.526809	0.866737	1.153753	5
56	0.655180	0.755472	1.323675	1.526297	0.867246	1.153075	4
57	0.655400	0.755282	1.324009	1.525785	0.867756	1.152398	3
58	0.655620	0.755091	1.324344	1.525274	0.868266	1.151721	2
59	0.655840	0.754900	1.324678	1.524763	0.868776	1.151045	1
60	0.656059	0.754710	1.325013	1.524253	0.869287	1.150368	0
	Cosines.	Sines.	Cosecants.	Secants.	Cotangents.	Tangents.	49°

41°	Sines.	Cosines.	Secants.	Cosecants.	Tangents.	Cotangents.	
0′	0.656059	0.754710	1.325013	1.524253	0.869287	1.150368	60′
1	0.656279	0.754519	1.325348	1.523743	0.869798	1.149693	59
2	0.656498	0.754328	1.325684	1.523234	0.870309	1.149018	58
3	0.656717	0.754137	1.326019	1.522725	0.870820	1,148348	57
4	0.656937	0.753946	1.326355	1.522217	0.871332	1.147669	56
5	0.657156	0.753755	1.326692	1.521709	0.871844	1.146995	55
6	0.657375	0.753563	1.327028	1.521201	0.872356	1.146322	54
7	0.657594	0.753372	1.327365	1.520694	0.872868	1.145649	53
8	0.657814	0.753181	1.327702	1.520188	0.873381	1.144976	52
9	0.658033	0.752989	1.328040	1.519682	0.873894	1.144304	51
10	0.658252	0.752798	1.328378	1.519176	0.874407	1.143633	50
11	0.658471	0.752607	1.328716	1.518671	0.874920	1.142962	49
12	0.658690	0.752415	1.329054	1.518166	0.875434	1.142291	48
13	0.658908	0.752223	1.329393	1.517662	0.875948	1.141621	47
14	0.659127	0.752032	1.329731	1.517158	0.876462	1.140951	46
15	0.659346	0.751840	1.330071	1.516655	0.876977	1.140282	45
16	0.659565	0.751648	1.330410	1.516152	0.877491	1.139613	44
17	0.659783	0.751456	1.330750	1.515650	0.878006	1.138944	43
18	0.660002	0.751264	1.331090	1.515148	0.878522	1.138276	42
19	0.660220	0.751072	1.331430	1.514646	0.879037	1.137609	41
20	0.660439	0.750880	1.331771	1.514145	0.879553	1.136941	40
21	0.660657	0.750688	1.332112	1.513645	0.880069	1.136275	39
22	0.660875	0.750496	1.332453	1.513145	0.880585	1.135609	38
23	0.661094	0.750303	1.332794	1.512645	0.881102	1.134943	37
24	0.661312	0.750111	1.333136	1.512146	0.881619	1.134277	36
25	0.661530	0.749919	1.333478	1.511647	0.882136	1.133612	35
26	0.661748	0.749726	1.333820	1.511149	0.882653	1.132948	34
27	0.661966	0.749534	1.334163	1.510651	0.883171	1.132284	33
28	0.662184	0.749341	1.334506	1.510154	0.883689	1.131620	32
29	0.662402	0.749148	1.334849	1.509657	0.884207	1.130957	31
30	0.662620	0.748956	1.335192	1.509161	0.884725	1.130294	30
31	0.662838	0.748763	1.335536	1.508665	0.885244	1.129632	29
32	0.663056	0.748570	1.335880	1.508169	0.885763	1.128970	28
33	0.663273	0.748377	1.336225	1.507674	0.886282	1.128309	27
34	0.663491	0.748184	1.336569	1.507179	0.886802	1.127648	26
35	0.663709	0.747991	1.336914	1.506685	0.887322	1.126987	25
36	0.663926	0.747798	1.337259	1.506192	0.887842	1.126327	24
37	0.664144	0.747605	1.337605	1.505698	0.888362	1.125667	23
38	0.664361	0.747412	1.337951	1.505205	0.888883	1.125008	22
39	0.664579	0.747218	1.338297	1.504713	0.889403	1.124349	21
40	0.664796	0.747025	1.338643	1.504221	0.889924	1.123691	20
41	0.665013	0.746832	1.338990	1.503730	0.890446	1.123033	19
