

The Sundial Primer - "Dialling Guides"

Horizontal Shadow Plane Sundial

created by
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The purpose of the "Dialling Guides" is to provide an easy method for laying out the hour lines for a number of shadow plane sundials located at various latitudes in either the Northern or Southern Hemispheres. The shadow plane sundials presented here are designed to be used as interactive sundials.

There are a total of 81 "Dialling Guides" that cover the range of latitudes from 25° to 65° inclusive in increments of 0.5°. The "Dialling Guides" are in the form of tables and provide the co-ordinates for a single point on each of the hour lines. The hour lines are provided in increments of 5 minutes. The "Dialling Guides" are designed so the sundial will show local apparent or solar time.

Each "Dialling Guide" contains 2 sets of tables. As the sundials are intended for people there is information available to construct sundials with east-west widths of 1 and 3 metres. The smaller layout can be used to construct a model while the larger layout can be used to construct a sundial of any shape and size you want.

A shadow plane sundial has a gnomon that the user can move so that it, and its shadow, lie in the sun's hour plane. The particular sundial presented here is a horizontal shadow plane sundial. Figure 1 illustrates the sundial. The layout of a horizontal shadow plane sundial is not difficult. It is created from an ordinary horizontal sundial. The first step is to rotate the dial plate of a horizontal sundial 180° about its origin. The gnomon is not rotated and remains in its original position. The hour lines are now in the positions shown in the figure. Only some are shown and they are dashed as they probably would not exist in the real sundial. Points on the hour line or short hour line segments are more likely to be used. The origin must also be marked. In place of the gnomon a post will be positioned on the true north-south line. From this post will come a length of rope that is long enough to extend beyond the outer boundary of the sundial. The rope is terminated on the post at a point that coincides with the original gnomon's style. This point is a nodus.

The origin and the termination point of the rope will always lie in the sun's hour plane for any time of the day. To use the shadow plane sundial all that needs to be done is to bring the rope into the sun's hour plane. This is very easy to do. The rope is first pulled taut. It does not matter how high it is above the ground. Move around the outside of the sundial while watching the rope's shadow. When the shadow passes through the origin the rope is then in the sun's hour plane. The rope's shadow will also be passing through the hour markers. Read the time. It's just that easy!

