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4. A 30m tape used for measuring a line was found to be 30.01m at the beginning and 30.03m at the end. The area of the plan drawn to a scale of 1cm = 10m was measured with the help of planimeter and was found to be 51.46 cm^2. Find the area of the field.

Solution:

Average actual length $l' = \frac{30.01 + 30.03}{2}$

$= 30.02m$

Measured area of the ground $= 51.46 \times 10^2$

$= 5146 m^2$

$\therefore$ Actual area of the field $= \left(\frac{l'}{l}\right)^2 \times$ measured area

$= \left(\frac{30.02}{30}\right)^2 \times 5146$

$= 5152.86 m^2$.

5. To measure a base line, a steel tape 30m long standarised at 15°C with a pull of 100N (10 kgf) was used. Find the correction per tape length if the temperature at the time of measurement was 20°C and the pull exerted was 160N (16 kgf).

Wt. of $1cm^3$ of steel = 0.0785N (7.85gmf).

Wt. of the tape = 8N, (0.8kgf).

$E = 2.1 \times 10^7$ (N/cm^2) (2.1×10^6 kgf/cm^2)

$\alpha = 7.1 \times 10^{-7}/°C$

solution:-

If $A \rightarrow$ cross sectional area,

$A * (30 * 100) * 0.0786 = 8$

$\Rightarrow A = 0.034\ m^2$

i) Temperature correction, $C_T = 7.1 * 10^{-7} * (20-15) * 30$
$= 0.0001065\ m$

ii) Pull correction, $C_P = \dfrac{(P - P_0) L}{AE}$

$= \dfrac{(16-10) * 30}{0.034 * 2.1 * 10^6} = 0.002521\ m$

iii) Sag correction, $C_{sag} = \dfrac{w^2 L}{24 P_m^2}$

$= \dfrac{8^2 * 30}{24 * 160^2} = 0.003125\ m$ (-ve)

$\therefore$ Total Correction $= 0.0001065 + 0.002521 - .003125$
$= -0.0004975\ m$

6. A steel tape of nominal length 30 m was used to measure a line AB by suspending it between supports. If the measured length was 29.861 m when the slope angle was $3^\circ 45'$, and the mean temperature and tension applied were respectively $10^\circ c$ and 100 N, determine the corrected horizontal length.

The standardised length of the tape was 30.004 m at $20^\circ c$ and 44.5 N tension. The tape length weighted

0.16 N/m and had a cross-sectional area of $4 mm^2$. $E = 2 * 10^5 N/mm^2$. $\alpha = 1.12 * 10^{-5} /°C$.

solution,

slope correction $= -L(1-\cos\theta)$

$= -29.861(1-\cos 3°45')$

$= -0.064 m$

standarisation correction $= L * \left(\frac{l'-l}{l}\right)$

$= 29.861 \left(\frac{30.004-30.00}{30.00}\right)$

$= 0.004 m$

Temperature correction,

$= \alpha(T-T_0)L$

$= 1.12 \times 10^{-5}(10-20) * 29.861$

$= -0.003 m$

Pull correction $= \frac{(P-P_0)L}{AE}$

$= \frac{(100-44.5) * 29.861}{4 \times 2 \times 10^5}$

$= +0.004 m$

Sag correction $= -\frac{w^2 l^3}{24 P^2}$

$= -0.003$

∴ Total correction $= -0.064 + 0.004 - 0.003 + 0.004 - 0.003$

$= -0.062$

∴ correct horizontal distance $= 29.861 - 0.062$

$= 29.799$

7. A steel tape ~~so~~ is 30m long between end graduations at a temperature of 27°c under a pull of 45N when lying on the flat. The tape is stretched over two supports between which it records 30.00m, and is supported at two intermediate supports equally spaced. All the supports are at same level, and the tape is allowed to sag freely between the supports.

If the temperature in the field is 32°c and the pull on the tape is 75N, calculate the actual length ~~of the~~ between the end graduations, ~~to~~ and the equivalent length at mean sea level if the measurement was made at an elevation of 1000.00m.

Area of cross-section $= 7 mm^2$

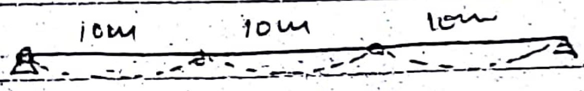
Mass of tape $= 1.6 kg$.

Coeff of expansion $= 1.1 \times 10^{-5} / °c$.

Young's modulus $= 2 \times 10^{5} N/mm^2$.

Radius of the earth $= 6370 km$.

solution,



1) Temperature correction,

$$C_T = L\alpha(\theta_2 - \theta_1)$$

$$= 30 \times \cancel{2\times10} \; 1.1 \times 10^{-5} \times (32-27)$$

$$= 0.00165 m.$$

ii) Pull correction $= \frac{(75-45)30}{2*10^5 \times 97*}$

$= 0.00064$

iii) Sag correction = no. of spans * correction for each span.

$= 3 * (-) \frac{10 * (\frac{1.6*9.81}{3})^2}{24 * 75^2}$

$= -0.00608$ m

Sea level correction

$= -\frac{Lh}{R} = \frac{30 * 1000}{6370 * 1000}$

$= -0.00446$ m

∴ Total correction $= 0.00165 + 0.00064 - 0.00608 - 0.00446$

$= -0.00825$

∴ Actual length at MSL $= 30 - 0.00825$

$= 29.991$ m.

8. Determine the correct length of a line reduced to mean sea level when the recorded length with a tape hanging in catenary at a tension of 85N and at temperature of 22°C is 30.071 m. The difference bet^n ends is 0.42m and the site is 2,000.00 m. above MSL.

The tape is had been previously standardised in catenary with tension of 50N and ~~the~~ at a temperature of 27°C, and the distance bet^n zeros was 30.035 m.

Wt of tape = 7N.
cross-sectional area = 3.9 mm^2
Coeff. of expansion = 1.15×10^{-5} /°C.
Young's Modulus = 2×10^5 N/mm^2
Radius of earth = 6370 km.

solution

Correction per tape length

i) standarisation correction = + 30.035 m.

ii) Pull Correction = $\frac{(85-50) \times 30}{3.9 \times 2 \times 10^5}$

= 0.001346 m.

iii) Temperature correction = $1.15 \times 10^{-5} (22-27) \times 30$

= −0.001725 m

iv) slope correction = $-\frac{d^2}{2L} = -\frac{0.42^2}{2 \times 30}$

= −0.00294 m.

~~standarised~~ sag correction:

in this type of standarisation (on Catenary) the correction should be done as below,

$$C_{sag} = +\frac{w^2L}{24P_{st}^2} - \frac{w^2L}{24P_m^2}$$

(cat. → flat) (flat → cat.)

$$= \frac{7^2 * 30}{24} \left[\frac{1}{850^2} - \frac{1}{85^2}\right]$$

$= +0.016$ m.

∴ Total correction $= +0.035 + 0.001346 - 0.001725 - 0.00294 + 0.016$.

$= 0.047681$ m.

∴ For field measurement,

$$\text{Correction} = \frac{0.047681}{30} \times 30.071$$

$= 0.0478$ m.

∴ Actual length $= 30.071 + 0.0478$

$= 30.119$ m

Altitude Correction $= -\frac{L * h}{R}$

$$= -\frac{30.119 * 2000}{6370 \times 1000}$$

$= -0.0009$

∴ Corrected length reduced to MSL

$= 30.119 - 0.0009$

$= 30.110$ ✗

9. A steel tape was exactly 30m long at 20°C when supported throughout its length under a pull of 10 kg. A line was measured with this tape under a pull of 15 kg and at a mean

temperature of 32°c and found to be 780 m long. The cross-sectional area of the tape = 0.03 cm^2, and its total weight = 0.693 kg. α for steel = 11×10^{-6} /°c and E for steel is 2.1×10^6 kg/cm^2. compute the true length of line if the tape was supported during measurement i) at every 30m (ii) at every 15 m.

solution,

$$\text{Temperature correction} = \alpha (T_m - T_0) \times L$$

$$= 11 \times 10^{-6} \times (32-20) \times 30$$

$$= 0.00396 \text{ m } (+ve)$$

$$\text{Pull correction} = \frac{(15-10) \times 30}{0.03 \times 2.1 \times 10^6}$$

$$= 0.00238 \ (+ve)$$

(a) When supported at 30m,

$$n = 1, \quad C_{sag} = \frac{L W^2}{24 n^2 P_m^2}$$

$$= \frac{30 \times 0.693}{24 \times 1^2 \times 15^2}$$

$$= 0.00385 \text{ m. } (-ve)$$

$\therefore$ Total correction / tape $= 0.00396 + 0.00238 - 0.00385$

$$= +0.00367 \text{ m } (+ve)$$

$$\therefore \text{Correction} = \frac{0.00367}{30} \times 780$$

$$= 0.09542 \text{ m}$$

$\therefore$ corrected length $= 780 + 0.09542$

$= 780.09542$ m

(b) When supported at every 15 m:

Here, n = 2;

$$\text{Sag correction} = \frac{LW^2}{24n^2P_m^2}$$

$$= \frac{30 \times (0.693/2)^2}{24 \times 2^2 \times (15)^2}$$

$$= 0.00067 \text{ (-ve)}$$

∴ Total correction = 0.00396 + 0.00238 − 0.00067

= 0.00567

∴ Correction for 780 m, $= \frac{0.00567}{30} \times 780$

= 0.147 m

∴ Corrected length = 780 + 0.147 = 70.147 m.

10. A steel tape was exactly 20 m at 20°C when supported throughout its length under a pull of 5 kg. A line measured with this tape under a pull of 16 kg and at mean temperature of 32°C, was found to be 680 m long. Assuming the tape is supported at every 20 m, find the true length of the line. Given that: (i) Cross-sectional area = 0.03 cm², (ii) $E = 21 \times 10^6$ kg/cm² (iii) $\alpha = 11 \times 10^{-6}$ /°C & (iv) wt. of tape = 10 gm/cc.

Solution,

correction per tape length,

→ Temp^r correction, $C_T = \alpha (T_m - T_0) * L$

$= 1.1 * 10^{-6} (32-20) * 20$

$= 0.000264$ (+ve)

→ Pull correction, $C_p = \dfrac{(16-5) * 20}{0.03 * 2.1 * 10^6}$

$= 0.00349$ m.

→ Sag correction, $C_s = \dfrac{L w^2}{24 P^2}$

$= \cancel{\dfrac{20 * 0.10 * 0.03 * 200}{* 10^{-3}}}$

$w = 10 * 0.03 * 2000 * 10^{-3} = 0.6$ kg

$\therefore C_s = \dfrac{20 * (0.6)^2}{24 * 16^2} = 0.00117$ m (-ve)

$\therefore$ Total correction of ~~tape~~ $= 0.000264 + 0.00349 - 0.00117$

$= \cancel{0.002584\,m}$ 0.00496

$\therefore$ Correction for 680m $= \dfrac{\cancel{0.002584}\ 0.00496}{\cancel{30}\ 20} * 680$

$= \cancel{0.0586\,m}$ 0.16864 m.

$\therefore$ Actual length $= \cancel{680 + 0.0586 = 680.0586\,m}$

$= 680 + 0.16864$

$= 680.16864$ m.

11. A 30 m tape (steel) was standarised at a temperature of 20°C and under a pull of 10 kg.

The tape was used in catenary to fix a distance of 28 m between two points at 40°c under a pull of 5kg. Given that
$A = 0.02 cm^2$, total weight = ~~5kg~~ 470 gm,
$\gamma_{steel} = 2.1 \times 10^6$ kg/cm², $\alpha = 11 \times 10^{-6}$ /°c. (a)
Find the ~~measured distance~~ correct distance between the points and (b) find the value of pull for which the measured distance would be equal to correct distance.

solution,

(a) $\boxed{\because 28 < 30, \text{use } L = 28.}$

→ Temperature correction $= 11 \times 10^{-6}(40-20) \times 28$
$= 0.00616$ m (+ve)

→ Pull correction $= \dfrac{(5-10) \times 28}{0.02 \times 2.1 \times 10^6}$
$= -0.00333$ m (-ve)

→ Sag correction, $= \dfrac{28\left(0.47 \times \frac{28}{30}\right)^2}{24 \times 5^2}$
$= 0.00898$ (-ve).

∴ Total correction, =
$0.00616 - 0.00333 - 0.00898$
$= -0.00615$ m.