42	0.665230	0.746638	1.339337	1.503239	0.890968	1.122375	18
43	0.665448	0.746445	1.339684	1.502748	0.891489	1.121718	17
44	0.665665	0.746251	1.340032	1.502258	0.892012	1.121062	16
45	0.665882	0.746057	1.340380	1.501768	0.892534	1.120405	15
46	0.666099	0.745864	1.340728	1.501279	0.893057	1.119750	14
47	0.666316	0.745670	1.341076	1.500790	0.893580	1.119094	13
48	0.666533	0.745476	1.341425	1.500302	0.894103	1.118439	12
49	0.666749	0.745282	1.341774	1.499814	0.894627	1.117785	11
50	0.666966	0.745088	1.342123	1.499327	0.895151	1.117131	10
51	0.667183	0.744894	1.342473	1.498840	0.895675	1.116477	9
52	0.667399	0.744700	1.342823	1.498353	0.896199	1.115824	8
53	0.667616	0.744506	1.343173	1.497867	0.896724	1.115171	7
54	0.667833	0.744312	1.343523	1.497381	0.897249	1.114518	6
55	0.668049	0.744117	1.343874	1.496896	0.897774	1.113866	5
56	0.668266	0.743929	1.344225	1.496411	0.898299	1.113215	4
57	0.668482	0.743729	1.344577	1.495927	0.898825	1.112564	3
58	0.668693	0.743534	1.344928	1.495443	0.899351	1.111913	2
59	0.668917	0.743339	1.345280	1.494960	0.899878	1.111262	1
60	0.669131	0.743145	1.345633	1.494477	0.900404	1.110613	0
	Cosines.	Sines.	Cosecants.	Secants.	Cotangents.	Tangents.	48°

42°	Sines.	Cosines.	Secants.	Cosecants.	Tangents.	Cotangents.	
0′	0.669131	0.743145	1.345633	1.494477	0.900404	1.110613	60′
1	0.669347	0.742950	1.345985	1.493994	0.900931	1.109963	59
2	0.669563	0.742755	1.346338	1.493512	0.901458	1.109314	58
3	0.669779	0.742561	1.346691	1.493030	0.901985	1.108665	57
4	0.669995	0.742366	1.347045	1.492549	0.902513	1.108017	56
5	0.670211	0.742171	1.347399	1.492068	0.903041	1.107369	55
6	0.670427	0.741976	1.347753	1.491588	0.903569	1.106722	54
7	0.670642	0.741781	1.348107	1.491108	0.904098	1.106075	53
8	0.670858	0.741586	1.348462	1.490628	0.904627	1.105428	52
9	0.671074	0.741391	1.348817	1.490149	0.905156	1.104782	51
10	0.671290	0.741195	1.349172	1.489670	0.905685	1.104137	50
11	0.671505	0.741000	1.349528	1.489192	0.906215	1.103491	49
12	0.671721	0.740805	1.349884	1.488714	0.906745	1.102846	48
13	0.671936	0.740609	1.350240	1.488237	0.907275	1.102202	47
14	0.672152	0.740414	1.350596	1.487760	0.907805	1.101558	46
15	0.672367	0.740218	1.350953	1.487283	0.908336	1.100914	45
16	0.672582	0.740023	1.351310	1.486807	0.908867	1.100271	44
17	0.672797	0.739827	1.351668	1.486332	0.909398	1.099628	43
18	0.673013	0.739631	1.352025	1.485857	0.909930	1.098986	42
19	0.673228	0.739435	1.352383	1.485382	0.910462	1.098344	41
20	0.673443	0.739239	1.352742	1.484907	0.910994	1.097702	40
21	0.673658	0.739044	1.353100	1.484433	0.911527	1.097061	39
22	0.673873	0.738848	1.353459	1.483960	0.912059	1.096420	38
23	0.674088	0.738652	1.353819	1.483487	0.912592	1.095780	37
24	0.674302	0.738455	1.354178	1.483014	0.913126	1.095140	36
25	0.674517	0.738259	1.354538	1.482542	0.913659	1.094500	35
26	0.674732	0.738063	1.354898	1.482070	0.914193	1.093861	34
27	0.674947	0.737867	1.355259	1.481599	0.914727	1.093222	33
