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SURVEYING

Text Book : Theory with worked out Examples and Practice Questions

10 Surveying

(Solutions for Text Book Practice Questions)

01. Fundamental Concepts

01. Ans: (c)

Sol: Plan area = 9.5 × 11.5 cm

= 109.25 cm^2

Ground area = 63500 m^2

$$\text{Scale} = \sqrt{\frac{\text{Map area}}{\text{Ground area}}} = \sqrt{\frac{109.25\times10^4}{63500}}$$

$$\simeq \frac{1}{2411}$$

02. Ans: (a)

Sol: Shrinkage factor = [100 – 6%]

= 94% = 0.94

L = ? B = ?

$$L = \frac{6}{0.94} \qquad B = \frac{9}{0.9}$$

L = 6.38 cm B = 9.58 cm

Dimension = 6.38 × 9.58 cm

03. Ans: (c)

Sol: Least count = $\frac{S}{n}$

$$0.01^\circ = \frac{\left(\frac{1}{5}\right)^\circ}{n}$$

Vernier dividing n = 20

Number of main scale dividing = 2n – 1

= 2 × 20 –1

= 39

04. Ans: (1 in 555.55)

Sol: Original R.F = 1 : 500

Shrunk factor = 0.9

$$\text{Revised R.F.} = \frac{1}{500}\times0.9$$

= 1 in 555.55

05. Ans: (c)

Sol: Theodolite is divided into degrees and half degrees in the length of 59 MSD, LC of direct vernier ?

$$\text{L.C.} = \frac{S}{n}$$

$$S = \frac{1}{2} = 30'$$

In direct vernier, 'n' div of V = (n – 1) div of M.S. n – 1 = 59

n = 60

$$\therefore \text{L .C} = \frac{30'}{60} = \frac{(30\times60)''}{60} = 30''$$

06. Ans: (c)

Sol: 1 cm = 100 m; O.L = 100 cm;

S.L. = 95 cm; M.A = 810 cm^2,

Correct Area = ?

Actual area in km^2 of survey

Planimeters which is a minor instrument is used for measurement of area of a map.

$$\text{C.A.} = \frac{\text{M.A.}}{(\text{S.F})^2}$$

$$\text{S.F.} = \frac{95}{100} = 0.95$$

$$\text{C.A.} = \frac{810}{(0.95)^2} = 897.501$$

$= 897.51 \text{ cm}^2$ (on map)

Scale:

1 cm = 100 m

C.A = 897.51 (100 × 100)

$= 8.9751 \times 10^6 \text{m}^2$

$= 8.9751 \times 10^6 \times 10^{-6} \text{ km}^2$

C.A. = 8.9751 km^2 (on ground)

Conventional Practice Solutions

01.

Sol: True area $A = A' \times \left[\frac{L'}{L}\right]^2$

$= (300 \times 450) \times \left[\frac{20.15}{20}\right]^2$

$= 1,37,032.6 \text{ m}^2$

02.

Sol: Let 'L' be the length the line in the plan

Actual length on the ground = 3000L 'm'

Measured length on the ground = 4000L 'm'

$\therefore$ Difference = 4000L – 3000L = 1000L 'm'

$$\% \text{ error in length} = \frac{1000L}{3000L} \times 100 = 33.33\%$$

% error in area

Actual area = $(3000L)^2$

Measured area = $(4000L)^2$

Difference in area = $(4000L)^2 - (3000L)^2$

% error in area

$$= \frac{[(4000L)^2 - (3000L)^2]}{(3000L)^2} \times 100$$

$$= \left(\frac{16-9}{9}\right) \times 100 = 77.77\%$$

03.

Sol: Shrinkage factor $= \frac{19.5}{20} = 0.975$

$$\text{True Area} = \frac{\text{M.A}}{(\text{S.F})^2} = \frac{98.55}{(0.975)^2}$$

$= 103.6686 \text{ cm}^2$

L = 30 m; L′ = 30.15 m

$$A = A'\left[\frac{L'}{L}\right]^2 = 103.6686 \times \left[\frac{30.15}{30}\right]^2$$

$= 104.71 \text{ cm}^2$

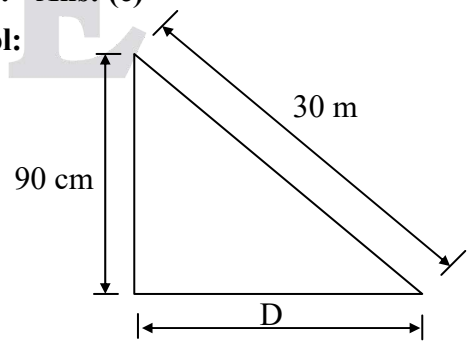
True area of land = [104.71 × 25 × 25]

$= 65,443.75 \text{ m}^2$

02. Linear Measurement Including Chain Survey

01. Ans: (c)

Sol:

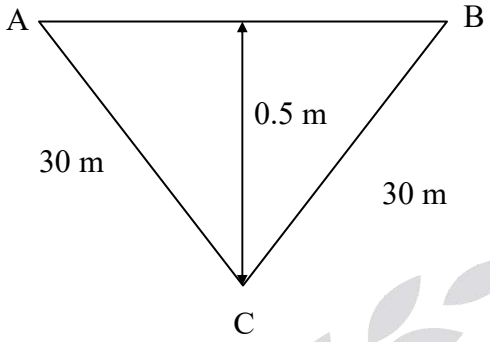


$D = \sqrt{(30)^2 - 0.9^2}$

= 29.986 cm

02. Ans: 59.992 m

Sol:



$$C_{M.A} = \frac{d^2}{L}$$

$$= \frac{(0.5)^2}{30} = 0.008\text{m} \ (-\text{ve})$$

Correct distance = 60 – 0.008

= 59.992 m

03. Ans: (d)

Sol: $C_{sag} = \frac{w^2 L}{24P^2}$

$$= \frac{25^2 \times 50}{24 \times 150^2}$$

= 0.0579 m (–)

Correct distance = 50 – 0.0579

= 49.942 m

04. Ans: (b)

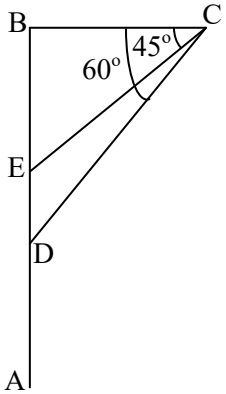
Sol: $\tan 60^\circ = \frac{BD}{BC}$

BD = 250 tan 60°

= 433.012 m

$\sin 60^\circ = \frac{BD}{CD}$

CD= 500 m



$\tan 45 = \frac{EB}{BC}$

EB = 250 m

$\sin 45 = \frac{BE}{EC}$

EC = 354 m

05. Ans: 213 m

Sol: $\sin\theta_1 = \frac{180}{300}$

$\theta_1 = 36.86$

$\sin\theta_2 = \frac{150}{240}$

$\theta_2 = 38.68$

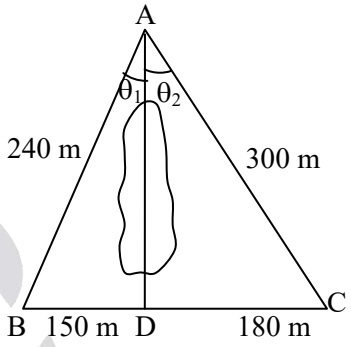
$\theta = \theta_1 + \theta_2 = 75.54$

150 + 180 = 330

$\tan\left(\frac{\theta}{2}\right) = \frac{330/2}{AD}$

AD = 212.9 m

$\simeq$ 213 m



06. Ans: (d)

Sol: Length of chain L = 30m

Incorrect length of chain L′ = 29.8m

Measured distance ℓ' = 450 m

Actual distance = $\ell'\left(\frac{L'}{L}\right)$

$= 450 \times \frac{29.8}{30} = 447$ m

07. Ans: (a)

Sol: Length of base line = 2500 m

Elevation = 200 m

Radius of the earth R = 6370 km

$$C_{MSL} = \frac{Lh}{R}$$

$$= \frac{2500 \times 200}{6370 \times 10^3} = -0.0785\text{m}$$

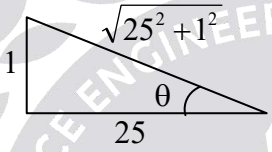
The correction is negative, if the measured distance is above MSL.