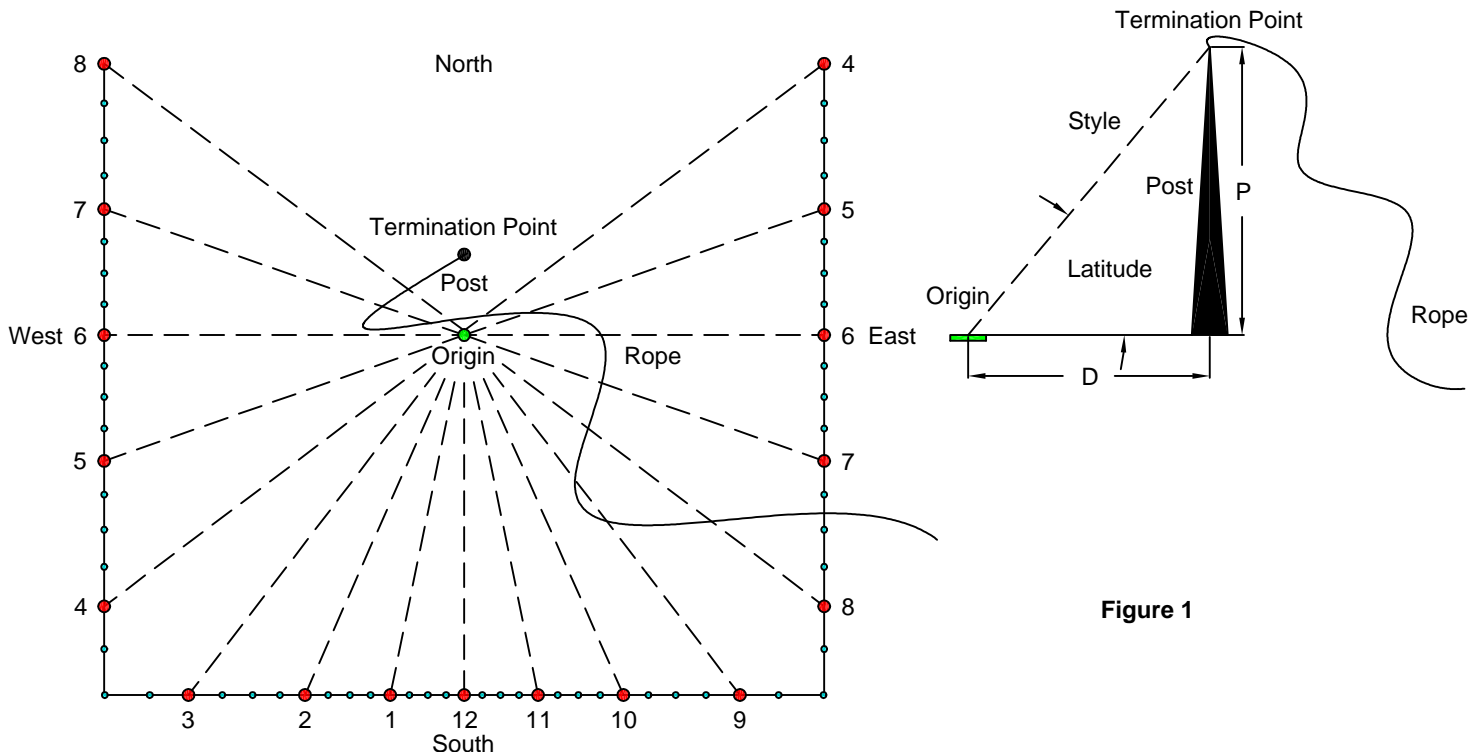


Figure 1

The "Dialling Guides" are based on an east-west dimensions of 1000 and 3000 millimetres. The north-south dimension will be determined by the number of hour lines that will be included in the design. The location of the post relative to the origin depends upon the desired post height and in turn the latitude. If the height of the termination point on the post is "P", the distance "D" from the origin to the termination point of the rope can be determined as follows:

$$D = P / \tan \varnothing \quad \text{where } \varnothing \text{ is the latitude at the sundial's location.}$$

To avoid this calculation Table 1 calculates "D" for a number of values of "P" at all latitudes for which "Dialling Guides" are available.

