

Ferris State University
Surveying Engineering
Surveying Computation - SURE 215

P R O B L E M N U M B E R 619

Solar Observation Reduction For Azimuth

Designed by: S.R. Hashimi

Write your answers in the spaces provided

From The Following Observation Compute:

- A. The Azimuth Of The Line For Each Set
- B. The Mean Of All The Sets And Its Standard Deviation

Station Occupied Name = "F"

Back Sight Station Name = "G"

Date of Observation (MM:DD:YYYY) = 11/19/2003

Latitude of Station (DD MM SS.ss)= 43 41 20.0

Longitude of Station (DD MM SS.ss)= -85 29 41.0

Standard Longitude of Station (HH MM SS.ss) = -5 0 0

Set Number	B.S. Dir. DDD MM SS	Sun Dir. DDD MM SS	Time Dir. HH MM SS	B.S. Rev. DDD MM SS	Sun Rev. DDD MM SS	Time Rev. HH MM SS
1	0 1 38	197 8 0	11 42 8	180 1 37	17 44 1	11 44 27
2	45 38 13	244 52 24	11 50 20	225 38 15	65 39 40	11 53 21
3	90 30 18	292 14 19	11 59 53	270 30 21	113 8 21	12 3 18
4	135 28 45	339 42 26	12 9 20	315 28 40	160 21 18	12 11 48

Set No.	Az. Line Dir.	Az. Line Rev.
1	_____	_____
2	_____	_____
3	_____	_____
4	_____	_____

Mean Az. of Line = _____



November 2003

2003	S U N	----- For 0 hrs Universal Time ---				----- Polaris --- 0 hrs UT ---			
Date	Declination	--- GHA ---	Eq o Time	Semi-Di	Declination	--- GHA ---	--- TUC ---		
	d m s	d m s	m s	m s	d m s	d m s	h m s		
Nov 1	SA -14 13 25.6	184 05 39.7	+16 22.65	16 06.7	89 16 50.9	0 34 09.4	23 53 47.8		
Nov 2	SU -14 32 40.7	184 06 06.7	+16 24.45	16 07.0	89 16 51.3	1 33 15.4	23 49 52.1		
Nov 3	MO -14 51 41.6	184 06 21.9	+16 25.46	16 07.2	89 16 51.7	2 32 22.8	23 45 56.2		
Nov 4	TU -15 10 27.9	184 06 25.2	+16 25.68	16 07.5	89 16 52.1	3 31 30.8	23 42 00.3		
Nov 5	WE -15 28 59.2	184 06 16.5	+16 25.10	16 07.7	89 16 52.5	4 30 38.8	23 38 04.5		
Nov 6	TH -15 47 15.1	184 05 55.6	+16 23.70	16 08.0	89 16 52.8	5 29 46.1	23 34 08.6		
Nov 7	FR -16 05 15.3	184 05 22.3	+16 21.49	16 08.2	89 16 53.1	6 28 52.4	23 30 12.8		
Nov 8	SA -16 22 59.4	184 04 36.6	+16 18.44	16 08.5	89 16 53.5	7 27 57.8	23 26 17.1		
Nov 9	SU -16 40 26.9	184 03 38.4	+16 14.56	16 08.7	89 16 53.8	8 27 02.3	23 22 21.5		
Nov 10	MO -16 57 37.6	184 02 27.5	+16 09.83	16 08.9	89 16 54.2	9 26 06.3	23 18 25.9		
Nov 11	TU -17 14 31.0	184 01 03.8	+16 04.25	16 09.2	89 16 54.5	10 25 10.3	23 14 30.2		
Nov 12	WE -17 31 06.7	183 59 27.3	+15 57.82	16 09.4	89 16 54.9	11 24 14.7	23 10 34.6		
Nov 13	TH -17 47 24.5	183 57 38.0	+15 50.53	16 09.6	89 16 55.3	12 23 20.3	23 06 38.9		
Nov 14	FR -18 03 23.8	183 55 35.8	+15 42.38	16 09.8	89 16 55.7	13 22 27.3	23 02 43.0		
Nov 15	SA -18 19 04.3	183 53 20.6	+15 33.37	16 10.0	89 16 56.1	14 21 36.1	22 58 47.1		
Nov 16	SU -18 34 25.7	183 50 52.5	+15 23.50	16 10.2	89 16 56.5	15 20 46.8	22 54 51.0		
Nov 17	MO -18 49 27.5	183 48 11.5	+15 12.76	16 10.5	89 16 56.9	16 19 59.4	22 50 54.8		
Nov 18	TU -19 04 09.3	183 45 17.6	+15 01.17	16 10.7	89 16 57.3	17 19 13.3	22 46 58.6		
Nov 19	WE -19 18 30.7	183 42 10.9	+14 48.73	16 10.9	89 16 57.7	18 18 27.9	22 43 02.2		
Nov 20	TH -19 32 31.5	183 38 51.6	+14 35.44	16 11.1	89 16 58.1	19 17 42.3	22 39 05.9		
Nov 21	FR -19 46 11.1	183 35 19.7	+14 21.31	16 11.3	89 16 58.4	20 16 55.5	22 35 09.7		
Nov 22	SA -19 59 29.2	183 31 35.4	+14 06.36	16 11.5	89 16 58.7	21 16 06.8	22 31 13.6		
Nov 23	SU -20 12 25.4	183 27 38.9	+13 50.59	16 11.6	89 16 59.0	22 15 16.2	22 27 17.6		
Nov 24	MO -20 24 59.3	183 23 30.4	+13 34.03	16 11.8	89 16 59.4	23 14 24.2	22 23 21.7		
Nov 25	TU -20 37 10.7	183 19 10.3	+13 16.69	16 12.0	89 16 59.7	24 13 32.3	22 19 25.8		
Nov 26	WE -20 48 59.0	183 14 38.8	+12 58.59	16 12.2	89 17 00.1	25 12 41.9	22 15 29.8		
Nov 27	TH -21 00 24.1	183 09 56.3	+12 39.75	16 12.4	89 17 00.6	26 11 54.0	22 11 33.7		
Nov 28	FR -21 11 25.4	183 05 02.9	+12 20.20	16 12.6	89 17 01.0	27 11 09.1	22 07 37.3		
Nov 29	SA -21 22 02.7	182 59 59.1	+11 59.94	16 12.7	89 17 01.4	28 10 26.8	22 03 40.8		
Nov 30	SU -21 32 15.7	182 54 45.2	+11 39.01	16 12.9	89 17 01.8	29 09 46.2	21 59 44.1		