∴ Correct distance $= 28 - 0.00615$
$= 27.99385$ m.

(b) The measured distance will be equal

to correct length if the correction due to sag and pull is equal.

Let, normal tension $= P_n$.

Then, $C_{pull} = C_{sag}$.

$$\frac{(P_n - P_0)L}{AE} = \frac{LW^2}{24 P_n^2}$$

$$\frac{(P_n - 10)}{0.02 * 2.1 * 10^6} = \frac{(0.47 * 28/30)^2}{24 * P_n^2}$$

$$24 P_n^3 - 240 P_n^2 - 80895 = 0$$

$$P_n^3 - 10 P_n^2 - 337.3 = 0$$

$\Rightarrow P_n = 12.248$ kg

12. A 30m steel tape measured 30.015 m when standardized fully supported under 70N pull at a temperature of 20°c. The tape weighed 0.90 kg (9N) and had a cross-sectional area of 0.028 cm². What is true length of the recorded distance AB for following conditions. (Assume all full tape lengths except in the last one).

Recorded distance AB	Avg. Temp.	Means of supports	Tension	Elevation diff. per 100m.
114.095m	12°	suspended	150N	2.54

Solution,

→ correction for standarisation,

$$= \left(\frac{30.015-30}{30}\right) * 114.095$$

$$= +0.057m.$$

→ Temperature correction,

$$= 114.095 * 1.15*10^{-5} (12-20)$$

$$= -0.0104967 4m.$$

→ Pull Correction = $\frac{(100-70) * 114.095}{(0.028) * (21*10^7)}$

$$= 0.00582114m.$$

→ sag correction = $\left(\frac{9^2 * 30}{24*100^2}\right) * 3 + \frac{\left(\frac{9}{30} * 24.095\right)^2 * 24.095}{24*100^2}$

$$= .030375 + 0.0052450$$

$$= 0.0356208 \ (-ve).$$

→ correction for slope,

$$= -\frac{d^2}{2L} = -\frac{2.5*2.5}{2*100}$$

$$= -0.03125 m/100m.$$

∴ correction for 114.095 m,

$$= -\frac{0.03125}{100} * 114.095$$

$$= -0.0356546 m$$

∴ Total correction = $0.057 - 0.01049 + 0.0058 - 0.356 - 0.03565 = -0.01894 m$

Corrected length = 114.076 m.

(13) Scale

The area of the plan of an old map plotted to a scale of 1cm = 40m measures as 125.50 cm^2 by planimeter. The original length of any line 20cm is now 19.5cm. The tape used for measuring was 5cm too long [20m]. Find the correct ground area.

solution

$$\text{shrinkage factor} = \frac{\text{shrunk length}}{\text{original length}}$$

$$= 19.5/20$$

$$= 0.975$$

Present area = $125.50\ cm^2$

∴ Correct area from map = $\frac{125.50}{(0.975)^2}$

$$= 132.018\ cm^2$$

∴ plotting scale : 1 cm : 40m

$1cm^2 = 40^2 m^2 = 1600 m^2$

∴ ground area = $1600 \times 132.018 = 211228.8\ m^2$

Tape was 5cm too long

∴ $L' = 20.05$

∴ correct area = $\left(\frac{L'}{L}\right)^2 \times$ area measured

$$= \left(\frac{20.05}{20}\right)^2 \times 211228.8 = 212286.26\ m^2$$

COMPASS

— Khemraj Regmi

1. (a) Convert WCB to QB or QB to WCB.

(i) $56^\circ 20'$ (ii) $218^\circ 30'$ (iii) $272^\circ 50'$

(iv) $S\ 30^\circ 14'\ E$ (v) $S\ 02^\circ 10'\ W$ (vi) $N\ 18^\circ 20'\ W$.

Solution,

(i) $56^\circ 20'$ (WCB) $\rightarrow$ $N\ 56^\circ 20'\ E$ (QB)

(ii) $218^\circ 30'$ (WCB) $\rightarrow$ ~~180~~ $218^\circ 30' - 180^\circ$

$= 38^\circ 30' = S\ 38^\circ 30'\ W$ (QB)

(iii) $272^\circ 50'$ (WCB) $\rightarrow$ ~~272~~ $360^\circ - 272^\circ 50'$

$= N\ 87^\circ 10'\ W$ (QB)

(iv) $S\ 30^\circ 14'\ E$ (QB) $\rightarrow$ $180^\circ - 30^\circ 14' = 149^\circ 46'$ (WCB)

(v) $S\ 02^\circ 10'\ W$ (QB) $\rightarrow$ $180^\circ + 02^\circ 10' = 182^\circ 10'$ (WCB)

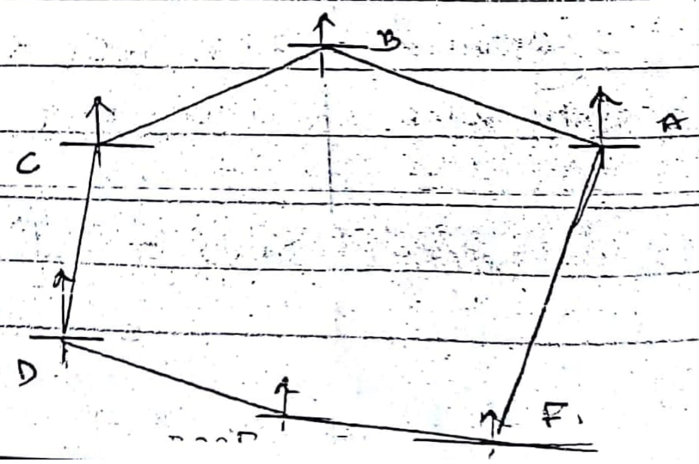
(vi) $N\ 18^\circ 20'\ W$ (QB) $\rightarrow$ $360^\circ - 18^\circ 20' = 341^\circ 40'$ (WCB)

2. The whole circle bearings of the sides of a traverse ABCDEF are given below. Compute the internal angles.

AB $\rightarrow$ $290^\circ 45'$; BC $\rightarrow$ $250^\circ 48'$

CD $\rightarrow$ $196^\circ 12'$; DE $\rightarrow$ $175^\circ 24'$

EF $\rightarrow$ $112^\circ 18'$ FA $\rightarrow$ $30^\circ 00'$



FB of AB = $290°45'$ BB of AB = $290°45' - 180° = 110°45'$

" BC = $250°48'$ BB of BC = $250°48' - 180° = 70°48'$

" CD = $196°12'$ " CD = $196°12' - 180° = 16°12'$

DE = $175°24'$ DE = $355°24'$

EF = $112°18'$ EF = $292°18'$

FA = $30°00'$ FA = $210°00'$

∠A = ~~BB of FA~~ − FB of AB − BB of FA.

= $290°45' - 210°00' = 80°45'$.

∠B = FB of BC − BB of AB

= $250°48' - 110°45' = 140°03'$

∠C = FB of CD − BB of BC

= $196°12' - 70°48' = 125°24'$

∠D = FB of DE − BB of CD

= $175°24' - 16°12' = 159°12'$

∠E = FB of EF − BB of DE

= $112°18' - 355°24' = -243°06' + 360° = 116°54'$.

∠F = FB of FA − BB of EF

= $30°0' - 292°18' = -262°18' + 360° = 97°42'$.

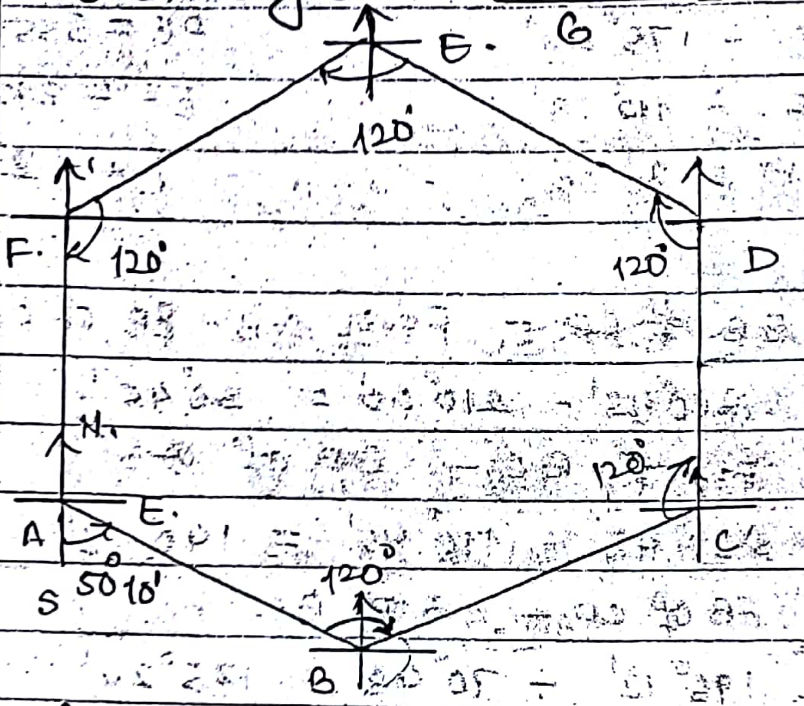
3. Compute and tabulate the bearings of a regular hexagon given the starting bearing of side AB = S 50°10' E (station C is easterly from B).

solution

The total ~~interior~~ internal angles

$= (2n-4) \times 90^\circ = (2 \times 6 - 4) \times 90 = 8 \times 90^\circ$

$\therefore$ Each angle $= \dfrac{8 \times 90^\circ}{6} = 120^\circ$



solution,

WCB of AB $= 180^\circ - 50^\circ 10' = 129^\circ 50'$

$\therefore$ WCB of BC $=$ ~~120° + 129°50'~~ $=$ BB of AB + clockwise angle

$= (180^\circ + 129^\circ 50') + 120^\circ$

$= 429^\circ 50' \; (-360^\circ)$

$= 69^\circ 50'$

WCB of CD $=$ BB of BC + clockwise $\angle$

$= (69^\circ 50' + 180^\circ) + 120^\circ$

$= 369^\circ 50' \; (-360^\circ)$

$= 09^\circ 50'$

WCB of DE = BB of CD + clockwise ∢

$= (09°50' + 180°) + 120°$

$= 309°50'$

WCB of EF = BB of DE + clockwise ∢

$= (309°50' - 180°) + 120°$

$= 249°50'$

WCB of AA = BB of EF + clockwise ∢

$= (249°50' - 180° + 120°)$

$= 189°50'$

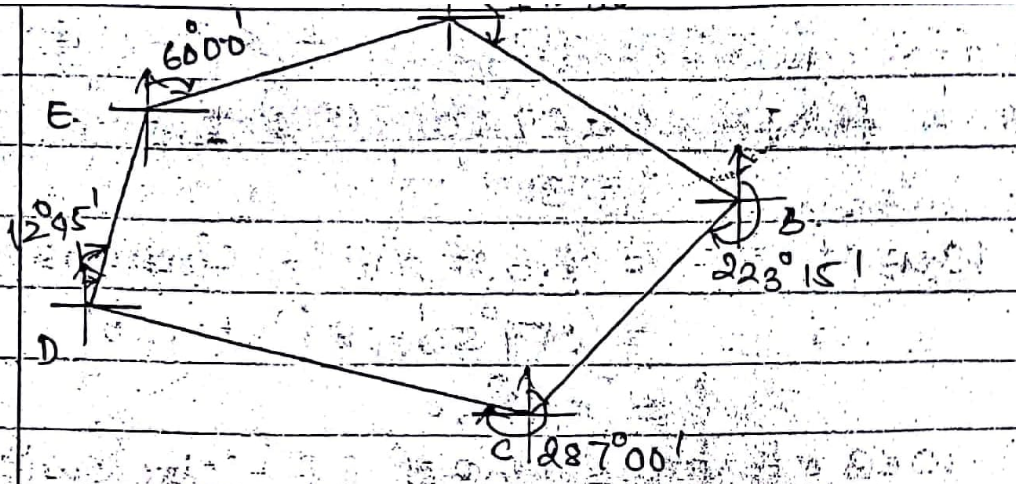
4. Following are the bearings taken in a closed traverse.

Line	FB	BB
AB	S 37°30' E	N 37°30' W
BC	S 43°15' W	N 44°15' E
CD	N 73°00' W	S 72°15' E
DE	N 12°45' E	S 13°15' W
EA	N 60°00' E	S 59°00' W

Compute the interior angles and correct them for observational errors.

Solution, Converting the given bearings into WCB.