Horizontal Shadow Plane Sundial

Latitude deg	Height of termination Point P - mm										Latitude deg	Height of termination Point P - mm									
	500.0	750.0	1000.0	1250.0	1500.0	1750.0	2000.0	2250.0	2500.0			500.0	750.0	1000.0	1250.0	1500.0	1750.0	2000.0	2250.0	2500.0	
25.0	1072.3	1608.4	2144.5	2680.6	3216.8	3752.9	4289.0	4825.1	5361.3		45.5	491.3	737.0	982.7	1228.4	1474.0	1719.7	1965.4	2211.1	2456.7	
25.5	1048.3	1572.4	2096.5	2620.7	3144.8	3669.0	4193.1	4717.2	5241.4		46.0	482.8	724.3	965.7	1207.1	1448.5	1690.0	1931.4	2172.8	2414.2	
26.0	1025.2	1537.7	2050.3	2562.9	3075.5	3588.0	4100.6	4613.2	5125.8		46.5	474.5	711.7	949.0	1186.2	1423.4	1660.7	1897.9	2135.2	2372.4	
26.5	1002.8	1504.3	2005.7	2507.1	3008.5	3510.0	4011.4	4512.8	5014.2		47.0	466.3	699.4	932.5	1165.6	1398.8	1631.9	1865.0	2098.2	2331.3	
27.0	981.3	1472.0	1962.6	2453.3	2943.9	3434.6	3925.2	4415.9	4906.5		47.5	458.2	687.2	916.3	1145.4	1374.5	1603.6	1832.7	2061.7	2290.8	
27.5	960.5	1440.7	1921.0	2401.2	2881.5	3361.7	3842.0	4322.2	4802.5		48.0	450.2	675.3	900.4	1125.5	1350.6	1575.7	1800.8	2025.9	2251.0	
28.0	940.4	1410.5	1880.7	2350.9	2821.1	3291.3	3761.5	4231.6	4701.8		48.5	442.4	663.5	884.7	1105.9	1327.1	1548.3	1769.5	1990.6	2211.8	
28.5	920.9	1381.3	1841.8	2302.2	2762.7	3223.1	3683.5	4144.0	4604.4		49.0	434.6	652.0	869.3	1086.6	1303.9	1521.3	1738.6	1955.9	2173.2	
29.0	902.0	1353.0	1804.0	2255.1	2706.1	3157.1	3608.1	4059.1	4510.1		49.5	427.0	640.6	854.1	1067.6	1281.1	1494.6	1708.2	1921.7	2135.2	
29.5	883.7	1325.6	1767.5	2209.4	2651.2	3093.1	3535.0	3976.9	4418.7		50.0	419.5	629.3	839.1	1048.9	1258.6	1468.4	1678.2	1888.0	2097.7	
30.0	866.0	1299.0	1732.1	2165.1	2598.1	3031.1	3464.1	3897.1	4330.1		50.5	412.2	618.3	824.3	1030.4	1236.5	1442.6	1648.7	1854.8	2060.8	
30.5	848.8	1273.2	1697.7	2122.1	2546.5	2970.9	3395.3	3819.7	4244.2		51.0	404.9	607.3	809.8	1012.2	1214.7	1417.1	1619.6	1822.0	2024.5	
31.0	832.1	1248.2	1664.3	2080.3	2496.4	2912.5	3328.6	3744.6	4160.7		51.5	397.7	596.6	795.4	994.3	1193.2	1392.0	1590.9	1789.7	1988.6	
31.5	815.9	1223.9	1631.9	2039.8	2447.8	2855.7	3263.7	3671.7	4079.6		52.0	390.6	586.0	781.3	976.6	1171.9	1367.2	1562.6	1757.9	1953.2	
32.0	800.2	1200.3	1600.3	2000.4	2400.5	2800.6	3200.7	3600.8	4000.8		52.5	383.7	575.5	767.3	959.2	1151.0	1342.8	1534.7	1726.5	1918.3	
32.5	784.8	1177.3	1569.7	1962.1	2354.5	2746.9	3139.4	3531.8	3924.2		53.0	376.8	565.2	753.6	941.9	1130.3	1318.7	1507.1	1695.5	1883.9	
33.0	769.9	1154.9	1539.9	1924.8	2309.8	2694.8	3079.7	3464.7	3849.7		53.5	370.0	555.0	740.0	925.0	1109.9	1294.9	1479.9	1664.9	1849.9	
33.5	755.4	1133.1	1510.8	1888.5	2266.3	2644.0	3021.7	3399.4	3777.1		54.0	363.3	544.9	726.5	908.2	1089.8	1271.4	1453.1	1634.7	1816.4	
34.0	741.3	1111.9	1482.6	1853.2	2223.8	2594.5	2965.1	3335.8	3706.4		54.5	356.6	535.0	713.3	891.6	1069.9	1248.3	1426.6	1604.9	1783.2	
34.5	727.5	1091.3	1455.0	1818.8	2182.5	2546.3	2910.0	3273.8	3637.5		55.0	350.1	525.2	700.2	875.3	1050.3	1225.4	1400.4	1575.5	1750.5	
35.0	714.1	1071.1	1428.1	1785.2	2142.2	2499.3	2856.3	3213.3	3570.4		55.5	343.6	515.5	687.3	859.1	1030.9	1202.7	1374.6	1546.4	1718.2	
35.5	701.0	1051.5	1401.9	1752.4	2102.9	2453.4	2803.9	3154.4	3504.9		56.0	337.3	505.9	674.5	843.1	1011.8	1180.4	1349.0	1517.6	1686.3	
36.0	688.2	1032.3	1376.4	1720.5	2064.6	2408.7	2752.8	3096.9	3441.0		56.5	330.9	496.4	661.9	827.4	992.8	1158.3	1323.8	1489.2	1654.7	
36.5	675.7	1013.6	1351.4	1689.3	2027.1	2365.0	2702.8	3040.7	3378.6		57.0	324.7	487.1	649.4	811.8	974.1	1136.5	1298.8	1461.2	1623.5	
37.0	663.5	995.3	1327.0	1658.8	1990.6	2322.3	2654.1	2985.9	3317.6		57.5	318.5	477.8	637.1	796.3	955.6	1114.9	1274.1	1433.4	1592.7	
37.5	651.6	977.4	1303.2	1629.0	1954.8	2280.6	2606.5	2932.3	3258.1		58.0	312.4	468.7	624.9	781.1	937.3	1093.5	1249.7	1406.0	1562.2	
38.0	640.0	960.0	1279.9	1599.9	1919.9	2239.9	2559.9	2879.9	3199.9		58.5	306.4	459.6	612.8	766.0	919.2	1072.4	1225.6	1378.8	1532.0	
38.5	628.6	942.9	1257.2	1571.5	1885.8	2200.1	2514.3	2828.6	3142.9		59.0	300.4	450.6	600.9	751.1	901.3	1051.5	1201.7	1351.9	1502.2	
39.0	617.4	926.2	1234.9	1543.6	1852.3	2161.1	2469.8	2778.5	3087.2		59.5	294.5	441.8	589.0	736.3	883.6	1030.8	1178.1	1325.4	1472.6	
39.5	606.5	909.8	1213.1	1516.4	1819.6	2122.9	2426.2	2729.5	3032.7		60.0	288.7	433.0	577.4	721.7	866.0	1010.4	1154.7	1299.0	1443.4	
40.0	595.9	893.8	1191.8	1489.7	1787.6	2085.6	2383.5	2681.4	2979.4		60.5	282.9	424.3	565.8	707.2	848.7	990.1	1131.5	1273.0	1414.4	
40.5	585.4	878.1	1170.8	1463.6	1756.3	2049.0	2341.7	2634.4	2927.1		61.0	277.2	415.7	554.3	692.9	831.5	970.0	1108.6	1247.2	1385.8	
41.0	575.2	862.8	1150.4	1438.0	1725.6	2013.1	2300.7	2588.3	2875.9		61.5	271.5	407.2	543.0	678.7	814.4	950.2	1085.9	1221.7	1357.4	
41.5	565.1	847.7	1130.3	1412.9	1695.4	1978.0	2260.6	2543.2	2825.7		62.0	265.9	398.8	531.7	664.6	797.6	930.5	1063.4	1196.3	1329.3	
42.0	555.3	833.0	1110.6	1388.3	1665.9	1943.6	2221.2	2498.9	2776.5		62.5	260.3	390.4	520.6	650.7	780.9	911.0	1041.1	1171.3	1301.4	
42.5	545.7	818.5	1091.3	1364.1	1637.0	1909.8	2182.6	2455.4	2728.3		63.0	254.8	382.1	509.5	636.9	764.3	891.7	1019.1	1146.4	1273.8	
43.0	536.2	804.3	1072.4	1340.5	1608.6	1876.6	2144.7	2412.8	2680.9		63.5	249.3	373.9	498.6	623.2	747.9	872.5	997.2	1121.8	1246.5	
43.5	526.9	790.3	1053.8	1317.2	1580.7	1844.1	2107.6	2371.0	2634.5		64.0	243.9	365.8	487.7	609.7	731.6	853.5	975.5	1097.4	1219.3	
44.0	517.8	776.6	1035.5	1294.4	1553.3	1812.2	2071.1	2329.9	2588.8		64.5	238.5	357.7	477.0	596.2	715.5	834.7	954.0	1073.2	1192.4	
44.5	508.8	763.2	1017.6	1272.0	1526.4	1780.8	2035.2	2289.6	2544.0		65.0	233.2	349.7	466.3	582.9	699.5	816.0	932.6	1049.2	1165.8	
45.0	500.0	750.0	1000.0	1250.0	1500.0	1750.0	2000.0	2250.0	2500.0												