28	0.675161	0.737670	1.355619	1.481128	0.915262	1.092584	32
29	0.675376	0.737474	1.355980	1.480657	0.915796	1.091946	31
30	0.675590	0.737277	1.356342	1.480187	0.916331	1.091309	30
31	0.675808	0.737081	1.356703	1.479718	0.916867	1.090671	29
32	0.676019	0.736884	1.357065	1.479248	0.917402	1 090035	28
33	0.676233	0.736688	1.357428	1.479780	0.917938	1.089398	27
34	0.676448	0.736491	1.357790	1.478311	0.918474	1.088762	26
35	0.676662	0.736294	1.358153	1.477843	0.919010	1.088127	25
36	0.676876	0.736097	1.358516	1.477376	0.919547	1.087492	24
37	0.677090	0.735900	1.358880	1.476908	0.920084	1.086857	23
38	0.677304	0.735703	1.359244	1.476442	0.920621	1.086223	22
39	0.677518	0.735506	1.359608	1.475975	0.921159	1.085589	21
40	0.677732	0.735309	1.359973	1.475510	0.921697	1.084955	20
41	0.677946	0.735112	1.360337	1.475044	0.922235	1.084322	19
42	0.678160	0.734915	1.360702	1.474579	0.922773	1.083690	18
43	0.678373	0.734717	1.361068	1.474114	0.923312	1.083057	17
44	0.678587	0.734520	1.361433	1.473650	0.923851	1.082425	16
45	0.678801	0.734323	1.361800	1.473186	0.924391	1.081794	15
46	0.679014	0.734125	1.362166	1.472723	0.924930	1.081163	14
47	0.679228	0.733928	1.362532	1.472260	0.925470	1.080532	13
48	0.679441	0.733730	1.362899	1.471798	0.926010	1.079902	12
49	0.679655	0.733532	1.363267	1.471335	0.926551	1.079272	11
50	0.679868	0.733335	1.363634	1.470874	0.927091	1.078642	10
51	0.680081	0.733137	1.364002	1.470412	0.927632	1.078013	9
52	0.680295	0.732939	1.364370	1.469951	0.928174	1.077385	8
53	0.680508	0.732741	1.364739	1.469491	0.928715	1.076756	7
54	0.680721	0.732543	1.365108	1.469031	0.929257	1.076128	6
55	0.680934	0.732345	1.365477	1.468571	0.929800	1.075501	5
56	0.681147	0.732147	1.365846	1.468112	0.930842	1.074873	4
57	0.681360	0.731949	1.366216	1.467653	0.930885	1.074247	3
58	0.681573	0.731750	1.366586	1.467195	0.931428	1.073620	2
59	0.681786	0.731552	1.366957	1.466737	0.931971	1.072994	1
60	0.681998	0.731354	1.367328	1.466279	0.932515	1.072369	0
	Cosines.	Sines.	Cosecants.	Secants.	Cotangents.	Tangents.	47°

43°	Sines.	Cosines.	Secants.	Cosecants.	Tangents.	Cotangents.	
0′	0.681998	0.731354	1.367328	1.466279	0.932515	1.072369	60′
1	0.682211	0.731155	1.367699	1.465822	0.933059	1.071744	59
2	0.682424	0.730957	1.368070	1.465365	0.933603	1.071119	58
3	0.682636	0.730758	1.368442	1.464909	0.934148	1.070494	57
4	0.682849	0.730560	1.368814	1.464453	0.934693	1.069870	56
5	0.683061	0.730361	1.369186	1.463997	0.935238	1.069247	55
6	0.683274	0.730162	1.369559	1.463842	0.935783	1.068623	54
7	0.683486	0.729964	1.369932	1.463088	0.936329	1.068000	53
8	0.683698	0.729765	1.370305	1.462633	0.936875	1.067378	52
9	0.683911	0.729566	1.370678	1.462179	0.937422	1.066756	51
10	0.684123	0.729367	1.371052	1.461726	0.937968	1.066134	50
11	0.684335	0.729168	1.371427	1.461273	0.938515	1.065513	49
12	0.684547	0.728969	1.371801	1.460820	0.939063	1.064892	48
13	0.684759	0.728770	1.372176	1.460368	0.939610	1.064271	47
