

Simple Celestial Navigation

Getting a Noon sun sight using a shadow stick

DISCLAIMER:

Getting a LAT / LONG fix using this method is only accurate to ~0.25 degree in both Latitude and Longitude. This equates to an on the ground accuracy of ~ 25Km. Many variables will affect the accuracy of the readings that could put the final calculated Lat/Long fix out side of this.

With careful setup and use, accuracy of under 10km is achievable.

USE AT OWN RISK.

What you will need:

- Dowel Stick 5 or 6mm diameter and 500mm long (cut to exact length)
- Tape (duct, masking, insulation.... Your choice)
- 1 X Glass tumbler, / tin can / bottle etc to attach the Dowel stick to.... Must have vertical sides
- Flat table surface at least 1m long
- 3m measuring tape
- Bubble level
- Pen or pencil with a fine tip
- 2 x extra A4 Paper sheets
- A watch set to local time and set as accurately as possible
- Calculator

Method:

- Make up Gnomon (Pg 3)
- Calculate Estimated Solar Noon (Pg 4)
- Set up table
- Place Gnomon at one end so shadow falls down length of table
- Align table using Solar compass (Pg 5)
- Level table with bubble level..... The more level the better
- Check Gnomon is perpendicular to the table surface
- Place a paper sheet under the Gnomon and tape down the paper so it cannot move
- Mark Gnomon origin point (Pg 3)
- Place a second sheet or paper under the end of the shadow cast by the Gnomon aligning the end of the shadow close to the western edge of the paper.
- Tape the paper down so it cannot move
- Mark the tip of the Gnomon shadow at 1 minute intervals starting ~ 20 min before estimated solar Noon (Pg 3 and example on Pg 9)
- Note time of each 1 min mark (example on Pg 9)
- Keep Marking the Gnomon shadow tip as the shadow gets shorter with each passing minute
- Once the shadow starts to get longer again stop marking and note the time at the shortest shadow mark (example on Pg 9)
- Remove Gnomon from table and measure to the nearest mm the distance from the Gnomon origin and the shortest shadow mark (example on Pg 9)
- Find Solar Angle based on measured distance in the table provided (Pg 6)
- Calculate Latitude and Longitude with equations (Pg 2) and tables (Pg 7 & 8) provided

Tips:

- The flatter the table surface the better the results
- The more level the table surface the better the results
- The closer to perpendicular (in both planes) the gnomon is to the table surface the better the results
- The more accurate your watch is the better the results
- The more accurate your markings of the shadow tip the better the results
- On the first day using this method use a longer time before solar noon so as to make sure you do not miss it. Once an accurate solar noon is know only a short period of measurement is required to capture the require information.
- If Gnomon shadow is already getting longer (angle <90 deg) at the start of measurement you have missed Solar Noon – try again tomorrow and start earlier

Latitude Calculation:

Latitude = Solar Angle + Solar Declination (+ve =North and –ve = South)

Where:

Solar Angle – Using Gnomon Shadow length measured at Solar Noon read Solar Angle value from “Solar Angle From Gnomon Shadow Length” Table (Pg 6).

Where Gnomon Shadow points south the Solar angle must be given an –ve sign

Solar Declination – Look up date in “Solar Declination and EQT” tables (Pg 7 & 8) and read declination value.

Longitude Calculation:

Longitude = (720 – GMT of Solar Noon – EQT) / 4

(+ve =East and –ve = West)

Where:

GMT of Solar Noon – Is local time of Solar Noon (in 24 hr format) minus the time zone difference (keep the time zone sign) and converted into minutes.

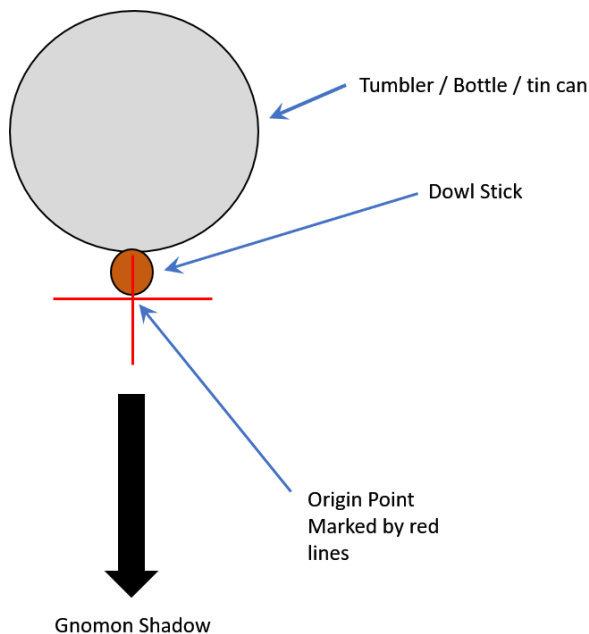
If day light saving is applicable it must be taken into account

EQT– Look up date in “Solar Declination and EQT” tables (Pg 7 & 8) and read EQT value.