Table 1

The Sundial Primer - "Dialling Guides"

Horizontal Shadow Plane Sundial

Obtain a set of horizontal shadow plane sundial "Dialling Guides" that are closest to the latitude where the sundial will be located. The tables provided in each "Dialling Guide" are based on the east-west dimension of the sundial. The two sizes available are 1000 and 3000 millimetres. The 1000 mm "Dialling Guide" can be used to calculate the information required to construct any size of shadow plane sundial should the one provided be unsuitable. All you need to do is calculate a multiplier as follows: (Desired east-west dimension in mm / 1000).

For purposes of the instructions let's design horizontal shadow plane sundials for the latitudes 50.0° North and South with an east-west dimension of 1000 mm, 15 minute time increments and a time range from 4:00 a.m. to 8:00 p.m. Table 2 shows the "Dialling Guide" that will be used. Let's say that the the dimension "P", the height of the termination point on the post, is 250 mm. The dimension "D", the distance from the origin to the termination point of the rope is 209.8 mm. "D" is less than the dimension "Y" of 376.8 mm at 4:00 a.m./8:00 p.m. obtained from Table 2. In this example "Y" becomes the limit for the north-south dimension above the origin. The minimum required north-south distance is 876.8 mm.

Latitude: 50.0° N/S

Earliest Sunrise: 3:49 a.m. Latest Sunset: 8:11 p.m.