14	0.684971	0.728570	1.372551	1.459916	0.940158	1.063651	46
15	0.685183	0.728371	1.372927	1.459464	0.940706	1.063031	45
16	0.685395	0.728172	1.373303	1.459013	0.941255	1.062412	44
17	0.685607	0.727972	1.373679	1.458562	0.941803	1.061793	43
18	0.685818	0.727773	1.374055	1.458112	0.942352	1.061174	42
19	0.686030	0.727573	1.374432	1.457662	0.942902	1.060556	41
20	0.686242	0.727374	1.374809	1.457213	0.943451	1.059938	40
21	0.686453	0.727174	1.375187	1.456764	0.944001	1.059321	39
22	0.686665	0.726974	1.375565	1.456315	0.944552	1.058704	38
23	0.686876	0.726775	1.375943	1.455867	0.945102	1.058087	37
24	0.687088	0.726575	1.376321	1.455419	0.945653	1.057470	36
25	0.687299	0.726375	1.376700	1.454971	0.946204	1.056854	35
26	0.687510	0.726175	1.377079	1.454524	0.946756	1.056239	34
27	0.687721	0.725975	1.377458	1.454077	0.947307	1.055624	33
28	0.687933	0.725775	1.377838	1.453631	0.947868	1.055009	32
29	0.688144	0.725575	1.378218	1.453185	0.948412	1.054394	31
30	0.688355	0.725374	1.378599	1.452740	0.948965	1.053780	30
31	0.688566	0.725174	1.378979	1.452295	0.949518	1.053166	29
32	0.688777	0.724974	1.379360	1.451850	0.950071	1.052553	28
33	0.688987	0.724773	1.379742	1.451406	0.950625	1.051940	27
34	0.689198	0.724573	1.380123	1.450962	0.951178	1.051328	26
35	0.689409	0.724372	1.380505	1.450518	0.951733	1.050715	25
36	0.689620	0.724172	1.380888	1.450075	0.952287	1.050103	24
37	0.689830	0.723971	1.381270	1.449632	0.952842	1.049492	23
38	0.690041	0.723771	1.381656	1.449190	0.953397	1.048881	22
39	0.690251	0.723570	1.382037	1.448748	0.953953	1.048270	21
40	0.690462	0.723369	1.382420	1.448306	0.954508	1.047660	20
41	0.690672	0.723168	1.382804	1.447865	0.955064	1.047050	19
42	0.690882	0.722967	1.383189	1.447424	0.955621	1.046440	18
43	0.691093	0.722766	1.383573	1.446984	0.955177	1.045831	17
44	0.691303	0.722565	1.383958	1.446544	0.956734	1.045222	16
45	0.691513	0.722364	1.384344	1.446104	0.957292	1.044614	15
46	0.691723	0.722163	1.384729	1.445665	0.957849	1.044006	14
47	0.691933	0.721962	1.385115	1.445226	0.958407	1.043398	13
48	0.692143	0.721760	1.385502	1.444788	0.958966	1.042790	12
49	0.692253	0.721559	1.385888	1.444350	0.959524	1.042183	11
50	0.692563	0.721357	1.386275	1.443912	0.960083	1.041557	10
51	0.692773	0.721156	1.386663	1.443475	0.960642	1.040970	9
52	0.692983	0.720954	1.387050	1.443038	0.961202	1.040368	8
53	0.693192	0.720753	1.387438	1.442601	0.961761	1.039759	7
54	0.693402	0.720551	1.387827	1.442165	0.962322	1.039154	6
55	0.693611	0.720349	1.388215	1.441730	0.962882	1.038549	5
56	0.693821	0.720148	1.388604	1.441294	0.963443	1.037945	4
57	0.694030	0.719946	1.388994	1.440859	0.964004	1.037340	3
58	0.694240	0.719744	1.389383	1.440425	0.964565	1.036737	2
59	0.694449	0.719542	1.389773	1.439990	0.965127	1.036133	1
60	0.694658	0.719340	1.390164	1.439557	0.965689	1.035630	0
	Cosines.	Sines.	Cosecants.	Secants.	Cotangents.	Tangents.	46°

44°	Sines.	Cosines.	Secants.	Cosecants.	Tangents.	Cotangents.	
