Angles: 34° 25.6' = 34.256, times 12h 34m 21s = 12.3412

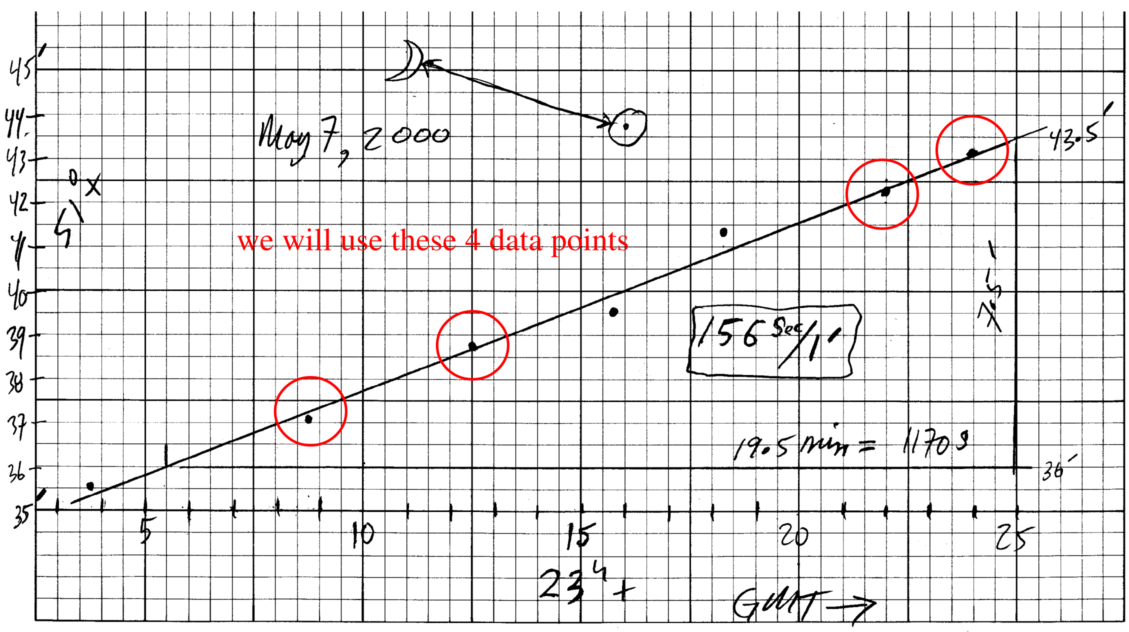
Lunar Distance Example, reduced by Stark Tables and by Computer solutions

Due to its own orbital motion around the earth, the apparent position of the moon among the stars changes daily. It circles the earth in about 30 days so the rate is 360°/30day = about 12° per day. If the moon is next to the star Aldebaran one night at 10 pm say, then the next night at 10 pm it will be about 12° to the east of the star.

Moving at 12°/day, we can figure its hourly rate as: 12 x60'/24hr = 30'/hr — it can actually be a bit faster than this since its period is closer to 28 days than to 30 days, or in practice rather slower than this if the reference body is not in line with the moon's motion. We can express this another way as the number of seconds it takes the lunar distance to change by 1' — ie, 1hr/30' = 3600sec/30' = 120 seconds per 1' of lunar distance. This can get as low as about 112 seconds per 1' but this is the limit we are dealing with. If our sight is wrong by 1', the GMT we figure from it will be wrong by at least 112 seconds. Hence the best we can hope to do in typical conditions is about 50 seconds of time accuracy... maybe a bit better with some luck.