E-W Dimension: 1000 mm

Local Time	X	Y	Local Time	X	Y	Local Time	X	Y			
12:00	0.0	-500.0									
11:55	12:05	8.4	-500.0	8:25	3:35	500.0	-478.6	4:55	7:05	500.0	190.2
11:50	12:10	16.7	-500.0	8:20	3:40	500.0	-457.0	4:50	7:10	500.0	205.8
11:45	12:15	25.1	-500.0	8:15	3:45	500.0	-436.1	4:45	7:15	500.0	221.6
11:40	12:20	33.5	-500.0	8:10	3:50	500.0	-415.8	4:40	7:20	500.0	237.6
11:35	12:25	41.9	-500.0	8:05	3:55	500.0	-396.1	4:35	7:25	500.0	253.8
11:30	12:30	50.4	-500.0	8:00	4:00	500.0	-376.8	4:30	7:30	500.0	270.4
11:25	12:35	59.0	-500.0	7:55	4:05	500.0	-358.1	4:25	7:35	500.0	287.2
11:20	12:40	67.5	-500.0	7:50	4:10	500.0	-339.8	4:20	7:40	500.0	304.4
11:15	12:45	76.2	-500.0	7:45	4:15	500.0	-321.9	4:15	7:45	500.0	321.9
11:10	12:50	84.9	-500.0	7:40	4:20	500.0	-304.4	4:10	7:50	500.0	339.8
11:05	12:55	93.7	-500.0	7:35	4:25	500.0	-287.2	4:05	7:55	500.0	358.1
11:00	1:00	102.6	-500.0	7:30	4:30	500.0	-270.4	4:00	8:00	500.0	376.8
10:55	1:05	111.6	-500.0	7:25	4:35	500.0	-253.8	3:55	8:05	500.0	396.1
10:50	1:10	120.8	-500.0	7:20	4:40	500.0	-237.6	3:50	8:10	500.0	415.8
10:45	1:15	130.0	-500.0	7:15	4:45	500.0	-221.6	3:45	8:15	500.0	436.1
10:40	1:20	139.4	-500.0	7:10	4:50	500.0	-205.8				
10:35	1:25	148.9	-500.0	7:05	4:55	500.0	-190.2				
10:30	1:30	158.7	-500.0	7:00	5:00	500.0	-174.9				
10:25	1:35	168.5	-500.0	6:55	5:05	500.0	-159.7				
10:20	1:40	178.6	-500.0	6:50	5:10	500.0	-144.7				
10:15	1:45	188.9	-500.0	6:45	5:15	500.0	-129.8				
10:10	1:50	199.4	-500.0	6:40	5:20	500.0	-115.1				
10:05	1:55	210.1	-500.0	6:35	5:25	500.0	-100.5				
10:00	2:00	221.1	-500.0	6:30	5:30	500.0	-85.9				
9:55	2:05	232.4	-500.0	6:25	5:35	500.0	-71.5				
9:50	2:10	244.0	-500.0	6:20	5:40	500.0	-57.1				
9:45	2:15	255.9	-500.0	6:15	5:45	500.0	-42.8				
9:40	2:20	268.2	-500.0	6:10	5:50	500.0	-28.5				
9:35	2:25	280.8	-500.0	6:05	5:55	500.0	-14.2				
9:30	2:30	293.9	-500.0	6:00	6:00	500.0	0.0				
9:25	2:35	307.4	-500.0	5:55	6:05	500.0	14.2				
9:20	2:40	321.4	-500.0	5:50	6:10	500.0	28.5				
9:15	2:45	335.9	-500.0	5:45	6:15	500.0	42.8				
9:10	2:50	351.0	-500.0	5:40	6:20	500.0	57.1				
9:05	2:55	366.7	-500.0	5:35	6:25	500.0	71.5				
9:00	3:00	383.0	-500.0	5:30	6:30	500.0	85.9				
8:55	3:05	400.1	-500.0	5:25	6:35	500.0	100.5				
8:50	3:10	418.0	-500.0	5:20	6:40	500.0	115.1				
8:45	3:15	436.8	-500.0	5:15	6:45	500.0	129.8				
8:40	3:20	456.5	-500.0	5:10	6:50	500.0	144.7				
8:35	3:25	477.2	-500.0	5:05	6:55	500.0	159.7				
8:30	3:30	499.2	-500.0	5:00	7:00	500.0	174.9				

The sign of the X co-ordinates, for the Northern Hemisphere, will be positive for the a.m. hours and negative for the p.m. hours. The sign of the X co-ordinates, for the Southern Hemisphere, will be negative for the a.m. hours and positive for the p.m. hours.

The tables can be made easier to follow by highlighting the rows of values that will be used in building the sundial. All the extraneous information can also be stroked out. This will help to ensure that the correct values are used during construction.

Table 2

The Sundial Primer - "Dialling Guides"

Horizontal Shadow Plane Sundial

All the information is now available for the construction of the horizontal shadow plane sundial. The following is one method that can be used to lay out the sundial. You may find another one that is better suited for you.

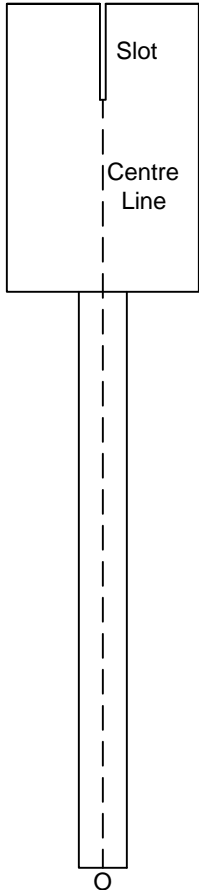


Figure 2

The first step is to establish the true north-south line or local meridian line at the location of the sundial. To do this both the latitude and longitude must be known. The time that the sun passes over the local meridian on the day that this procedure will be carried out must be determined. This is local apparent or solar noon. An accurately set clock or watch is also required.