08. Ans: (b)

Sol: Slope correction = ?

Length = 60 m

Gradient = 1 in 25



$$\cos\theta = \frac{25}{\sqrt{25^2+1^2}} = 0.99$$

= 60 (1-cos2.29) = 48 mm

09. Ans: (d)

Sol: Length of tape L = 30 m

Pull = 10 kg

3 spans of 10 m

Area of cross section A = 0.08 sq. cm

Density of tape = 7.86 g/cc

$$\text{Correction for sag} = \frac{w^2\ell}{24n^2P^2}$$

w = 7.86 ×0.08 × 30 × 100 = 1.88 kg

$$C_{sag} = \frac{(1.88)^2(30)}{24 \times 3^2 \times 10^2} = -0.0049\,\text{m}$$

10. Ans: (a)

Sol: 30 m chain 10 cm too long measured distance = 2500 m

15 cm too long at the end of day total distance = 4500 m

True distance =?

$$\text{For 2500 m; } L' = \frac{30+30.1}{2} = 30.05\,\text{m}$$

$$\ell_1 = 2500 \times \frac{30.05}{30} = 2504.16\text{ m}$$

$$\text{For 2000 m; } L' = \frac{30.1+30.15}{2} = 30.125$$

$$\ell_2 = 2000 \times \frac{30.125}{30} = 2008.33\,\text{m}$$

Total = 2504.16 + 2008.33

= 4512.49 m

11. Ans: (d)

Sol: Length of tape = 50 m

Std. temperature = 20°C

Pull = 10 kg

Measured temperature =50°

$\alpha = 1 \times 10^{-6}/°C$

$C_{Temp} = l\alpha\,\Delta T$

$= 50 \times 1 \times 10^{-6}$ (50–20)

$= 1.5 \times 10^3$ m

True length of a tape = 50.0015 m

Conventional Practice Solutions

01.

Sol:

(i) Correction for temperature,

$C_t = L\,\alpha\,(T_m - T_o)$

$= 50 \times (11.5 \times 10^{-6}) \times (50 - 30)$

$= 0.0115$ m

(ii) Correction for pull $C_p = \dfrac{(P - P_o)L}{AE}$

$$= \frac{(150-100)\times 50}{(6\times10^{-6})2\times10^{5}\left(\frac{1}{10^{-6}}\right)}$$

$$= 2.083 \times 10^{-3}$$

$$= 0.0021 \text{ m}$$

(iii) Correction for sag $= \dfrac{W^2L}{24P^2}$ $(\because n = 1)$

$$W = \gamma \times V = \frac{0.0756\times10^{-3}}{10^{-9}} \times (6\times10^{-6})\times 50$$

$$= 22.680 \text{ N}$$

$$C_{sag} = \frac{W^2L}{24P^2} = \frac{(22.680)^2\times 50}{24\times150^2} = 0.0476 \text{ m (–)}$$

Total correction = 0.0115 + 0.0021 – 0.0476

$$= -0.034 \text{ m}$$

02.

Sol: $\sin^2\alpha = \left[\dfrac{6.25S^2}{100^2} - e^2\right] \times \dfrac{1}{\ell^2}$

1 cm = 'S' m S = 20 m

$$\sin^2 3 = \left[\frac{6.25\times20^2}{100^2} - (2.5\times10^{-4})^2\right] \times \frac{1}{\ell^2}$$

$$\therefore 0.0523 = \left[0.25 - (2.5\times10^{-4})^2\right] \times \frac{1}{\ell^2}$$

$$0.0523 = 0.2499 \times \frac{1}{\ell^2}$$

$\therefore l = 9.55$ m

03.

Sol: $P = \dfrac{0.204W\sqrt{AE}}{\sqrt{P - P_o}}$;

L = 25 m, P_o = 200 N

W = 78600 × (5 × 10^{-6}) × 25

= 9.825 N

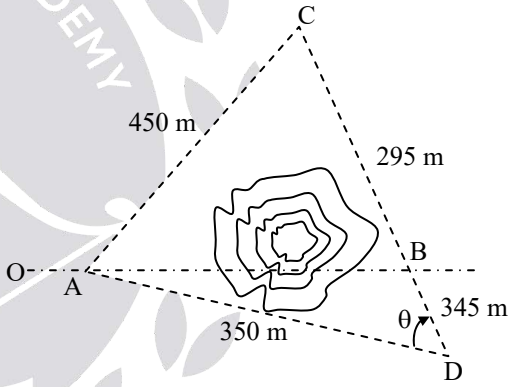
E = 2 × 10^{11} N/m^2

$$P = \frac{0.204\times9.825\sqrt{5\times10^{-6}\times2\times10^{11}}}{\sqrt{P-200}}$$

$\therefore$ P = 259.60 N

04.

Sol:



Triangle ADC:

$$\cos\theta = \frac{DA^2 + DC^2 - CA^2}{2\times DA\times DC}$$

$$= \frac{350^2 + 640^2 - 450^2}{2\times350\times640} = 0.7357$$

Triangle ADB:

$$\cos\theta = \frac{350^2 + 345^2 - AB^2}{2\times350\times345} = 0.7357$$

$350^2 + 345^2 - AB^2 = 177671.55$

AB = 252.69 m

03. Compass Survey

01. Ans: (a)

Sol: M.B = N 5^o 30′ E (5^o 30′)

T.B = N 10^o 30′ w (349^o 30′)

Magnetic declination = T.B –M.B

$= 349^o.30' - 5^o\ 30'$

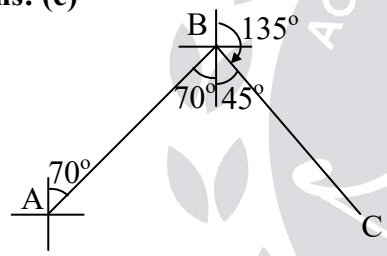
$= 344^o$

$= 16^o \ \because 360^o - 344^o$

= N 16^oW

02. Ans: (c)

Sol:



$\angle B = 70^o + 45^o = 115^o$

03. Ans: (d)

Sol: $W.C.B = \frac{6\pi}{3} \times \frac{180}{\pi} = 360^o$

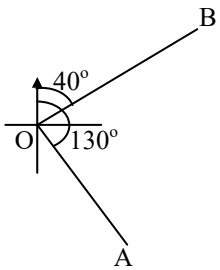
$= 0^o$N

04. Ans: (c)

Sol: Included angle

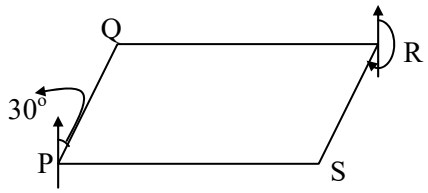
$= 130^o - 40^o$

$= 90^o$



05. Ans: (a)

Sol:



Bearing of RS

$= 180^o + 30^o$

$= 210^o$

06. Ans: (b)

Sol:

Line	F.B
PQ	50°
QR	170°
RS	230°
SP	310°

F.B of SP – F.B of SR

$\angle S = 310° - (230° - 180°) = 260°$

07. Ans: (d)

Sol:

			Corrected		
Line	**FB**	**BB**	**FB**	**BB**	**Correction**
AB	126°30′	307°45′	127°15′	307°15′	–0°30′@ B
BC	49°	227°15′	**48°30′**	228°30′	+1°15′@ C
CD	340°15′	161°30′	341°30′	161°30′	
DE	258°15′	78°15′	258°15′	78°15′	
FA	212°15′	31°30′	212°15′	32°15′	+0°45′@ A

08. Ans: (a)

Sol: D = 6°30′ W

MB = ?

TB = S32°30′E = 147°30′

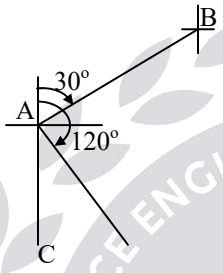
TB = MB ± D

147°30′ + 6°30′ = MB

MB = 154°

09. Ans: (a)

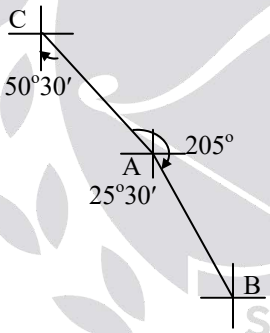
Sol:



∠BAC = 90°

10. Ans: (b)

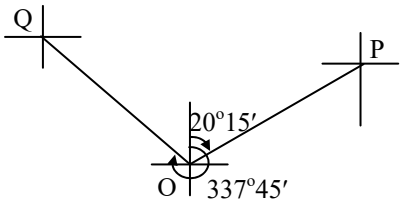
Sol:



∠CAB = 205°

11. Ans: (d)

Sol:



∠QOP = 42°30′

12. Ans: (b)

Sol: True bearing = magnetic bearing ± declination

= 187°30′ – 2° = 185°30′

T.B = 185°30′ – 3°30′ = 182°

13. Ans: (b)

Sol: FB of PA

= N48°45′W (360° –48°45′ – 311°15′)

BB of PA = 311°15′ – 180° = 131°15′

= FB of AP

Observed F.B of AP S50°30′E (129°30′)

∴ Correction for L.A = +1°45′ at A

Corr. M F.B of AB = 80°50′ + 1°45′

= 82°35′

Corr T.B of AB = 82°35′ + 3° = 85°35′

= N85°35′ E

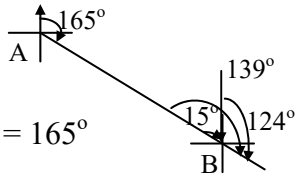
14. Ans: (d)

Sol:

Line	F.B	B.B	
AB	20°	201°	200° –1 at B
BC	100°	**280°**	
CA	230°	50°	

15. Ans: (a)

Sol:



Bearing of a line AB = 165°

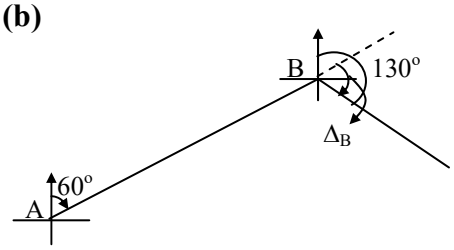
∠ABC = 139°

FB of BC = 139° –15°

= 124°

16. Ans: (b)

Sol:



$\Delta_B = 130^o - 60^o = 70^o$

Conventional Practice Solutions

01.

Sol: I.A = F.B of successive line – F.B of preceding. line

Note: If a calculated included angle is –ve, add 360^o to get actual included angle

$\angle A$ = FB of AB – FB of AD

$= [70^o30' - 140^o47'] + 360^o = 289^o43'$

$\angle B$ = FB of BC – FB of BA

$= [120^o45' - 250^o30'] + 360^o = 230^o15'$

$\angle C$ = FB of CD – FB of CB

$= [223^o30' - 300^o45'] + 360^o = 282^o45'$

$\angle D$ = FB of DA – FB of DC

$= [320^o47' - 43^o30'] = 277^o17'$

Sum of the included angles

$= \angle A + \angle B + \angle C + \angle D$

$= 1080^o$

Check:

Sum = $(2n + 4) \times 90^o = 1080^o$

$(2 \times 4 + 4) \times 90^o = 1080^o$

$\therefore$ No closing error

02.

Sol: FB of successive line = I.A + FB of preceeding. line

FB of BC = $\angle B$ + FB of BA

$= [138^o30' + 206^o35'] = 345^o5'$

FB of CD = $\angle C$ + FB of CB

$= 131^o30' + 165^o5' = 296^o35'$

FB of DE = $\angle D$ + FB of DC

$= 90^o + 116^o35' = 206^o35'$

FB of EA = $\angle E$ + FB of ED

$= 111^o15' + 26^o35' = 137^o50'$

FB of AB = $\angle A$ + FB of AE

$= [68^o45' + 317^o50'] - 360^o$

$= 26^o35'$

03.

Sol: Correction for local attraction:

(i) Calculation of I.A

$\angle A$ = FB of AB – FB of AE

$= 188^o45' - 113^o = 75^o45'$

$\angle B$ = FB of BC – FB of BA

$= 118^o15' - 7^o45' = 110^o30'$

$\angle C$ = FB of CD – FB of CB

$= 346^o35' - 298^o15' = 48^o20'$

$\angle D$ = FB of DE – FB of DC

$= 337^o05' - 166^o30' = 170^o35'$

$\angle E$ = FB of EA – FB of ED

$= 293^o30' - 158^o10' = 135^o20'$

(ii) Arithmetic Check:

Sum = $(2n - 4) \times 90^o$

$540^o30' = 540^o$

Total correction = –30'

Correction to each angle $= \frac{-30'}{5} = -6'$

(iii) Corrected I.A:

$\angle A = 75^o39'$

$\angle B = 110^o24'$

$\angle C = 48^o14'$

$\angle D = 170^o29'$

$\angle E = 135^o14'$

(iv) Calculation of corrected bearings:

As the difference between BC and CB is 180^o, stations B and C are free from local attraction, Hence start from station 'C' to correct the bearings.

Correct FB of CB = $298^o15'$

Correct FB of CD = $298^o15' + 48^o14'$

$= 346^o29'$

Correct FB of DC = $166^o29'$

Correct FB of DE = $166^o29' + 170^o29'$

$= 336^o58'$

Correct FB of EA = $156^o58' + 135^o14'$

$= 292^o12'$

Correct FB of AB = $112^o12' + 75^o39'$

$= 187^o51'$

Correct FB of BC = $7^o51' + 110^o24'$

Correct = $118^o15'$

Corrected Bearings of Lines

Line	FB	BB
AB	$187^o51'$	$7^o51'$
BC	$118^o15'$	$298^o15'$
CD	$346^o29'$	$166^o29'$
DE	$336^o58'$	$156^o28'$
EA	$292^o12'$	$112^o12'$

04.