AB	142°30'	322°30'
BC	223°15'	44°15'
CD	287°00'	107°45'
DE	12°45'	193°15'
EA	60°00'	239°00'



For the calculation of clockwise internal angles we should move in anticlockwise direction and vice versa. so it is necessary to lay out the approximate directions of survey lines.

~~Includ~~

We have;

Included Angle = FB of next line − BB of previous line

Exterior angle calculations:-

$\angle A$ = FB of AB − BB of EA

$= 142°30' - 239°00' = -96°30' = -96°30' + 360°$

$= 263°30'$

$\angle B$ = FB of BC − BB of AB

$= 223°15' - 322°30' = -99°15'$

$= -99°15' + 360° = 260°45'$

$\angle C$ = FB of CD − BB of BC $= 287°00' - 44°15' = 242°45'$

$\angle D$ = FB of DE − BB of CD $= 12°45' - 107°45'$

$= -95°00' = 95°00' + 360°$

$= 265°00'$

$\angle E$ = FB of EA − BB of DE
$= 60°00' - 193°15' = -133°15'$
$= -133°15' + 360° = 226°45'$.

$\therefore$ Sum $= \angle A + \angle B + \angle C + \angle D + \angle E$
$= 263°30' + 260°45' + 242°45' + 265°00' + 226°45'$
$= 1258°45'$

Theoretical sum $= (2n+4) \times 90°$
$= (2\times5+4)\times 90° = 1260°$.

$\therefore$ Error $= 1258°45' - 1260°$
$= -1°15' = -75'$

$\therefore$ Correction $= +75'$

correction/each angle $= +75'/15$
$= +15'$.

Hence, corrected included angles are:

$\angle A = 263°30' + 15' = 263°45'$
$\angle B = 260°45' + 15' = 261°00'$
$\angle C = 242°15' + 15' = 242°30'$
$\angle D = 265°00' + 15' = 265°15'$
$\angle E = 226°45' + 15' = 227°00'$.

Note: ~~The included angle~~

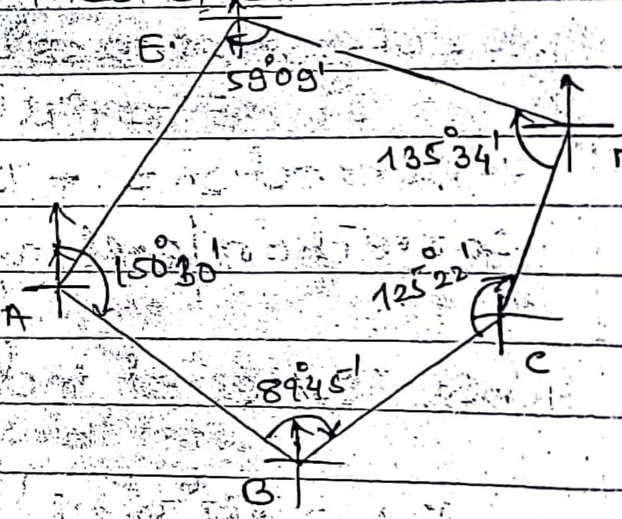
5. In a closed traverse ABCDE, the bearing of line AB was measured as $150°30'$. The included angles were measured as under $\angle A = 130°10'$, $\angle B = 89°45'$, $\angle C = 125°22'$, $\angle D = 135°34'$, $\angle E = 59°09'$. Calculate the bearings of all other lines.

solution,

Sum of angles $= \angle A + \angle B + \angle C + \angle D + \angle E$

$= 130°10' + 89°45' + 125°22' + 135°34' + 59°09'$

$= 540°00'$ = Theoretical value.



Bearing of BC = Bearing of BA + $\angle ABC$.

$= 150°30' + 180° + 89°45'$

$= 420°15' = 60°15'$.

Bearing of CD = Bearing of CB + $\angle BCD$

$= 60°15' + 180° + 125°22'$

$= 365°37' = 05°37'$.

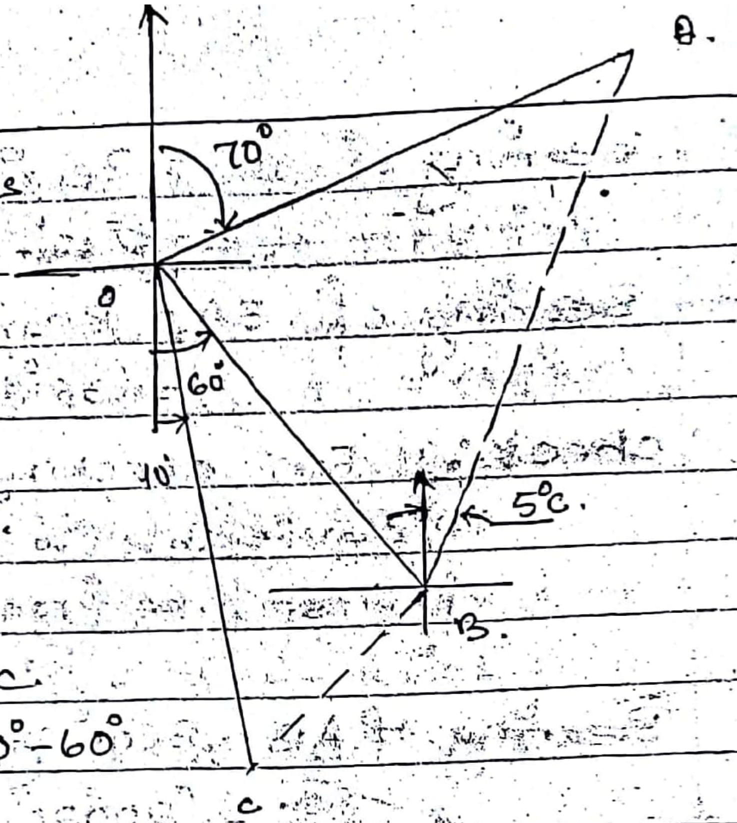
Bearing of DE = Bearing of DC + ∡CDE
$= 5°37' + 180° + 135°34' = 321°11'$

Bearing of EA = Bearing of ED + ∡DEA
$= (321°11' - 180°) + 59°09' = 200°20'$

Check: For checking the calculations, it is advisable to calculate the bearing of first line from bearing of last line.

Bearing of AB = Bearing of AE + ∡EAB
$= (200°20' - 180°) + 130°10'$
$= 150°30'$ (checked).

6. Three ships A, B and C started sailing from Bombay at the same time. The speed of all the three ships were the same at 30 km/hr. Their bearings were measured and found to be N 70° E, S 60° E and S 10° E, respectively. After an hour the captain of ship B, determined the bearings of other two ships, with respect to his own ship and calculate the distances. Calculate the bearings and distances which might have been determined by the captain of ship B.



solution,

Speed of the ships $= 30$ km/hr.

$t = \cancel{30}$

After one hour,

$OA = OB = OC$
$= 30$ km.

$\angle BAO = \angle OBA$

$\angle OCB = \angle OBC$

$\angle AOB = 180° - 70° - 60°$
$= 50°$

$\angle COB = 60° - 10° = 50°$

$\angle OAB = \angle OBA = \angle OBC = \angle OCB$
$= (180° - 50°)/2 = 65°$

Bearing of OB $=$ S $60°$ E
$= 120°$

Bearing of BA $=$ FB of OB $+ \angle OBA$
$= 120° + 65° = 185°$
$= 185° - 180° = 5°$

Hence, bearing of BA $=$ N $5°$ E.

Bearing of BC $=$ FB of OB $+ \angle OBC$
$= 120° + (360° - 65°)$
$= 415°$
$= 415° - 180° = 235°$
$=$ S $55°$ W.

Bearing of BC = S 55° W

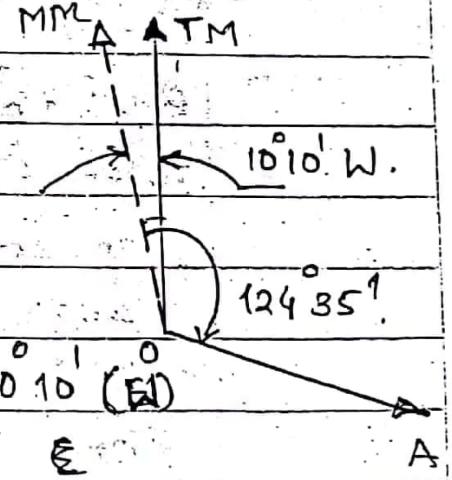
In Δ OAB, from sine rule,

$$\frac{AB}{\sin 50^\circ} = \frac{OA}{\sin 65^\circ} = \frac{OB}{\sin 65^\circ}$$

$$AB = 30 \times \frac{\sin 50}{\sin 65^\circ} = 23.56 \text{ km}$$

BC = BA , BC = 23.56 km

7. The magnetic bearing of line PA is 124°35'. Find its true bearings, if the magnetic declination is 10° 10' W. (E).



∴ True bearing =
magnetic bearing ± magnetic declination E| W.

∴ True meridian = 124°35' − 10°10' (E)
= 114°25' E

True meridian = 125°35' + 10°10' (E)
= 134°45'

8. The bearings observed in traversing with a compass at a place where local attraction was suspected are given below :

Line	FB	BB
AB	S 45° 30' E	N 45° 30' W
BC	S 60° 00' E	N 60° 00' W
CD	N 03° 20' E	S 05° 30' W
DA	S 85° 00' W	N 83° 30' E

At what stations do you suspect local attraction? Find the corrected bearings of the lines?

solution:

The numerical value of the fore and back bearings of the line AB is the same. Hence stations A and B are free from local attraction and therefore FB of BC observed at station B is accepted to be correct.

Convert the quadrantal bearing to WCB.

AB	134° 30'	314° 30'
BC	120° 00'	299° 20'
CD	03° 20'	185° 30'
DA	265° 00'	83° 30'

Since the stations A and B are free from local attraction. The bearings of line from stations A & B i.e. AB, BA, BC, AD are correct

FB of BC = 120°00' (correct)

Add 180° = ~~300°00'~~ +180°

Correct ~~Bearing~~ BB of BC = 300°00'.

Observed BB of BC = 299°20'.

Error at C = −40'

∴ correction at C = +40'.

Observed FB of CD = 03°20'.

correction = +40'

Correct FB of CD = 04°00'.

Add 180° +180°

Correct BB of CD = 184°00'.

observed BB of CD = 185°30'.

Error at D = 1°30'.

∴ correction at D = −1°30'.

~~Correct~~ observed FB of DA = 265°00'

correction at D = −1°30'.

Correct BB of DA = 263°30'

Subtract ~~Add~~ 180 −180°

= 83°30'

Correct B.B of BB of DA = 83°30'.

Observed ,,

Bearings corrected for local attraction are:

Line	FB	BB
AB →	134°30' (S 45°30' E)	314°30' (N 45°30' W)
BC →	120°00'. (S 60°00' E)	300°00'. (N 60°00' W)
CD →	4°00'. (N 4°00' E).	184°00' (N 4°00' W)
DA →	263°30' (S 83°30' W)	83°30' (N 83°30' E).

9. The following bearings were taken in running a closed traverse.

Line	FB	BB
AB	48°25'	230°00'
BC	177°45'	356°00'
CD	104°15'	284°55'
DE	165°15'	345°15'
EA	259°30'	79°00'

i) State the stations which are affected by local attraction and by how much?

ii) Determine the correct bearings.

iii) Calculate the true bearings, if the declination was 1°30' W.

Here, the FB and BB of line DE differ by 180°, the stations D and E are free from local attraction. Hence the bearings of line DC, DE, ED, EA are correct.

FB of EA	= 259°30' (correct)
Subtract 180°	− 180°
Correct BB of EA	= 79°30'
Observed BB of EA	= 79°00'
Error at A	= −30'
Correction at A	= +30'

Observed FB of AB	= 48°25'
Correction at A	+30'
Correct FB of AB	= 48°55'
Add 180°	+ 180°
Correct BB of AB	= 228°55'
Observed BB of AB	= 230°00'
Error at B	= +1°05'
Correction at B	= −1°05'
Observed FB of BC	= ~~~~ 177°45'
Correction at B	−1°05'
Correct FB of BC	= ~~~~ 176°40'
~~Subtract~~ ~~Add~~ add 180°	+ 180°
Correct BB of BC	= 356°40'
Observed BB of BC	= 356°00'
Error at C	= −40'
Correction at C	= +40'
~~Correct~~ Observed FB of CD	= 104°15'
Correction at C	= +40'
∴ Correct ~~bearing~~ FB of CD	= 104°55'
Add 180°	+ 180°
∴ Correct BB of CD	= 284°55'
	(checked)

The stations affected by local attraction are A, B and C and by −30', +1°05', and −40', respectively.