[to December](#)

SOLAR OBSERVATION WORKSHEET

Name IMA A. STUDENT

Sheet 1 of 2

	Set 1 Direct	Set 1 Reverse	Set 2 Direct	Set 2 Reverse	Comments
1 Backsight	0° 01' 30"	180° 01' 37"	45° 30' 13"	225° 30' 15"	
2 Foresight	197° 08' 00"	17° 44' 01"	244° 52' 24"	65° 30' 40"	
3 Angle	197° 06' 22"	197° 42' 24"	199° 14' 11"	200° 01' 25"	2 - 1
4 Observation Time	11h 42m 08s	11h 44m 27s	11h 50m 20s	11h 53m 21s	If time not UTC
5 Time Zone Correction	5h 00m 00s	5h	5h	5h	
6 UT Time	16h 42m 08s	16h 44m 27s	16h 50m 20s	16h 53m 21s	5+6
7 Equation Time 0 ^h	0h 14m 48.73s	0h 14m 48.73s	0h 14m 48.73s	0h 14m 48.73s	
8 Equation Time 24 ^h	0h 14m 35.44s	0h 14m 35.44s	0h 14m 35.44s	0h 14m 35.44s	
9 Equation Time, obs.	0h 14m 39.48s	0h 14m 39.46s	0h 14m 39.41s	0h 14m 39.30s	(8-7)/24*6+7
10 -12 ^h	-12h 00m 00s	-12h	-12h	-12h	
11 GHA, hours	4h 56m 47.48s	4h 59m 06.46s	5h 04m 59.41s	5h 08m 00.30s	6+9+10
12 GHA, arc	74° 11' 52.2"	74° 46' 36.9"	76° 14' 51.2"	77° 00' 05.7"	11 * 15
13 Longitude	-85° 29' 41"	-85° 29' 41"	-85° 29' 41"	-85° 29' 41"	W longitude (-)
14 Latitude	43° 41' 20"	43° 41' 20"	43° 41' 20"	43° 41' 20"	
15 LHA	348° 42' 11.2"	349° 16' 55.9"	350° 45' 10.2"	351° 30' 24.7"	12 + 13
16 t *	11° 17' 48.0"	10° 43' 04.1"	9° 14' 49.9"	8° 29' 35.3"	
17 Declination 0 ^h	-19° 18' 30.7"	-19° 18' 30.7"	-19° 18' 30.7"	-19° 18' 30.7"	
18 Declination 24 ^h	-19° 32' 31.5"	-19° 32' 31.5"	-19° 32' 31.5"	-19° 32' 31.5"	
19 Declination, obs.	-19° 28' 15.8"	-19° 28' 17.2"	-19° 28' 20.6"	-19° 28' 22.4"	(18-17)/24*6+17
20 Z **	168° 00' 53.2"	168° 44' 34.9"	170° 16' 22.7"	171° 03' 36.0"	Azimuth of sun
21 Azimuth	331° 02' 11.2"	331° 02' 10.9"	331° 02' 11.7"	331° 02' 11.0"	20 - 3
22 Average per Set	331° 02' 11.0"		331° 02' 11.4"		