Mark the position of the sundial's origin "O" at the site location. This point is shown in both Figure. A vertical device will be positioned at the origin "O" that will cast a shadow on the ground. The position of the shadow will be marked at solar noon and the line drawn from "O" to the marked point will be the true north-south or meridian line. This line must be established as carefully and accurately as possible because it is the basis of the remainder of the layout. The device can be a "straight" section of pipe or rod. Make it as long as possible. If a solid device is used you will have to estimate the centre of the shadow. Figure 2 illustrates a device that uses a small band of light. Take a thin (1/8") piece of wood and cut a slot the width of a saw blade as shown in the figure. The dimensions of this device can be about 100 mm wide and 150 mm high with a slot 50 mm in length. Attach the device to a "straight" length of wood and draw a vertical line from the centre of the slot to the bottom of the extension. This is the dashed line in the figure.

Position the completed device so the bottom of the dashed line is located on the origin "O". Ensure that the line is vertical in all directions. This is where having a "straight" extension helps. The device can be attached to a step-ladder to hold it in position. You will note that the slot will cast a band of light on the ground. As the time approaches noon the device can be rotated to keep the slot in line with the sun. Any adjustments requiring you to use a ladder should be done from a second step-ladder. A few minutes before noon check that everything is aligned and vertical. If you are marking pavement position a piece of paper where the band of light from the slot is falling. If this procedure is being done on soil then have a couple of small nails ready. You will be marking the two edges of the band of light. Now you are ready.

Be prepared! It is amazing how quickly the sun moves when you are keeping track of time and watching the band of light. At precisely solar noon mark the two edges of the band of light on the paper with a pen or on the soil with the two nails. Now relax. Mark the spot at the point midway between these two points in the pavement or soil in some permanent manner.

The line between this point and the origin "O" is the local meridian. You may want to carry out this procedure a couple of times just to increase the accuracy. If you get a slightly different position the second time for no apparent reason you can average the two positions.

If this line is shorter than the required north-south dimension of the shadow plane sundial you are building then extend it to the appropriate length. For our example this would be a distance of 376.8 mm. The east-west line must now be established. To do this a "3-4-5" triangle will be used. Figure 3 illustrates this triangle. The relative dimensions of this triangle makes it simple to calculate the dimensions of the remaining two sides when a value is applied to one. Table 3 provides calculated values that are ready to be used based on pre-assigned values for the "4" side. The multiplier for the "3" side is 0.75 and for the "4" side 1.25. The lengths are in millimetres.

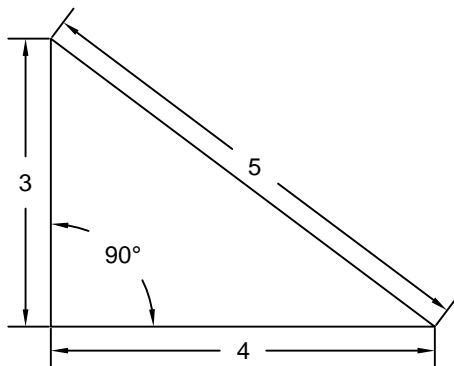


Figure 3

"3"	"4"	"5"	"3"	"4"	"5"
37.5	50	62.5	600	800	1000
75	100	125	637.5	850	1062.5
112.5	150	187.5	675	900	1125
150	200	250	712.5	950	1187.5
187.5	250	312.5	750	1000	1250
225	300	375	787.5	1050	1312.5
262.5	350	437.5	825	1100	1375
300	400	500	862.5	1150	1437.5
337.5	450	562.5	900	1200	1500
375	500	625	937.5	1250	1562.5
412.5	550	687.5	975	1300	1625
450	600	750	1012.5	1350	1687.5
487.5	650	812.5	1050	1400	1750
525	700	875	1087.5	1450	1812.5
562.5	750	937.5	1125	1500	1875

Table 3

The Sundial Primer - "Dialling Guides"

Horizontal Shadow Plane Sundial

The locations of the points for the desired hour lines are established by using the co-ordinates from the "Dialling Guide" in Table 2 and by measuring along the appropriate line from points E, F or noon. If the latitude is far enough north or south measurements will also be done from point L. The position of the post where the rope is terminated was determined earlier to be 209.8 mm above the origin and on the true north-south line. Make this post as vertical as possible and ensure that the termination point is directly above the required position. The horizontal shadow plane sundials for the Northern and Southern Hemispheres will appear as in Figure 6. The sundials for our example have hour points every 15 minutes.