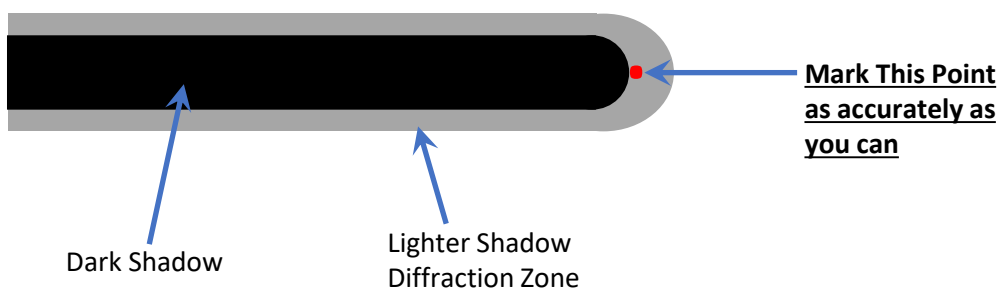
Build the Gnomon

- You will need a glass tumbler / tin can/ bottle etc with sides that are as close to vertical as you can get them.
- Tape the 500mm long Dowl stick to the tumbler / can etc so that the stick is perfectly vertical and level with the base of the tumbler / can.
- Make sure the dowl stick securely attached.
- Place on a flat and level surface and check that the gnomon is as perpendicular as you can get it and that the tip of the dowl is exactly 500mm from the table surface