Here is some real data from May 7, 2000 (times in GMT)
Temp = 52°F, pressure = 1017 mb, elevation = 62 feet, IC = 0.0', Location = 47.405 N, 122.239 W

GMT	Ds (lunar distance straight from sextant)
23.0349	51.360
23.0843	51.376
23.1230	51.392
23.1542	51.400
23.1815	51.418
23.2158	51.427
23.2400	51.436



We cannot take all the sights at the same time, but in principle, we need to know the altitudes of the two bodies (moon and companion) and the distance between them all at the same moment. If you are computing them, this does not matter; just compute the altitudes at the time of the distance. But if you are actually measuring them as you would in some emergency without an almanac or DR position using precomputed distances, then you need this technique or something equivalent to reduce the altitudes to the time of the distance. This form below and the Stark tables would have to be applied to both bodies. Here we bring a sun altitude before and after a distance measurement in tune to the distance time.

Form For Adjusting Observed Altitudes to a Common Time

For Use With Bruce Stark's
Tables For Clearing the Lunar Distance and Finding GMT By Sextant Observation

Date	May 7, 2000

Body	Sun

Elapsed Time between 1st Altitude and Time of Lunar Distance Observation

Time of 1st Altitude	23h 03m 49s		
Time of Lunar Distance Obs.	08 43s		
Difference	4m 54	Table 8	1 1.0894

Elapsed time Between 1st Altitude and Last Altitude

Time of 1st Altitude	23 03 49		
Time of Last Altitude.	23 12 30		
Difference	8m 41s	Table 8	2 0.8395

Subtract 2 from 1	3 0.2499

Change in Altitude Between 1st and Last Observation

1st Observed Altitude	42° 36.3		
Last Observed Altitude.	41° 16.0		
Difference	1° 20.3	Table 7	4 0.4755

