Faculty of Engineering

Prince of Songkla University

This is a closed book exam. Books, lecture notes, needed materials, and all other documents are definitely **_not_** allowed. However, dictionary, scientific calculator and needed stationery are exempted.

Instructions

1. There are 5 problems in this exam. (100 points)

2. Attempt all problems.

3. Books and lecture notes are not allowed.

4. Students can bring in a calculator and a dictionary.

5. Students can use pencils in the answer-books.

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1)   Name the systems of spherical-coordinates that can be specified the positions of any celestial bodies on the celestial sphere. Sketch only one diagram of your choice that clearly displays the relationship among the celestial bodies, the primary and secondary reference planes as well as the coordinates themselves. Also explain the technical terms associated with your diagram. (15 points)

2)   On October 10^{th}1984, the observed altitude of the sun at station A was 31° 20′ 35″ at 14^{h} 41^{m} 35^{s} local time. The latitude of the station A is 37° 52′ 20″ N. The temperature and barometric pressure during the observation was 80°F and 28.7 inch Hg respectively. The mean horizontal angle (measured clockwise) from the reference station B to the sun was 60° 01′ 57″. What are the azimuth of the sun (measured from the north) and the azimuth of the reference line AB? (25 points) **Hint:** GMT = Local time + 8^{h}.

3)   Prepare the table required for staking out at every 50 m. full station of a horizontal curve by chord-deflection angle method. Given the required radius of the curve R = 250 m., the deflection angle θ = 60° and the stationing at PI = 12 km. +853.892 m. Also calculate the stationing of the PC and the PT. (25 points)

4)   An entering grade of + 3% meets a departing grade of -2% at station 8+645.00 km. The two grades intersect at an elevation of +37.667 m. above mean sea level. If these two grades are connected by a 500-m equal-tangent curve, compute and plot the elevation-profile of this vertical curve at every 50m. full-station. Also determine the location and elevation of the highest point on this vertical curve. (25 points)

5)   Name and explain the types of circular arcs that are very common in highways design. Also sketch the diagrams of these arcs with all necessary information related to each type of the arcs.   (10 points)

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TABLE 1

SOLAR EPHEMERIS OCTOBER 1984
For 0ʰ Universal Time or Greenwich Civil Time

Day of Month & Week		The Sun's Apparent Declination	Diff. in Declin. for 1 hour	True Sol. Time = LCT + Eq. of Time (m s)	Differ. for 1 hour (s)	GHA of Polaris
1	M	S03 10.3	0.97	+10 16.3	0.80	335 41.2
2	TU	S03 33.5	0.97	+10 35.5	0.79	336 40.1
3	W	S03 56.7	0.97	+10 54.4	0.78	337 39.1
4	TH	S04 19.9	0.96	+11 13.0	0.76	338 38.0
5	FR	S04 43.0	0.96	+11 31.3	0.75	339 37.0
6	SA	S05 06.1	0.96	+11 49.2	0.73	340 36.0
7	SU	S05 29.1	0.96	+12 06.7	0.71	341 35.0
8	M	S05 52.0	0.95	+12 23.9	0.70	342 34.0
9	TU	S06 14.9	0.95	+12 40.6	0.68	343 33.0
10	W	S06 37.6	0.94	+12 56.9	0.66	344 32.0
11	TH	S07 00.3	0.94	+13 12.7	0.64	345 31.0
12	FR	S07 22.9	0.94	+13 28.0	0.62	346 29.9
13	SA	S07 45.4	0.93	+13 42.8	0.59	347 28.9
14	SU	S08 07.8	0.93	+13 57.1	0.57	348 27.8
15	M	S08 30.0	0.92	+14 10.8	0.55	349 26.8
16	TU	S08 52.2	0.92	+14 24.0	0.52	350 25.8
17	W	S09 14.2	0.91	+14 36.5	0.50	351 24.7
18	TH	S09 36.1	0.91	+14 48.5	0.47	352 23.7
19	FR	S09 57.8	0.90	+14 59.8	0.45	353 22.7
20	SA	S10 19.4	0.89	+15 10.5	0.42	354 21.8
21	SU	S10 40.9	0.89	+15 20.5	0.39	355 20.9
22	M	S11 02.2	0.88	+15 29.8	0.36	356 20.0
23	TU	S11 23.4	0.87	+15 38.5	0.33	357 19.1
24	W	S11 44.3	0.87	+15 46.5	0.30	358 18.1
25	TH	S12 05.1	0.86	+15 53.7	0.27	359 17.2
26	FR	S12 25.7	0.85	+16 00.2	0.24	000 16.2
27	SA	S12 46.1	0.84	+16 06.1	0.21	001 15.2
28	SU	S13 06.4	0.83	+16 11.1	0.18	002 14.2
29	M	S13 26.4	0.82	+16 15.5	0.15	003 13.2
30	TU	S13 46.2	0.82	+16 19.1	0.12	004 12.3
31	W	S14 05.8	0.81	+16 21.9	0.09	005 11.4
32	TH	S14 25.1		+16 23.9		006 10.5

Hourly differences in declination and equation of time are for the 24-hours following 0-hours of date in left column.