0′	0.694658	0.719340	1.390164	1.439557	0.965689	1.035530	60′
1	0.694868	0.719138	1.390554	1.439123	0.966251	1.034928	59
2	0.695077	0.718936	1.390945	1.438690	0.966814	1.034325	58
3	0.695286	0.718733	1.391337	1.438257	0.967377	1.033724	57
4	0.695495	0.718531	1.391728	1.437825	0.967940	1.033122	56
5	0.695704	0.718329	1.392120	1.437393	0.968504	1.032521	55
6	0.695913	0.718126	1.392513	1.436962	0.969067	1.031920	54
7	0.696122	0.717924	1.392905	1.436531	0.969632	1.031320	53
8	0.696331	0.717721	1.393299	1.436100	0.970196	1.030719	52
9	0.696539	0.717519	1.393692	1.435669	0.970761	1.030120	51
10	0.696748	0.717316	1.394086	1.435239	0.971326	1.029520	50
11	0.696957	0.717113	1.394480	1.434810	0 971892	1.028921	49
12	0.697165	0.716911	1.394874	1.434381	0.972458	1.028323	48
13	0.697374	0.716708	1.395269	1.433952	0.973024	1.027724	47
14	0.697582	0.716505	1.395664	1.433523	0.973590	1.027126	46
15	0.697791	0.716302	1.396059	1.433095	0.974157	1.026529	45
16	0.697999	0.716099	1.396455	1.432667	0.974724	1.025932	44
17	0.698207	0.715896	1.396851	1.432240	0.975291	1.025335	43
18	0.698415	0.715693	1.397248	1.431813	0.975859	1.024738	42
19	0.698623	0 715490	1.397645	1.431386	0.976427	1.024142	41
20	0.698832	0.715286	1.398042	1.430960	0.976996	1.023546	40
21	0.699040	0.715083	1.398439	1.430534	0.977564	1.022951	39
22	0.699248	0.714880	1.398837	1.430109	0.978133	1.022356	38
23	0.699456	0.714676	1.399238	1.429684	0.978703	1.021761	37
24	0.699663	0.714473	1.399634	1.429259	0.979272	1.021166	36
25	0.699871	0.714269	1.400033	1.428835	0.979842	1.020572	35
26	0.700079	0.714066	1.400432	1.428411	0.980413	1.019979	34
27	0.700287	0.713862	1.400831	1.427987	0.980983	1.019385	33
28	0.700494	0.713658	1.401231	1.427564	0.981554	1.018792	32
29	0.700702	0.713454	1.401632	1.427141	0.982126	1.018200	31
30	0.700909	0.713250	1.402032	1.426718	0.982697	1.017607	30
31	0.701117	0.713047	1.402433	1.426296	0.983269	1.017016	29
32	0.701324	0.712843	1.402834	1.425874	0.983842	1.016424	28
33	0.701531	0.712639	1.403236	1.425453	0.984414	1.015833	27
34	0.701739	0.712434	1.403638	1.425032	0.984987	1.015242	26
35	0.701946	0.712230	1.404040	1.424611	0.985560	1.014651	25
36	0.702153	0.712026	1.404443	1.424191	0.986134	1.014061	24
37	0.702360	0.711822	1.404846	1.423771	0.986708	1.013471	23
38	0.702567	0.711617	1.405249	1.423351	0.987282	1.012882	22
39	0.702774	0.711413	1.405653	1.422932	0.987857	1.012293	21
40	0.702981	0.711209	1.406057	1.422513	0.988432	1.011704	20
41	0.703188	0.711004	1.406462	1.422095	0.989007	1.011115	19
42	0.703395	0.710800	1.406867	1.421677	0.989583	1.010527	18
43	0.703601	0.710595	1.407272	1.421259	0.990158	1.009939	17
44	0.703808	0.710390	1.407677	1.420842	0.990735	1.009352	16
45	0.704015	0.710685	1.408083	1.420425	0.991311	1.008765	15
46	0.704221	0.709981	1.408489	1.420008	0.991888	1.008178	14
47	0.704428	0.709776	1 408896	1.419592	0.992465	1.007592	13
48	0.704634	0.709571	1.409303	1.419176	0.993043	1.007006	12
49	0.704841	0.709366	1.409710	14.18761	0.993621	1.006420	11
50	0.705047	0.709161	1.410118	1.418345	0.994199	1.005835	10
51	0.705253	0.708956	1.410526	1.417931	0.994778	1.005250	9
52	0.705459	0.708750	1.410934	1.417516	0 995357	1.004665	8
53	0.705666	0.708545	1.411343	1.417102	0.995936	1.004081	7
54	0.705872	0.708340	1.411752	1.416688	0.996515	1.003497	6
55	0.706078	0.708135	1.412161	1.416275	0.997095	1.002913	5
56	0.706284	0.707920	1.412571	1.415862	0.997676	1.002330	4
57	0.706489	0.707724	1.412981	1.415449	0.998256	1.001747	3
58	0.706695	0.707518	1.413392	1.415037	0.998837	1.001164	2
59	0.706901	0.707312	1.413802	1.414625	0.999418	1.000582	1
60	0.707107	0.707107	1.414214	1.414214	0.100000	1.000000	0
	Cosines.	Sines.	Cosecants.	Secants.	Cotangents.	Tangents.	45°

TABLE OF THE RATE OF INCLINE PLANES CORRESPONDING TO THE FOLLOWING VERTICAL ANGLES, FOR SETTING OUT RAILWAY, TRAM-ROAD, OR UNDERGROUND GRADIENTS.