Marking The Gnomon Origin Point

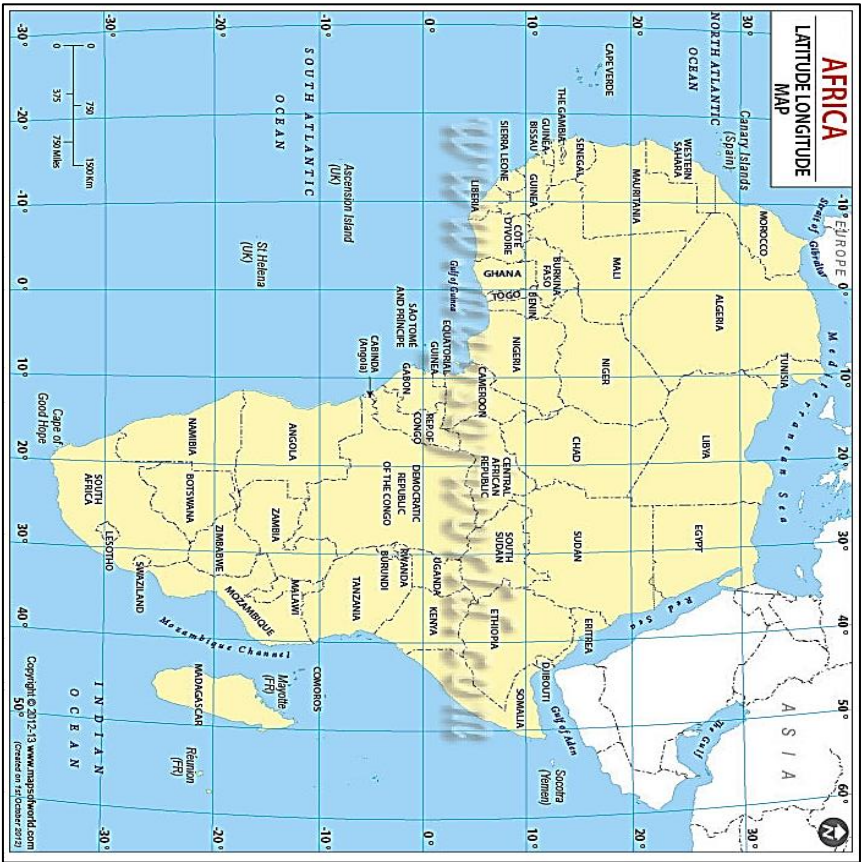


Marking The Gnomon Shadow Tip



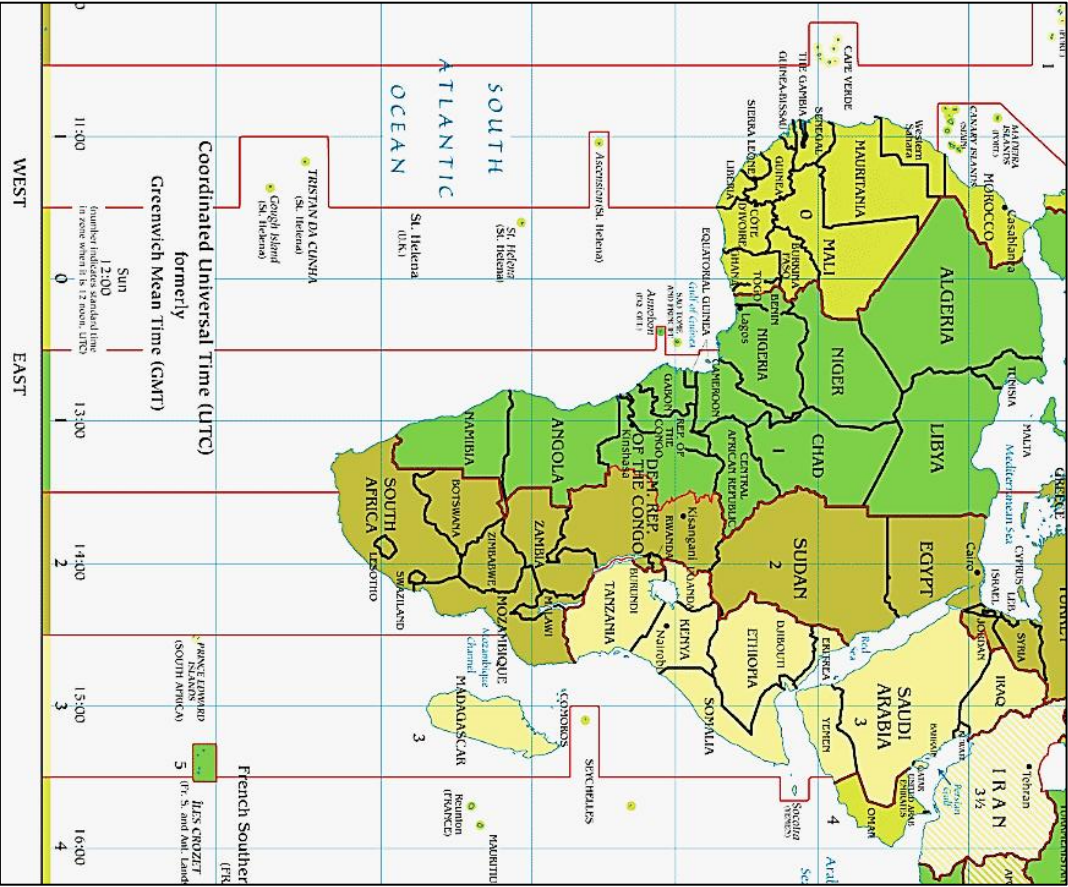
Solar Noon At Estimated Longitude

- Steps:
1. Estimate Longitude of position on Map1 (get as close as possible)
 2. Get Minutes ahead / behind GMT from estimated Longitude by multiplying Longitude by 4
 3. Get Time Zone From Map 2
 4. Convert Time zone hours to Minutes (eg 2 hours = 120 min)
 5. Calculate the difference in Minutes between those calculated in Point 2 and those in Point 4
 6. If Estimated Longitude is West of central meridian of Time zone add minutes from point 5 to 12:00
 7. If Estimated Longitude is East of central meridian of Time zone subtract minutes from point 5 from 12:00