Average Azimuth of line 331° 01' 59.0"

Note that values in red in Comments column indicate value for a specific row number. Black values are constant terms or set variables.

* If LHA > 180°, t = 360° - LHA and t is east and +. If LHA < 180°, t = LHA and t is west and -

** Z is computed from:

$$\tan Z = \frac{\sin t}{\tan \delta \cos \phi - \sin \phi \cos t}$$

SOLAR OBSERVATION WORKSHEET

Name _____

	Set 3 Direct	Set 3 Reverse	Set 4 Direct	Set 4 Reverse	Comments
1 Backsight	90° 30' 18"	270° 30' 21"	135° 28' 45"	315° 28' 40"	
2 Foresight	292° 14' 19"	113° 08' 21"	330° 42' 26"	160° 21' 18"	
3 Angle	201° 44' 01"	202° 38' 00"	204° 13' 41"	204° 52' 38"	2 - 1
4 Observation Time	11h 59m 53s	12h 03m 18s	12h 09m 20s	12h 11m 48s	If time not UTC
5 Time Zone Correction	5h 00m 00s	5h	5h	5h	
6 UT Time	16h 59m 53s	17h 03m 18s	17h 09m 20s	17h 11m 48s	5+6
7 Equation Time 0 ^h	0h 14m 48.73s	0h 14m 48.73s	0h 14m 48.73s	0h 14m 48.73s	
8 Equation Time 24 ^h	0h 14m 35.44s	0h 14m 35.44s	0h 14m 35.44s	0h 14m 35.44s	
9 Equation Time, obs.	0h 14m 39.32s	0h 14m 39.29s	0h 14m 39.23s	0h 14m 39.21s	(8-7)/24*6+7
10 -12 ^h	-12h 00m 00s	-12h	-12h	-12h	
11 GHA, hours	5h 14m 32.32s	5h 17m 57.29s	5h 23m 59.23s	5h 26m 21.21s	6+9+10
12 GHA, arc	78° 30' 04.8"	79° 29' 19.4"	80° 59' 48.4s	81° 36' 48.2s	11 * 15
13 Longitude	-85° 29' 41"	-85° 29' 41"	-85° 29' 41"	-85° 29' 41"	W longitude (-)
14 Latitude	43° 41' 20"	43° 41' 20"	43° 41' 20"	43° 41' 20"	
15 LHA	353° 08' 23.8"	353° 59' 38.4"	355° 30' 07.5"	356° 07' 07.2"	12 + 13
16 t *	6° 51' 36.2"	6° 00' 21.7"	4° 29' 52.5"	3° 52' 52.8"	
17 Declination 0 ^h	-19° 18' 30.7"	-19° 18' 30.7"	-19° 18' 30.7"	-19° 18' 30.7"	
18 Declination 24 ^h	-19° 32' 31.5"	-19° 32' 31.5"	-19° 32' 31.5"	-19° 32' 31.5"	
19 Declination, obs.	-19° 28' 26.2"	-19° 28' 28.2"	-19° 28' 31.7"	-19° 28' 33.2"	(18-17)/24*6+17
20 Z **	172° 46' 10.7"	173° 39' 58.3"	175° 15' 09.7"	175° 54' 08.5"	Azimuth of sun
21 Azimuth	331° 02' 09.7"	331° 01' 58.3"	331° 01' 28.7"	331° 01' 30.5"	20 - 3
22 Average per Set	331° 02' 04.0"		331° 01' 28.6"		

Average Azimuth of line _____

Note that values in red in Comments column indicate value for a specific row number. Black values are constant terms or set variables.