TABLE 1

SOLAR EPHEMERIS NOVEMBER 1984
For 0ʰ Universal Time or Greenwich Civil Time

Day of Month & Week		The Sun's Apparent Declination	Diff. in Declin. for 1 hour	True Sol. Time = LCT + Eq. of Time (m s)	Differ. for 1 hour (s)	GHA of Polaris
1	TH	S14 25.1	0.80	+16 23.9	0.05	006 10.5
2	FR	S14 44.2	0.79	+16 25.2	0.02	007 09.7
3	SA	S15 03.1	0.78	+16 25.7	0.01	008 08.9
4	SU	S15 21.7	0.77	+16 25.4	0.05	009 08.0
5	M	S15 40.1	0.75	+16 24.3	0.08	010 07.2
6	TU	S15 58.2	0.74	+16 22.3	0.12	011 06.3
7	W	S16 16.1	0.73	+16 19.5	0.15	012 05.5
8	TH	S16 33.6	0.72	+16 15.9	0.19	013 04.6
9	FR	S16 50.9	0.71	+16 11.5	0.22	014 03.7
10	SA	S17 07.9	0.70	+16 06.2	0.26	015 02.9
11	SU	S17 24.7	0.68	+16 00.1	0.29	016 02.0
12	M	S17 41.1	0.67	+15 53.1	0.33	017 01.1
13	TU	S17 57.2	0.66	+15 45.2	0.36	018 00.2
14	W	S18 13.0	0.65	+15 36.5	0.40	018 59.4
15	TH	S18 28.5	0.63	+15 26.9	0.44	019 58.6
16	FR	S18 43.7	0.62	+15 16.4	0.47	020 57.9
17	SA	S18 58.5	0.60	+15 05.1	0.51	021 57.1
18	SU	S19 13.0	0.59	+14 52.9	0.54	022 56.4
19	M	S19 27.1	0.58	+14 39.9	0.58	023 55.7
20	TU	S19 40.9	0.56	+14 26.1	0.61	024 54.9
21	W	S19 54.4	0.55	+14 11.4	0.65	025 54.1
22	TH	S20 07.5	0.53	+13 55.9	0.68	026 53.3
23	FR	S20 20.2	0.51	+13 39.6	0.71	027 52.5
24	SA	S20 32.5	0.50	+13 22.5	0.74	028 51.7
25	SU	S20 44.5	0.48	+13 04.6	0.78	029 50.9
26	M	S20 56.1	0.47	+12 46.0	0.81	030 50.1
27	TU	S21 07.3	0.45	+12 26.7	0.83	031 49.4
28	W	S21 18.0	0.43	+12 06.6	0.86	032 48.7
29	TH	S21 28.4	0.42	+11 45.9	0.89	033 48.0
30	FR	S21 38.4	0.40	+11 24.5	0.92	034 47.4
31	SA	S21 47.9		+11 02.5		035 46.7

Hourly differences in declination and equation of time are for the 24-hours following 0-hours of date in left column.