Bearings corrected for local attraction are:

Line	FB	BB
AB	48°55'	228°55'
BC	176°40'	356°40'
CD	104°55'	284°55'
DE	165°15'	345°15'
EA	259°30'	79°30'

If declination is 1°30' W, (-ve declination)

Corrected bearings are,

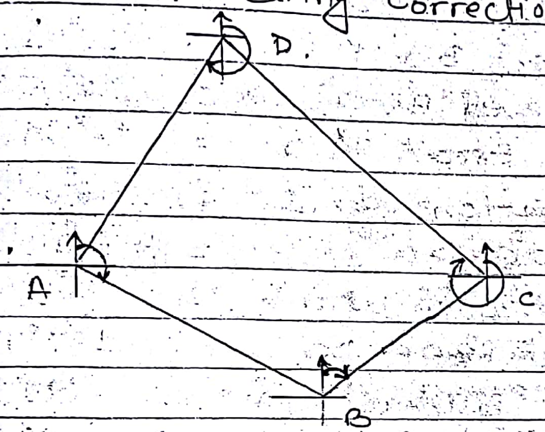
Line	FB	BB
AB	48°55' - 1°30' = 47°25'	228°55' - 1°30' = 227° 25'
BC	176°40' - 1°30' = 175°10'	356°40' - 1°30' = 355° 10'
CD	104°55' - 1°30' = 103°25'	284°55' - 1°30' = 283°25'
DE	165°15' - 1°30' = 163°45'	345°15' - 1°30' = 343°45'
EA	259°30' - 1°30' = 258°00'	79°30' - 1°30' = 78°00'

10. Given below are the bearings observed in a traverse survey conducted with a prismatic compass at a place where local attraction was suspected :→

Line	FB	BB
AB	124°30'	304°30'
BC	68°15'	246°00'
CD	310°30'	135°15'
DA	200°15'	17°45'

At what stations do you suspect local attraction? Find the correct bearings of the lines and the included angles.

1) Method I: Bearing Correction Method:



Here the bearing of line AB is correct since its bearings differ by 180°. Hence the stations A & B can be accepted as the local attraction free stations.

Bearing of line AB, BA, BC & AD are correct.

R.B. of BC	$= 68°15'$
Add 180	$+180°$
Correct BB of BC	$= 248°15'$
observed "	$= 246°00'$
Error at C	$= -2°15'$
Correction at C	$= +2°15'$

Observed FB of CD = $310°30'$
correction at C = $+2°15'$
Correct FB of CD = $312°45'$
~~Obser~~ subtract 180° = $-180°$
Correct BB of CD = $132°45'$
Observed BB of CD = $135°15'$
Error at D = $+2°30'$
correction at D = $-2°30'$
Observed FB of DA = $200°15'$
correction at D = $-2°30'$
Correct FB of DA = $197°45'$
Subtract 180° = $-180°$
correct BB of DA = $17°45'$
Observed BB of DA = $17°45'$ (checked).

ii) Method II: By Included Angle;
Running the traverse anticlockwise;

$\angle A$ = FB of AB − BB of DA.
$= 124°30' - 17°45' = 106°45'$.

$\angle B$ = FB of BC − BB of AB
$= 68°15' - 304°30' = -236°15'$
$= 360° - 236°15' = 123°45'$

$\angle C$ = FB of CD − BB of BC
$= 310°30' - 246°00'$
$= 64°30'$

$\angle D$ = FB of DA − BB of CD
$= 200^\circ 15' - 135^\circ 15' = 65^\circ 00'$.

$\therefore$ Sum $= \angle A + \angle B + \angle C + \angle D$.
$= 106^\circ 45' + 123^\circ 45' + 64^\circ 30' + 65^\circ 00'$.
$= 360^\circ 00'$.

$\therefore$ Theoretical sum $= (2n-4) \times 90^\circ = (2 \times 4 - 4) \times 90^\circ$
$= 360^\circ$.

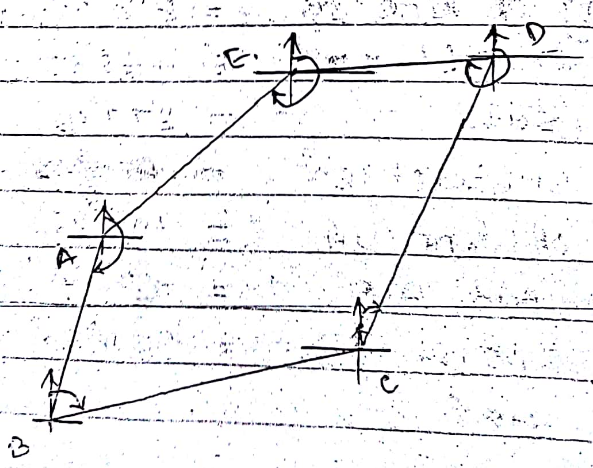
Calculation of Bearings:-

Bearing of line AB	$= 124^\circ 30'$ (correct).
Add $\angle B$	$+123^\circ 45'$
sum	$= 248^\circ 15'$
$> 180^\circ$, subtract 180°	$- 180^\circ$
Bearing of line BC.	$= 68^\circ 15'$.
Add $\angle C$	$+ 64^\circ 30'$
sum.	$= 132^\circ 45'$
$< 180^\circ$, Add 180°	$+ 180^\circ$
Bearing of line CD	$= 312^\circ 45'$
Add $\angle D$	$+ 65^\circ 00'$
sum	$= 377^\circ 45'$
$> 180^\circ$, subtract 180°	$- 180^\circ$
Bearing of line DA	$= 197^\circ 45'$.
Add $\angle A$	$+ 106^\circ 45'$
sum	$= 304^\circ 30'$
$> 180^\circ$, $- 180^\circ$	$- 180^\circ$
Bearing of line AB	$= 124^\circ 30'$.

11. Given the corrected bearings of the following traverse taken from a compass survey.

Line	F.B	B.B
AB	191°30'	13°00'
BC	69°30'	246°30'
CD	32°15'	210°30'
DE	262°45'	80°45'
EA	230°15'	53°00'

solution: on examining the values of bearings of the lines it will be noticed that no line in the traverse has a difference of 180° in its bearings. so the correction must be done by included angle method.



∠A = FB of AB − BB of EA

= $191^\circ30' - 53^\circ00' = 138^\circ30'$

∠B = FB of BC − BB of AB

= $69^\circ30' - 13^\circ00' = 56^\circ30'$.

∠C = FB of CD − BB of BC.

= $32^\circ15' - 246^\circ30' = -214^\circ15' + 360^\circ = 145^\circ45'$

∠D = FB of DE − BB of CD.

= $262^\circ45' - 210^\circ30' = 52^\circ15'$

∠E = FB of EA − BB of DE.

= $233^\circ15' - 83^\circ45' = 149^\circ30'$.

Sum = $138^\circ30' + 56^\circ30' + 145^\circ45' + 52^\circ15' + 149^\circ30'$

= $542^\circ30'$.

Theoretical sum = $(2 \times 5 - 4) \times 90 = 540^\circ00'$.

∴ Error = $542^\circ30' - 540^\circ00' = 2^\circ30'$.

Correction = $-2^\circ30' = -150'$.

∴ Correction/each angle = $-150'/5 = -30'$.

∴ Corrected Angles:

∠A = $138^\circ30' - 30' = 138^\circ00'$

∠B = $56^\circ30' - 30' = 56^\circ00'$.

∠C = $145^\circ45' - 30' = 145^\circ15'$

∠D = $52^\circ15' - 30' = 51^\circ45'$.

∠E = $149^\circ30' - 30' = 149^\circ00'$.

Computation of Correct bearings:→.

As all the stations are affected by the correction, the line having ~~least~~

least deviation from 180° in its fore and back bearings is chosen, and correct it, the error is equally divided into fore and back bearing.

Line	FB	BB	Diff.	correction	Correct FB
AB	191°30'	13°00'	178°30'	1°30'/2 = 45'	192°15'
BC	69°30'	246°30'	177°00'		
CD	32°15'	210°30'	178°15'		
DE	262°45'	80°45'	182°00'		
EA	230°15'	53°00'	177°15'		

Corrected FB of AB = 192°15'
+ ∠B = + 56°00'
Sum = 248°15'
>180° subtract 180° = −180°
Corrected FB of BC = 68°15'
Add ∠C = + ~~68°15'~~ 145°15'
Sum = 213°30'
>180°, subtract 180° = ~~33°30'~~ −180°
Corrected FB of CD = 33°30'
Add ∠D = +51°45'
Sum = 85°15'
<180° ~~Add~~ Add 180° +180°
Corrected FB of DE = 265°15'
Add ∠E = 149°00'

sum = 414°15'

>180° subtract 180° = -180°

corrected FB of EA = 234°15'

Add ∠A = 138°00'

sum = 372°15'

>180° subtract 180° = -180°

corrected FB of AB = ~~193~~ 192°15' (checked)

∴

Line	FB
AB	192°15'
BC	68°15'
CD	33°30'
DE	265°15'
EA	234°15'

****

LEVELLING

- Khemraj Regmi

1. The following figures are staff readings taken in order on a particular scheme, the backsights being underlined.
0.813, 2.170, 2.908, 2.630, 3.133, 3.752, 3.277, 1.899, 2.390, 2.810, 1.542, 1.274, 0.643.

The first reading was taken on a benchmark 39.563. Enter the readings in level book form, check the entries, and find the reduced level of the last point.

~~comment on your comp~~

BS - FS = Rescued + RL

BS	IS	FS	HI	RL	Remarks
0.813			40.376	39.563	BM
	2.170			38.206	
	2.908			37.468	
	2.630			37.746	
3.752	~~[illegible]~~	3.133	40.995	37.243	TP_1
	3.277			37.718	
	1.899			~~35.869~~ 39.096	
2.810		2.390	41.415	38.605	TP_2
	1.542			39.873	
	1.274			40.141	
		0.643		40.772	Last point
7.375	~~14.476~~	~~5.513~~			

15.700 6.166.

change of instrument → BS (known)
— just before change of instrument → FS (unknown)
others in IS

Table 5.1
i) $HI = RL + BS$
ii) $RL = HI - IS/FS$

$\Sigma BS - \Sigma FS = 7.375 - \cancel{5.523}\ 6.166$

$= +1.209$

Last RL − First RL = 40.772 − 39.563

$= +1.209$

2. The following readings were observed successively with a levelling ~~staff~~ instrument. The instrument was shifted after fifth and eleventh readings:
(1) 0.585; (2) 1.010; (3) 1.735; (4) 3.295 (5) 3.775
(6) 0.350; (7) 1.300 (8) 1.795 (9) 2.575 (10) 3.375
(11) 3.895 (12) 1.735 (13) 0.635 (14) 1.605 m.

Draw up a page of level book and determine the RL of various points if the R.L of the point on which the first reading was taken is 136.440. (Rise fall Method).

station	BS	IS	FS	Rise	Fall	RL	Remarks.
A	0.585			–	–	136.440	BM
B		1.010			0.425	136.015	IP_1
C		1.735			0.725	135.290	IP_2
D		3.295			1.560	133.730	IP_3
E	0.350		3.775		0.480	133.250	TP_4
F		1.300			0.950	132.300	IP_5
G							

G		1.795			0.495	131.805
H		2.575			0.780	131.025
I		3.375			0.800	130.225
J	1.735		3.895		0.520	129.705
K		0.635		1.100		130.805
L			1.605		.970	129.835
Σ	2.670		9.275	1.100	7.705	

Check :

$\Sigma BS - \Sigma FS = 2.670 - 9.275$

$= -6.605$

Last RL − first RL $= 129.835 - 136.440$

$= -6.605$

$\Sigma Rise - \Sigma Fall = 1.100 - 7.705$

$= -6.605.$

3. The following consecutive readings were taken with a level and a 4.0 m staff on a continuously sloping ground at a common interval of 30 m.

0.780, 1.535, 1.955, 2.430, 2.985, 3.480, 1.155, 1.960, 2.365, 3.640, 0.935, 1.045, 1.630, and 2.545.