Map 1

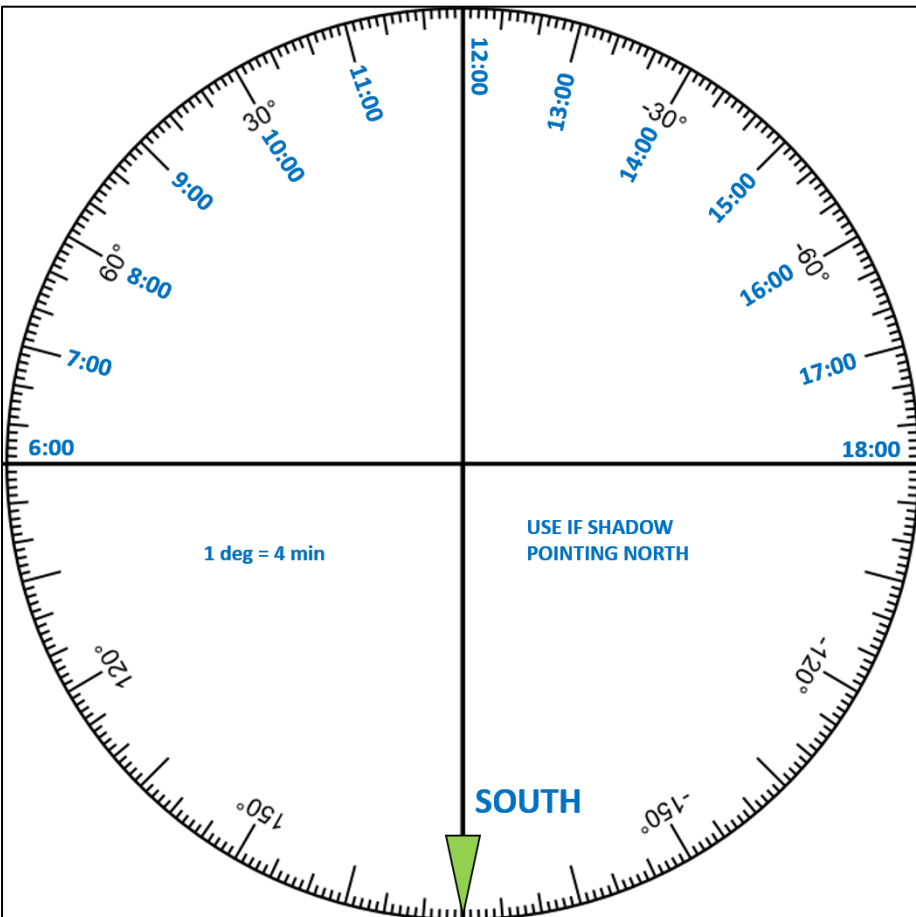
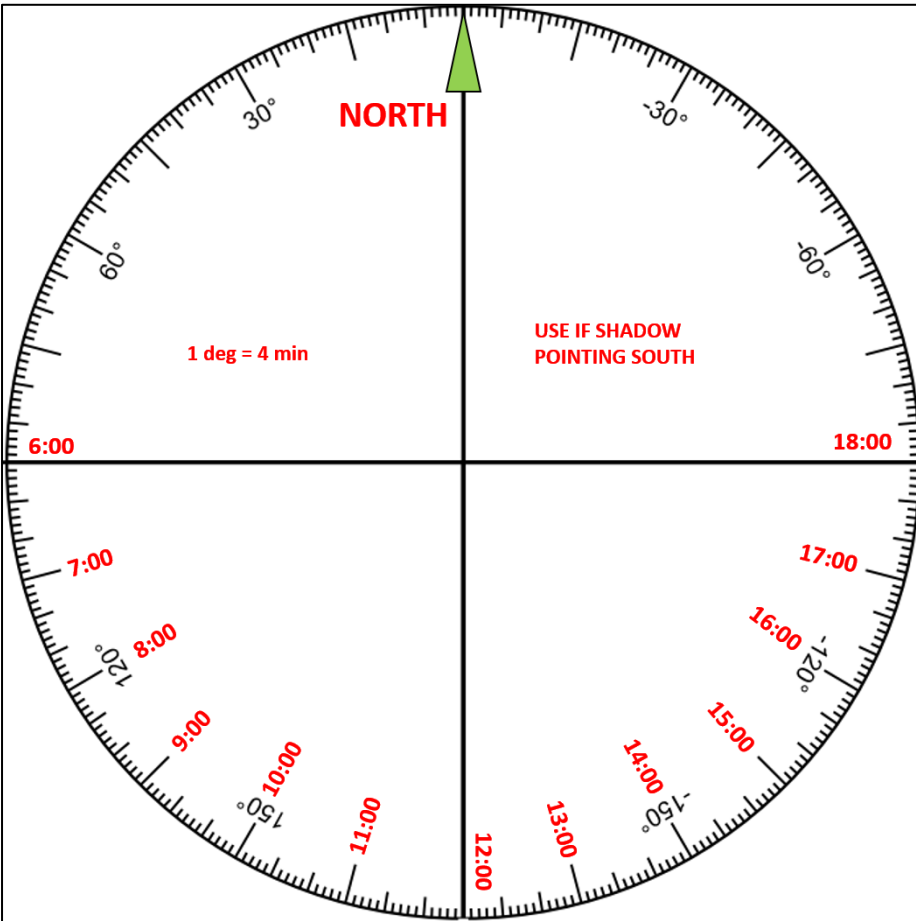
Time Difference in Min = Longitude X 4



Map 2

SOLAR COMPASS:

- Choose correct compass based on whether Gnomon shadow is pointing to the North or South (of the East – West Line)
- Align compass with the green arrow pointing down the length of the table and pointing at the Gnomon
- Hold pen up right at the center point of the compass
- Rotate table until the pens shadow points to the correct hour mark (or sub division)



These Solar Compasses are only accurate at Solar Noon each day and are only really usable for general orientation

