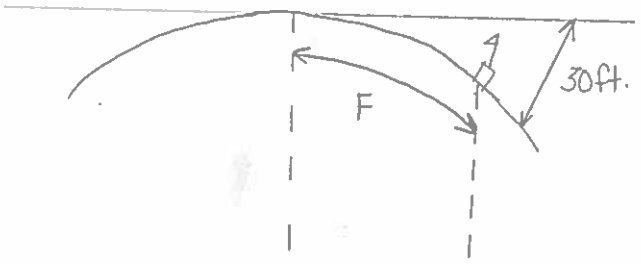
CVG 2171 – Surveying and Measurements

Assignment # 2 – Leveling

SOLUTIONS

Problem 1

On a large lake without waves, how far from shore is a sailboat when the top of its 30-ft mast disappears from the view of a person lying at the water's edge?



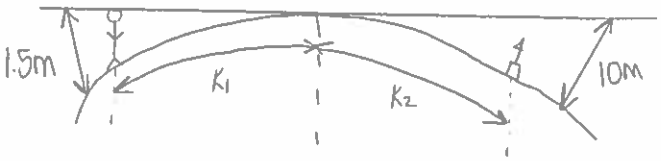
$$F = \sqrt{\frac{h_f}{0.0206}} \times 1000$$

$$= \sqrt{\frac{30}{0.0206}} \times 1000$$

$$F = 38,161.64 \text{ ft.} \quad \text{ANS}$$

Problem 2

Similar to Problem 1, except for a 5-m mast and a person whose eye height is 1.5 m above the water's edge.



$$K = \sqrt{\frac{h_m}{0.0675}} \text{ [KM]}$$

$$K_1 = \sqrt{\frac{1.5m}{0.0675}} = 4.7140 \text{ KM}$$

$$K_2 = \sqrt{\frac{1.5m}{0.0675}} = 8.6066 \text{ km}$$

$\therefore$ total distance $= K_1 + K_2$

$= 4.7140 + 8.6066$

$= 13.3206 \text{ km}$

$\simeq 13.3 \text{km}$ ANS

Problem 3

Prepare a set of level notes for the data listed. Perform a check and adjust the misclosure. Elevation of BM7 is 2,303.45 ft. If the total loop length is 2,400 ft., what order of leveling is represented? Assume all readings are in feet.

Point	+ S (BS)	- S (FS)
BM7	5.68	
TP1	9.42	7.58
TP2	9.26	5.81
BM8	6.45	4.59
TP3	9.59	8.50
BM7		13.95

Step 1: Setup Table

Station	BS (+) (ft.)	HI (ft.)	FS (-) (m)	Elevation (ft.)	Adjusted Elevation (ft.)
BM7	5.68	2,309.13		2,303.45	2,303.45
TP1	9.42	2,310.97	7.58	2,301.55	2,301.56
TP2	9.26	2,314.42	5.81	2,305.16	2,305.17
BM8	6.45	2,316.28	4.59	2,309.83	2,309.85
TP3	9.59	2,317.37	8.50	2,307.78	2,307.20
BM7			13.95	2,303.42	2,303.45
Σ	40.40		40.43		

Step 2: Calculation Check

$(\sum BS - \sum FS) + 1st\ elevation = last\ elevation$

$(40.40 - 40.43) + 2,303.45 = 2,303.42\ ft$ = last elevation

↘ calculations ok

Step 3: Misclosure Adjustment (MA)

$closure = 1st\ elevation - last\ elevation$

$= 2,303.45 - 2,303.42$

$= 0.03$

$MA = \frac{closure}{\#\ of\ setups}$

$= \frac{0.03}{5}$

$= 0.006$

Step 4: Adjust Elevations

$Adj\ Elev. = Elev. \pm (\#\ of\ cumulative)(MA)$

$TP1_{AE} = 2,301.55 + (1)(0.006) = 2,301.556\ ft.$

$TP2_{AE} = 2,305.16 + (2)(0.006) = 2,305.172\ ft$

$BM8_{AE} = 2,309.83 + (3)(0.006) = 2,309.848\ ft$

$TP3_{AE} = 2,307.78 + (4)(0.006) = 2,307.204\ ft.$

$BM7_{AE} = 2,303.42 + (5)(0.006) = 2,303.450\ ft.$

Step 5: Order of Leveling

$C = m\sqrt{K}$

$C = 0.03\ ft. \times \frac{1m}{3.2808\ ft} = 0.009144\ m \approx 9.144\ mm$

$K = 2,400\ ft \times \frac{1m}{3.2808\ ft} = 731.5289\ m = 0.73153\ km$

$\therefore m = \frac{C}{\sqrt{K}} = \frac{9.144}{\sqrt{0.73153}} = 10.69 \quad \therefore 3^{rd}\ order$