Sol: T.B = M.B ± Declination = $148^o30' + 3^o30'$

$= 152^o$

M.B = T.B ∓ Declination = $152^o - 2^o15'$

$= 149^o45'$

04. Plane Table Survey

01. Ans: (c)

Sol: PP′ = e.K

E = 50 cm = 500 mm;

$K = \frac{1}{1000}$

$= 500.\frac{1}{1000} = \frac{1}{2} = 0.5$ mm

02. Ans: 0.125 mm

Sol: PP′ = e.K

$K = \frac{1}{2000} = 250.\frac{1}{2000} = 0.125\,\text{mm}$

05. Levelling

01. Ans: 1 in 24

Sol: 0.750, 1.55, 2.25, 2.85, 3.55, 1.75, 2.45, 3.65, 0.950, 2.95, 3.15, 3.75

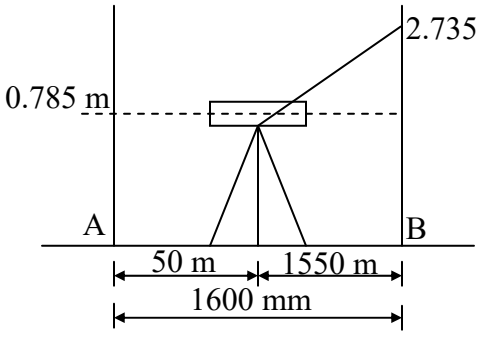
BS	IS	FS	Rise	Fall	RL
0.750					100.50
	1.550			–0.80	
	2.250			–0.70	
	2.850			0.60	
1.75		3.550		–0.70	
	2.450			–0.70	
0.950		3.650		–1.20	
	2.95			–2.0	
	3.15			–0.2	
		3.75		–0.6	93.00

$$\text{Gradient} = \frac{\text{Difference in RL's}}{9\times 20}$$

$$= \frac{7.50}{9\times 20} = 1 \text{ in } 24$$

02. Ans: (a)

Sol:



C.S.R on B = $2.735 - 0.06735 \times 1.55^2$

$= 2.573$ m

T.R.L difference between A & B

$= 2.573 - 0.785$

$= 1.788 \text{ m} \simeq 1.8$ m

03. Ans: (b)

Sol: Dip of horizon, $\theta = \frac{D}{R}$ in radians

$$d = \sqrt{\frac{h}{0.06735}} = \sqrt{\frac{45}{0.06735}}$$

$d = 25.84$ m

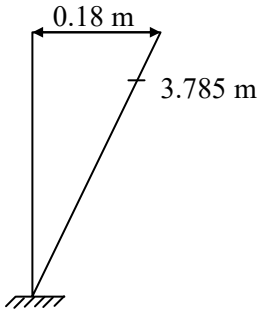
$$\theta = \frac{25.84}{6371} = 0.004\,\text{m}$$

04. Ans: 3.781 m

Sol: The correct reading

$= \sqrt{3.785^2 - 0.18^2}$

$= 3.781$ m



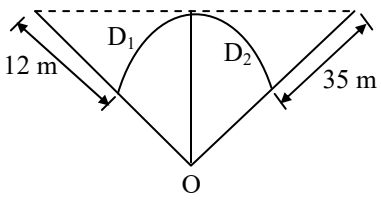
05. Ans: (a)

Sol: Radius of curvature of bubble tube $= \frac{n\ell D}{S}$

$$= \frac{5\times(2\times 10^{-3})\times 100}{0.05} = 20 \text{ m}$$

06. Ans: (b)

Sol:

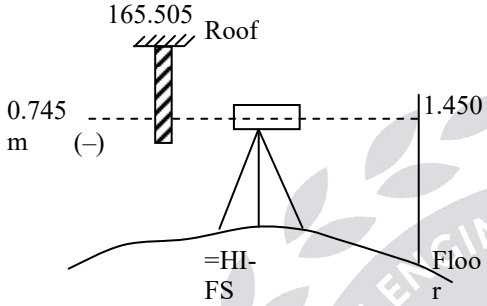


$$D = D_1 + D_2$$

$$= \sqrt{\frac{12}{0.06735}} + \sqrt{\frac{35}{0.06735}} = 36.144 \text{ km}$$

07. Ans: (c)

Sol:



R.L of floor = (165.505–0.745)–1.450
=163.310 m

08. Ans: (a)

Sol:

Instrument	Staff reading A	Staff reading B
A	1.625	2.545
B	0.725	1.405

$A_1 \to A \Rightarrow h_a$ $\quad B_1 \to A \Rightarrow h_a'$

$A_1 \to B \Rightarrow h_b$ $\quad B_1 \to B \Rightarrow h_b'$

I-Instrument Set up:

$N \to N \Rightarrow h_a$

$\to F \Rightarrow h_b$

II-Instrument Setup:

Near to near = h_b'

Near to further = h_a'

$$e = \frac{-1}{2}\left[(h_a - h_b) - (h_a' - h_b')\right]$$

$$= \frac{-1}{2}\left[(1.625 - 2.545) - (0.725 - 1.405)\right]$$

$$= 0.12$$

$e = e_{col} + e_c + e_R$

$0.12 = e_{col} + 0.07857(1)^2 + (-0.01122(1)^2)$

$e_{col} = 0.05265$ m

$$\theta = \tan^{-1}\left(\frac{0.05265}{1000}\right) = 10.86''$$

09. Ans: 151.40 m

Sol: $\sum$ Rise – $\sum$Fall = Last R.L. – First R.L

= 2.645 – (1.245)

= L.R.L – 150.500

$\Rightarrow$ L.R.L = 151.40 m

10. Ans: (d)

Ans: $60^2 = \frac{h}{0.06735} \Rightarrow h = 242.46$ m

11. Ans: (a)

Sol: 0.680 m, 1.455 m, 2.330 m, 2.885 m, 3.380 m 1.055 m

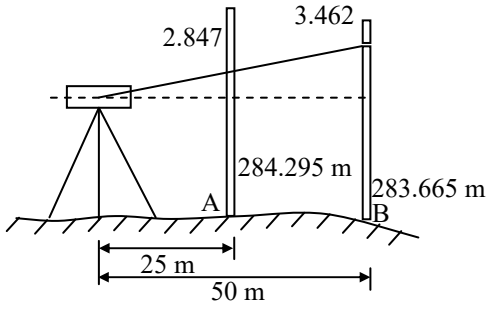
Stn.	BS	IS	FS	Rise	Fall	RL	Remarks
1	0.680					**81.305**	
2.		1.455			0.775		
3.		2.330			0.875		
4.		2.885			0.555	79.100	
5	1.055	3.380					

81.305 – 0.775 = RL of 2

RL of 2 – 0.875 = RL of 3

12. Ans: (d)

Sol:



Difference in staff reading = 3.462 – 2.847
= 0.615 m

Difference in R.L. = 284.295 – 283.665 m
= 0.63 m

Difference of the above = 0.615 – 0.63
= 0.015 m

e_{col} = 0.015 m of 25 m

$100\,\text{m} \rightarrow \frac{100}{25} \times 0.015 = 0.06$ m

13. Ans: (a)

Sol: ΣB.S – ΣFS = L.R.L – F.R.L

–6.2 – (? + 0.85) = 196.1 – 200

? = –3.150 m

14. Ans: (a)

Sol: $H = \frac{1}{2}[(1.03 - 1.630) + (0.950 - 2.740)$

$= -1.195$

R.L of Q = 450 – 1.195 = 448.805 m

15. Ans: (b)

Sol:

BS	IS	FS
3.425		
	2.650	
2.150		**0.850**
2.850		1.780
	1.250	
		0.525

16. Ans: (d)

Sol:

	P	Q
P	1.525	2.325
Q	1.545	2.265

$e = \frac{-1}{2}[(1.525 - 2.325) - (1.545 - 2.265)]$

= 0.04 m

17. Ans: (c)

Sol: $\alpha' = \frac{S}{nD}(206265)$

$= \frac{1.60 - 1.55}{4 \times 100}(206265) = 25.78$ sec

18. Ans: (a)

Sol: 74.500 + 4.685 = 79.185 m

19. Ans: (b)

Sol: Error = 0.015

$e = e_{col} + e_c + e_r$

$\Rightarrow 0.015 = e_{col} + 0.06735\,(1.5)^2$

$\Rightarrow e_{col} = -0.1365$ m

20. Ans: (d)

Sol: n = 1, R = 1.1 m

$$\alpha' = \frac{\ell}{R} = \frac{1}{1.1\times10^3}$$

$$= \frac{1}{1100}$$

21. Ans: (a)

Sol: Refer previous ESE-Obj-(Vol-2) solutions Book (Cha-5, 24th Question -pg: 874)

Conventional Practice Solutions

01.

Sol:

Station	BS	IS	FS	Rise	Fall	RL	Remarks
A	0.675					97.51	
B		1.305			0.63	96.88	
C	0.625		–1.815	3.12		100.000	BM
D		1.195			0.57	99.43	
E	2.620		1.225		0.03	99.4	
F		1.345		1.275		100.675	
G			–2.005	3.35		104.025	

$$\text{Check} = \Sigma BS - \Sigma FS = 3.92 + 2.595 = 6.515$$
$$= \text{Last R.L} - \text{First R.L} = 104.025 - 97.51 = 6.515 \Big\} \text{OK}$$

02.

Sol:

Station	BS	IS	FS	Rise	Fall	RL	Remarks
A	1.785					100.000	BM
B		2.065			0.28	99.72	
C	1.865		1.315	0.75		100.47	CP
D		1.635		0.23		100.70	
E	1.025		0.875	0.76		101.46	CP
F			1.315		0.29	101.17	
Sum	4.675		3.505	1.74	0.57		

Check $\Sigma B.S = \Sigma F.S = \Sigma$ Rise $- \Sigma$Fall = Last RL – First R.L

$= 4.65 - 3.505 = 1.74 - 0.57 = 101.17 - 100$

$= 1.17 = 1.17 = 1.17$

03.

Sol: As both the stations are at a considerable distance from the level, the corrections to curvature and refraction have to be applied to the readings taken from both the stations.

For (A) 450 m $= 0.06735 \times 0.45^2$

$= 0.0136$ m (–)

For (B) 750 m $= 0.06735 \times 0.75^2$

$= 0.0379$ m (–)

Corr. staff reading on 'A' = 1.850 – 0.0136

= 1.8364 m

Corr. staff reading on 'B' = 2.35 – 0.0379

= 2.3121 m

True difference in elevation between A & B

$= 2.3121 - 1.8364 = 0.4757$ m

$= 0.475$ m

[Fall from A to B]

04.

Sol: $H = \frac{1}{2}[(1.425 - 2.725) + (1.430 - 2.505)]$

$= \frac{1}{2}[-1.3 - 1.075] = -1.1875$m

[fall from P to Q]

Collimation error for

$1250\,\text{m} = \frac{0.003}{150} \times 1250$

$e_{col} = 0.025$ m

Error due to curvature $= e_c = 0.0785D^2$

$= 0.07857 \times 1.25^2$

$= 0.1228$ m

With the instrument at P:

corr. reading at

$Q = 2.725 - (0.1228 + 0.025 - e_R)$

$= 2.725 - (0.1228 + 0.025 - e_R)$

True difference in elevation

$= [2.725 - (0.1228 + 0.025 - e_R) - 1.425]$

$= 1.1522 + e_R$ ..... (1)

With the instrument at Q:

corr. reading at P

$= 1.430 – (0.1228 + 0.025 – e_R)$

True difference in elevation

$= [2.505 – [1.430 – 0.1228 – 0.025 + e_R]]$

$= 1.2228 – e_R$……. (2)

$\therefore$ Equating these two (1) = (2)

$1.1522 + e_R = 1.2228 – e_R$

$= 0.0353$ m

05.

Sol: True difference in elevation between A and B when the instrument is in the middle of A & B = 3.175 – 2.615 = 0.56 m

Apparent difference in elevation

= 2.340 –1.905

When the instrument is at 25 m = 0.435 m from A

Reading at A = 1.905 m from C

True difference in Reduced Levels = 0.56 m

$\therefore$ Reading at B = 1.905 + 0.56 = 2.465 m

But observed at B is less than the actual and hence Line of sight is inclined downwards. If α be the inclination of Line of sight

Correction reading at A = 1.905 + 25 tanα

Correction reading at B = 2.340 + 75 tanα

$\therefore$ Difference in elevation

$= (2.340 + 75 \tan\alpha) – (1.905 + 25 \tan\alpha)$

$= 0.435 + 50 \tan\alpha$

But the true difference in elevation = 0.56 m

$\therefore 0.435 + 50 \tan\alpha = 0.56$

$\therefore \alpha = 8'36''$

correction reading at A

$= 1.905 + 25 \tan 8'36'' = 1.967$ m

correction reading at B

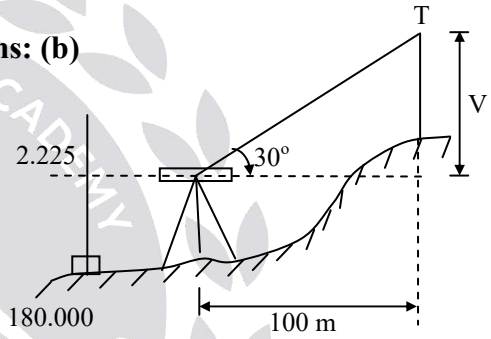
$= 2.340 + 75 \tan 8'36'' = 2.527$ m

Check: Difference = 2.527 – 1.967 = 0.56 m

07. Trigonometrical Levelling

01. Ans: (b)

Sol:



$V = 1000 \tan 30^o$

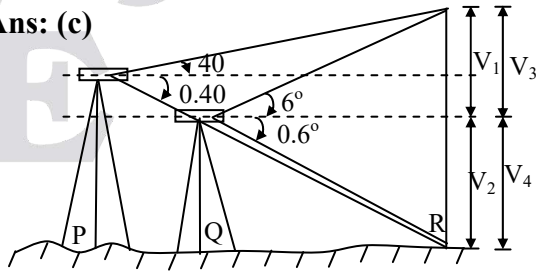
$= 577.35$ m

R.L of T = 180 + 2.225 + 577.35

= 759.575 m

02. Ans: (c)

Sol:



$V_1 + V_2 = V_3 + V_4$

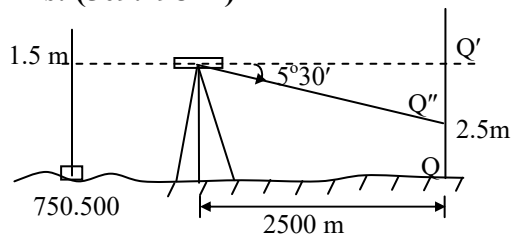
$D(\tan 6^o + \tan 0.6^o) = (D+250)(\tan 4^o + \tan 0.4^o)$

$\therefore D = 496.77$ m

Height of tower, $V_1 + V_2 = 57.4266$

03. Ans: (509.198 m)

Sol:



Corr. S.R = 2.5 – 0.06735 × 2.5

= 20.79 m

Q′Q″ = 2500 tan5°30′

= 240.723 m

R.L of Q = 750.500 + 1.5 – 240.723 – 2.072

= 509.198 m

04. Ans: (a)

Sol: $2.650 - 0.750 = V_2 - V_1$

$= (D + 100)\tan 14^\circ 30' - D\tan 20^\circ 30'$

$\therefore D = 207.806$ m

$V_1 = 207.806 \tan 20^\circ 30' = 77.69$ m

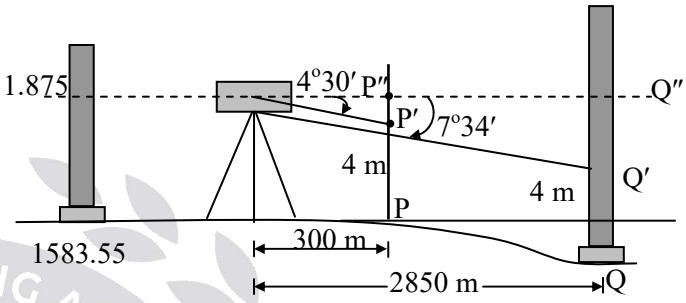
R.L. of C = 500 + 2.65 + 77.695

= 580.345 m

Conventional Practice Solutions

01.

Sol: Q′ Q″ = 8078.01 m = 2850 tan 70° 34′



P′ P″ = 300 tan 4° 30′ = 23.61 m

RL of P = 1583.55 + 1.875 – 23.61 – 4

= 1557.81 m

Q′ Q″ = 2850 tan 7° 34′ = 378.584 m

Combined correction

$= 0.06375 \times 2.85^2$

$= 0.518$ m^2

Correct reading = 4 – 0.518

= 3.482 m

R.L of Q

= 1583.55 + 1.875 – 378.584 – 3.482

= 1203.359 m

08. Traversing & Omitted Measurements

01. Ans: (d)

Sol: Latitude = $\ell \cos\theta$

$-102.65 = \ell \cos 235^\circ 30'$

$\ell = 181.23$

$\because \ell$ = Length of line

02. Ans: –124.22, 174.99

Sol: T.L of B = –34.5 – 128 cos 45° 30′

= – 124.22 m

T.D of B = 83.7 + 128 sin 45° 30′

= 174.99 m

B = (– 124.22, 174.99)

03. Ans: (b)

Sol: L = Latitude = 89 m (N)

D = Departure = – 49.4 [W]

FB at PQ $\Rightarrow \theta = \tan^{-1}\left[\frac{D}{L}\right]$

$\theta = \tan^{-1}\left[\frac{49.4}{89}\right]$

$\theta = 29.03^{o}$

FB at PQ = N 29.03° W

WCB at PQ = 360° – 29.03°

= 330.97°

= 330° 58′

04. Ans: (d)

Sol: P = 1500 m

$$\text{Relative error} = \frac{1}{P/e} = \frac{1}{2343}$$

$$e = \sqrt{0.5^2 + 0.4^2} = 0.6403\,m$$

$$r = \frac{e}{p} = \frac{0.6403}{1500} = \frac{1}{2343}\,m$$

05. Ans: (a)

Sol: 200cosθ + 98cos 178° + l cos (270°) + 86.4 cos (1°) = 0

200 sinθ + 98sin (178°) + l sin270° +86.4 sin 1° = 0

l cos (270°) + 200 cos θ = 11.55

l sin (270°) + 200 sin θ = –4.92

200 cosθ = 11.55

$$\Rightarrow \theta = \cos^{-1}\left(\frac{1.55}{200}\right) = 86.7^{o}$$

$\Rightarrow l$ = 204.588 m

06. Ans: (c)

Sol:

	A	B
L	40	20
D	–20	30

$$F.B = \tan^{-1}\frac{30+20}{20-40} = 68°11'$$

= S68° 11′ E

$$B.B = \tan^{-1}\frac{-20-30}{40-20}$$

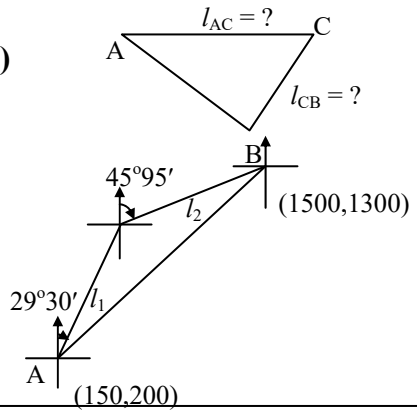
$L_2 - L_1 = 20 - 40 = -20$ (S)

$D_2 - D_1 = 30 - (-20) = 50$ (E)

$$AB = \sqrt{(-20)^2 + (50)^2} = 53.85\,m$$

07. Ans: (a)

Sol:



FB of AC = N29°30′E

FB of BC = S 45°45′W

$\sum L = 1500 - 150 = l_1 \cos 29°30' + l_2 \cos 45° 45'$

$\sum D = 1300 - 200 = l_1 \sin 29°30' + l_2 \sin 45°45'$

$1350 = l_1 \cos 29°30' + l_2 \cos 45°45'$ …… (1)

$1100 = l_1 \sin 29°30' + l_2 \sin 45°45'$ ……(2)

By solving 1 & 2 $l_1 = 712.714$ m

$l_2 = 1045.7$ m

08. Ans: (b)

Sol: Length $= \sqrt{(1.39)^2 + (2.17)^2}$

$= 2.577$ m

Closing error

$$\theta = \tan^{-1}\left(\frac{2.17}{1.39}\right) = 57°35'$$

$$180° - \tan^{-1}\left(\frac{2.17}{1.39}\right) = 122° 39'$$

09. Ans: (c)

Sol: D = 10

$$\theta = \tan^{-1}\left(\frac{10}{10}\right) = 45°$$

10. Ans: (a)

Sol: $\theta = \tan^{-1}\left(\frac{L}{D}\right) = \tan^{-1}\left(\frac{100}{60}\right) = 59° 3'$

11. Ans: (d)

Sol: CA = 245°

CB = 164°30′

AC = ? BC = ?

AC = N65°E BC = N 15°30′W

Northing of C

$600 + l_1 \cos 65 = -450 + l_2 \cos 15°30'$

Easting of C

$600 + l_1 \sin 65° = 500 + l_2 \sin 15°30'$

$l_1 = -381.272$ $l_2 = 921.91$

Easting of C = $600 - 381.272 \sin 65°$

$= 254.45$

Conventional Practice Solutions

01.