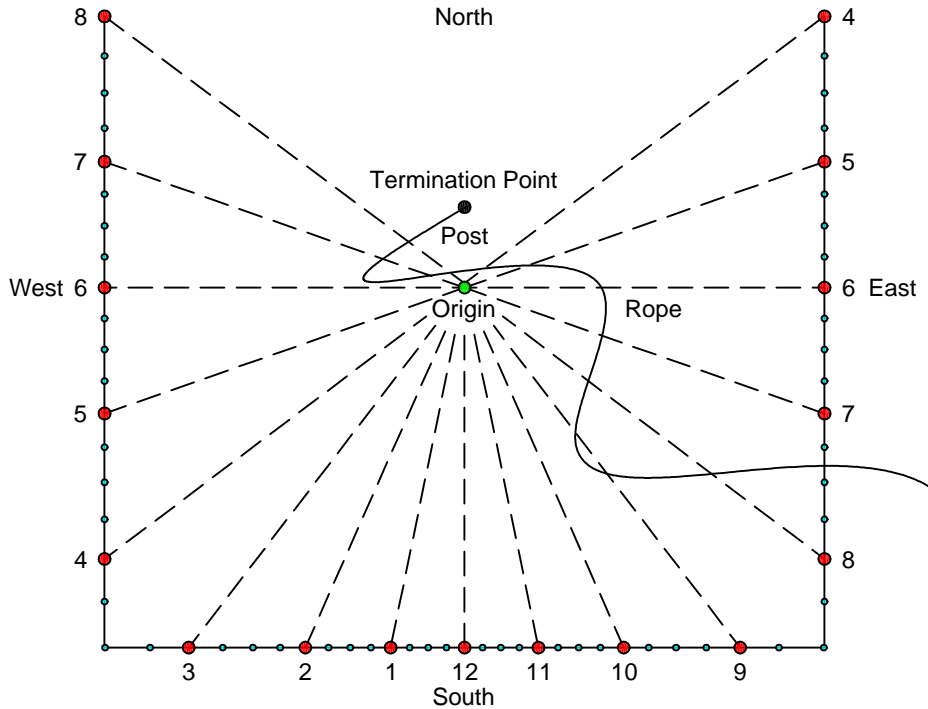
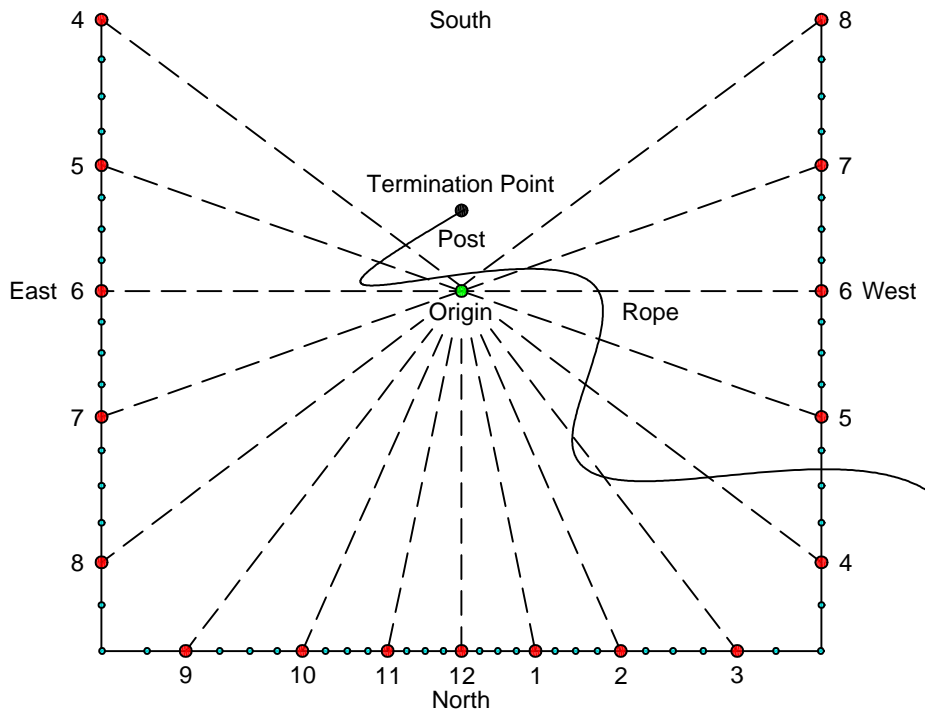


Figure 6

Horizontal Shadow Plane Sundial
Northern Hemisphere



Horizontal Shadow Plane Sundial
Southern Hemisphere

The Sundial Primer - "Dialling Guides"

Horizontal Shadow Plane Sundial

If the points for the hour lines are laid out in a non-permanent way they can be used to lay out a sundial of any appropriate shape or size. To reposition an hour line point secure a string at the origin. Pull the string taut and position it so that it passes over an hour line point. Mark any point or line segment along the string and that is the new marker for the hour line. Repeat this for all the other hour lines. The origin and the post remain in their previous positions. Figure 7 illustrates this idea by using a portion of a circle and changing the hour line markers from points to short line segments. Just use your imagination!

