## Chapter 2

2.1

a. 138.32'
b. 1.56 sq. mi.
c. 57.877 m
d. 306°
e. 148.2417°
f. 43,054 sf
g. 7/8"
h. 4,781.04'
i. 105 $m^2$
j. 35° 52' 21"

2.2 104° 15' 15"; 104.2542°

2.3

a. B = 45°, b = 4.87', c = 6.89'
b. A = 60°, B = 30°, a = 30.35'
c. c = 44.72', A = 26° 33' 54", B = 63° 26' 06"
d. c = 110', A = 36° 52' 12", B = 53° 07' 48"

2.4 BD = 530.06' (needed to solve remaining sides)
AB = 224.87', BC = 609.73', CD = 351.06'

2.5 c = 54.33', A = 51° 03' 58", B = 103° 56' 01"

2.6 A = 57° 46' 09", B = 84° 22' 28", C = 37° 51' 23"

2.7

a. 721.9 sf
b. 250 $m^2$
c. 3594 sf
d. 406 $m^2$
e. 5,672 sf

2.8

a. Area = 7,000 sf
b. AC = 128.1'
c. BAC = 51° 20' 25"
d. Yes; the bearings of AC and ED are identical

## CHAPTER 3

**3.1** a) F, b) F, c) F, d) T, e) F

**3.2** For very short distances (less than 100ft or 30 m), measurements using a steel tape are usually more accurate and faster to accomplish. For longer distances, total stations and other electronic instruments are superior, both for accuracy and length of time of measurement. When distances are long and the terrain is difficult, the advantages of electronic techniques become much more pronounced

**3.3** **a)** - looking for survey evidence to begin a survey;
rough-checking a construction layout
**b)** - auto: identifying rural fence corners;
wheel: frontage measurements for assessment purposes;
wheel: measurements for accident surveys
**c)** - taking a baseline measurement;
measuring over long distances or difficult terrain
**d)** - measuring across a busy highway;
setting a calibration baseline for industrial use
e**)** - doing quantity measurements on a construction site;
measuring less important detail
**f)** - measuring control lines for any small-area survey;
measuring key components in a structural layout.

**3.4** **a)** 16.23 x 66 = **1,071.18 ft**. x.3048 = **326.50 m**
**b)** 70.10 x 66 = **4626.60 ft**. x.3048 = **1410.19 m**
**c)** 6.77 x 66 = **446.82 ft**. x.3048 = **131.19 m**
**d)** 4.10 x 66 = **270.60 ft**. x.3048 = **82.48 m**

**3.5** Clearance = 61.6 + 3.8 = **65.4 ft** (Tan $45^o$ = 1.00)

**3.6** Distance = 88.00 - 0.8 = **87.20 ft**

**3.7** Distance = 100.00 +0.48 = **100.48 ft**

**3.8** H = 37.277 Cos $1^o42'$ = **37.261 m**

**3.9** H = $\sqrt{90.07^2 - 5.21^2}$ = **89.92 ft**

**3.10** Tan(slope angle) = .02; slope angle = arctan(.02) = $1.1457628^o$
H = (118.060)cos $1.1457628^o$ = **118.036 m**

**3.11**
The impact of temperature on the layout distance is minimal at such short distances

| | Layout Distance (ft.) | | | |
|---|---|---|---|---|
| Line | a. T = 68°F | b. T = 100°F | c. T = 10°F | d. Slope = 10%, T = 68° |
| 1-2 | 29.15 | 29.14 | 29.16 | 29.26 ($slope\ distance = \sqrt{2.5^2 + 29.15^2}$) |
| 1-3 | 35.36 | 35.37 | 35.35 | 35.45 |
| 1-4 | 29.15 | 29.16 | 29.14 | 29.19 |
| 1-5 | 21.21 | 21.22 | 21.21 | 21.26 |
| 1-6 | 24.61 | 24.62 | 24.61 | 24.69 |
| 1-7 | 24.61 | 24.62 | 24.61 | 24.65 |
| 1-8 | 32.53 | 32.54 | 32.52 | 32.59 |
| 1-9 | 32.53 | 32.54 | 32.52 | 32.63 |

Note on (d); draw a profile along the centerline of the N-S drive to find the distance from point 1 to points 2-9 perpendicular to the slope. At 10% slope, points 2 and 3 are 2.5' higher than point 1; points 4 and 5 are 1.5' higher; points 6 and 8 are 2.0' higher; point 7 is 1.43' higher, and point 9 is 2.56' higher.

| e. | 8X8 slab | 10X10 slab |
|---|---|---|
| Diagonal (edge of slab) | 11.31' | 14.14' |
| Diagonal (outside of formwork) | 11.67' (11' 8 $^1/_{16}$") | 14.49' (14'- 5 $^{15}/_{16}$") |

**3-12**

| PACING EXERCISE | | | |
|---|---|---|---|
| PACES/100.00 FT | (40+40.5+41+41.5)/4 = 40.5 paces/100ft | | |
| | | | |
| STA | FWD (PACES) | BACK (PACES) | AVE DIST (FT) |
| 1 | | | |
| | 163 | 164 | 163.5p X 100ft/40.5p = **403.7ft** |
| 2 | | | |
| | 70 | 70 | **172.84ft** |
| 3 | | | |
| | 87 | 89 | **217.28ft** |
| 4 | | | |
| | 48 | 49 | **119.75ft** |
| 1 | | | |

| TAPING EXERCISE | | | | |
|---|---|---|---|---|
| STA | FWD | BACK | AVE DIST (FT) | DIFF (FT) |
| 1 | | | | |
| | 404.79 | 404.81 | 404.80 | +1.1 |
| 2 | | | | |
| | 174.42 | 174.35 | 174.39 | +1.5’ |
| 3 | | | | |
| | 218.55 | 218.54 | 218.55 | +1.3 |
| 4 | | | | |
| | 120.02 | 119.94 | 119.98 | +0.23 |
| 1 | | | | |
| The crew is consistently underestimating the distance when pacing. Check pace calibration on grass versus hard surface. Factors such as slope, soft ground, long grass, etc. can cause pace length to vary significantly. | | | | |