Sol:

(i) Calculation of I.A from given bearings:

∠A = FB of AB – FB of AD

= 319°15' – 76°45' = 242°30'

∠B = FB of BC – FB of BA

= [51°30' – 139°15'] + 360° = 272°15'

∠C = FB of CD – FB of CB

= [131°45' – 231°30'] + 360° = 260°15'

∠D = FB of DA – FB of DC

= [256°45' – 311°45'] + 360° = 305°0'

(ii) Arithmetic check:

Sum = (2n + 4) × 90° = 1080°

1080° = (2 × 4 + 4) × 90° = 1080°

Traverse is closed. No closing error

(iii) Balancing by Bowditch's Method:

Line	Length (m)	Bearing	Latitude	Departure	Corr. for Latitude	Corr. for Departure	Corrected Latitude	Corrected Departure
AB	105.8	N40°45'W	80.15	–69.06	0.0271	0.0946	80.1771	–68.9654
BC	142.5	N51°30'E	88.71	111.52	0.0364	0.1275	88.7464	111.6475
CD	188.8	S48°15'E	–125.72	140.85	0.0482	0.1689	–125.6718	141.0189
DA	188.9	S76°45'W	–43.3	–183.87	0.0483	0.1690	–43.2517	–183.7010
Σ=	626 m		ΣE = – 0.16	ΣD = – 0.56				

Bowditch's

$$C_L = (-\Sigma L) \times \frac{\ell}{P}$$

$$C_D = (-\Sigma D) \times \frac{\ell}{P}$$

Correction for latitude of

(i) $AB = 0.16 \times \frac{105.8}{626} = 0.0271$

(ii) $BC = \frac{0.16}{626} \times 142.5 = 0.0364$

(iii) $CD = \frac{0.16}{0.626} \times 188.8 = 0.0482$

(iv) $DA = \frac{0.16}{0.626} \times 188.9 = 0.0483$

Correction for departure of

(i) $AB = 0.56 \times \frac{105.8}{626} = 0.0946$

(ii) $BC = \frac{0.56}{626} \times 142.5 = 0.1275$

(iii) $CD = \frac{0.56}{626} \times 188.8 = 0.1689$

(iv) $DA = \frac{0.56}{626} \times 188.9 = 0.1690$

02.

Sol:

(i) Arithmetic Check:

Sum = (2n – 4) × 90° = 540°1'30" = 540°0'

Total correction = –1'30"

Correction to each station $= \frac{-1'30'}{5} = 18"$

Corrected Included angle

∠P = 131°14'12"

∠R = 116°35'07"

∠Q = 84°19'07"

∠S = 119°57'47"

∠T = 87°53'47"

(ii) Calculation of correction bearings:

Bearing of PQ = S36°12'30"E (correct)

FB of QR = Bearing of QP + ∠Q

= [323°47'30" + 84°19'07"] – 360°

= 48°6'37"

FB of RS = Bearing RQ + ∠R

= 228°6'37" + 116°35'07"

$= 344^{o}41'44"$

FB of ST = Bearing of SR + $\angle$S

$= 164^{o}41'44" + 119^{o}57'47"$

$= 284^{o}39'31"$

FB of TP = FB of TS + $\angle$T

$= 104^{o}39'31" + 87^{o}53'47"$

$= 192^{o}33'18"$

Check:

FB of PQ = FB of PT + $\angle$P

$= 12^{o}33'18" + 131^{o}14'12"$

$= 143^{o}47'30"$ (S$36^{o}12'30"$E)

Line	Length (m)	Bearing	Latitude	Departure	Corr. for Latitude	Corr. for Departure	Corrected Latitude	Corrected Departure
PQ	102.8	$143^{o}47'30"$	–82.9467	60.7263	0.00054	–0.0002	–82.9463	60.7261
QR	98.4	$48^{o}6'37"$	65.7015	73.2520	0.0004	–0.0003	65.7018	73.2517
RS	110.8	$344^{o}41'44"$	106.876	–29.2454	0.0005	–0.0001	106.8711	–29.2455
ST	82.8	$284^{o}39'31"$	20.9532	–80.1049	0.0001	–0.0003	20.9533	–80.1052
TP	113.29	$192^{o}33'18"$	–110.5809	–24.6266	0.0006	–0.0001	–110.5803	–24.6267
			$\Sigma L = -0.002$	$\Sigma D = 0.001$			$\simeq 0$	$\simeq 0$

$L_S = 387.053$, $D_S = 267.955$

$$C_L = (-\Sigma L) \times \frac{L}{L_S}$$

$$C_D = (-\Sigma D) \times \frac{D}{D_S}$$

Latitude:

$$PQ = \frac{0.002}{387.053} \times 82.947 = 0.0004$$

$$QR = \frac{0.002}{387.053} \times 65.702 = 0.0003$$

$$RS = \frac{0.002}{387.053} \times 106.871 = 0.0005$$

$$ST = \frac{0.002}{387.053} \times 20.953 = 0.0001$$

$$TP = \frac{0.002}{387.053} \times 110.581 = 0.0006$$

Departure:

$$\frac{-0.001}{267.955} \times 60.726 = -0.0002$$

$$\frac{-0.001}{267.955} \times 73.252 = -0.0003$$

$$\frac{-0.001}{267.955} \times 29.245 = -0.0001$$

$$\frac{-0.001}{267.955} \times 80.105 = -0.0003$$

$$\frac{-0.001}{267.955} \times 24.627 = -0.0001$$

03.

Sol: For closed traverse ABCDA

Line	Length (m)	Bearing	Lat.	Dep.
AB	230.5	N36°45'E	184.69	137.91
BC	250.2	S82°48'E	–31.36	248.23
CD	210.8	S10°15'E	– 207.43	37.51
			ΣL = – 54.1	ΣD = 423.65
DA		-	-	-

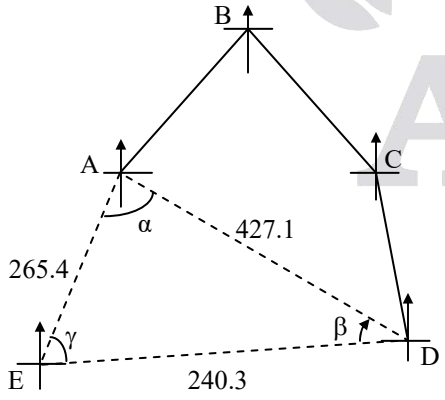
Lat. of DA = + 54.1; Dep. of DA = – 423.65

$$DA = \sqrt{(54.1)^2 + (-423.65)^2} = 427.1 \text{ m}$$

$$\text{Bearing of DA} = \theta = \tan^{-1}\left[\frac{423.65}{54.1}\right]$$

$= 82°43'21"$

$= N82°43'21"W$



$$S = \frac{427.1 + 240.3 + 265.4}{2} = 466.4 \text{ m}$$

$$\Delta = \sqrt{466.4(466.4-427.1)(466.4-265.4)(466.4-240.3)}$$

$= 28861.83 \text{ m}^2$

$$\Delta = \frac{1}{2} \times 427.1 \times 265.4 \times \sin\alpha = 28{,}862$$

$\therefore \alpha = 30°36'48"$

$$\Delta = \frac{1}{2} \times 427.1 \times 240.3 \times \sin\beta = 28{,}862$$

$\therefore \beta = 34°13'28"$

Bearing of DE

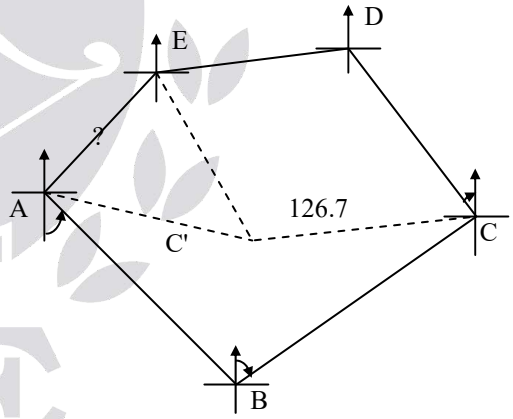
$= 180° – (82°43'21" + 34°13'27")$

$= 63°03'11" = S63°03'11"W$

Bearing of AE = 82°43'21" – 30°36'36"

$= 52°06'45" = S52°06'45"E$

04.