* If LHA > 180°, t = 360° - LHA and t is east and +. If LHA < 180°, t = LHA and t is west and -

** Z is computed from:

$$\tan Z = \frac{\sin t}{\tan \delta \cos \phi - \sin \phi \cos t}$$

Solar Azimuth Determination

Longitude	-85	-29	-41										
Latitude	43	41	20										
Equation of Time 0-hr	0	14	48.73										
Equation of Time 24-hr	0	14	35.44										
Declination, 0-hr	-19	-18	-30.7										
Declination, 24-hr	-19	-32	-31.5										
Azimuth Determination - Solar Observations													
			SET 1						SET 2				
Backsight	0	1	38	180	1	37	45	38	13	225	38	15	
Foresight	197	8	0	17	44	1	244	52	24	65	39	40	
	197.1061			197.7067			199.2364			200.0236			
Angle	197	6	22	197	42	24	199	14	11	200	1	25	
Observation Time	11	42	8	11	44	27	11	50	20	11	53	21	
Time Zone Corr	5			5			5			5			
UT Time	16.70222			16.74083			16.83889			16.88917			
Change in Eq. Time			0.2443			0.244294			0.244279			0.244272	
-12 hours	-12			-12			-12			-12			
GHA, hours	4.946523			4.985128			5.083168			5.133438			
GHA, arc	74.19784			74.77692			76.24752			77.00157			
LHA	-11.2969	348.7031		-10.7178	349.2822		-9.2472	350.7528		-8.49315	351.5069		
t	11.29688			10.71781			9.247199			8.493149			
Declination, 0-hr	-19	-18	-30.7	-19	-18	-30.7	-19	-18	-30.7	-19	-18	-30.7	
Declination, 24-hr	-19	-32	-31.5	-19	-32	-31.5	-19	-32	-31.5	-19	-32	-31.5	
Change in Declination			-0.16254			-0.16291			-0.16387			-0.16436	
Declination @ Obs.	-19.4711			-19.4714			-19.4724			-19.4729			
t,lat,decl - radians	0.197168	0.762515	-0.33983	0.187061	0.762515	-0.33984	0.161394	0.762515	-0.33986	0.148233	0.762515	-0.33987	
Z	-0.93301	-0.20695	168.1426	-0.93435	-0.19647	168.743	-0.93744	-0.16977	170.273	-0.93885	-0.15603	171.06	
	-28.9636	331.0364		-28.9636	331.0364		-28.9634	331.0366		-28.9636	331.0364		
Azimuth	331	2	11.19872	331	2	10.9058	331	2	11.67553	331	2	10.94527	
	331.0364						331.0365						
Set Average				331	2	11.05226				331	2	11.3104	
	331.033	0.004783											
Average Azimuth	331	1	59.0										
Standard Deviation	0	0	17.2										

Solar Azimuth Determination

Azimuth Determination - Solar Obs												
	SET 3						SET 4					
Backsight	90	30	18	270	30	21	135	28	45	315	28	40
Foresight	292	14	19	113	8	21	339	42	26	160	21	18
	201.7336			202.6333			204.2281			204.8772		
Angle	201	44	1	202	37	60	204	13	41	204	52	38
Observation Time	11	59	53	12	3	18	12	9	20	12	11	48
Time Zone Corr	5			5			5			5		
UT Time	16.99806			17.055			17.15556			17.19667		
Change in Eq. Time			0.244255			0.244246			0.244231			0.244224
-12 hours	-12			-12			-12			-12		
GHA, hours	5.24231			5.299246			5.399786			5.440891		
GHA, arc	78.63466			79.48869			80.99679			81.61336		
LHA	-6.86007	353.1399		-6.00603	353.994		-4.49793	355.5021		-3.88136	356.1186	
t	6.860067			6.006031			4.49793			3.881358		
Declination, 0-hr	-19	-18	-30.7	-19	-18	-30.7	-19	-18	-30.7	-19	-18	-30.7
Declination, 24-hr	-19	-32	-31.5	-19	-32	-31.5	-19	-32	-31.5	-19	-32	-31.5
Change in Declination			-0.16542			-0.16597			-0.16695			-0.16735
Declination @ Obs.	-19.4739			-19.4745			-19.4755			-19.4759		
t,lat,decl - radians	0.119731	0.762515	-0.33988	0.104825	0.762515	-0.339894	0.078504	0.762515	-0.33991	0.067742	0.762515	-0.33992
Z	-0.94149	-0.12619	172.7696	-0.94265	-0.11055	173.6662	-0.94433	-0.08286	175.2527	-0.94488	-0.07152	175.9024
	-28.964	331.036		-28.9672	331.0328		-28.9754	331.0246		-28.9749	331.0251	
Azimuth	331	2	9.683234	331	1	58.21254	331	1	28.69676	331	1	30.48667
	331.0344						331.0249					
Set Average				331	2	3.947888				331	1	29.59172