## CHAPTER 4

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **4.1 a)** | i | 2.05 | **b)** | i | 1.165 | **c)** | i | 2.05 | **d)** | i | 1.085 | **e)** | i | 3.10 | **f)** | i | 1.165 |
| | ii | 1.90 | | ii | 1.120 | | ii | 1.79 | | ii | 1.005 | | ii | 2.8 | | ii | 1.045 |
| | iii | 1.56 | | iii | 1.020 | | iii | 1.45 | | iii | 0.970 | | iii | 2.54 | | iii | 0.990 |
| | iv | 1.20 | | iv | 0.960 | | iv | 1.25 | | iv | 0.940 | | iv | 2.26 | | iv | 0.915 |
| | v | 0.90 | | v | 0.910 | | v | 0.95 | | v | 0.900 | | v | 1.98 | | v | 0.860 |

**4.2**

| STATION | BS | HI | FS | ELEVATION |
|---|---|---|---|---|
| BM 50 | 1.27 | 315.04 | | 313.77 |
| TP 1 | 2.33 | 342.16 | 4.91 | 310.13 |
| TP 2 | | | 6.17 | 306.29 |
| | *Σ BS = 3.60* | | *Σ FS = 11.08* | *313.77 +3.60 -11.08 = 306.29* ***check*** |

**4.3**

| STATION | BS | HI | IS | FS | ELEVATION |
|---|---|---|---|---|---|
| BM 61 | 4.72 | 324.92 | | | 320.20 |
| 0+00 | | | 4.42 | | 320.50 |
| 0+50 | | | 4.30 | | 320.62 |
| TP 1 | 5.11 | 328.02 | | 2.01 | 322.91 |
| 1+00 | | | 4.66 | | 323.36 |
| 1+50 | | | 3.98 | | 324.04 |
| 1+75 | | | 1.20 | | 326.82 |
| TP 2 | | | | 1.80 | 326.22 |
| | Σ BS = 9.83 | | | FS = 3.81 | 320.20 +9.83 -3.81 = 326.22 ***check*** |

**4.4**

| STATION | BS | HI | FS | ELEVATION |
|---|---|---|---|---|
| BM 3 | 1.613 | 399.635 | | 398.022 |
| TP 1 | 1.425 | 399.133 | 1.927 | 397.708 |
| TP 2 | 1.307 | 398.730 | 1.710 | 397.423 |
| TP 3 | 1.340 | 398.797 | 1.273 | 397.457 |
| BM 3 | | | 0.780 | 398.017 |
| | Σ BS = 5.685 | | Σ FS = 5.690 | 398.022 +5.685 -5.690 = 398.017 ***ck*** |

**4.5** Error = 398.022 – 398.017 = 0.005m
2nd order Class 1 (U.S.) = 6mm √K = .006 √0.7 = .005
2nd order (Canada) = 8mm√ K = .008√.7 = .007. The error qualifies for 2nd order in both countries.

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**4.6**

| STATION | BS | HI | FS | ELEVATION |
|---|---|---|---|---|
| BM 100 | 2.71 | 179.27 | | 176.56 |
| TP 1 | 3.62 | 178.01 | 4.88 | 174.39 |
| TP 2 | 3.51 | 177.55 | 3.97 | 174.04 |
| TP 3 | 3.17 | 177.91 | 2.81 | 174.74 |
| TP 4 | 1.47 | 177.76 | 1.62 | 176.29 |
| BM 100 | | | 1.21 | 176.55 |
| | Σ BS = 14.48 | | Σ FS = 14.49 | |

176.56 +14.48 -14.49 = 176.55 ***check***

**4.7** Error = 176.56 -176.55 = 0.01 ft. 2nd order allowable error = .035 √1000/5280 = 0.015

Therefore the results qualify for second order – according to Table 4.2.

**4.8**

| STATION | BS | HI | IS | FS | ELEVATION |
|---|---|---|---|---|---|
| BM S101 | 0.475 | 202.500 | | | 202.025 |
| 0+000 | | | 0.02 | | 202.48 |
| 0+020 | | | 0.41 | | 202.09 |
| 0+040 | | | 0.73 | | 201.77 |
| 0+060 | | | 0.70 | | 201.80 |
| 0+066.28 | | | 0.726 | | 201.774 |
| 0+080 | | | 1.38 | | 201.12 |
| 0+100 | | | 1.75 | | 200.75 |
| 0+120 | | | 2.47 | | 200.03 |
| TP 1 | 0.666 | 200.173 | | 2.993 | 199.507 |
| 0+140 | | | 0.57 | | 199.60 |
| 0+143.78 | | | 0.634 | | 199.539 |
| 0+147.02 | | | 0.681 | | 199.492 |
| 0+160 | | | 0.71 | | 199.46 |
| 0+180 | | | 0.69 | | 199.48 |
| 0+200 | | | 1.37 | | 198.80 |
| TP 2 | 0.033 | 198.501 | | 1.705 | 198.468 |
| BM S102 | | | | 2.891 | 195.610 |
| | Σ BS = 1.174 | | Σ FS = 7.589 | | |