The reduced level of the first point A was 180.750 m. Rule out a page of a level field book and enter the above readings. Calculate the reduced levels of points by the

ΣBS − ΣFS =

~~Last RL − First RL~~ =

Rise − Fall =

If r = +ve / −ve Rise / Fall | Gradient = Rise/Fall / Run

collimation system, and the rise and fall system. Also calculate the gradient of the line joining the first and last point.

solution,

The first reading of 0.780 at station A must be a backsight reading. Since the readings were taken on a continuously sloping ground with a 4.0 m staff, the largest reading that can be taken is 4.0m; Therefore, the position of the level must have been changed after the largest reading of each series: such as after 3.480 (of 1st series) and 3.640 (of the end series) The last observation of 2.545 must be a foresight reading.

Station	Distance	Readings BS	IS	FS	HI	RL	Remarks
A	0	0.780	—	—	181.530	180.750	BM
	30		1.535			179.995	
	60		1.955			179.575	
	90		2.430			179.100	
	120		2.985			178.545	
	150	1.155		3.480	179.205	178.050	CP
	180		1.96			177.245	
	210		2.365			176.870	

	240	0.935		3.640	176.500	175.565	CP
	270		1.045	–		175.455	
	300		1.630			174.870	
B.	330	–	–	2.545		173.955	t
Σ		2.780		9.665			

fig ① Table for Collimation Method

Check:

$\Sigma BS - \Sigma FS = 2.780 - 9.665 = -6.795$

RL of last pt − RL of first pt. $= 173.955 - 180.750 = -6.795$

St	Distance	Reading BS	IS	FS	Rise	Fall	RL
					–		180.750
A	0	0.780			–	0.755	179.995
	30		1.535		–	0.420	179.575
	60		1.955		–	0.475	179.100
	90		2.430		–	0.555	178.545
	120		2.985		–	0.495	178.050
	150	1.155		3.480	–	0.805	177.245
	180		1.960		–	0.405	176.840
	210		2.365		–	1.275	175.565
	240	0.935		3.680	–	0.110	175.455
	270		1.045		–	0.585	174.870
	300		1.630		–	0.915	173.955
B.	330			2.545			
Σ		2.870		9.665	0	6.975	

check:

$\Sigma BS - \Sigma FS$

$= 2.870 - 9.665 = -6.795$

$\Sigma Rise - \Sigma fall$

$= 0 - 6.795 = -6.795$

Last RL - first RL.

$= 173.955 - 180.750 = -6.795.$

Gradient:

There is a fall of 6.795 m in 330 m.

$$\text{Gradient} = \frac{6.975}{330} = 1 \text{ in } 48.56$$

4. The following successive readings were taken with a dumpy level along a chain line at common intervals of 20m. The first reading was taken on a chainage 140m. The RL of the second change point was 107.215m. The instrument was shifted after the third & seventh readings. Calculate the RLs of all points.

3.150, 2.245, 1.125, 3.860, 2.125, ~~___~~, 0.760, 2.235, 0.470, 1.935, 3.225 and 3.390 m.

solution.

	Stn	chainage	BS	IS	FS	Rise	fall	RL
	1	140	3.15			~~0.905~~		103.565
	2	160		2.245		0.905		104.470
1st cp.	3	180	3.860		1.125	1.120		105.590
	4	200		2.125		1.735		107.325
	5	220		0.760		1.365		108.690
2nd cp	6	240	0.470		2.235	~~1.475~~	1.475	107.215
	7	260		1.935			1.465	105.750
	8	280		3.225			1.290	104.460
	9	300			3.890		0.665	103.795
	Σ		7.480		7.250	5.125	4.895	

check :

$\Sigma BS - \Sigma FS = 7.480 - 7.250 = +0.23\,m$

$\Sigma Rise - \Sigma Fall = 5.125 - 4.895 = 0.23\,m$

Last RL − First RL = 103.795 − 103.565 = 0.23m

Procedure :

1. First calculate the rise and fall as usual.

2. Now calculate RLs from the 2nd cp to the last point ~~as~~ as usual. ~~Then~~ and the points above the 2nd cp the RLs are calculated as following example:

RL of point 5 = RL of CP_2 ∓ Rise or ∓ fall

$= 107.125 + 1.475$

$= 108.690$

RL of point 4 = RL of point 5 − Rise

$= 108.690 - 1.365 = 107.325$

And so on.

5. The following consecutive readings were taken with level and a 4-metre levelling staff on a continuously sloping ground at common intervals of 30m;

0.85 (on A), 1.545, 2.335, 3.115, 3.825, 0.455, 1.380, 2.055, 2.855, 3.455, 0.585, 1.015, 1.850, 2.755, 3.845 (on B).

The RL of A was 380.500. make entries in a level book and apply the usual checks. Determine Gradient of AB.

solution

Procedure:

observe that the given readings are gradually increasing initially, but they suddenly decrease after the fifth and tenth readings. This indicates that the instrument was shifted after 5th and 10th readings.

St^n	Chainage	BS	IS	FS	H.I	RL	Remarks
					381.355	380.500	
A	0	0.855				379.81	
	30		1.545			379.020	
	60		2.335			378.240	
	90		3.115			377.530	
	120	0.455		3.825	377.985	377.530	CP
	150		1.380			376.605	
	180		2.055			375.930	
	210		2.855			375.130	
	240	0.585		3.455	375.115	374.530	CP.
	270		1.015			374.100	
	300		1.850			373.265	
	330		2.755			372.360	
B.	360			3.845		371.270	
Σ		1.895		11.125	—		—

Check!

$\Sigma BS = 1.895, \ \Sigma FS = 11.125$

$\Sigma BS - \Sigma FS = 1.895 - 11.125 = -9.230$

Last RL − first RL $= 371.270 - 380.5$

$= -9.230.$

checked Gridient $= \frac{9.230}{360} = \frac{1}{39}$ (down

6. In running fly levels, from a benchmark of RL 183.185, the following readings were obtained.

Backsight: 2.085, 1.025, 1.890, 0.625
foresight: 1.925 2.820, 0.890.

From the last position of the instrument five pegs at 25 m interval are to be set out on an uniformly falling gradient of line 100 with 1st peg to have a RL of 182.350. Determine the staff readings required for setting the ~~tops~~ of the five pegs on the given gradient.

solution,

SN	Dist.	BS	IS	FS	HI	RL	Remarks.
1.		2.085			185.270	183.185	
2.		1.025		1.925	184.370	183.345	
3.		1.890		2.820	183.440	181.550	
4.		0.625		0.890	183.175	182.55	
5	0		0.825			182.350	1st peg
6.	25		1.075			182.100	2nd peg
7.	50		1.325			181.8500	3rd peg
8	75		1.575			181.600	4th peg
9.	100			1.825		181.350	5th peg.
Σ		5.625		7.460			

Check: $\Sigma BS - \Sigma FS = 5.625 - 7.460 = -1.835$

Last RL - first RL = 181.35 - 183.185 = -1.835

Procedure:

Upto the point 4 the RL calculation and data entry is as usual. for the reading of 5th point or first peg the following procedure is adopted.

reading for 1st peg = HI of point 4 − RL of point 5 (1st peg)

$= 183.175 - 182.350$ (known)

$= 0.825$

reading for 2nd peg = reading for 1st peg + slope * distance

$= 0.825 + \frac{1}{100} * 25$

$= 1.075$

for 3rd peg $= 0.825 + \frac{1}{100} * 50$

$= 1.325$ and so on.

7. In running fly levels from a BM of RL 2.500m, the following reading (in m) were obtained.

Backsight: 1.315, 2.035, 1.980, 2.625

Foresight: 1.150, 3.450, 2.255

From the position of the last instrument five pegs at 20m interval are to be set out on a uniform rising gradient of 1 in 40. The first peg is to have a RL of 227.245m. Work out the staff readings required for setting the tops of the pegs on the given gradient.

Solution→

Enter BS and FS readings in the level book page and work out the reduced levels of stations.

St.	Dist.	BS	IS	FS	HI	RL	Remarks
1		1.315			251.315	250.000	BM
2		2.035		1.150	252.200	250.165	
3		1.980		3.450	250.730	248.750	
4		2.625		2.255	251.100	248.475	
5	0		3.855			247.245	
6	20		3.355			247.745	
7	40		2.855			248.245	
8	60		2.355			248.745	
9	80			1.855		249.245	
Σ		7.955		8.710			

check:

$\Sigma BS - \Sigma FS = 7.955 - 8.710 = -0.755$

Last RL - First RL = $249.245 - 250.000 = -0.755$

Reduced levels of pegs:

Peg 1 = 247.245

Peg 2 = $247.245 + \frac{1}{40} * 20 = 247.745$

Peg 3 = $247.245 + \frac{1}{40} * 40 = 248.245$

Peg 4 = $247.245 + \frac{1}{40} * 60 = 248.745$

Peg 5 = $247.245 + \frac{1}{40} * 80 = 249.245$.

Staff readings at pegs.

~~Peg 1 = 251.100 - 247.245 = 3.855m.~~

Peg 2 = 251.100 - 247.745 = 3.355m

Peg 3 = 251.100 - 248.245 = 2.855m

Peg 4 = 251.100 - 248.745 = 2.355m

Peg 5 = 251.100 - 249.245 = 2.855 m

3. The under noted readings in meters on a levell[ing] with a dumpy staff were taken on a road way AB with a starting level, the staff being held in 1st case at a starting point A and then 20m intervals: 0.765, 1.064, [0.616] 1.835, 1.524, the level was then moved forward to another position and further readings were taken. These were as follows: the last reading being at B: 2.356, 1.378, [2.063], 0.677, 2.027, The level of A is 41.819 m. Set out the readings and complete the bookings. Calculate the gradient from A to B. Figures in brackets denote inverted staff readings.

Chainage	St^n	BS	IS	FS	Rise	Fall	RL (m)	Remarks
							41.819	A
0	1	0.755						
20	2		1.064		-	0.299	41.520	
40	3		-0.616		1.680		43.200	
60	4		1.835			2.451	40.749	
80	5	2.356		1.524	0.311		41.060	
100	6		1.378		0.978		42.038	
120	7		-2.063		3.441		45.479	
140	8		0.677			2.740	42.739	
160	9			2.027		1.350	41.389	B
	Σ	3.121		3.551	6.410	6.840		

Check: ΣBS − ΣFS = 3.121 − 3.551 = −0.430

Σ Rise $- \Sigma$ fall $= 6.410 - 6.840 = -0.430$

Last RL $-$ first RL $= 41.389 - 41.819 = -0.430$

Gradient $= \dfrac{\text{difference in level}}{\text{total distance}} = \dfrac{0.43}{160}$

$= 1$ in 372.093.

3. A Page of an old level book had damaged by white ants and the readings marked X are missing. Find the missing data with the help of available readings and apply arithmetic check.

Dist. (m)	BS	IS	FS	HI	RL	Remarks
	X			X	209.510	BM
0		1.675			X	
30		X			210.425	
60		3.355			209.080	
X	0.840		X	209.520	X	CP
120		X			208.275	
150		X			210.635	underside of bridge girder
X	X		2.680	X	X	
210		X			205.640	
240		1.920			205.395	
270			X		205.690	

Missing readings can be obtained as follows;

i) Difference in R.L' between 240 & 270,

= 205.895 - 205.690

= 0.205.

FS reading corresponding to 270 m chainge = 1.92+0.205

= 2.125 m.

ii) RL at 210 = 206.040.

RL at 240 = 205.890.

Diff. in level = 0.0145.

Hence IS corresponding to 210 m chainage =

1.920 + 0.145 = 2.065 m

iii) With RL = 205.895 & IS = 1.920.

HI at 210 m chainage = 205.895 + 1.920

= 207.815 m

iv) After 150 m chainge will be 150+30 = 180 m.

FS = 2.630 & HI = 209.520,

RL at 180 m will be 209.520 - 2.63 = 206.89 m

Corresponding backsight = 207.815 - 206.890

= 0.925 m

v) At 150, RL = 210.635,

HI = 209.520 m.

IS reading = 209.520 - 210.635 = -1.115 m

vi) At ~~210~~ 120 m, IS = 209.520 - 208.275 = 1.245 m

vii) After 60 m distance will be 90 m.