Vertical Angle.	One in	Vertical Angle.	One in	Vertical Angle.	One in	Vertical Angle.	One in	Vertical Angle.	One in
° ′ ″		° ′ ″		° ′ ″		° ′ ″		° ′ ″	
0 8 30	400	0 16 5	214	0 26 51	128	0 51 30	66.75	1 1 39	55.75
0 8 48	390	0 16 13	212	0 27 17	126	0 51 41	66.50	1 1 57	55.50
0 9 3	380	0 16 22	210	0 27 43	124	0 51 54	66.25	1 2 14	55.25
0 9 17	370	0 16 28	209	0 28 10	122	0 52 6	66.00	1 2 31	55.00
0 9 33	360	0 16 37	207	0 28 40	120	0 52 18	65.75	1 2 48	54.75
0 9 50	350	0 16 46	205	0 29 10	118	0 52 30	65.50	1 3 5	54.50
0 10 7	340	0 16 56	203	0 29 38	116	0 52 42	65.25	1 3 23	54.25
0 10 25	330	0 17 6	201	0 30 10	114	0 52 53	65.00	1 3 40	54.00
0 10 44	320	0 17 17	199	0 30 41	112	0 53 6	64.75	1 3 55	53.75
0 11 5	310	0 17 27	197	0 31 15	110	0 53 18	64.50	1 4 16	53.50
0 11 27	300	0 17 38	195	0 31 50	108	0 53 31	64.25	1 4 34	53.25
0 11 40	295	0 17 54	192	0 32 25	106	0 53 43	64.00	1 4 52	53.00
0 11 50	290	0 18 6	190	0 33 3	104	0 53 56	63.75	1 5 10	52.75
0 12 2	286	0 18 17	188	0 33 42	102	0 54 10	63.50	1 5 29	52.50
0 12 10	282	0 18 29	186	0 34 20	100	0 54 21	63.25	1 5 48	52.25
0 12 21	278	0 18 41	184	0 35 5	98	0 54 34	63.00	1 6 7	52.00
0 12 33	274	0 18 53	182	0 35 48	96	0 54 47	62.75	1 6 26	51.75
0 12 44	270	0 19 6	180	0 36 34	94	0 54 53	62.50	1 6 45	51.50
0 12 55	266	0 19 19	178	0 37 20	92	0 55 14	62.25	1 7 5	51.25
0 13 7	262	0 19 32	176	0 38 10	90	0 55 27	62.00	1 7 25	51.00
0 13 20	258	0 19 46	174	0 38 35	89	0 55 47	61.75	1 7 45	50.75
0 13 32	254	0 19 59	172	0 39 4	88	0 55 54	61.50	1 8 5	50.50
0 13 45	250	0 20 13	170	0 39 31	87	0 56 7	61.25	1 8 23	50.25
0 13 52	248	0 20 28	168	0 39 59	86	0 56 22	61.00	1 8 46	50.00
0 14 5	244	0 20 42	166	0 40 27	85	0 56 36	60.75	1 9 7	49.75
0 14 20	240	0 20 58	164	0 40 56	84	0 56 50	60.50	1 9 27	49.50
0 14 26	238	0 21 13	162	0 41 26	83	0 57 4	60.25	1 9 48	49.25
0 14 40	234	0 21 30	160	0 41 55	82	0 57 26	60.00	1 10 10	49.00
0 14 49	232	0 21 48	158	0 42 27	81	0 57 30	59.75	1 10 32	48.75
0 14 57	230	0 22 2	156	0 42 58	80	0 57 47	59.50	1 10 53	48.50
0 15 0	228	0 22 19	154	0 43 30	79	0 58 2	59.25	1 11 16	48.25
0 15 10	227	0 22 37	152	0 44 5	78	0 58 16	59.00	1 11 37	48.00
0 15 12	226	0 22 55	150	0 44 40	77	0 58 31	58.75	1 11 59	47.75
0 15 16	225	0 23 14	148	0 45 14	76	0 58 46	58.50	1 12 24	47.50
0 15 20	224	0 23 32	146	0 45 50	75	0 59 2	58.25	1 12 45	47.25
0 15 29	222	0 23 51	144	0 46 28	74	0 59 16	58.00	1 13 9	47.00
0 15 33	221	0 24 12	142	0 47 8	73	0 59 32	57.75	1 13 32	46.75
0 15 38	220	0 24 33	140	0 48 45	72	0 59 47	57.50	1 13 56	46.50
0 15 42	219	0 24 55	138	0 48 25	71	1 0 3	57.25	1 14 20	46.25