202.025 +1.174 -7.589 = 195.610 ***check***

**4.9**

| STATION | BS | HI | FS | SS | ELEV | DESCRIPTION |
|---|---|---|---|---|---|---|
| BM1 | 4.58 | **104.58** | | | 100.00 | X on conc., 1st floor, East entry |
| TP1 | 8.25 | **111.24** | 1.59 | | **102.99** | |
| TP2 | 8.19 | **117.83** | 1.60 | | **109.64** | |
| 1 | 4.59 | **117.80** | 4.62 | | **113.21** | X on conc., 2nd floor, top of E stairs |
| TP3 | 4.58 | **117.92** | 4.46 | | **113.34** | |
| 2 | 2.25 | **115.57** | 4.60 | | **113.32** | X on conc., 2nd floor, top of N stairs |
| TP4 | 4.61 | **108.43** | 11.75 | | **103.82** | |
| TP5 | 1.65 | **101.25** | 8.83 | | **99.60** | |
| 3 | 4.58 | **101.25** | 4.58 | | **96.67** | X on conc., 1st floor, N entry |
| 4 | 4.58 | **101.92** | 3.91 | | **97.34** | X on conc., top of ramp in N-S hallway |
| 5 | 4.64 | **104.65** | 1.91 | | **100.01** | X on conc., top of ramp in E-W hallway |
| 6 | | | | 9.25 | **95.40** | Floor of mezzanine level |
| 7 | | | | 5.76 | **98.89** | Floor of sunken area in main lobby |
| 8 | | | | 15.22 | **89.43** | Floor of mechanical room, basement level |
| BM1 | | | 4.64 | | **100.01** | **(100.00)** |
| | | | | | | |

a. Difference between 1st and 2nd floors at east end of building - 13.21'
b. Difference between 1st and 2nd floors at north end of building - 16.65'
c. Difference between 2nd floor and mechanical room floor - 23.78 to 23.87' (2nd floor is not level)
d. Difference between 1st and 2nd floors at east end of building - 13.21'
(Note: 2nd floor is not level as seen by difference in elevation at top of N stairs and top of E stairs)

**4.10** (inadvertently duplicates 4.8)

**4.11**

| STATION | BS | HI | IS | FS | ELEVATION |
|---|---|---|---|---|---|
| BM 41 | 6.21 | 353.76 | | | 347.55 |
| TP 13 | 4.10 | 356.97 | | 0.89 | 352.87 |
| 12+00 | | | | | |
| 50 ft. left | | | 3.9 | | 353.1 |
| 18.3 ft. left | | | 4.6 | | 352.4 |
| □ | | | 6.33 | | 350.64 |
| 20.1 ft. right | | | 7.9 | | 349.1 |
| 50 ft. right | | | 8.2 | | 348.8 |
| 13+00 | | | | | |
| 50 ft. left | | | 5.0 | | 352.0 |
| 19.6 ft. left | | | 5.7 | | 351.3 |
| □ | | | 7.54 | | 349.43 |
| 20.7 ft. right | | | 7.9 | | 349.1 |
| 50 ft. right | | | 8.4 | | 348.6 |
| TP 14 | 7.39 | 363.24 | | 1.12 | 355.85 |
| BM S22 | | | | 2.41 | 360.83 |
| | Σ BS = 17.70 | | | Σ FS = 4.42 | |

347.55+17.70 - 4.42= 360.83 ***check***

**4.12**

| Station | BS | HI | FS | Elevation | Left | | ℄ | | Right |
|---|---|---|---|---|---|---|---|---|---|
| BM 107 | 7.71 | 206.60 | | 198.89 | | | | | |
| | | | | | 60' | 28' | 0' | 32 | 60' |
| 80+50 | | | | | 9.7 | 8.0 | 5.7 | 4.3 | 4.0 |
| | | | | | 196.9 | 198.6 | 200.9 | 202.3 | 202.6 |
| | | | | | 60' | 25' | 0' | 30' | 60' |
| 81+00 | | | | | 10.1 | 9.7 | 6.8 | 6.0 | 5.3 |
| | | | | | 196.5 | 196.9 | 199.8 | 200.6 | 201.3 |
| | | | | | 60' | 27' | 0' | 33' | 60' |
| 81+50 | | | | | 11.7 | 11.0 | 9.2 | 8.3 | 8.0 |
| | | | | | 194.9 | 195.6 | 197.4 | 198.3 | 198.6 |
| TP 1 | | | 10.17 | 196.43 | | | | | |

**4.13** a) Correct difference in elevation = 8.72-5.61 = 3.11 ft.
b) Correct reading @ A would have been 5.42+3.11 = 8.53 ft.
c) Error is (8.57- 8.53) = +0.04 ft. in 300 ft.
d) Upper/lower reticle capstan screws are loosened/tightened until the cross hair falls on 8.53 on the rod @ A.

**4.14** a) V = 148.61 sin 9º26' = 24.36 ft.
Elevation of lower station = 324.28 + 4.66 - 24.36 - 4.88 = 299.70 ft.
b) H = 148.61 cos 9º26' = 146.60 ft.
Lower station = 110+71.25 + 146.42 = 112+17.85

**4.15** a) First elevation difference = 2.417-0.673 = 1.744
Second elevation difference = 2.992 - 1.252 = 1.740
Average elevation difference = 1.742
Elevation of B = 187.298-1.742 = 185.556m
b) Error = 0.004m

**4.16 a)** Error = 167.174 – 167.185 = - 0.011m

Accuracy limit for 2nd order = .007 √.8 = .006

Accuracy limit for 3rd order = .012 √.8 = .011 (U.S.)

or = .024 √.8 = .021 (Canada)

(See Tables 4.2 and 4.3)

Therefore the error of - 0.011 satisfies the requirements for 3rd order accuracy in both the U.S. and Canada.

