

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	<u>2.33</u>	342.16	4.91	310.13
	TP 2			<u>6.17</u>	306.29
		$\Sigma BS = 3.60$		$\Sigma FS = 11.08$	$313.77 + 3.60 - 11.08 = 306.29$ <i>check</i>

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	<u>5.11</u>	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				<u>1.80</u>	326.22
		$\Sigma BS = 9.83$			$FS = 3.81$	$320.20 + 9.83 - 3.81 = 326.22$ <i>check</i>

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	<u>1.340</u>	398.797	1.273	397.457
	BM 3			<u>0.780</u>	398.017
		$\Sigma BS = 5.685$		$\Sigma FS = 5.690$	$398.022 + 5.685 - 5.690 = 398.017$ <i>ck</i>

4.5 Error = $398.022 - 398.017 = 0.005\text{m}$
 2nd order Class 1 (U.S.) = $6\text{mm} \sqrt{K} = .006 \sqrt{0.7} = .005$
 2nd order (Canada) = $8\text{mm} \sqrt{K} = .008 \sqrt{.7} = .007$. The error qualifies for 2nd order in both countries.

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	<u>1.47</u>	177.76	1.62	176.29
	BM 100			<u>1.21</u>	176.55
		$\Sigma BS = 14.48$		$\Sigma FS = 14.49$	$176.56 + 14.48 - 14.49 = 176.55$ <i>check</i>

4.7 Error = $176.56 - 176.55 = 0.01$ ft. 2nd order allowable error = $0.035 \sqrt{1} = 0.035$

000/5280 =

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
$202.025 + 1.174 - 7.589 = 195.610$ <i>check</i>					

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., 2 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., 2 nd 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., 1 st 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)

- Difference between 1st and 2nd floors at east end of building - 13.2 1'
- Difference between 1st and 2nd floors at north end of building - 16.6 5'
- Difference between 2nd floor and mechanical room floor - 23.7 8 t o 2 3.8 7' (nd floor is not level)
- Difference between 1st and 2nd floors at east end of building - 13.2 1'
- Difference between 1st and 2nd floors at north end of building - 16.6 5'

- f. Difference between 2nd floor and mechanical room floor - 23.78 to 23.87' (2nd floor is not level)
- g. Difference between 1st floor and mezzanine level floor - 4.6'
- h. Difference between 1st and 2nd floors at east end of building - 13.21'
- i. Difference between 1st and 2nd floors at north end of building - 16.65'
- j. Difference between 2nd floor and mechanical room floor - 23.78 to 23.87' (2nd floor is not level)
- k. Difference between 1st floor and mezzanine level floor - 4.6'

4.10	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	<u>7.39</u>	363.24		1.12	355.85
	BM S22				<u>2.41</u>	360.83
		$\Sigma BS = 17.70$			$\Sigma FS = 4.42$	
					$347.55 + 17.70 - 4.42 = 360.83$ <i>check</i>	

4.11	Station	BS	HI	FS	Elevation	Left	C	Right
	BM 107	7.71	206.60		198.89		L	
	80+50					60' 28' 0'	32	60'
						9.7 8.0 5.7	4.3	4.0
						196.9 198.6	200.9 202.3	202.6
	81+00					60' 25' 0'	30'	60'
						10.1 9.7 6.8	6.0	5.3
						196.5 196.9	199.8 200.6	201.3
	81+50					60' 27' 0'	33'	60'
						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			

- 4.12 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.

- 4.13 a) $V = 148.61 \sin 9^\circ 26' = 24.36 \text{ ft.}$
 Elevation of lower station = $324.28 + 4.66 - 24.36 - 4.88 = 299.70 \text{ ft.}$
 b) $H = 148.61 \cos 9^\circ 26' = 146.60 \text{ ft.}$
 Lower station = $110+71.25 + 146.42 = 112+17.85$

- 4.14 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 = $187.298 - 1.742 = 185.556 \text{ m}$
 b) Levelling error = 0.004 m

- 4.15 a) Error = $167.174 - 167.185 = -0.011 \text{ m}$ Accuracy
 limit for 2nd order = $0.7 \sqrt{.8} = 0.06$
 Accuracy limit for 3rd order = $0.12 \sqrt{.8} = 0.11 \text{ (U.S.)}$
 or = $0.24 \sqrt{.8} = 0.21 \text{ (Canada)}$
 (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.

4.15(b)

Station	Cumulative Distance	Elevation	Correction	Adjusted Elevation
BM 130		168.657		168.657
TP 1	130	168.248	$130/780 \times 0.011 = +0.002$	168.250
TP 2	260	168.539	$260/780 \times 0.011 = +0.004$	168.543
TP 3	390	166.318	$390/780 \times 0.011 = +0.006$	166.324
BM K110	520	166.394	$520/780 \times 0.011 = +0.007$	166.401
TP 4	650	166.579	$650/780 \times 0.011 = +0.009$	166.588
BM 132	780	167.618	$780/780 \times 0.011 = +0.011$	167.629

$C = 167.629 - 167.618 = -0.011$

The adjusted elevation of BM K110 is 166.401 m

4.16

Error = $0.11'$ in 3 miles. The project requires at least Third Order contouring.
 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	$0.4/3.0 \times 0.11 = 0.01'$	1325.14
2	0.7	1328.94	$0.7/3.0 \times 0.11 = 0.03'$	1328.91
3	0.95	1331.55	$0.95/3.0 \times 0.11 = 0.03'$	1328.52
4	1.20	1329.01	$1.20/3.0 \times 0.11 = 0.04'$	1328.97
5	1.8	1327.86	$1.8/3.0 \times 0.11 = 0.07'$	1327.79
6	2.4	1333.67	$2.4/3.0 \times 0.11 = 0.09'$	1333.58
111	3.0	1320.39	$3.0/3.0 \times 0.11 = 0.11'$	1320.28
		Error = $1320.39 - 1320.28 = 0.11'$		