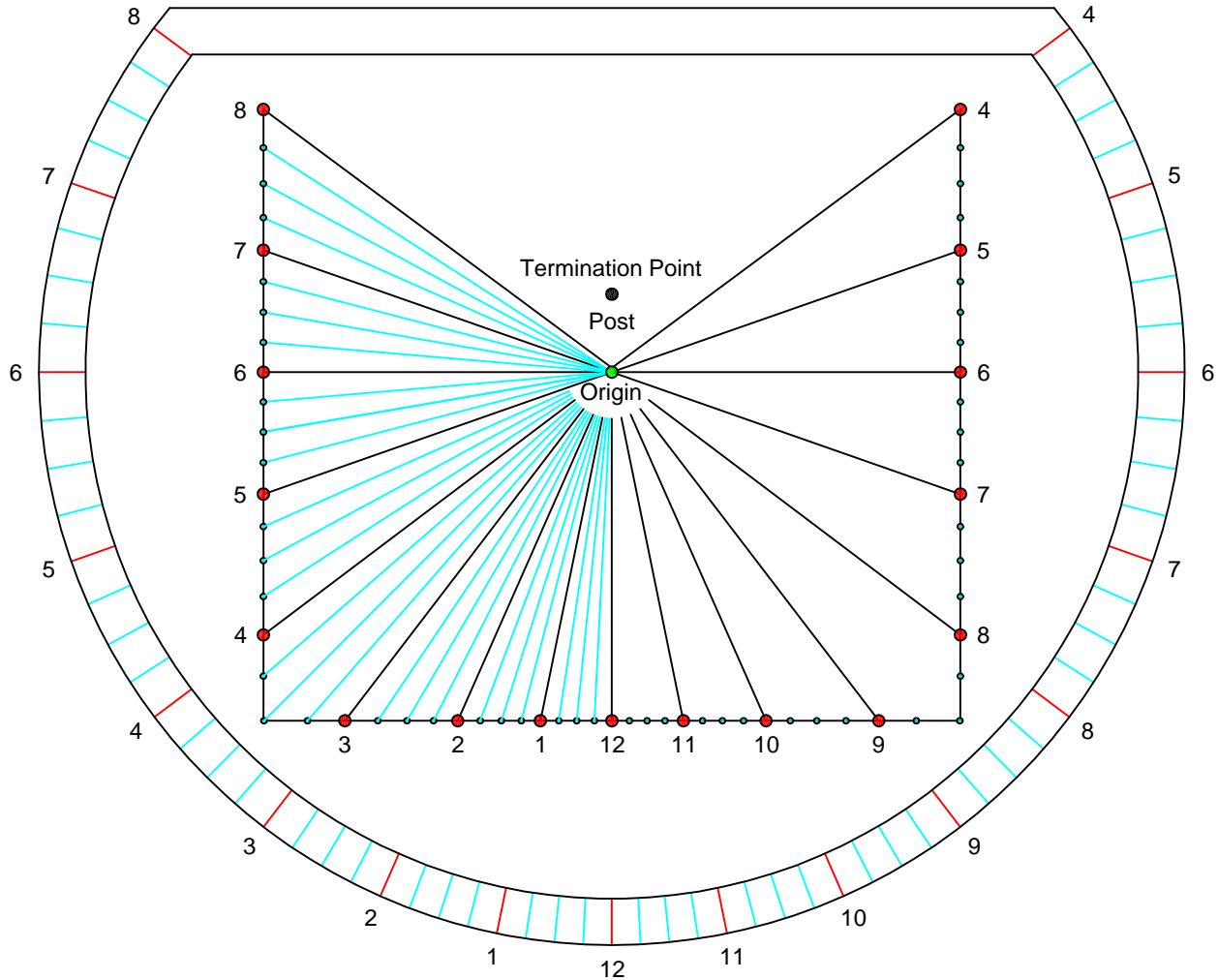


Figure 7

A sundial that indicates local apparent or solar time has hour lines that are symmetrical about both the north-south and east-west lines. This fact can be used to simplify laying out your sundial.

Happy Dialling!