**4.16(b)**

| Station | Cumulative Distance | Elevation | Correction | Adjusted Elevation |
|---|---|---|---|---|
| BM 130 | | 168.657 | | 168.657 |
| TP 1 | 130 | 168.248 | 130/780 x.011 = +.002 | 168.250 |
| TP 2 | 260 | 168.539 | 260/780 x.011 = +.004 | 168.543 |
| TP 3 | 390 | 166.318 | 390/780 x.011 = +.006 | 165.324 |
| **BM K110** | 520 | 166.394 | 520/780 x.011 = +.007 | **166.401** |
| TP 4 | 650 | 166.579 | 650/780 x.011 = +.009 | 166.588 |
| BM 132 | 780 | 167.618 | 780/780 x.011 = +.011 | 167.629 |

C = 167.629 – 167.618 = - 0.011

The adjusted elevation of BM K110 is 166.401m

**4.17**

a. Error = 0.11' in 3 miles. The project requires at least Third Order control per Table 2.3(a):

Allowable error = 0.06 $\sqrt{3}$ = 0.10'. The results are minimally acceptable for Third order work.

| BM | Cumulative Loop Distance (mi) | Field Elevation (ft) | Correction (ft) | Adjusted Elevation (ft) |
|---|---|---|---|---|
| 111 | -- | 1320.28 (fixed) | -- | 1320.28 |
| 1 | 0.4 | 1325.15 | 0.4/3.0 X 0.11 = 0.01' | 1325.14 |
| 2 | 0.7 | 1328.94 | 0.7/3.0 X 0.11 = 0.03' | 1328.91 |
| 3 | 0.95 | 1331.55 | 0.95/3.0 X 0.11 = 0.03' | 1328.52 |
| 4 | 1.20 | 1329.01 | 1.20/3.0 X 0.11 = 0.04' | 1328.97 |
| 5 | 1.8 | 1327.86 | 1.8/3.0 X 0.11 = 0.07' | 1327.79 |
| 6 | 2.4 | 1333.67 | 2.4/3.0 X 0.11 = 0.09' | 1333.58 |
| 111 | 3.0 | 1320.39 | 3.0/3.0 X 0.11 = 0.11' | 1320.28 |
| | | Error = 1320.39 – 1320.28 = 0.11' | | |

**CHAPTER 5**

**5.1** Prism constant = AC-AB-BC
= 488.255 – 198.690 – 289.595 = - 0.030m

**5.2** H = 2,183.71 Cos +2°45'30" = 2,181.18 ft.
V = 2,183.71 Sin +2°45'30" = 105.09 ft.
Elevation of target station = 285.69 +105.09 = 390.78 ft.

**5.3** Inst. @ A, H = 1,458.777 Cos - 2° 40' 40" = 1,457.184m
Elevation difference = 1,458.777 Sin 1°26'50" = - 68.153m
Inst.@ B, H = 1,458.757 Cos 2° 40' 00" = 1,457.177m
Elevation difference = 1,458.757 Sin 2° 40" = 67.869m
a)Horizontal distance = (1,457.184+1,457.177)/2 = 1,457.181m
b)Elev. B = 211.841 - (68.153+ 67.869)/2 = 143.833m

**5.4** $LL^1$ = 3,000.00 Sin 3°30' = +183.15 ft.
c+r = .0206 x $3^2$ = +0.19 ft.
Elevation difference, K to L, = +183.34 ft
Elevation of L = 232.47+183.34 = 415.81 ft.

$MM^1$ = 3000.00 Sin -1°30' = - 78.53 ft.
c+r = .0206 x $3^2$ = +0.19 ft.
Elevation difference, K to M, = -78.34 ft.
Elevation of M = 232.47- 78.34 = 154.13 ft.

c+r = .0206 x $2^2$ = + 0.08 ft.
Elevation difference, K to N, = +0.08 ft.
Elevation of N = 232.47 + 0.08 = 232.55 ft.

**5.5** ΔHR - Δhi = 0.150 - 0.100 = 0.050m
SinΔα = (0.050 Cos 4°18'30")/387.603
Δα = 0°00'27"
$\alpha_K$ = 0°00'27"+4°18'30" = 4°18'57"
H = 387.603 Cos 4°18'57" = 386.504m
Elevation of B = 110.222+1.601+ (387.603 Sin 4°18'57") - 1.915
= 139.077m.

**5.6** ΔHR-Δhi = 0.39-0.31 = 0.08 ft.
SinΔα = (0.08 Cos 3°14'30")/536.88
Δα = 0°00'31"
$\alpha_K$ = 0°00'31"+3°14'30" = 3°15'01"
H = 536.88 Cos 3°15'01" = 536.02 ft.
Elevation B = 531.49+5.21 + (536.88 Sin 3°15'01") - 5.78
=561.36 ft.

## CHAPTER 8

**8.1** E = 114° 31'

**8.2**
A 70°10'30" +30 = 70°11'00"
B 142°41'00" +30 = 142°41'30"
C 83°51'30" +30 = 83°52'00"
D 117°25'30" +30 = 117°26'00"
E 125°49'00" +30 = 125°49'30"
539°57'30" 150" 537°179'60" = 540°00'00"

**8.3**
a) S 7°29'W
b) S 38°06'E
c) N14°43'30"W
d) N 56°09E
e) S73°42'W
f) S 43°09'E

**8.4**
a) 347°09'
b) 66°14'
c) 144°56'
d) 183°12'
e) 326°47'
f) 179°54'

**8.5**
a) 8°23'
b) 347°52'
c) 150°09'50"
d) 209°33'
e) 81°50'
f) 346°59'

**8.6**
a) S7°51'E
b) S76°14'W
c) N33°33'W
d) N 4°39'E
e) S 37°18'E
f) N 0°38'W

**8.7**
AB = N20°41'E
B + 1°03
BC = N21°44'E
C +2°58'
CD = N24°42'E
D - 7°24'
DE = N17°18'E
E - 6°31'
EF = N 10°47'E
F +1°31'
FG = N 12°18'E
G - 8°09'
GH = N 4°09E

**8.8** Angle at A = Azimuth DA + 180 – Azimuth AB (subtract 360° if > 1 rev)
A = **51°05'**
B = **134°33'**
C = **102° 04'**
D = **72°18'**
**Sum of interior angles = 360° (check)**

**8.9** **CLOCKWISE**
AB N48° 30′E
BC S53° 41′E
CD S21° 37′W
DE S88° 32′W
EA N30° 02′W

---

**8.10 CLOCKWISE**

Az AB = 58°40'
Az BA = 238°40'
-B 102°11'
Az BC = 136°29'
Az CB = 316°29'
-C 104°42'
Az CD = 211°47'
Az DC = 391°47'
-D 113°05'
Az DE = 278°42'
Az ED = 458°42'
-E 118°34'
Az EA = 340°08'
Az AE = 160°08'
-A 101°28'
Az AB = 58°40 ' **CHECK**