TABLE 1

SOLAR EPHEMERIS DECEMBER 1984
For 0ʰ Universal Time or Greenwich Civil Time

Day of Month & Week		The Sun's Apparent Declination	Diff. in Declin. for 1 hour	True Sol. Time = LCT + Eq. of Time (m s)	Differ. for 1 hour (s)	GHA of Polaris
1	SA	S21 47.9	0.38	+11 02.5	0.94	035 46.7
2	SU	S21 57.1	0.36	+10 39.8	0.97	036 46.1
3	M	S22 05.8	0.35	+10 16.5	0.99	037 45.4
4	TU	S22 14.1	0.33	+09 52.7	1.02	038 44.7
5	W	S22 21.9	0.31	+09 28.2	1.04	039 44.1
6	TH	S22 29.4	0.29	+09 03.3	1.06	040 43.4
7	FR	S22 36.4	0.27	+08 37.8	1.08	041 42.7
8	SA	S22 42.9	0.25	+08 11.8	1.10	042 41.9
9	SU	S22 49.0	0.24	+07 45.3	1.12	043 41.2
10	M	S22 54.6	0.22	+07 18.4	1.14	044 40.6
11	TU	S22 59.8	0.20	+06 51.1	1.15	045 39.9
12	W	S23 04.6	0.18	+06 23.4	1.17	046 39.3
13	TH	S23 08.9	0.16	+05 55.3	1.18	047 38.7
14	FR	S23 12.7	0.14	+05 26.9	1.20	048 38.1
15	SA	S23 16.1	0.12	+04 58.1	1.21	049 37.6
16	SU	S23 19.0	0.10	+04 29.1	1.22	050 37.0
17	M	S23 21.4	0.08	+03 59.8	1.23	051 36.4
18	TU	S23 23.4	0.06	+03 30.3	1.24	052 35.8
19	W	S23 24.9	0.04	+03 00.7	1.24	053 35.2
20	TH	S23 25.9	0.02	+02 30.8	1.25	054 34.5
21	FR	S23 26.4	0.00	+02 00.9	1.25	055 33.9
22	SA	S23 26.5	0.02	+01 30.9	1.25	056 33.3
23	SU	S23 26.2	0.04	+01 00.9	1.25	057 32.6
24	M	S23 25.3	0.06	+00 30.9	1.24	058 32.1
25	TU	S23 24.0	0.07	+00 01.0	1.24	059 31.5
26	W	S23 22.2	0.09	-00 28.9	1.24	060 31.0
27	TH	S23 19.9	0.11	-00 58.6	1.23	061 30.5
28	FR	S23 17.2	0.13	-01 28.2	1.22	062 30.0
29	SA	S23 14.0	0.15	-01 57.5	1.21	063 29.5
30	SU	S23 10.3	0.17	-02 26.7	1.20	064 29.0
31	M	S23 06.2	0.19	-02 55.6	1.19	065 28.5
32	TU	S23 01.6		-03 24.1		066 27.9

Hourly differences in declination and equation of time are for the 24-hours following 0-hours of date in left column.

TABLE 2
REFRACTION AND SUN'S PARALLAX
(To be applied to observed altitudes. See page 16)
Bar. = 29.6 in. Temp. = 50° F

Measured Altitude	Refraction	Sun's Par.	Measured Altitude	Refraction	Sun's Par.
7 30	6.88	0.15	17 30	3.02	0.14
7 40	6.75	0.15	18 00	2.93	0.14
7 50	6.62	0.15	18 30	2.85	0.14
8 00	6.50	0.15	19 00	2.77	0.14
8 10	6.37	0.15	19 30	2.70	0.14
8 20	6.25	0.15	20 00	2.62	0.14
8 30	6.13	0.15	21 00	2.48	0.14
8 40	6.02	0.15	22 00	2.36	0.14
8 50	5.92	0.15	23 00	2.25	0.14
9 00	5.82	0.15	24 00	2.15	0.14
9 10	5.72	0.15	25 00	2.05	0.14
9 20	5.63	0.15	26 00	1.96	0.13
9 30	5.53	0.15	27 00	1.88	0.13
9 40	5.43	0.15	28 00	1.80	0.13
9 50	5.34	0.15	29 00	1.73	0.13
10 00	5.26	0.15	30 00	1.66	0.13
10 20	5.10	0.15	32 00	1.53	0.13
10 40	4.95	0.14	34 00	1.42	0.12
11 00	4.81	0.14	36 00	1.32	0.12
11 20	4.67	0.14	38 00	1.23	0.12
11 40	4.54	0.14	40 00	1.15	0.11
12 00	4.42	0.14	42 00	1.07	0.11
12 30	4.25	0.14	44 00	1.00	0.11
13 00	4.09	0.14	46 00	0.93	0.10
13 30	3.93	0.14	48 00	0.86	0.10
14 00	3.78	0.14	50 00	0.80	0.09
14 30	3.65	0.14	55 00	0.67	0.08
15 00	3.52	0.14	60 00	0.55	0.07
15 30	3.42	0.14	65 00	0.45	0.06
16 00	3.32	0.14	70 00	0.35	0.05
16 30	3.22	0.14	80 00	0.17	0.03
17 00	3.12	0.14	90 00	0.00	0.00

The refraction values in Table 2 are corrected by multiplying them by the multipliers in Table 2a when the barometric pressure and the temperature differ from those on which Table 2 is based, i.e. 29.6 inches and 50° F.

If the barometric pressure is not known, it may be estimated from the elevation of the locality in accordance with the values given in Table 2a. Otherwise the elevations are disregarded.

TABLE 2a

To correct Table 2. See Examples below.