With BS 0.840 m and HI = 209.520,

RL = 208.680 m

viii) Difference in RL betⁿ 60 & 90

$= 209.08 - 208.68 = 0.400$

Hence, FS at 90m $= 3.355 + 0.400$

$= 3.755$ m

HI $= 209.080 + 3.755 = 312.435$ m

ix) at 30 m, RL = 210.245

HI = 212.435 ; IS = 2.010

x) With IS = 1.675

RL = 212.435 − 1.675 = 210.760 m.

writing the missing readings, the booking will be

Dist. (m)	BS	IS	FS	HI	RL	Remarks
—	2.925			212.435	209.510	
0		1.675			210.760	
30		2.010			210.425	
60		3.355			209.080	
90	0.840		3.755	209.520	208.680	CP
120		1.245			208.275	
150		-1.115			210.635	underside of bridge girder.
180	0.925		2.630	207.815	205.890	CP
210		1.175			206.640	
240		1.920			205.895	
270			2.125		205.690	
Σ	4.690		8.510			

Check:

$\sum BS - \sum FS = ~~6.69~~ 4.690 - 8.510 = -3.820$

Last RL - first RL = 205.690 - 209.510 = -3.820

∴ Checked.

10. Following is a page of level field book. Fill in the missing readings and calculate the reduced level of all the points. Apply the usual checks.

Stn	BS	IS	FS	Rise	Fall	RL	Remarks
						? ①	BM
1	3.250				0.750	? ③	CP
2	1.755		? ②			? ④	
3		1.950				? ⑥	
4	? ⑤		1.920			? ⑦	
5		2.340		1.500		? ⑧	
6		? ⑨		1.00		250.00	CP.
7	1.350		2.1850			? ⑩	
8		1.575				? ⑫	
9		? ⑪				? ⑭	CP
10	? ⑬		1.895		1.650	? ⑮	Last Point
11			1.350	0.750			

solution

~~Missing ⑧ = 250.00~~

Missing ② = 3.250 + 0.750 = 4.000

Fall ~~Rise~~ in point ③ from 2 ∴ = 1.950 - 1.755

= 0.195

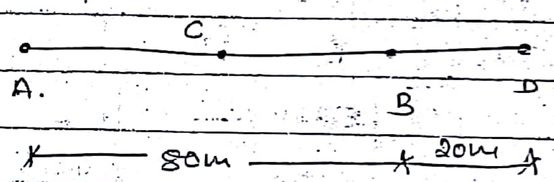
Rise bet^n point 3 & 4 = 1.95 - 1.92 = 0.030
missing (5) = 2.340 + 1.500 = 3.840
missing (9) = 2.340 - 1.00 = 1.340
Rise bet^n point 7 and 8 = 1.850 - 1.575 = 0.275
missing (11) = 1.895 - 1.650 = 0.245
missing (13) = 1.350 + 0.750 = 2.100
Now RLs of the points and rise and falls are calculated as usual.

	BS	IS	FS	Rise	Fall	RL	Remarks
						249.260	
1	3.250						
2	1.755		4.00		0.750	248.510	CP
3		1.950			0.195	248.315	
4	3.840		1.920	0.030		248.345	CP
5		2.340		1.500		249.845	
6		1.340		1.000		250.845	
7	1.850		2.185		0.845	250.000	CP
8		1.575		0.275		250.275	
9		0.245		1.330		251.605	
10	2.100		1.895		1.650	249.995	CP
11			1.350	0.750		250.705	Last pt.
Σ	12.795		11.350	4.895	3.440		

Check: Σ BS - Σ FS = 12.795 - 11.350 = 1.445
Σ Rise - Σ Fall = 4.885 - 3.440 = 1.445
Last RL - First RL = 250.705 - 249.260 = 1.445

11. A dumpy level was set up midway between two pegs 80 m apart. The readings on the staff at two pegs were 3.200 m & 3.015 m, respectively. The instrument was the moved by 20 m ahead of the second peg, in line with two pegs. The readings were 2.825 m and 2.690 m. Calculate the staff readings on two pegs to provide a horizontal line of sight.

solution →



Instrument at C :-

True difference in elevation of A & B

$d_1 = 3.200 - 3.015 = 0.185 m$

(B higher)

Instrument at D :-

Apparent difference in elevation bet^n A & B.

$d_2 = 2.825 - 2.690$

$= 0.135$ (B higher)

since d_1 & d_2 are not same, the line of collimation is not in adjustment.

Now, observed reading on A $= 2.825$ m

True diff of elevation $d_1 = 0.185$ m

The corresponding reading on B = 2.825 - 0.185
= 2.640 m.

Since, the observed reading on B (2.690 m) is more than the correct one (2.640 m), the line of collimation is inclined upwards.

The collimation error = $\overset{obs}{2.690} - \overset{cal}{2.640} = 0.050$

increase in staff reading at A $= \frac{80+20}{80} \times 0.05$

$= 0.0625$

∴ the correct reading at A,

$= 2.825 + 0.0625$

$= 2.8875$ m.

Increase in reading at B $= \frac{20}{80} \times 0.05$

$= 0.0125$

∴ Correct reading at B = 2.690 + 0.0125

= 2.7025 m

check:

True elevation diff = 2.8875 - 2.7025

= 0.185 m.

12. The following observations were taken during the testing of dumpy level.

Instrument at	Staff readings at A	Staff readings at B
A	1.875	2.005
B	1.040	1.660

Is the instrument in adjustment? To what reading should the line of collimation be adjusted when the instrument at B.

Sol^n →

Instrument at A :→

Apparent diff in level = 2.005 − 1.275
= 0.73 m

Instrument at B.

App. diff. in level = 1.660 − 1.040
= 0.62 m.

Since two difference are not equal, the line of collimation is not in adjustment. True difference of level. $= \frac{0.73 + 0.62}{2}$
= 0.675 m.

Collimation error when instrument at B:

correct reading at B = 0.166 m

correct reading at A = 0.166 − 0.675 = 0.985 m

The observed reading on A (1.040 m) being more than the correct one (0.985 m) the line of collimation is inclined upwards.

The amount of inclination = 1.040 − 0.985
= 0.055 m.

13. The following notes refer to the reciprocal levels taken with one level :

Inst. St^n	Staff readings on A	Staff readings on B	Remarks
A	1.03	1.630	Dist. A-B = 800m
B	0.95	1.540	RL of A = 450m

Find: (i) true RL of B
(ii) Combined correction for curvature & refraction
(iii) the error in collimation adjustment of instrument

solution

Instrument at A:

Apparent diff. in levels = 1.63 − 1.03 = 0.6 m.

Instrument at B:

Apparent diff. in levels = 1.540 − 0.95 = 0.59 m.

∴ True diff. in levels of A & B = $\frac{0.6+0.59}{2}$

= 0.595 m.

(A being higher)

(i) ∴ True RL of B = RL of A − diff. in levels.

= 450 − 0.595 = 449.405 m.

(ii) Combined correction for curvature & refraction

$= 0.0673 D^2 = 0.0673 \left(\frac{800}{1000}\right)^2$

= 0.043 m.

(iii) Error in collimation adjustment

Reading at A = 1.03 m.

Fall from A to B = 0.595 m

∴ Required reading of level line = 1.03 + 0.595

= 1.625 m

The actual staff reading at B $= 1.625 + 0.043$
$= 1.668$ m.

But observed reading at B $= 1.630$ m.

$\therefore$ Error in collimation adjustment
$= 1.668 - 1.630 = 0.038$ m.

$\because$ Collimation is −ve since the observed reading (1.63) is less than actual one (1.668)
$\therefore$ collimation is downward.

14. The results of reciprocal levelling between stations A and B 250m apart on opposite side of wide river were as follows:

Level at	Height of eyepiece (m)	Staff reading
A	1.399 a_1	2.518 on B b_1
B	1.332 b_2	0.524 on A a_2

Find: (a) True difference of level bet^n the stations.
(b) The error due to imperfect adjustment of instrument assuming the mean radius of the earth 6365 km.

Solution

True diff. in level $= \frac{1}{2}[(a_1 - b_1) + (a_2 - b_2)]$
$= \frac{1}{2}[(1.399 - 2.518) + (0.524 - 1.332)]$
$= -0.964$ m.

A is lower than B.

Total error $= \frac{1}{2}\left[(a_2-b_2) - (a_1-b_1)\right]$

$= \frac{1}{2}\left[-0.808 - (-1.119)\right]$

$= +0.156m.$

Error due to curvature & refraction

$= \frac{6L^2}{7 \times 2R} = \frac{6 \times 250^2}{7 \times 2 \times 6365000}$

$= 0.00421 m.$

$\therefore$ Error due to collimation $= 0.156 - 0.004$

$= 0.152$ in 250m.

$\therefore$ error/100m $= \frac{0.152 \times 100}{250} = 0.061 m.$

15. The following observations were taken in reciprocal levelling:

Instrument at	Staff readings at A	Staff readings at B
A	1.625	2.545
B	0.725	1.405

Determine the RL of B if that of A is 100.105. Also calculate the angular error in collimation if the distance betn A & B is 1000m.

Soln →

True difference in levels of A & B

$= \frac{(1.625-2.545)+(0.725-1.405)}{2}$

$= -0.800 m.$

$\therefore$ RL of B = 100.105 − 0.800 = 99.305 m.

$$e = \cancel{\frac{(1.625 - 2.545) - (0.725 - 1.405)}{2}}$$

$$e = \frac{(0.725 - 1.405) - (1.625 - 2.545)}{2}$$

$e = +0.120$

error due to collimation $= 0.12 - 0.0673\,d^2$

$= 0.12 - 0.0673 \times \left(\frac{1000}{1000}\right)^2$

$= 0.0527$ m.

As e is +ve, the line of sight is inclined upwards.

If α is the angular error of collimation,

$$\tan\alpha = \frac{e}{1000} = \frac{0.0527}{1000} = 3.02 \times 10^{-3}\ \text{degree}$$

$= 10.87''$

* * * *

THEODOLITE

- Khemraj Regmi

→ In this chapter, the numerical question used to ask as before is only one type & computation of the horizontal angle and correction if necessary.

065 shrawan

1. The following are field notes of theodolite survey on traverse ABCDA.

Station	Sighted to	Horizontal Circle Readings					
		Face Left			Face Right		
		°	'	''	°	'	''
A	D	00	00	00	179	59	50
	B	60	42	20	240	42	10
B	A	00	00	00	180	00	10
	C	98	55	40	278	55	50
C	B	00	00	10	180	00	00
	D	82	12	30	262	12	20
D	C	00	00	10	179	59	50
	A	118	10	30	289	10	10

Compute the Horizontal angles and correct them if necessary.

solution:

Calculation table: Next page,

$$\text{error} = 360^\circ 00' 45'' - 360^\circ 00' 00'' = 00^\circ 00' 45''$$

$$\therefore \text{Correction/each angle} = -\frac{00^\circ 00' (45'')}{4} = -00^\circ 00' 11.25''$$

$$\therefore -11''(3) + -12''(1)$$

↳ larger angle ∠D.

Station	Sighted to	Face	Horizontal angle Observation						Horizontal Angle			Correction			Corrected Angle		
			Observation set			Mean											
			°	'	"	°	'	"	°	'	"	°	'	"	°	'	"
A	D	L	00	00	00	60	42	20	60	42	20	(−) 00	00	11	60	42	09
	B	L	60	42	20												
	D	R	179	59	50	60	42	20									
	B	R	240	42	10												
B	A	L	00	00	00	98	55	40	98	55	40	(−) 00	00	11	98	55	29
	C	L	98	55	40												
	A	R	180	00	10	98	55	40									
	C	R	278	55	50												
C	B	L	00	00	10	82	12	30	82	12	25	(−) 00	00	11	82	12	14
	D	L	82	12	30												
	B	R	180	00	00	82	12	20									
	D	R	262	12	20												
D	C	L	00	00	10	118	10	20	118	10	20	(−) 00	00	12 (larger angle)	118	10	08
	A	L	118	10	30												
	C	R	179	59	50	118	10	20									
	A	R	298	10	10												
Total									360	00	45	(−) 00°	00'	45"	360	00'	00

2. The following are the field note of theodolite traverse survey.

Station	Sighted to	Horizontal Circle Reading					
		Direct			Reverse		
		°	'	"	°	'	"
A	C	00	00	10	180	00	00
	B	30	00	20	210	00	00
B	A	00	00	00	180	00	20
	C	60	00	00	240	00	10
C	B	00	00	10	180	00	00
	A	90	00	05	270	00	10

Compute the horizontal and Apply the check.