**8.11 CLOCKWISE**

Az AB = 55°55'
Az BA = 235°55'
-B 102°11'
Az BC = 133°44'
Az CB = 313°44'
-C 104°42'
Az CD = 209°02'
Az DC = 389°02'
-D 113°05'
AZ DE = 275°57'
Az ED = 455°57'
-E 118°34'
Az EA = 337°23'
Az AE = 157°23'
-A 101°28'
Az AB = 55°55' **CHECK**

**COUNTER-CLOCKWISE**

Az AB = 55°55'
+A 101°28'
Az AE =157°23'
Az EA = 337°23'
+E 118°34'
Az ED = 455°57'
Az ED = 95°57'
Az DE = 275°57'
+D 113°05'
Az DC = 389°02'
Az DC = 29°02'
Az CD = 209°02'
+C 104°42'
Az CB = 313°44'
Az BC = 133°44'
+B 102°11'
Az BA = 235°55'
Az AB = 55°55' **CHECK**

**8.12**

a) A 51°23'
B 105°39'
C 78°11'
D 124°47'
358°120'
360°00'

**CHECK**
(n-2)180 =
(4-2)180 = 360°

b)

**AZIMUTH**

Az AB = 64°40'
Az BA = 244°40'
-B 105°39'
Az BC = 139°01'
Az CB = 319°01'
-C 78°11'
Az CD = 240°50'
Az DC = 420° 50
-D 124°47'
Az DA = 296° 03'
Az AD = 116°03'
- A 51°23'
Az AB = 64°40'

**BEARING**

N64°40'E

S40°59'E

S60°50'W

N63°57'W

N64°40'E **CHECK**

c)

| Course | Azimuth | Bearing | Distance | Latitude | Departure |
|---|---|---|---|---|---|
| AB | 64°40' | N64°40'E | 713.93 | 305.48 | 645.27 |
| BC | 139°01' | S40°59'E | 606.06 | -457.51 | 397.48 |
| CD | 240°50' | S60°50'W | 391.27 | -190.69 | -341.66 |
| DA | 296°03' | N63°57'W | 781.18 | 343.06 | -701.82 |
| | | | P = 2492.44 | $\Sigma_{L=}$+ 0.34 | $\Sigma_{D=}$ -0.73 |

Error, E = $\sqrt{0.34^2 + 0.73^2}$= 0.81.Precision = E/P = 0.810/2492.44 = 1:3,095 = 1:3,100

**8.13**

| Course | $C_{LAT}$ | $C_{DEP}$ | Corrected Lat. | Corrected dep. |
|---|---|---|---|---|
| AB | -0.09 | +0.22 | +305.39 | +645.49 |
| BC | -0.09 | +0.18 | -457.60 | +397.66 |
| CD | -0.05 | +0.11 | -190.74 | -341.55 |
| DA | -0.11 | +0.22 | +342.95 | -701.60 |
| | -0.34 | +0.73 | 0.00 | 0.00 |

| Course | Corrected Bearing | Corrected Azimuth | Corrected Distance |
|---|---|---|---|
| AB | N64°40'50"E | 64°40'50" | 714.09', |
| BC | S40°59'27"E | 139°00'33" | 606.24', |
| CD | S60°49'07"W | 240 49'07" | 391.20', |
| DA | N63°57'00"W | 296°03'00" | 780.93' |
| | | | P = 2,492.46' |

**8.14**

| Station | Coordinates North | East |
|---|---|---|
| A | 1,000.00 | 1,000.00 |
| | + 305.39 | + 645.49 |
| B | 1,305.39 | 1,645.49 |
| | - 457.60 | + 397.66 |
| C | 847.79 | 2,043.15 |
| | - 190.74 | - 341.55 |
| D | 657.05 | 1,701.60 |
| | + 342.95 | - 701.60 |
| A | 1,000.00, | 1,000.00 **CHECK** |

**8.15**

$X_A(Y_D-Y_B)$ = 1000.00(657.05 – 1305.39) = - 648340
$X_B(Y_A-Y_C)$ = 1645.49(1000.00-847.79) = + 250,460
$X_C(Y_B-Y_D)$ = 2043.15(1305.39 -657.05) = + 1,324,656
$X_D(Y_C-Y_A)$ = 1701.60(847.79-1000.00) = - 259,001

Double Area, 2A = 667,775 sq ft.
Area = 333,888 sq ft.
Also, Area = 333,888/43,560 = 7.665 acres,.

**8.16**

**a)** Angles

A 38°30'
B 100°38'
C 149°50'
D 85°59'
E 165°03'

537°180'
= 540°00'

**CHECK**
(n-2)180 =
3 x 180 = 540°

**b)**

| | Azimuth | Bearing |
|---|---|---|
| | Az AB = 306°31' | N53°29'W |
| | Az BA = 126°31' | |
| | + B 100°38' | |
| | Az BC = 227°09' | S47°09W |
| | Az CB = 47°09 | |
| | + C 149°50' | |
| | Az CD = 196 59' | S 16°59'W |
| | Az DC = 16°59' | |
| | + D 85°59' | |
| | Az DE = 102°58' | S77°02'E |
| | Az ED = 282°58' | |
| | + E 165°03' | |
| | Az EA = 448°01' | |
| or, | Az EA = 88°01' | N88°01'E |
| | Az AE = 268°01' | |
| | + A 38°30' | |
| | Az AB = 306°31' | N53°29'W **CHECK** |

**8.16 c**)

| Course | Distance | Azimuth | Bearing | Latitude | Departure |
|---|---|---|---|---|---|
| AB | 371.006 | 306°31' | N53°29'W | 220.770 | -298.172 |
| BC | 110.222 | 227°09' | S47°09'W | - 74.960 | -80.808 |
| CD | 139.872 | 196°59' | S 16°59'W | -133.772 | - 40.856 |
| DE | 103.119 | 102°58' | S77°02'E | - 23.138 | 100.490 |
| EA | 319.860 | 88°01' | N88°01'E | 11.070 | 319.668 |
| | 1,044.079 | | | - 0.030 | +0.322 |

