**Faculty of Engineering**

**Prince of Songkla University**

Final Examination                                            1<sup>st</sup> Semester 2007

October 8<sup>th</sup>, 2007                                         Room A401

221 – 361 Surveying II                                      Time: 9:00 - 12:00 (3 hours)

# 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 calculators and dictionaries.
5. Students can use pencils in the answer books.

<div align="right">นาย รุจ ศุภวิไล ผู้ออกข้อสะ บ</div>

1)      Explain the effects of parallax and refraction on astronomical observation. Also sketch the diagram that clearly shows the relations among parallax, refraction, altitude of a celestial body and the position of the observer. (10 points)

2)      On October 11$^{th}$, the observed altitude of the sun at the station A is 31° 20' 35" at 14$^h$ 41$^m$ 35$^s$ local time. The latitude of A is 37° 52' 20" N and the longitude of A is 120° W. The temperature during the observation is 75°F and the barometric pressure is 29.3" Hg. The mean horizontal angle (measured clockwise) from the reference station B to the sun is 60° 01' 57". Compute the azimuth of the sun as well as the azimuth of the reference line AB. (25 points)  Hint: GMT =  Local time + 8h

3)      Prepare the table required for staking out at every 100 ft. full station of a horizontal curve by deflection angle method.  Given the degree of the curve $D_a$ = 12° according to the arc definition (Arc basis). the deflection angle θ = 104° 36'  and the stationing at PI = 96+03.900 ft.  Also calculate the stationings of PC and PT. (Using feet as a unit of measurement) (25 points)

4)      An entering grade of − 2.75% meets a departing grade of +1.25% at station 18+050.00 km. The two grades intersect at an elevation of 123.190 m. above mean sea level.  If these two grades are connected by a 300-m equal-tangent parabolic curve, computing the elevation of points BVC, EVC and all full stations POC for every 20m. Also determine the location and elevation of the lowest point on the curve. (25 points)

5)      From the astronomical triangle PZS where P is the north celestial pole, Z is the observer's zenith and S is the celestial body (the star). Using the principle of spherical trigonometry show that.

$$Cos\ Z\ =\ (Sin\ δ\ /\ Cos\ h\ Cos\ Φ) − Tan\ h\ Tan\ Φ$$

Where

|       |   |                                   |
|-------|---|-----------------------------------|
| δ     | = | declination of the celestial body |
| h     | = | altitude of the celestial body    |
| Φ     | = | latitude of the observer          |
| Z     | = | azimuth of the celestial body     |

(15 points)

## 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 | Differ for 1 hour | GHA of Polaris |
|---|---|---|---|---|---|---|
| | | ° ′ | ′ | m s | s | ° ′ |
| 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 25.7 |
| 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.

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## 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 | Differ for 1 hour | GHA of Polaris |
|---|---|---|---|---|---|---|
| | | ° ′ | ′ | m s | s | ° ′ |
| 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 | 0 00 07.2 |
| 6 | TU | S15 58.2 | 0.74 | +16 22.3 | 0.12 | 0 01 06.3 |
| 7 | W | S16 16.1 | 0.73 | +16 19.5 | 0.15 | 0 02 05.5 |
| 8 | TH | S16 33.6 | 0.72 | +16 15.9 | 0.19 | 0 03 04.6 |
| 9 | FR | S16 50.9 | 0.71 | +16 11.5 | 0.22 | 0 04 03.7 |
| 10 | SA | S17 07.9 | 0.70 | +16 06.2 | 0.26 | 0 05 02.9 |
| 11 | SU | S17 24.7 | 0.68 | +16 00.1 | 0.29 | 0 06 02.0 |
| 12 | M | S17 41.1 | 0.67 | +15 53.1 | 0.33 | 0 07 01.1 |
| 13 | TU | S17 57.2 | 0.66 | +15 45.2 | 0.36 | 0 08 00.2 |
| 14 | W | S18 13.0 | 0.65 | +15 36.5 | 0.40 | 0 08 59.4 |
| 15 | TH | S18 28.5 | 0.63 | +15 26.9 | 0.44 | 0 09 58.6 |
| 16 | FR | S18 43.7 | 0.62 | +15 16.4 | 0.47 | 0 00 57.9 |
| 17 | SA | S18 58.5 | 0.60 | +15 05.1 | 0.51 | 0 01 57.1 |
| 18 | SU | S19 13.0 | 0.59 | +14 52.9 | 0.54 | 0 02 56.4 |
| 19 | M | S19 27.1 | 0.58 | +14 39.9 | 0.58 | 0 03 55.7 |
| 20 | TU | S19 40.9 | 0.56 | +14 26.1 | 0.61 | 0 04 54.9 |
| 21 | W | S19 54.4 | 0.55 | +14 11.4 | 0.65 | 0 05 54.1 |
| 22 | TH | S20 07.5 | 0.53 | +13 55.9 | 0.68 | 0 06 53.3 |
| 23 | FR | S20 20.2 | 0.51 | +13 39.6 | 0.71 | 0 07 52.5 |
| 24 | SA | S20 32.5 | 0.50 | +13 22.5 | 0.74 | 0 08 51.7 |
| 25 | SU | S20 44.5 | 0.48 | +13 04.6 | 0.78 | 0 09 50.9 |
| 26 | M | S20 56.1 | 0.47 | +12 46.0 | 0.81 | 0 0 50.1 |
| 27 | TU | S21 07.3 | 0.45 | +12 26.7 | 0.83 | 0 1 49.4 |
| 28 | W | S21 18.0 | 0.43 | +12 06.6 | 0.86 | 0 2 48.7 |
| 29 | TH | S21 28.4 | 0.42 | +11 45.9 | 0.89 | 0 3 48.0 |
| 30 | FR | S21 38.4 | 0.40 | +11 24.5 | 0.92 | 0 4 47.4 |
| 31 | SA | S21 47.9 | | +11 02.5 | | 0 5 46.7 |

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

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## 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 00 | 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 | 1.80 | 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 | 3.53 | 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.

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## 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 | + 94 | 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 | 4536 | 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. = 28 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 in. 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′.

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