MULTIPLIERS FOR OBSERVED BAROMETRIC PRESSURE OR ELEVATION

Bar. (Inches)	Elev. (Feet)	Multiplier	Bar. (Inches)	Elev. (Feet)	Multiplier
30.5	− 451	1.03	23.9	+ 6194	0.81
30.2	− 181	1.02	23.6	6538	0.80
30.0	00	1.01	23.3	6887	0.79
			23.0	7239	0.78
29.9	+ 91	1.01			
29.6	366	1.00	22.7	7597	0.77
29.3	643	0.99	22.4	7960	0.76
29.0	924	0.98	22.1	8327	0.75
28.7	1207	0.97	21.8	8700	0.74
28.4	1493	0.96	21.5	9077	0.73
28.1	1783	0.95	21.2	9460	0.72
27.8	2075	0.94	20.9	9848	0.71
27.5	2371	0.93	20.6	10242	0.70
27.2	2670	0.92	20.3	10642	0.69
			20.0	11047	0.68
26.9	2972	0.91			
26.6	3277	0.90	19.7	11458	0.67
26.3	3586	0.89	19.4	11875	0.66
26.0	3899	0.88	19.1	12299	0.65
25.7	4215	0.87	18.8	12729	0.64
25.4	4535	0.86	18.5	13165	0.63
25.1	4859	0.85	18.2	13608	0.62
24.8	5186	0.84	17.9	14058	0.61
24.5	5518	0.83			
24.2	5854	0.82			

MULTIPLIERS FOR TEMPERATURE

Temp. Deg. F	Multiplier	Temp. Deg. F	Multiplier	Temp. Deg. F	Multiplier
− 20	1.16	+ 30	1.04	+ 80	0.94
− 10	1.13	+ 40	1.02	+ 90	0.93
0	1.11	+ 50	1.00	+100	0.91
+ 10	1.08	+ 60	0.98	+110	0.90
+ 20	1.06	+ 70	0.96	+120	0.88

Example. Sun: Meas. Alt. = 30°; Bar. = 26 in. or Elev. 3900 ft.; Temp. 70° F.
Refraction = 1.66' (0.88) (0.96) = 1.40'. Parallax = 0.13'.
True Alt. = 30° 00.00' − 1.40' + 0.13' = 29° 58.73'.

Example. Star: Meas. Alt. = 25°; Bar. = 24.5 or Elev. 5518 ft.; Temp. 10° F.
Refraction = 2.05' (0.83) (1.08) = 1.84'.
True Alt. = 25° 00.00' − 1.84' = 24° 58.16'.

TABLE 3

POLAR DISTANCE OF POLARIS 1984
For 0h Universal Time or Greenwich Civil Time

1984		Angle	Cotan	1984		Angle	Cotan
		° ' "				° ' "	
Jan.	1	0 48.24	71.26	July	9	0 48.71	70.57
	11	0 48.21	71.30		19	0 48.70	70.59
	21	0 48.19	71.33		29	0 48.69	70.60
	31	0 48.19	71.33				
Feb.	10	0 48.19	71.33	Aug.	8	0 48.67	70.63
	20	0 48.20	71.32		18	0 48.64	70.67
					28	0 48.61	70.72
Mar.	1	0 48.23	71.27	Sep.	7	0 48.56	70.78
	11	0 48.26	71.23		17	0 48.52	70.85
	21	0 48.30	71.17		27	0 48.46	70.94
	31	0 48.35	71.10				
Apr.	10	0 48.40	71.02	Oct.	7	0 48.40	71.02
	20	0 48.45	70.95		17	0 48.34	71.11
	30	0 48.50	70.88		27	0 48.28	71.20
May	10	0 48.54	70.82	Nov.	6	0 48.21	71.30
	20	0 48.59	70.75		16	0 48.15	71.39
	30	0 48.63	70.69		26	0 48.09	71.48
June	9	0 48.66	70.64	Dec.	6	0 48.04	71.56
	19	0 48.68	70.61		16	0 47.98	71.64
	29	0 48.70	70.59		26	0 47.94	71.70

Declination = 90° − Polar Distance

TABLE 4

THE SUN'S SEMI-DIAMETER 1984
For 0h Universal Time or Greenwich Civil Time

Date	Semi-Diam.	Date	Semi-Diam.	Date	Semi-Diam.
1984		1984		1984	
Jan. 1	16.29	May 10	15.86	Sep. 7	15.90
11	16.29	20	15.83	14	15.93
21	16.28	30	15.80	27	15.98
31	16.26				
Feb. 10	16.24	June 9	15.78	Oct. 7	16.03
20	16.20	19	15.76	17	16.08
		29	15.76	27	16.12
Mar. 1	16.17	July 9	15.76	Nov. 6	16.16
11	16.12	19	15.76	16	16.20
21	16.08	29	15.78	26	16.23
31	16.03				
Apr. 10	15.99	Aug. 8	15.80	Dec. 6	16.26
20	15.94	18	15.83	16	16.28
30	15.90	28	15.86	26	16.29