0 15 46	218	0 25 17	136	0 49 7	70	1 0 20	57.00	1 14 44	46.00
0 15 52	217	0 25 39	134	0 49 55	69	1 0 35	56.75	1 15 10	45.75
0 15 55	216	0 26 8	132	0 50 37	68	1 0 51	56.50	1 15 32	45.50
0 16 0	215	0 26 30	130	0 51 19	67	1 1 24	56.25	1 15 58	45.25

TABLE OF THE RATE OF INCLINE PLANES—*continued.*

Vertical Angle.	One in	Vertical Angle.	One in	Vertical Angle.	One in	Vertical Angle.	One in	Vertical Angle.	One in
° ′ ″		° ′ ″		° ′ ″		° ′ ″		° ′ ″	
1 16 24	45.00	1 44 9	33.00	2 43 30	21.00	6 20 26	9.00	13 34 0	4.15
1 16 50	44.75	1 44 56	32.75	2 45 20	20.75	6 24 16	8.90	13 42 0	4.10
1 17 15	44.50	1 45 46	32.50	2 47 45	20.50	6 28 34	8.80	13 52 0	4.05
1 17 41	44.25	1 46 34	32.25	2 49 24	20.25	6 33 0	8.70	14 2 0	4.00
1 18 8	44.00	1 47 20	32.00	2 51 36	20.00	6 37 24	8.60	14 6 0	3.98
1 18 35	43.75	1 48 14	31.75	2 53 50	19.75	6 42 39	8.50	14 10 0	3.96
1 19 2	43.50	1 49 7	31.50	2 56 56	19.50	6 47 20	8.40	14 14 0	3.94
1 19 30	43.25	1 49 58	31.25	2 59 0	19.25	6 52 0	8.30	14 18 0	3.92
1 19 57	43.00	1 50 41	31.00	3 1 20	19.00	6 57 0	8.20	14 23 0	3.90
1 20 24	42.75	1 51 47	30.75	3 3 20	18.75	7 2 10	8.10	14 27 0	3.88
1 20 54	42.50	1 52 48	30.50	3 5 30	18.50	7 7 0	8.00	14 31 0	3.86
1 21 28	42.25	1 53 36	30.25	3 8 45	18.25	7 12 0	7.90	14 35 0	3.84
1 21 53	42.00	1 54 33	30.00	3 10 25	18.00	7 18 0	7.80	14 40 0	3.82
1 22 20	41.75	1 55 32	29.75	3 13 0	17.75	7 24 0	7.70	14 45 0	3.80
1 22 49	41.50	1 56 30	29.50	3 16 20	17.50	7 29 20	7.60	14 49 0	3.78
1 23 21	41.25	1 57 27	29.25	3 19 10	17.25	7 35 0	7.50	14 53 0	3.76
1 23 50	41.00	1 58 31	29.00	3 21 40	17.00	7 41 25	7.40	14 58 0	3.74
1 24 21	40.75	1 59 32	28.75	3 24 20	16.75	7 47 10	7.30	15 3 0	3.72
1 24 52	40.50	2 0 30	28.50	3 28 40	16.50	7 54 0	7.20	15 9 0	3.70
1 25 25	40.25	2 1 20	28.25	3 31 10	16.25	8 1 0	7.10	15 12 0	3.68
1 25 57	40.00	2 2 30	28.00	3 34 16	16.00	8 7 0	7.00	15 17 0	3.66
1 26 29	39.75	2 3 20	27.75	3 37 10	15.75	8 14 0	6.90	15 23 0	3.64
1 26 55	39.50	2 4 50	27.50	3 41 26	15.50	8 21 24	6.80	15 26 0	3.62
1 27 35	39.25	2 6 10	27.25	3 45 49	15.25	8 29 16	6.70	15 32 0	3.60
1 28 8	39.00	2 7 24	27.00	3 48 19	15.00	8 36 10	6.60	15 37 0	3.58
1 28 42	38.75	2 8 28	26.75	3 52 29	14.75	8 44 0	6.50	15 41 0	3.56
1 29 17	38.50	2 9 38	26.50	3 56 24	14.50	8 52 42	6.40	15 46 0	3.54
1 29 51	38.25	2 10 54	26.25	4 0 0	14.25	9 1 0	6.30	15 51 0	3.52
1 30 29	38.00	2 12 9	26.00	4 5 10	14.00	9 9 0	6.20	15 57 0	3.50
1 31 3	37.75	2 13 26	25.75	4 9 20	13.75	9 18 0	6.10	16 2 0	3.48
1 32 9	37.50	2 14 12	25.50	4 14 0	13.50	9 27 0	6.00	16 7 0	3.46