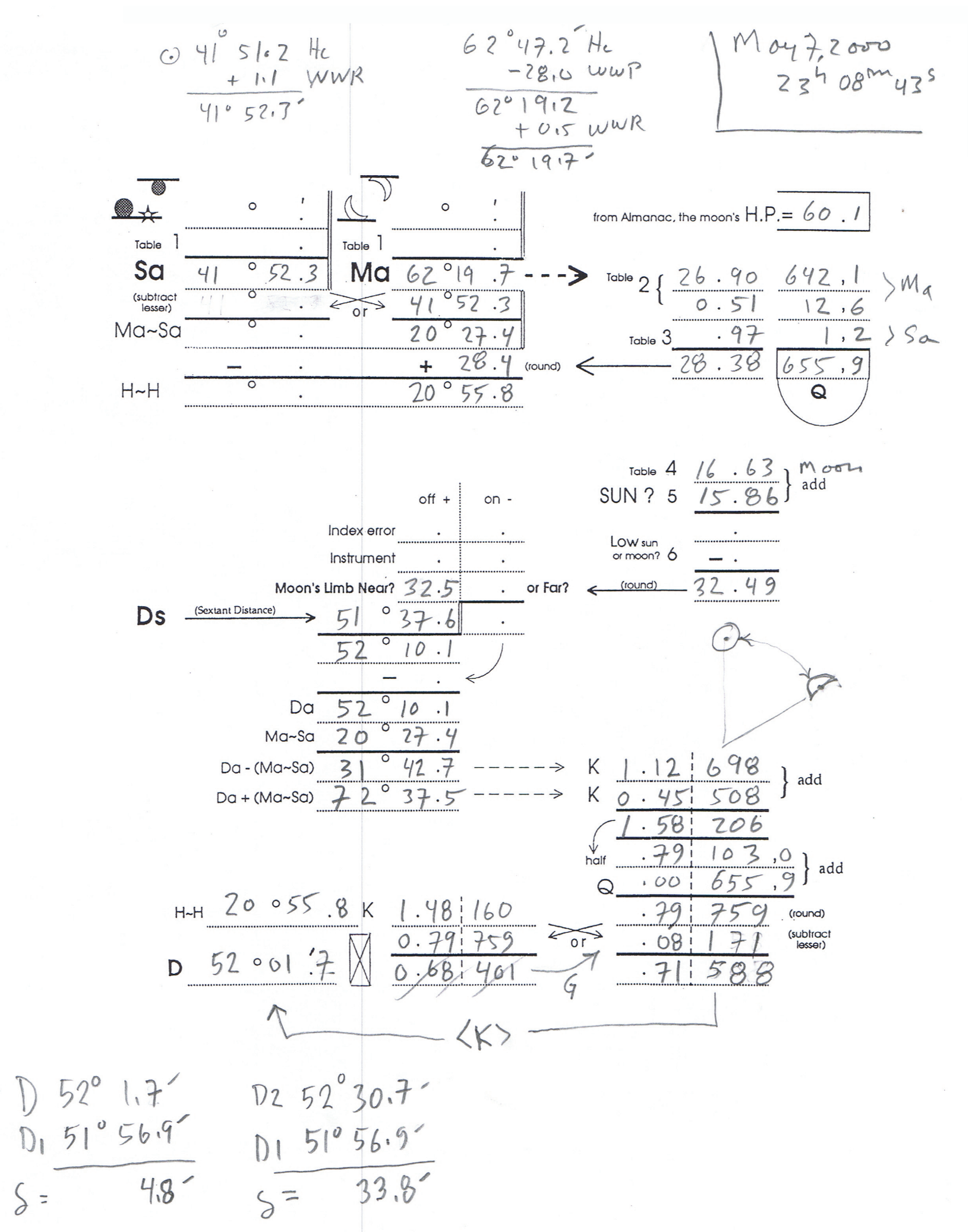
Add 3 and 4,	5 0.7254

Enter argument 5 into **Table 7**, extract value, then add or subtract to **1st** observed altitude	0° 45.2'

1st Observed Altitude	42° 36.3'
Increment to be Added to or Subtracted from, **1st** Altitude Observation	− 45.2'
Observed Altitude adjusted to common time	41° 51.1'

Robert Eno - Iqaluit, NT

The example given earlier for May 7, 2000 was a series of sights. Here is an example of reducing one of them (23h 08m 43s) with the Stark Tables. It was chosen at random. All the data are there for checking the others for more practice. This first page clears the Lunar Distance, based on the two calculated altitudes, using the WWP and WWRef tables. We end up with a cleared distance of 52° 01.7' This is the same as we get from the Frank Reed online computation, shown later here. The altitudes can also be computed using the USNO AA cel nav data site.



Now the task is to find out what the true lunar distance should be at that time, and the difference between that and what we observed can be used to figure the error in our watch time. (In this example, we know our watch was right, so any discrepancy we get now is actually our error in measurement and analysis.) In this approach you assume you know the hour before the right time. If this does not work out, then you can change that hour and do it again. So we enter all the data for the sun and moon at that hour and the one after it, and figure the two distances at those times, and interpolate then the time that corresponds to the cleared distance we observed. Refer to the book for how to fill out the tables.

May 7, 2000 Sun Moon

date: May 7, 2000 GMT

Previous Hour: 23

STAR: S.H.A. ° ' } add
G.H.A. Aries
-3 6 0 ?

☉ G.H.A.	165° 52'.7		
G.H.A.	110° 45.4		
difference	55° 07.3	--> K	.66 942
Dec. (N. or S.?)	21° 34.1	----> log Dec. ---->	.03 152
☉ Dec. (N. or S.?)	17° 06.0	----> log Dec. ---->	.01 963
difference	4° 28.1	K 2.81 823	.72 057
		.72 057	or .00 346 (subtract lesser)
D#1	51° 56.9	~~2.09 766~~	.71 711

(K)

date: May 7, 2000 GMT

Following Hour: 24

STAR: S.H.A. ° ' } add
G.H.A. Aries
-3 6 0 ?