Solar Angle From Gnomon Shadow Length

Solar Angle	Shadow length	Solar Angle	Shadow length	Solar Angle	Shadow length	Solar Angle	Shadow length	Solar Angle	Shadow length	Solar Angle	Shadow length	Solar Angle	Shadow length
0	0	11	97	22	202	33	325	44	483	55	714	66	1123
0.2	2	11.2	99	22.2	204	33.2	327	44.2	486	55.2	719	66.2	1134
0.4	3	11.4	101	22.4	206	33.4	330	44.4	490	55.4	725	66.4	1144
0.6	5	11.6	103	22.6	208	33.6	332	44.6	493	55.6	730	66.6	1155
0.8	7	11.8	104	22.8	210	33.8	335	44.8	497	55.8	736	66.8	1167
1	9	12	106	23	212	34	337	45	500	56	741	67	1178
1.2	10	12.2	108	23.2	214	34.2	340	45.2	504	56.2	747	67.2	1189
1.4	12	12.4	110	23.4	216	34.4	342	45.4	507	56.4	753	67.4	1201
1.6	14	12.6	112	23.6	218	34.6	345	45.6	511	56.6	758	67.6	1213
1.8	16	12.8	114	23.8	221	34.8	348	45.8	514	56.8	764	67.8	1225
2	17	13	115	24	223	35	350	46	518	57	770	68	1238
2.2	19	13.2	117	24.2	225	35.2	353	46.2	521	57.2	776	68.2	1250
2.4	21	13.4	119	24.4	227	35.4	355	46.4	525	57.4	782	68.4	1263
2.6	23	13.6	121	24.6	229	35.6	358	46.6	529	57.6	788	68.6	1276
2.8	24	13.8	123	24.8	231	35.8	361	46.8	532	57.8	794	68.8	1289
3	26	14	125	25	233	36	363	47	536	58	800	69	1303
3.2	28	14.2	127	25.2	235	36.2	366	47.2	540	58.2	806	69.2	1316
3.4	30	14.4	128	25.4	237	36.4	369	47.4	544	58.4	813	69.4	1330
3.6	31	14.6	130	25.6	240	36.6	371	47.6	548	58.6	819	69.6	1344
3.8	33	14.8	132	25.8	242	36.8	374	47.8	551	58.8	826	69.8	1359
4	35	15	134	26	244	37	377	48	555	59	832	70	1374
4.2	37	15.2	136	26.2	246	37.2	380	48.2	559	59.2	839		
4.4	38	15.4	138	26.4	248	37.4	382	48.4	563	59.4	845		
4.6	40	15.6	140	26.6	250	37.6	385	48.6	567	59.6	852		
4.8	42	15.8	141	26.8	253	37.8	388	48.8	571	59.8	859		
5	44	16	143	27	255	38	391	49	575	60	866		
5.2	46	16.2	145	27.2	257	38.2	393	49.2	579	60.2	873		
5.4	47	16.4	147	27.4	259	38.4	396	49.4	583	60.4	880		
5.6	49	16.6	149	27.6	261	38.6	399	49.6	587	60.6	887		
5.8	51	16.8	151	27.8	264	38.8	402	49.8	592	60.8	895		
6	53	17	153	28	266	39	405	50	596	61	902		
6.2	54	17.2	155	28.2	268	39.2	408	50.2	600	61.2	909		
6.4	56	17.4	157	28.4	270	39.4	411	50.4	604	61.4	917		
6.6	58	17.6	159	28.6	273	39.6	414	50.6	609	61.6	925		
6.8	60	17.8	161	28.8	275	39.8	417	50.8	613	61.8	932		
7	61	18	162	29	277	40	420	51	617	62	940		
7.2	63	18.2	164	29.2	279	40.2	423	51.2	622	62.2	948		
7.4	65	18.4	166	29.4	282	40.4	426	51.4	626	62.4	956		
7.6	67	18.6	168	29.6	284	40.6	429	51.6	631	62.6	965		
7.8	68	18.8	170	29.8	286	40.8	432	51.8	635	62.8	973		
8	70	19	172	30	289	41	435	52	640	63	981		
8.2	72	19.2	174	30.2	291	41.2	438	52.2	645	63.2	990		
8.4	74	19.4	176	30.4	293	41.4	441	52.4	649	63.4	998		
8.6	76	19.6	178	30.6	296	41.6	444	52.6	654	63.6	1007		
8.8	77	19.8	180	30.8	298	41.8	447	52.8	659	63.8	1016		
9	79	20	182	31	300	42	450	53	664	64	1025		
9.2	81	20.2	184	31.2	303	42.2	453	53.2	668	64.2	1034		
9.4	83	20.4	186	31.4	305	42.4	457	53.4	673	64.4	1044		
9.6	85	20.6	188	31.6	308	42.6	460	53.6	678	64.6	1053		
9.8	86	20.8	190	31.8	310	42.8	463	53.8	683	64.8	1063		
10	88	21	192	32	312	43	466	54	688	65	1072		
10.2	90	21.2	194	32.2	315	43.2	470	54.2	693	65.2	1082		
10.4	92	21.4	196	32.4	317	43.4	473	54.4	698	65.4	1092		
10.6	94	21.6	198	32.6	320	43.6	476	54.6	704	65.6	1102		
10.8	95	21.8	200	32.8	322	43.8	479	54.8	709	65.8	1113		