Problem 4

A differential leveling circuit began on BM Hydrant (elevation 6,012.03 ft.) and closed on BM Rock (elevation 6,022.90 ft.). The plus and minus sight distances were kept approximately equal. Readings (in feet) given in the order taken are 1.85 (+ S) on BM Hydrant, 3.56 (- S) and 8.80 (+ S) on TP1, 5.63 (- S) and 9.78 (+ S) on BM1, 6.88 (- S) and 5.54 (+ S) on BM2, 3.11 (- S) and 6.98 (+ S) on TP2, and 3.00 (- S) on BM Rock. Prepare, check, and adjust the notes.

Step 1: Setup Table

Station	BS (+) (ft.)	HI (ft.)	FS (-) (m)	Elevation (ft.)	Adjusted Elevation (ft.)
BM Hydrant	1.85	6,013.88		6,012.03	6,012.03
TP1	8.80	6,019.12	3.56	6,010.32	
BM1	9.78	6,023.27	5.63	6,013.49	
BM2	5.54	6,021.93	6.88	6,016.39	
TP2	6.98	6,025.80	3.11	6,018.82	
BM Rock			3.00	6,022.80	6,022.90*
Σ	32.95		22.18		

Step 2: Calculation Check

$(\sum BS - \sum FS) + 1st\ elevation = last\ elevation$

$(32.95 - 22.18) + 6,012.03 = 6,022.80$ ft. = last elevation

↘ calculations ok

Step 3: Misclosure Adjustment (MA)

$$MA = \frac{closure}{\#\ of\ setups}$$

$$= \frac{6,022.90^{*} - 6,022.80}{5}$$

$$= 0.02$$

Step 4: Adjust Elevations

$$Adj\ Elev. = Elev. \pm (\#\ of\ cumulative)(MA)$$

$TP1_{AE} = 6{,}010.32 + (1)(0.02) = 6{,}010.34$ ft

$BM1_{AE} = 6{,}013.49 + (2)(0.02) = 6{,}013.53$ ft

$BM2_{AE} = 6{,}016.39 + (3)(0.02) = 6{,}016.45$ ft

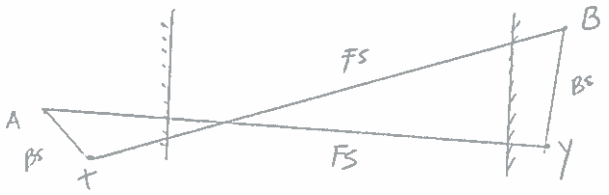
$TP2_{AE} = 6{,}018.82 + (4)(0.02) = 6018.90$ ft

$BM\ Rock_{AE} = 6{,}022.80 + (5)(0.02) = 6{,}022.90$ ft

Problem 5

Reciprocal leveling gives the following readings in meters from a setup near A: on *A*, 1.365; on *B*, 4.928, 4.924, and 4.926. At the setup near *B*: on *B*, 4.251; on *A*, 0.687, 0.688, and 0.689. The elevation of *A* is 564.872 m. Determine the elevation of *B*.

Step 1: Picture



Step 2: Setup Table

A		B	
BS (+) (m)	FS (-) (m)	BS (+) (m)	FS (-) (m)
1.365	4.928	4.251	0.687
	4.924		0.688
	4.926		0.689
Average	4.926		0.688

Δ elev from A = BS − FS = 1.365 − 4.926 = −3.561 m

A is lower than B by 3.561 m

Δ elev from B = BS − FS = 4.251 − 0.688 = 3.563 m

B is higher than A by 3.563 m

$$\text{Average difference} = \left| \frac{\Delta \text{elev}_A + \Delta \text{elev}_B}{2} \right| = \left| \frac{3.561 + 3.563}{2} \right| = 3.562 \text{ m}$$

We know B is higher than A

$\therefore$ elev @ B = 564.872 + 3.562 = 568.434 m