Sighted to	Face	Horizontal angle observation									Correction	Corrected angle
		Observation set			Angle			Mean				
		°	'	"	°	'	"	°	'	"		
C	L	00	00	10"	30	00	10				(+)	30° 00' 12"
B	L	30	00	20				30	00	05	00° 00'	
C	R	180	00	00	30	00	00				07"	
B	R	210	00	00								
A	L	00	00	00	60	00	00				(+)	60° 00' 02"
C	L	60	00	00				59	59	55	00° 00'	
A	R	180	00	20	59	59	50				07"	
C	R	240	00	10								
B	L	00	00	10	89	59	05				(+)	89° 59' 46"
A	L	90	00	05				89	59	38	00° 00'	
B	R	180	00	00	90	00	10				08"	
A	R	270	00	10								

P.60

∴ sum of observed angles = $179^\circ 59' 38''$.

~~error~~

Theoretical sum = $(2\times3-4)\times90^\circ = 180^\circ 00' 00''$

∴ Error = $-22''$

∴ Correction/each angle = $+22''/3 = +7.33''$

$= +7''(2) + +8''(1)$.

3. The following observations were recorded in a theodolite traverse ABCDA. Compute the mean horizontal angles and adjust them if necessary.

Inst. Stn	Target Stn	Horizontal Circle Readings:-	
		FL	FR
A	D	$90^\circ 00' 10''$	$269^\circ 59' 50''$
	B	$209^\circ 25' 40''$	$29^\circ 25' 30''$
B	A	$89^\circ 59' 30''$	$270^\circ 00' 10''$
	C	$180^\circ 16' 10''$	$00^\circ 16' 00''$
C	B	$90^\circ 00' 00''$	$269^\circ 59' 50''$
	D	$179^\circ 03' 40''$	$359^\circ 03' 20''$
D	C	$89^\circ 59' 50''$	$270^\circ 00' 10''$
	A	$160^\circ 12' 40''$	$340^\circ 12' 30''$

Inst. st.	Target st.	Face	Horizontal Angle observation: Observation °	'	"	Angle °	'	"	Mean °	'	"	Correction °	'	"	Corrected Angle °	'	"	Remarks
A	D	L	90	00	10	119	25	30	119	25	35	(−) 2°	15	45	117	09	50	
	B	L	209	25	40													
	D	R	269	59	50	119	25	40										
	B	R	29	25	30													
B	A	L	89	59	30	90	16	40	90	16	15	(−) 2	15	45	88	00	30	
	C	L	180	16	10													
	A	R	270	00	10	90	15	50										
	C	R	00	16	00													
C	B	L	90	00	00	89	08	40	89	08	35	(−) 2	15	45	86	52	50	
	D	L	179	08	40													
	B	R	269	59	50	89	08	30										
	D	R	359	08	20													
D	C	L	89	59	50	70	12	50	70	12	35	(−) 2	15	45	67	56	50	
	A	L	160	12	40													
	C	R	270	00	10	70	12	20										
	A	R	340	12	30													
						Σ			369	03	00							

Error = $369^\circ 03' 00'' - 360^\circ 00' 00'' = 09^\circ 03' 00''$

$\therefore$ Correction / each angle = $-\ 09^\circ 03' 00''/4 = -2^\circ 15' 45''$ ##

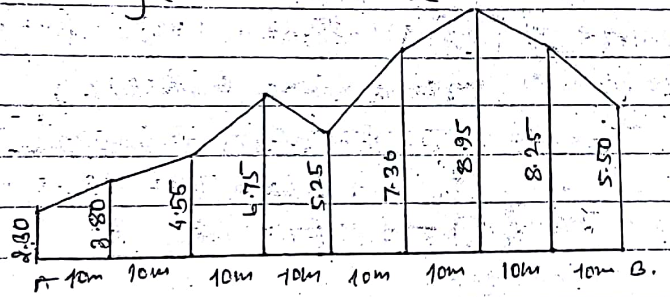
****

AREA, VOLUMES

- Khemraj Regmi

1. The following perpendicular offsets were taken at 10m intervals from a survey line AB to an irregular boundary line, 2.30, 3.80, 4.55, 6.75, 5.25, 7.30, 8.95, 8.25 and 5.50 meters. Calculate the area in square meters, enclosed between the survey lines and irregular boundary the first and last offsets by using:

ⓐ the simpson's rule
ⓑ The trapezoidal rule.
ⓒ Average ordinate rule:-



Given:

Common distance = 10m,

ⓐ Simpson's rule,

A = $\frac{d}{3}$ [First offset + last offset + twice the sum of remaining odd offsets + four times the sum of remaining even offsets]

$= \frac{10}{3}$ [2.30 + 5.50 + 2 * (4.55 + 5.25 + 8.95) + 4 * (3.80 + 6.75 + 7.30 + 8.25)]

$= \frac{10}{3}$ * 149.7 = 499 m²

Not simpson's rule is only applicable for the case when the no. of ordinates are odd ~~and~~. If the even no. of ordinates are there, the last one is ommitted first for the use of simpson's rule application and then thats area is added to the area from simpson's rule.

(b) Trapezoidal rule

$$A = \frac{d}{2}[\text{first offset} + \text{last offset} + 2 * \text{sum of remaining offsets}]$$

$$= \frac{10}{2}[2.30 + 5.50 + 2(3.80 + 4.85 + 6.75 + 5.25 + 7.30 + 8.95 + 8.25)]$$

$$= 5 * 97.5 = 487.5\ m^2$$

(c) Average ordinate rule

$$A = \frac{\text{sum of ordinates}}{\text{No. of ordinates}} * \text{length of base}$$

$$= \frac{(2.30 + 3.50 + 4.55 + 6.75 + 5.25 + 7.30 + 8.95 + 8.25 + 5.50)}{9} * 80$$

$$= \frac{42.12 * \cancel{80}}{9} = 468.00\ m^2.$$

2. A series of offsets were taken from a chain line to a curved boundary line at an interval of 10m in the following order.
0, 2.85, 3.95, 6.45, 8.60, 8.90, 5.25, 0 meters.
Calculate the area between the chain line and the curved boundary line by the simpson's rule.

Solⁿ

Here are eight (even) offsets. Hence the direct application of the Simpson's rule is ~~rejected~~ prohibited. The problem is solves as following.

$$A = \frac{10}{2}(0 + 2.85) + \frac{10}{3}\left[2.85 + 0 + 2(6.45 + 8.90) + 4 * (3.95 + 8.60 + 5.25)\right]$$

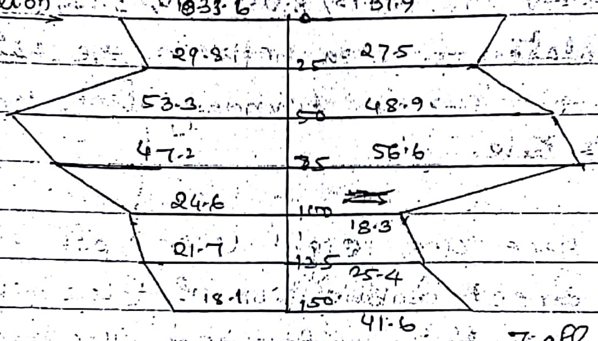
$$= 350.6\ m^2$$

3. Calculate ~~the~~ using simpson's rule the area enclosed between the boundaries of the field, offsets to which have been taken from a chain line at intervals of 25m to the right and left.

offset left	Distance	offset right
33.6 meters	0 meters	31.9 meters
29.8 "	25 "	27.5 "
55.3 "	50 "	48.9 "

47.2 m	75 m	56.6 m
24.6 m	100 m	18.3 m
21.7 m	125 m	25.4 m
18.4 m	150 m	41.6 m

solution



7 offsets.

The area enclosed by the chain line and ends of offsets right,

$$A = \frac{d}{3}\left[h_1 + h_n + 2(h_3 + h_5 + \cdots) + 4(h_2 + h_4 + \cdots)\right]$$

$$= \frac{25}{3}\left[31.9 + 41.6 + 2(48.9 + 18.3) + 4(27.5 + 56.6 + 25.4)\right]$$

$= 5382.5$ sq.m.

similarly on left,

$$A = \frac{d}{3}\left[h_1 + h_n + 2(h_3 + h_5 + \cdots) + 4(h_2 + h_4 + \cdots)\right]$$

$$= \frac{25}{3}\left[33.6 + 18.4 + 2(53.3 + 24.6) + 4(29.8 + 47.2 + 21.7)\right]$$

$= 5052.5$ sq. m.

$\therefore$ Total area $A = A_1 + A_2$

$= 5382.5 + 5052.5$

$= 10435$ sq m.

4. calculate the area enclosed by a closed traverse with the following data:

Side	Latitudes (m)		Departures (m)	
	N(+)	S(-)	E(+)	W(-)
AB	220.5	-	120.0	-
BC	-	240.2	200.5	
CD	-	160.0	-	100.5
DA	179.7	-	-	220.0.

(a) From co-ordinates:→

Let co-ordinates of A be (N 500 E 500)

Side	Lat.	Dep.	station	Independent co-ordinates	
AB	+220.5	+220.0	A	500.0	500.0
BC	-240.2	+200.5	B	720.5	620.0
CD	-160.0	-100.5	C	480.3	820.5
DA	+179.7	-220.	D	320.3	720.0
			A	500.0	500.0

500 720.5 480.3 320.3 500.0

500 620.5 820.5 720.0 500.0

$\Sigma P = 500 * 620.5 + 720.5 * 820.5 + 480.3 * 720.0 + 320.3 * 500.0$

$= 1407386.25$

$\Sigma Q = 500 * 720.5 + 620.5 * 480.3 + 820.5 * 320.3 + 720.0 * 500.0$

$= 1281082.30$

$A = \frac{(\Sigma P - \Sigma Q)}{2} = \frac{1407386.25 - 1281082.30}{2} = 63151.975$ sq m

(b) From DMD

calculation of DMD

DMD of AB = 120.0

DMD of BC = 120.0 + 120.0 + 200.5 = 440.5

DMD of CD = 440.5 + 200.5 − 100.5 = 540.5

DMD of DA = 540.5 − 100.5 − 220.0 = 220.0.

$$\text{Area} = \frac{1}{2}\left[\Sigma \text{latitude of line} * \text{DMD of respective line}\right]$$

$$= \frac{1}{2}\left|\left[120 * 220.5 + 440.5 * (-240.2) + 540.5\,(-160.0) + 220.0 * 179.7\right]\right|$$

$$= \frac{1}{2}\left|-126294.1\right| = 63147.05$$

DMD = DMD & departure of the preceeding line + departure of itself

ⓒ Area from the departures and total latitudes :-

1	2	3	4	5	6	7
Side	Lat.	Dep.	St^{n}.	Total Lat.	Algebric sum of adjoining dep.	col-5 x col-6
AB	220.5	+120.0	B	220.5	320.5	70670.25
BC	−240.2	+200.5	C	−19.7	100.0	−1970.0
CD	−160.0	−100.5	D	−179.7	−320.5	57593.85
DA	+179.7	−220.0	A	0.0	−100	0.00
						−126294.40

$$\therefore \text{Area} = \frac{1}{2}\left|-126294.10\right|$$

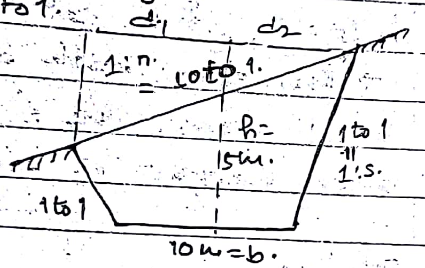
$$= 63147.05\ m^2$$

Volumes:

5. Compute the volume of the earthwork in a road cutting 50 meters long from the following data:

The formation width 10 m, side slopes 1 to 1; average depth of the cutting along the centre line 5 m; slope of the ground transverse to cross-section 10 to 1.