ERROR, E = $\sqrt{0.030^2 + 0.322^2} = 0.323$m
ACCURACY = E/P = 0.324/1044.079 = 1/3228 = 1/3200

**8.17**

| Course | $C_{LAT}$ | $C_{DEP}$ | Corrected lat. | Corrected dep. |
|---|---|---|---|---|
| AB | +0.011 | -0.114 | 220.781 | -298.286 |
| BC | +.003 | -0.034 | - 74.957 | -80.842 |
| CD | +.004 | -0.044 | -133.768 | - 40.900 |
| DE | +0.003 | -0.032 | - 23.135 | 100.458 |
| EA | +0.009 | -0.098 | 11.079 | 319.570 |
| | +0.030 | -0.322 | 0.000 | 0.000 |

**8.18**

| Station | Coordinates North | East |
|---|---|---|
| B | 1,000.000 | 1,000.000 |
| | - 74.957 | - 80.842 |
| C | 925.043 | 919.158 |
| | -133.768 | - 40.900 |
| D | 791.275 | 878.258 |
| | -23.135 | +100.458 |
| E | 768.140 | 978.716 |
| | + 11.079 | +319.570 |
| A | 779.219 | 1,298.286 |
| | +220.781 | - 298.286 |
| B | 1,000.000 | 1,000.000 **Check** |

**8.19**

$X_A(Y_E-Y_B)$ = 1298.286(768.140 -1000.000) = - 307,595
$X_B(Y_A-Y_C)$ = 1000.000(779.219 – 925.043) = - 101,857
$X_C(Y_B-Y_D)$ = 919.158(1000.000- 791.275) = +205,309
$X_D(Y_C-Y_E)$ = 878.258(925.043-768.140) = +134,625
$X_E(Y_D-Y_A)$ = 978.716(791.275- 779..219) = - 35,876

2A = 105,394 $m^2$
Area, A = 52,697 $m^2$
or, Area, A = 5.27 ha

**8.20**

| Course | Distance | Bearing | Latitude | Departure |
|---|---|---|---|---|
| AB | 80.32 | N70°10'07"E | + 27.25 | + 75.56 |
| BC | 953.83 | N74°29'00"E | +255.17 | +919.07 |
| CD | 818.49 | N70°22'45"E | +274.84 | +770.9 |
| AD | | | +557.26 | +1765.59 |

Tan Brg AD = 1765.59/557.26,Brg AD = N72°28'59"E
Distance AD = $\sqrt{557.26^2 + 1765.59^2}$ = 1851.44 ft.

**8.21**

| Course | Distance | Bearing | Latitude | Departure |
|---|---|---|---|---|
| EA | 483.669 | N26°58'31"W | +431.047 | - 219.395 |
| AB | 537.144 | N37°10'49"E | +427.963 | + 324.609 |
| BC | 1,109.301 | N79°29'49"E | +202.212 | +1090.715 |
| EC | | | +1,061.222 | +1,195.929 |

Tan Brg EC = 1195.929/1061.222; Brg EC = **N48°24'55"E**
Distance EC = $\sqrt{1061.222^2 + 1195.929^2}$ = **1598.887 m**

Angle @ C = 48°24'55" -18°56'31" = 29°28'24"
Sin 29°28'24" x 1598.887/953.829 = Sin D
D = 55°33'52" **Or** 124°26'08": From given data, D = 124°26'08"
E = 180° - (124°26'08" + 29°28'24") = 26°05'28"
CD = Sin 26°05'28" x 1598.887/Sin124°26'08"
CD = 852.597 m.; Bearing DE = S74°30'23"W

**8.22**

Distance AB =$\sqrt{(738.562-559.319)^2 + (666.737-207.453)^2}$ = 493.021m
Tan Brg AB = 459.284/179.243,Brg AB = N68°40'52"E
Distance BC =$\sqrt{(541.742-738.562)^2 + (688.350-666.737)^2}$ = 198.003m
Tan Brg BC = 21.613/-196.82; Brg BC = S 6°16'00"E
Distance CD =$\sqrt{(379.861-541.742)^2 + (839.008-688.350)^2}$ = 221.141m
Tan Brg CD = 150.658/-161.881;Brg CD = S42°56'36"E
Distance DE = $\sqrt{(296.099-379.861)^2 + (604.048-839.008)^2}$ = 249.444m
Tan Brg DE = -234.960/-83.762;Brg DE = S70°22'45"W
Distance EF =$\sqrt{(218.330-296.099)^2 + (323.936-604.048)^2}$ = 290.707m
Tan Brg EF = -280.112/-77.769;Brg EF = S74°29'00"W
Distance FA = $\sqrt{(559.319-218.330)^2 + (207.453-323.936)^2}$ = 360.336m
Tan Brg FA = -116.483/340.989;Brg FA = N18°51'37"W

**8.23**

$X_A(Y_B-Y_F)$ = 207.453(738.562-218.330) =+107,924
$X_B(Y_C-Y_A)$ = 666.737(541.742-559.319) = - 11,719
$X_C(Y_D-Y_B)$ = 688.350(379.861-738.562) = -246,912
$X_D(Y_E-Y_C)$ = 839.008(296.099-541.742) = -206,096
$X_E(Y_F-Y_D)$ = 604.048(218.330-379.861) = - 97,572
$X_F(Y_A-Y_E)$ = 323.936(559.319-296.099) = + 85,266
2A = 369,109
Area, A = 184,555m$^2$
or, A = 18.455 hectares