1 32 17	37.25	2 16 5	25.25	4 18 20	13.25	9 37 0	5.90	16 12 0	3.44
1 32 54	37.00	2 17 26	25.00	4 23 40	13.00	9 46 0	5.80	16 17 0	3.42
1 33 33	36.75	2 18 46	24.75	4 29 16	12.75	9 56 0	5.70	16 23 0	3.40
1 34 11	36.50	2 20 19	24.50	4 34 34	12.50	10 7 0	5.60	16 28 0	3.38
1 34 48	36.25	2 21 41	24.25	4 40 36	12.25	10 18 0	5.50	16 34 0	3.36
1 35 28	36.00	2 23 8	24.00	4 45 27	12.00	10 29 34	5.40	16 40 0	3.34
1 36 9	35.75	2 24 36	23.75	4 51 0	11.75	10 41 0	5.30	16 45 0	3.32
1 36 49	35.50	2 26 12	23.50	4 57 0	11.50	10 53 0	5.20	16 51 0	3.30
1 37 30	35.25	2 27 49	23.25	5 4 25	11.25	11 5 0	5.10	16 57 0	3.28
1 38 12	35.00	2 29 13	23.00	5 11 0	11.00	11 32 0	5.00	17 3 0	3.26
1 38 54	34.75	2 31 0	22.75	5 19 10	10.75	11 46 0	4.90	17 9 0	3.24
1 39 36	34.50	2 32 53	22.50	5 26 0	10.50	11 59 0	4.80	17 15 0	3.22
1 40 22	34.25	2 34 20	22.25	5 34 20	10.25	12 15 0	4.70	17 21 0	3.20
1 41 7	34.00	2 36 10	22.00	5 43 0	10.00	12 31 0	4.60	17 27 0	3.18
1 41 50	33.75	2 37 58	21.75	5 51 0	9.75	12 48 0	4.50	17 33 0	3.16
1 42 34	33.50	2 39 43	21.50	6 0 0	9.50	13 5 0	4.40	17 40 0	3.14
1 43 22	33.25	2 41 39	21.25	6 10 20	9.25	13 23 0	4.20	17 46 0	3.12

ERRATA.

Page 3, bottom line, *for* required, *read* necessary.
,, 4, second line from top, *for* metallic, *read* like.
,, 4, from 1666 to 1861, *read* west variations.
,, 5, third line from top, *for* Cinderford, *read* Cinderford, Gloucestershire.
,, 6, bottom line, *for* metallic, *read* iron rails.
,, 21, tenth line from top, *for* come, *read* came.
,, 24, first line, *for* branch of the mathematics, *read* branch of mathematics.
,, 35, eighth line from top, *for* 647.06, *read* 647.82.
,, 43, tenth line from bottom, *for* 1543680. *read* 15436.80
,, 46, sixth line from top, *for* tangent $\frac{1}{2}$ (B + A) = 10° 24′, *read* $\frac{1}{2}$ (A − B) = &c.
,, 48, ninth line from top, *for* A C D + the ∠ D C B, *read* A C D and ∠ D C B.
,, 57, second line from top, *for* where, from the circumstance of its affording greater facility, *read* and although the surface affords greater facility for surveying than is offered, &c.
,, 57, fourteenth line, *for* having produced, *read* producing.
,, 57, sixth line from bottom, *for* The above description, *read* This description.
,, 59, thirteenth line from top, *for* which forms, *read* this forms.
,, 86, second line from top, *for* .27639, *read* ,27639.
,, 105, eleventh line from bottom, *for* (This is, *read* (This last is, &c.
,, 105, second line from bottom, *for* This will, *read* These will, &c.

LONDON:
SAVILL AND EDWARDS, PRINTERS,
CHANDOS STREET.