Solution



$$A = \frac{d_1 d_2}{s} - \frac{b^2}{4s}$$

$$d_1 = \left(h + \frac{b}{2s}\right)\left(\frac{ns}{n+s}\right)$$

$$= \left(5 + \frac{10}{2.1}\right)\left(\frac{10 * 1}{10+1}\right)$$

$$= 10 * \frac{10}{11} = \frac{100}{11} \text{ m}$$

$$d_2 = \left(h + \frac{b}{2s}\right)\left(\frac{ns}{n-s}\right)$$

$$= \left(5 + \frac{10}{2.1}\right)\left(\frac{10 \times 1}{10-1}\right)$$

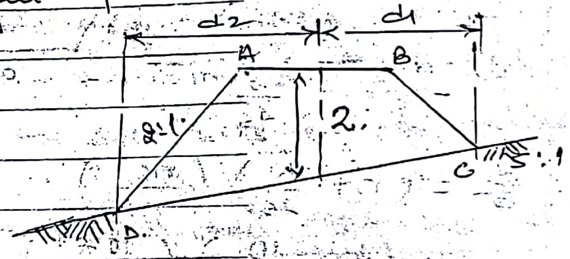
$$= 10 * \frac{10}{9} = \frac{100}{9} \text{ m}$$

$$A = \frac{d_1 d_2}{s} - \frac{b^2}{4s} = \frac{\frac{100}{11} * \frac{100}{9}}{10} - \frac{10^2}{4 * 10}$$

$$= 76.01 \text{ m}^2$$

$\therefore$ volume of cutting, $V = A \times l$
$= 76.01 * 50$
$= 3800.05\ m^3$

6. Compute the volume of the earth work in a road embankment 100 meters long from the following given data:
→ formation width 6m; side slope of banking 2 to 1. Transverse slope of ground 5 to 1; the mean height of the embankment 2 meters



Solution,
$b = 6m$
$n = 5$
$s = 2$
$h = 2m$
$l = 100m$,

$\cancel{As}\ d_1 = \left(h + \frac{b}{2s}\right)\left(\frac{ns}{n+s}\right)$

$= \left(2 + \frac{6}{2.2}\right)\left(\frac{5.2}{5+2}\right)$

$= 3.5 * \frac{10}{7} = 35/7\ m$

$d_2 = \left(h + \frac{b}{2s}\right)\left(\frac{ns}{n-s}\right)$

$= \left(2 + \frac{6}{2.2}\right)\left(\frac{5.2}{5-2}\right)$

$= 3.5 * \frac{10}{3} = \frac{35}{3}\ m$

$$A = \frac{d_1 d_2}{s} - \frac{b^2}{4s}$$

$$= \frac{\frac{35}{7} \times \frac{35}{3}}{2} - \frac{6^2}{4 \times 2}$$

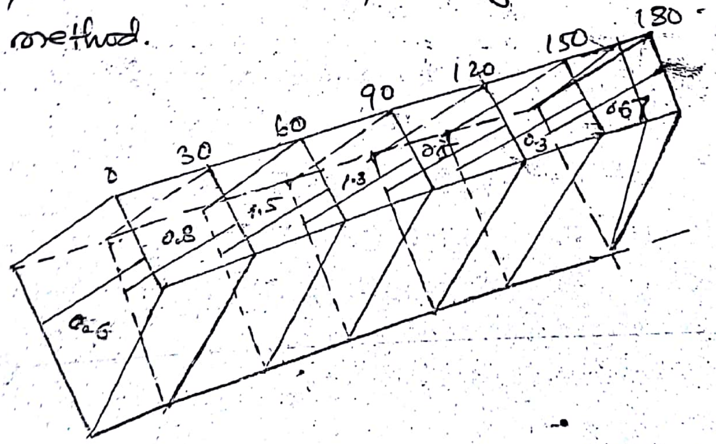
$$= \frac{35 \times 35}{42} - \frac{36}{8} = 24.67\,\text{sqm}$$

Volume of earthwork $= \cancel{24.67}\ A \times l$

$= 24.67 \times 100$

$= 2467\ m^3$

7. A railway embankment is 9m wide at formation level, with side slopes 2 to 1. Assuming the ground to be level transversely, calculate the volume of the embankment in cubic meters in a length of 180m, the centre heights at 30m intervals being 0.6, 0.8, 1.5, 1.8, 0.75, 0.3 and 0.67 m respectively. Use trapezoidal method.



Areas in different cross section:

at 0m, $A_1 = (b + sh) * h$

$= (9 + 2*0.6)*0.6 = 6.12 m^2$

30m, $A_2 = (9+2*0.8)*0.8 = 8.48 m^2$

60m, $A_3 = (9+2*1.5)*1.5 = 18.0 m^2$

90m, $A_4 = (9+2*1.8)*1.8 = 22.68 m^2$

120m, $A_5 = (9+2*0.75)*0.75 = 7.875 m^2$

150m, $A_6 = (9+2*0.3)*0.3 = 2.88 m^2$

180m, $A_7 = (9+2*0.67)*0.67 = 6.928 m^2$.

volume of the embankment by trapezoidal method,

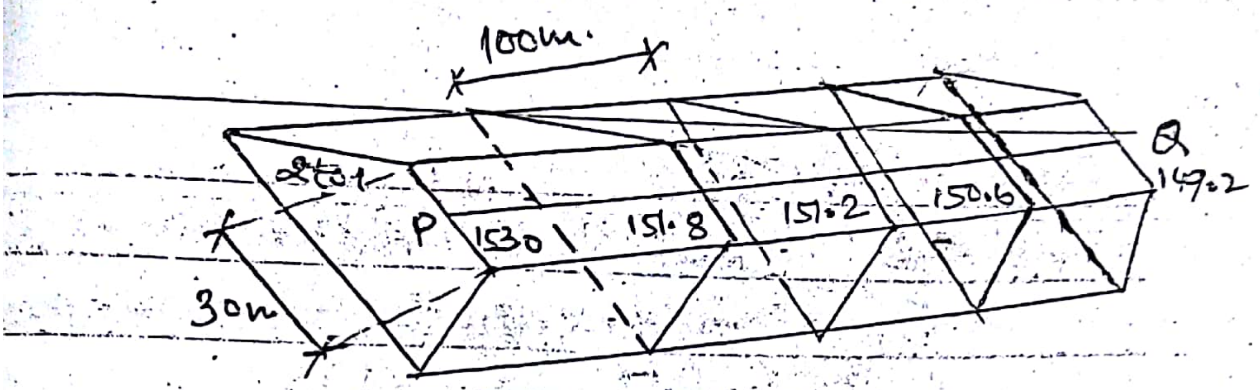
$$V = h\left[\frac{A_1+A_7}{2} + A_2 + A_3 + A_4 + A_5 + A_6\right]$$

$$= 30\left[\frac{6.12+6.928}{2} + 8.48 + 18.0 + 22.68 + 7.875 + 2.88\right]$$

$= 1993.35 m^3$. #.

8. A road embankment of 30m wide at the top with side slopes of 2 to 1. The ground levels at 100 meter intervals along line PQ are under P 153.0, 151.8, 151.2, 150.6, 149.2 Q.

The formation level at P is 161.4 m with uniform falling gradient of 1 in 50 from P to Q. Calculate by prismoidal formula the volume of earth work in cubic meters, assuming the ground to be level in cross-section.



formation levels:

at P, $Ch = \cancel{1\ldots}$ 161.4 m.

at 100m = $161.4 - \frac{100}{50} = 159.4$ m.

at 200 m = 157.4m

at 300m = 155.4m.

at 400m = 153.4 m.

The depths of the embankment at various sections

at 0m, = 161.4 − 153.0 = 8.4 m

100m, = 159.4 − 151.8 = 7.6 m

200m = 157.4 − 151.2 = 6.2m.

300m = 155.4 − 150.6 = 4.8m.

400m = 153.4 − 149.2 = 4.2m.

Areas at different sections:

$A_1 = (b+Sh)h.$

$= (30 + 2*8.4)\,8.4 = 393.12\,m^2$

$A_2 = (b+Sh)h.$

$= (30+2*7.6)*7.6 = 343.52\,m^2$

$A_3 = (30+2*6.2)*6.2 = 262.88\,m^2$

$A_4 = (30+2*4.8)*4.8 = 190.08\,m^2$

$A_4 = (30+2*4.2)*4.2 = 161.28\,m^2$

$A_5 = (30+2*4.2)*4.2 =$

From prismoidal

$V = \frac{100}{3}$ [Area of first section + area of last section + 4 * area of even sections + 2 * area of odd sections]

$= \frac{100}{3} [393.12 + 161.28 + 4(342.52 + 190.08) + 2 * 262.88]$

$= \frac{100}{3} [393.12 + 161.28 + 2134.4 + 525.76]$

$= 107152 m^3$.

9. In a certain road cutting the width ~~of~~ at the formation level is 20 meters, the sides of the cutting slopes are 1.5 horizontals to 1 vertical & the surface of ground has a uniform transverse slope of 1 in 10. Compute the volume of excavation contained in a length of 200 meters. The depth of cutting at 100m intervals along the centre of formation level are 25, 26, and 80 meters respectively at the three consecutive sections.

Solution

~~Section 1~~ $n = 10$, $s = 1.5$, $b = 20m$.

Section 1.

$h = 25$,

$d_1 = \left(h + \frac{b}{2s}\right)\left(\frac{ns}{n+s}\right)$

$= \left(25 + \frac{20}{2 \times 1.5}\right)\left(\frac{10 * 1.5}{10 + 1.5}\right)$

$$= \frac{950}{23} m.$$

$$d_2 = \left(h + \frac{b}{2s}\right)\left(\frac{ns}{n-s}\right)$$

$$= \left(25 + \frac{20}{2*1.5}\right)\left(\frac{10*1.5}{10-1.5}\right)$$

$$= \frac{950}{17} m.$$

$$A_1 = \frac{d_1 d_2}{s} - \frac{b^2}{4s} = \frac{\frac{950}{23} * \frac{950}{17}}{1.5} - \frac{20^2}{(4*1.5)}$$

$$= 1472.12 \ m^2$$

similarly, Section 2.

$$h = 26.$$

$$d_1 = \frac{980}{23}, \quad d_2 = \frac{980}{17}$$

$$A_2 = \frac{d_1 d_2}{s} - \frac{b^2}{4s} = \frac{\frac{980}{23} \times \frac{980}{17}}{1.5} - \frac{20^2}{4*1.5}$$

$$= 1570.84 \ m^2$$

And section 3,

$$h = 30.$$

$$d_1 = \frac{1100}{23}, \quad d_2 = \frac{1100}{17}$$

$$A_3 = \frac{d_1 d_2}{s} - \frac{b^2}{4s} = \frac{\frac{1100}{23} * \frac{1100}{17}}{1.5} - \frac{20^2}{4*1.5}$$

$$= 1996.42 m^2$$

① volume by Prismoidal formula

$$V = \frac{100}{3}\left((1472.12 + 1996.42) + 4 * 1570.84\right)$$

$= 325068.33\ m^3$.

(ii) Volume by end area formula,

$$V = 100\left(\frac{1472.12 + 1996.42}{2} + 1570.84\right)$$

$= 330511\ m^3$.

10. A road embankment 35m wide at formation level with side slopes 1:1 and with an average height of 12m is constructed with average gradient of 1 in 30 from contour 140m to 580m. The ground has an average slope of 12 to 1 in direction transverse to centre line. Calculate (i) length of the road; (ii) volume of the embankment in cu^3.

solution

$b = 35m$,

$s = 1$, $h = 12$, $n = 12$

Here change (difference) in gradient

$= 580 - 140 = 440m$.

Allowable rise is ~~30m~~ ; 1m in 30m.

∴ for 440m rise, length will be,

$30 * 440 = 13200m$

now for Area (Average)

$$d_1 = \left(h + \frac{b}{2s}\right)\left(\frac{ns}{n+s}\right)$$

$$= \left(12 + \frac{35}{2\cdot1}\right)\left(\frac{12\cdot1}{12+1}\right)$$

$$= \frac{59}{2} * \frac{12}{13} = \frac{354}{13}.$$

$$d_2 = \left(h + \frac{b}{2s}\right)\left(\frac{ns}{n-s}\right)$$

$$= \left(12 + \frac{35}{2*1}\right)\left(\frac{12*1}{12-1}\right)$$

$$= \frac{59}{2} * \frac{12}{11} = \frac{354}{11}$$

$$A = \frac{d_1 d_2}{s} - \frac{b^2}{4s} = \frac{\frac{354}{13} * \frac{354}{11}}{1} - \frac{35^2}{4*1}$$

$$= 570.085 \ m^2.$$

∴ volume of the embankment

$$V = A * L.$$

$$= 570.085 * 13200$$

$$= 7525130.77 \ m^3.$$

$$= 7.525 * 10^6 \ m^3.$$

$$= 7.525 * 10^6 * 10^6 \ cm^3.$$

$$= 7.525 * 10^{12} \ cm^3.$$

* * * *

Best of Luck