**8.24**

| | Coordinates | |
|---|---|---|
| Station | North | East |
| K | 2000.000 | 2000.000 |
| | + 10.000 | - 33.000 |
| A | 2010.000 | 1967.000 |
| K | 2000.000 | 2000.000 |
| | + 25.271 | + 19.455 |
| B | 2025.271 | 2019.455 |
| K | 2000.000 | 2000.000 |
| | - 0.311 | + 38.285 |
| C | 1999.689 | 2038.285 |
| K | 2000.000 | 2000.000 |
| | - 30.055 | + 7.245 |
| D | 1969.945 | 2007.245 |
| K | 2000.000 | 2000.000 |
| | - 12.481 | - 30.100 |
| E | 1987.519 | 1969.900 |

**8.25**

$X_A(Y_E-Y_B)$ = 1967.000(1987.519- 2025.271) = - 74,258
$X_B(Y_A-Y_C)$ = 2019.455(2010.000-1999.689) = + 20,823
$X_C(Y_B-Y_D)$ = 2038.285(2025.271-1969.945) = +112,770
$X_D(Y_C-Y_E)$ = 2007.245(1999.689-1987.519) = + 24,428
$X_E(Y_D-Y_A)$ = 1969.900(1969.945-2010.000) = - 78,904
2A = 4,859
Area, A = 2,430m$^2$

**8.26**

| Course | Lat | Dep | Bearing | Distance (m) |
|---|---|---|---|---|
| AB | +15.271 | +52.455 | N73$^o$46'06"E | 54.633 |
| BC | -25.582 | +18.830 | S36$^o$21'20"E | 31.765 |
| CD | -29.744 | -31.040 | S46$^o$13'17"W | 42.991 |
| DE | +17.574 | -37.345 | N64$^o$47'56"W | 41.273 |
| EA | +22.481 | - 2.900 | N 7$^o$21'02"W | 22.667 |
| **Check** | 0.000 | 0.000 | | |

**Chapter 9**

**9-1** A to B; ΔN = -77.773: ΔE = -280.126
Distance AB = 290.722: Brg = S74°29'00.4"W

B to C; ΔN = -35.982: ΔE = -223.047
Distance BC = 225.931: Brg = S80°50'09.5W

C to D; ΔN = +2.638: ΔE = +206.021
Distance CD = 206.038m: Brg = N89°15'59.0"E

D to A; ΔN = +111.117: ΔE = +297.152
Distance DA = 317.248: Brg = N69°29'50.0"E

**9-2**

| | |
|---|---|
| A | 4°59'10.4" |
| B | 186°21'09.1" |
| C | 8°25'49.5" |
| D | 160°13'51.0" |
| | 358°118'120.0" = 360°00'00.0" **Check** |

## Chapter 10

**10-2**

**Interior Angles**

| | | |
|---|---|---|
| A | 92°53' | |
| B | 184°00' | **Check** |
| C | 90°50' | (n-2) 180, |
| D | 112°10' | 5 x 180 = 900° |
| E | 127°37' | |
| F | 208°53' | |
| G | 83°37' | |
| | 896°240' | |
| = | 900°00' | |

Traverse Computations Used to Demonstrate Closure

| Course | Bearing | Distance | Latitude | Departure | |
|---|---|---|---|---|---|
| AB | N. 3°30'E. | 56.05 | + 55.95 | + 3.42 | |
| BC | N. 0°30'W. | 61.92 | + 61.92 | - 0.54 | |
| CD | N.88°40'E. | 100.02 | + 2.33 | + 99.99 | |
| DE | S. 23°30'E. | 31.78 | - 29.14 | + 12.67 | |
| EF | S.28°53'W. | 69.11 | - 60.51 | + 33.38 | |
| FG | SOUTH | 39.73 | - 39.73 | 0 | |
| GA | N.83°37'W. | 82.67 | + 9.18 | - 82.16 | |
| | | | 0.00 | 0.00 | ***check*** |