G.H.A.	180° 52'.8		
G.H.A.	125° 08.7		
difference	55° 44.1	--> K	.66 057
Dec. (N) or S.?)	21° 34.5	----> log Dec. ---->	.03 154
Dec. (N. or S.?)	17° 06.7	----> log Dec. ---->	.01 966
difference	4° 27.8	K 2.81 921	.71 177
		.71 177	or .00 338 (subtract lesser)
D#2	52° 30'.7	~~2.10 744~~	.70 839

Table

D ~ D#1	4'.8	7	1.6990	8 43 ← actual
D#2 ~ D#1	33.8	7	−0.8513	
		8	0.8477	8 min. 31 sec.

12s error

This corresponds to about 12s x 15'/60s = 3' of longitude

Electronic solution from Frank Reed's web site www.historicalatlas.com/lunars

Lunars Calculator (ver. 4)

SETUP:

DR Lat:	47	40.5	N
DR Lon:	122	23.9	W
I.C.:			
Temperature:	52	°F	
Pressure (SL):	30.03	inches Hg	
Height of Eye:	6	feet	
Body:	Sun		

ALTITUDES:
(Leave Blank to Calculate)

Body:			LL
Moon:			LL

LUNAR:

Greenwich Date:	May 7, 2000
Time:	23 : 08 : 43 Greenwich Mean Time
Distance:	51 37.6 Near
Options:	☐ Ignore Oblateness of the Earth ☐ Ignore Refractional Flattening of Moon & Sun

Calculate

Created by Frank Reed (HistoricalAtlas.com, ReedNavigation.com, fer3.com), first version: June 2004.

	GHA	Dec	HP
Moon:	112° 50.8'	21° 34.2'	60.11
Sun:	168° 03.5'	17° 06.1'	0.15

True LD: 52° 01.8'Moon Apparent Altitude at DR: 62° 19.7'
Moon Altitude correction: -0° 27.5'
Sun Apparent Altitude at DR: 41° 52.2'
Sun Altitude correction: 0° 01.0'Clearing using calculated Moon Altitude at DR.
Clearing using calculated Sun Altitude at DR.
Moon SD refractional flattening is negligible.
Sun SD refractional flattening is negligible.
cos Diff Azm: 0.06435
Corrected for oblateness of the Earth.
Cleared LD: 52° 01.7'
Error in Lunar: -0.1'
Approximate Error in Longitude: 0° 02.6'

http://www.usno.navy.mil/USNO/astronomical-applications/data-services/cel-nav-data

Celestial Navigation Data for 2000 May 7 at 23:08:43 UT

For Assumed Position: Latitude N 47 40.5
Longitude W 122 23.9

Object	GHA	Dec	Hc	Zn	Refr	SD	PA	Sum
	Almanac Data				Altitude Corrections			
	° '	° '	° '	°	'	'	'	'
SUN	168 03.5	N17 06.1	+41 51.2	246.6	-1.1	15.8	0.1	14.8
MOON	112 50.8	N21 34.2	+62 47.2	160.3	-0.5	16.6	27.9	44.0
VENUS	176 50.8	N13 14.8	+33 24.1	251.6	-1.5	0.1	0.1	-1.3
MARS	152 29.9	N21 11.0	+54 07.7	232.9	-0.7	0.0	0.0	-0.7
JUPITER	167 39.3	N16 19.0	+41 30.0	245.5	-1.1	0.3	0.0	-0.8
SATURN	165 05.2	N15 49.9	+42 40.6	242.5	-1.1	0.1	0.0	-0.9
ADHARA	108 37.0	S28 58.6	+12 21.1	167.7	-4.4	0.0	0.0	-4.4
ALDEBARA	144 17.7	N16 30.4	+54 00.4	217.5	-0.7	0.0	0.0	-0.7
ALIOTH	19 45.4	N55 57.7	+32 01.1	40.1	-1.6	0.0	0.0	-1.6
ALKAID	6 22.7	N49 18.9	+21 35.8	39.1	-2.5	0.0	0.0	-2.5
ALNILAM	129 13.3	S 1 12.3	+40 45.5	189.0	-1.2	0.0	0.0	-1.2