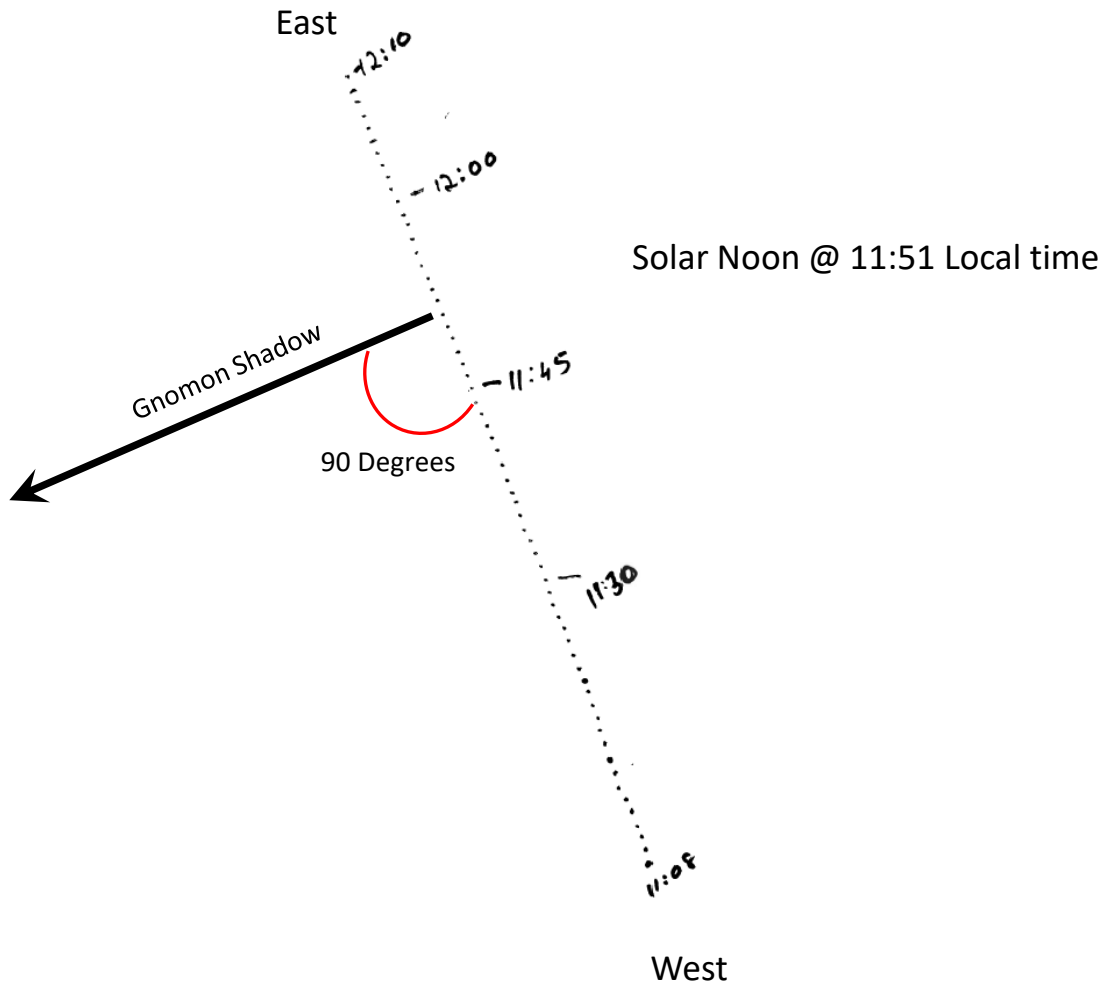
Gnomon Length = 500mm

January			February			March		
Date	Declin (deg)	EQT(minutes)	Date	Declin (deg)	EQT(minutes)	Date	Declin (deg)	EQT(minutes)
1	-23.02	-3.32	1	-17.17	-13.52	1	-7.30	-12.23
2	-22.94	-3.79	2	-16.88	-13.65	2	-6.92	-12.02
3	-22.84	-4.26	3	-16.59	-13.77	3	-6.54	-11.81
4	-22.74	-4.72	4	-16.30	-13.87	4	-6.15	-11.59
5	-22.64	-5.17	5	-16.00	-13.97	5	-5.76	-11.36
6	-22.52	-5.61	6	-15.69	-14.04	6	-5.38	-11.13
7	-22.40	-6.05	7	-15.38	-14.11	7	-4.99	-10.89
8	-22.27	-6.48	8	-15.07	-14.16	8	-4.60	-10.64
9	-22.14	-6.90	9	-14.75	-14.20	9	-4.21	-10.38
10	-21.99	-7.31	10	-14.43	-14.22	10	-3.81	-10.13
11	-21.84	-7.71	11	-14.11	-14.24	11	-3.42	-9.86
12	-21.68	-8.11	12	-13.78	-14.23	12	-3.03	-9.59
13	-21.52	-8.49	13	-13.44	-14.22	13	-2.63	-9.32
14	-21.35	-8.86	14	-13.10	-14.19	14	-2.24	-9.04
15	-21.17	-9.23	15	-12.76	-14.15	15	-1.84	-8.76
16	-20.98	-9.58	16	-12.42	-14.10	16	-1.45	-8.47
17	-20.79	-9.92	17	-12.07	-14.04	17	-1.05	-8.18
18	-20.59	-10.25	18	-11.72	-13.96	18	-0.66	-7.89
19	-20.39	-10.56	19	-11.37	-13.88	19	-0.26	-7.60
20	-20.17	-10.87	20	-11.01	-13.78	20	0.13	-7.30
21	-19.96	-11.16	21	-10.65	-13.67	21	0.53	-7.00
22	-19.73	-11.44	22	-10.29	-13.55	22	0.92	-6.71
23	-19.50	-11.71	23	-9.92	-13.42	23	1.32	-6.40
24	-19.26	-11.96	24	-9.55	-13.28	24	1.71	-6.10
25	-19.02	-12.20	25	-9.18	-13.13	25	2.10	-5.80
26	-18.77	-12.43	26	-8.81	-12.96	26	2.50	-5.50
27	-18.52	-12.65	27	-8.44	-12.79	27	2.89	-5.20
28	-18.26	-12.85	28	-8.06	-12.61	28	3.28	-4.90