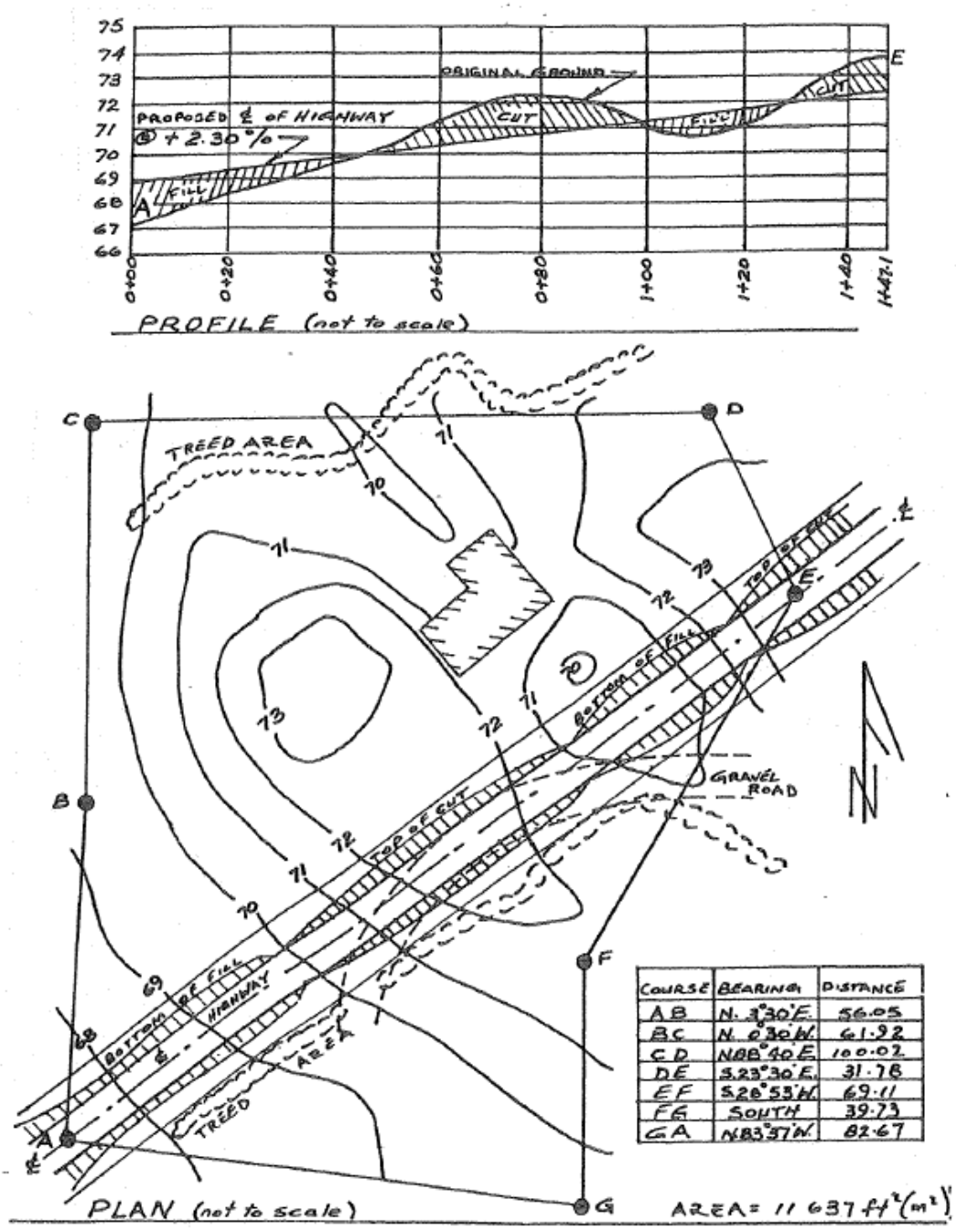
**10-5(d)**

Area Computations

**First,** compute coordinates - assume coordinates for station A to be 1,000.00 N and 1,000.00 E

| Station | Northing | Easting | |
|---|---|---|---|
| A | 1,000.00 | 1,000.00 | |
| | + 55.95 | + 3.42 | **Second,** compute the area: |
| B | 1,055.95 | 1,003.42 | XA(YB - YG) = 1,000.00(1,055.95 - 990.82) = 65,130 |
| | + 61.92 | - 0.54 | B(YC - YA) = 1,003.42(1,117.87 - 1,000.00) = 118,273 |
| C | 1,117.87 | 1,002.88 | XC(YD - YB) = 1,002.88(1,120.20 - 1,055.95) = 64,435 |
| | + 2.33 | + 99.99 | XD(YE - YC) = 1,102.87(1,091.06 - 1,117.87) = - 29,568 |
| D | 1,120.20 | 1,102.87 | XE(YF - YD) = 1,115.54(1,030.55 - 1,120.20) = - 100,008 |
| | - 29.14 | + 12.67 | XF(YG - YE) = 1,082.16(990.82 - 1,091.06) = - 108,476 |
| E | 1,091.06 | 1,115.54 | XG(YA - YF) = 1,082.16(1000.00 - 1,030.55) = - 33,060 |
| | - 60.51 | - 33.38 | Double area = - 23,274 |
| F | 1,030.55 | 1,082.16 | |
| | | | Area = 11,637 ft$^2$ or m$^2$ |
| | - 39.73 | 0.00 | |
| G | 990.82 | 1,082.16 | |
| | + 9.18 | - 82.16 | |
| A | 1,000.00 | 1,000.00 | ***check*** |

**10-6 and 10-8**




| COURSE | BEARING | DISTANCE |
|---|---|---|
| AB | N. 3°30'E. | 56.05 |
| BC | N. 0°30'W. | 61.92 |
| CD | N88°40'E. | 100.02 |
| DE | S.23°30'E. | 31.78 |
| EF | S.26°55'W. | 69.11 |
| FG | SOUTH | 39.73 |
| GA | N83°37'W. | 82.67 |

**10.9** **a)** H = SR.f = 20,000 x .153 = 3060m
Altitude = 3060 + 180 = 3240m

**b)** SR = 20,000 x 12 = 240,000
H = SR.f = 240,000 x 6.022/12 = 120,440 ft.
Altitude = 120,400 + 520 = 120,920 ft.

**10.10** **a)** Photo scale = 50,000 x 4.75/23.07 = 1:10,295

**b)** Photo scale = 100,000 x 1.85/6.20 = 1:29,839

**10.11** **a)** No. of photos required = $30 \times 45/1 \ \frac{(10,000)^2}{(30,000)^2} = 150$

**b)** No. of photos required = $15 \times 33/0.4 \ \frac{(10,000)^2}{(15,000)^2} = 550$

**c)** SR is 1:500 x 12 or 1:6000
No. of photos required = $10 \times 47/0.4 \ \frac{(10,000)^2}{(6,000)^2} = 3264$

**10.12** Assume that the negative size is 9 in. (228mm) square, the normal size.

**a)** Dimension across flight line = 10,000 x .228 = 2280m
or 10,000 x 0.75 = 7,500 ft.
Dimension along flight line = 2280 x 0.60 = 1368m
or 7,500 x 0.60 = 4500 ft.

**b)** SR is 1:400 x 12 or 1:4,800
Dimension across flight line = 4,800 x .228 = 1094m
or 4,800 x 0.75 = 3,600 ft.
Dimension along flight line = 1094 x 0.60 = 656 m
or 3,600 x 0.60 = 2160 ft.

**10.13** **a**) (i) Ground speed of aircraft = 350 km/hr
$= \frac{350 \times 1000}{60 \times 60} = 97.2$ m/s
camera would move $97.2 \times \frac{1}{100} = .972$m during exposure.

**(ii)** Ground speed of aircraft = 350 km/hr = 97.2 m/s
camera would move $97.2 \times \frac{1}{1000} = .097$m

**(iii)** Ground speed of aircraft = 200 miles per hour
$= \frac{200 \times 5280}{60 \times 60} = 293$ ft./sec.
camera would move 293 x1/500 = 0.59 ft. (018m)

**b)** The "image motion" during the exposure is least in situation (ii). Therefore, the resolution of an airphoto taken under these conditions would be higher, assuming that all other conditions (weather, film types) are equal.