29	-18.00	-13.04	29	-7.68	-12.43	29	3.67	-4.60
30	-17.73	-13.21				30	4.06	-4.30
31	-17.45	-13.37				31	4.44	-4.00
April			May			June		
Date	Declin (deg)	EQT(minutes)	Date	Declin (deg)	EQT(minutes)	Date	Declin (deg)	EQT(minutes)
1	4.83	-3.70	1	15.30	2.95	1	22.15	2.07
2	5.21	-3.41	2	15.60	3.06	2	22.28	1.91
3	5.59	-3.12	3	15.89	3.16	3	22.40	1.75
4	5.98	-2.83	4	16.18	3.25	4	22.52	1.57
5	6.36	-2.54	5	16.46	3.34	5	22.62	1.40
6	6.73	-2.26	6	16.74	3.41	6	22.73	1.21
7	7.11	-1.98	7	17.02	3.47	7	22.82	1.03
8	7.48	-1.71	8	17.29	3.52	8	22.91	0.83
9	7.85	-1.44	9	17.55	3.57	9	22.99	0.64
10	8.22	-1.17	10	17.82	3.60	10	23.06	0.44
11	8.59	-0.91	11	18.07	3.63	11	23.13	0.23
12	8.95	-0.65	12	18.32	3.64	12	23.19	0.03
13	9.32	-0.40	13	18.57	3.65	13	23.25	-0.18
14	9.68	-0.15	14	18.81	3.64	14	23.30	-0.39
15	10.03	0.08	15	19.04	3.63	15	23.34	-0.61
16	10.39	0.32	16	19.27	3.61	16	23.37	-0.82
17	10.74	0.55	17	19.49	3.58	17	23.40	-1.04
18	11.09	0.77	18	19.71	3.54	18	23.42	-1.26
19	11.43	0.98	19	19.93	3.49	19	23.43	-1.47
20	11.77	1.19	20	20.13	3.43	20	23.44	-1.69
21	12.11	1.39	21	20.33	3.36	21	23.44	-1.91
22	12.45	1.58	22	20.53	3.28	22	23.43	-2.13
23	12.78	1.77	23	20.72	3.20	23	23.41	-2.34
24	13.11	1.94	24	20.90	3.10	24	23.39	-2.55
25	13.43	2.11	25	21.08	3.00	25	23.36	-2.77
26	13.75	2.27	26	21.25	2.89	26	23.33	-2.98
27	14.07	2.43	27	21.42	2.77	27	23.29	-3.18
28	14.38	2.57	28	21.58	2.65	28	23.24	-3.39
29	14.69	2.71	29	21.73	2.51	29	23.18	-3.59
30	15.00	2.84	30	21.88	2.37	30	23.12	-3.78
			31	22.02	2.23			

July			August			September		
Date	Declin (deg)	EQT(minutes)	Date	Declin (deg)	EQT(minutes)	Date	Declin (deg)	EQT(minutes)
1	23.05	-3.98	1	17.82	-6.32	1	8.00	0.13
2	22.98	-4.16	2	17.56	-6.24	2	7.64	0.45
3	22.89	-4.35	3	17.30	-6.16	3	7.27	0.78
4	22.80	-4.52	4	17.03	-6.07	4	6.90	1.11
5	22.71	-4.70	5	16.76	-5.96	5	6.53	1.45
6	22.61	-4.86	6	16.49	-5.85	6	6.16	1.78
7	22.50	-5.02	7	16.21	-5.73	7	5.78	2.12
8	22.38	-5.18	8	15.92	-5.59	8	5.41	2.47
9	22.26	-5.32	9	15.63	-5.45	9	5.03	2.82
10	22.13	-5.46	10	15.34	-5.30	10	4.65	3.16
11	22.00	-5.59	11	15.04	-5.14	11	4.27	3.52
12	21.86	-5.72	12	14.74	-4.97	12	3.89	3.87
13	21.71	-5.84	13	14.43	-4.79	13	3.51	4.22
14	21.56	-5.94	14	14.12	-4.60	14	3.12	4.58
15	21.40	-6.04	15	13.81	-4.40	15	2.74	4.93
16	21.23	-6.14	16	13.49	-4.19	16	2.35	5.29
17	21.06	-6.22	17	13.17	-3.98	17	1.97	5.65
18	20.89	-6.29	18	12.85	-3.75	18	1.58	6.01
19	20.70	-6.36	19	12.52	-3.52	19	1.19	6.36
20	20.51	-6.41	20	12.19	-3.28	20	0.80	6.72
21	20.32	-6.46	21	11.86	-3.03	21	0.41	7.07
22	20.12	-6.50	22	11.52	-2.78	22	0.02	7.42
23	19.91	-6.52	23	11.18	-2.52	23	-0.37	7.78
24	19.70	-6.54	24	10.84	-2.25	24	-0.75	8.12
25	19.49	-6.55	25	10.50	-1.97	25	-1.14	8.47
26	19.26	-6.55	26	10.15	-1.69	26	-1.53	8.81
27	19.04	-6.53	27	9.80	-1.40	27	-1.92	9.15
28	18.80	-6.51	28	9.44	-1.10	28	-2.31	9.49
29	18.57	-6.48	29	9.09	-0.80	29	-2.70	9.82
30	18.32	-6.43	30	8.73	-0.50	30	-3.09	10.15
31	18.07	-6.38	31	8.37	-0.18			
October			November			December		
Date	Declin (deg)	EQT(minutes)	Date	Declin (deg)	EQT(minutes)	Date	Declin (deg)	EQT(minutes)
1	-3.48	10.48	1	-14.66	16.47	1	-21.91	10.79
2	-3.86	10.80	2	-14.98	16.49	2	-22.06	10.40
3	-4.25	11.11	3	-15.29	16.48	3	-22.20	10.01
4	-4.63	11.42	4	-15.60	16.47	4	-22.33	9.60
5	-5.02	11.72	5	-15.90	16.44	5	-22.46	9.18
6	-5.40	12.02	6	-16.20	16.39	6	-22.57	8.76
7	-5.78	12.31	7	-16.49	16.34	7	-22.68	8.33
8	-6.17	12.59	8	-16.78	16.26	8	-22.79	7.89
9	-6.55	12.86	9	-17.07	16.18	9	-22.88	7.44
10	-6.92	13.13	10	-17.35	16.08	10	-22.97	6.99
11	-7.30	13.39	11	-17.62	15.96	11	-23.05	6.53
12	-7.68	13.64	12	-17.89	15.83	12	-23.13	6.06
13	-8.05	13.89	13	-18.15	15.69	13	-23.19	5.59
14	-8.42	14.12	14	-18.41	15.53	14	-23.25	5.11
15	-8.79	14.34	15	-18.67	15.36	15	-23.30	4.63
16	-9.16	14.56	16	-18.92	15.17	16	-23.34	4.15
17	-9.52	14.76	17	-19.16	14.97	17	-23.38	3.66
18	-9.88	14.96	18	-19.40	14.76	18	-23.40	3.17
19	-10.24	15.14	19	-19.63	14.53	19	-23.42	2.67
20	-10.60	15.32	20	-19.85	14.29	20	-23.43	2.18
21	-10.96	15.48	21	-20.07	14.03	21	-23.44	1.68
22	-11.31	15.63	22	-20.28	13.76	22	-23.43	1.19
23	-11.66	15.77	23	-20.49	13.48	23	-23.42	0.69
24	-12.01	15.90	24	-20.69	13.19	24	-23.40	0.20
25	-12.35	16.02	25	-20.89	12.88	25	-23.37	-0.30
26	-12.69	16.12	26	-21.07	12.56	26	-23.34	-0.79
27	-13.03	16.21	27	-21.25	12.23	27	-23.29	-1.28
28	-13.36	16.29	28	-21.43	11.89	28	-23.24	-1.77
29	-13.69	16.36	29	-21.60	11.53	29	-23.18	-2.25
30	-14.02	16.41	30	-21.76	11.17	30	-23.11	-2.73
31	-14.34	16.45				31	-23.04	-3.21

Example

9



- Gnomon shadow when shortest (@ solar noon) will form a 90 degree angle with line of minute marks
- If the angle is greater than 90 degrees then Solar noon is still approaching
- If the angle is less than 90 degrees then solar noon has passed
- The line of minute marks will form a straight / almost straight West to East line between about 11h00 and 13H00, depending on the solar declination on that day.