C'A = ? from traverse ABCC'A traverse

Line	Length (m)	Bearing	Latitude	Departure
AB	178.6	S52°30'E	–108.73	141.69
BC	228.4	N48°45'E	150.60	171.72
CC'	126.7	S78°30'W	–25.26	–124.15
C'A	-	-	ΣL =16.61	ΣD = +189.26

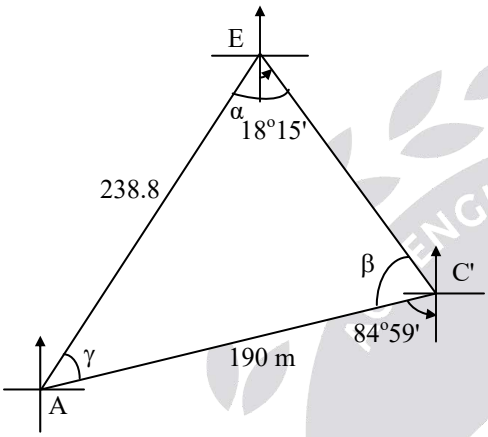
Length of C'A $= \sqrt{(16.61)^2 + (189.26)^2}$

$= 189.98$ m

Bearing of C'A $\theta = \tan^{-1}\left[\frac{189.26}{16.61}\right]$

$= 84^\circ 59'4'' = S84^\circ 59'4''W$

Triangle C'AE:



$\beta = 180^\circ - 84^\circ 59'4'' - 18^\circ 15'$

$= 76^\circ 45'56''$

$\frac{\sin\alpha}{190} = \frac{\sin 76^\circ 45'56''}{238.8} = 0.7745$

$\therefore \alpha = 50^\circ 45'40''$

$\gamma = 52^\circ 28'24''$

$\frac{EC'}{\sin 52^\circ 28'40''} = \frac{238.8}{\sin 76^\circ 46'}$

$\Rightarrow EC' = \frac{189.3963}{\sin 76^\circ 46'}$

$= 194.56$ m

$\therefore EC' = DC = 194.56$ m

Bearing of AE $= 84^\circ 59'4'' - 52^\circ 28'24''$

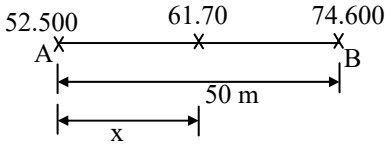
$= 32^\circ 30'40''$

$\therefore$ Bearing of EA $= S32^\circ 30'40''$ W

09. Contouring

01. Ans: (b)

Sol:



$x = \frac{61.70 - 52.500}{74.600 - 52.50} \times 50$

$x = 20.82$ m

02. Ans: (d)

Sol: H.E $= \frac{20}{(1/50)} = 1000$ m

$R = \frac{1000}{25{,}000} = 0.04$ m

03. Ans: (c)

Sol: Scale : 1 : 20000

Gradient $= \frac{4}{100}$

Interval = 20 m

Radius $= \frac{20}{20000} = 2.5$

04. Ans: (a)

Refer previous ESE-Obj-(Vol-2) solutions Book (Cha-9, 5th Question -pg: 898)

10. Areas & Volumes

01. Ans: (d)

Sol: A (10, 20)

B (30, 40)

C (50, –60)

D (70, 80)

400 – 600 = - 200

- 1800 – 2000 = - 3800

4000 + 4200 = 8200

1400 – 800 = 600

$$A = \frac{1}{2}(8800 - 4000)$$

$A = 2400\ m^2$

02. Ans: 2111 m^3

Sol: b = 8.8 n = 1.5 d = 20

$A = [b + nh]\ h$

$A_1 = [8.8 + 1.5 \times 1.8]\ 1.8 = 20.7\ m^2$

$A_2 = [\ 8.8 + 1.5 \times 2.4]\ 2.4 = 29.76\ m^2$

$A_3 = [8.8 + 1.5 \times 3]3 = 39.9\ m^2$

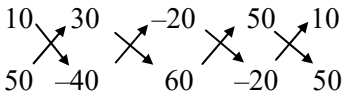
$A_4 = [8.8 + 1.5 \times 3.6]\ 3.6 = 51.12\ m^2$

$$V = 20\left[\frac{20.7 + 51.12}{2} + (29.76 + 39.9)\right]$$

$V = 2111\ m^3$

03. Ans: (d)

Sol:



Area of ABCDA

$$= \frac{1}{2}\left[\begin{matrix}(-400 - 1500) + (1800 - 800) + (400 - 3000) \\ + (2500 + 200)\end{matrix}\right]$$

$= -400\ m^2$

$= 0.04$ hectare's

04. Ans: 288000 m^3

Sol: $\text{Horizontal equivalent} = \dfrac{\text{Contour interval}}{\text{gradient}}$

$$= \frac{330 - 210}{\frac{1}{30}} = 3600\ m$$

1V – 0.5 H

4V – ? H = 8 m

$$\text{Volume} = \left(\frac{28 + 12}{2}\right) \times 3600 \times 4$$

$= 288000\ m^3$

05. Ans: (b)

Sol: $A_1 = 10 \times 4 = 40\ m^2$

$A_2 = 6 \times 2 = 12\ m^2$

$$A_m = \left(\frac{10 + 6}{2}\right)\left(\frac{4 + 2}{2}\right)$$

$= 8.2 = 24\ m^2$

$$V = \frac{h}{6}[A_1 + 4A_m + A_2]$$

$$= \frac{8}{6}[40 + 4(24) + 12]$$

$V = 197.33\ m^3$

06. Ans: (b)

Sol: $A = d\left[\frac{O_1 + O_n}{2} + O_2 + O_3 + ...O_{n-1}\right]$

$A_1 = 5\left[\frac{5+6}{2} + 4 + 5.5 + 5\right]$

$= 95$

$A_2 = 10\left[\frac{6+4.5}{2} + 4\right] = 92.5$

$A = A_1 + A_2 = 187.5 m^2$

07. Ans: (b)

Sol: A = M [F.R – I.R ± 10 N + C]

A = 10,000 [2.64 – 6.356 + 10 × 3 +0]

A = 2,62,840 mm^2

08. Ans: (38, 160 m^2)

Sol: A = M [FR – IR ± 10 N + C]

= 10 [7284 – 3468 – 10×2 + 20]

= 38,160 mm^2 (on the plan)

Scale 1:1000

1 mm = 1m

= (38,160 × 1 × 1) m^2

= 38,160 m^2

09. Ans: (b)

Sol: $V = \frac{h}{3}[\text{first} + \text{last}) + 4(\text{even}) + 2(\text{odd})]$

$= \frac{5}{3}[(3850 + 450) + 4(3450 + 800) + 2(2600)]$

$= 44166.66 m^3$

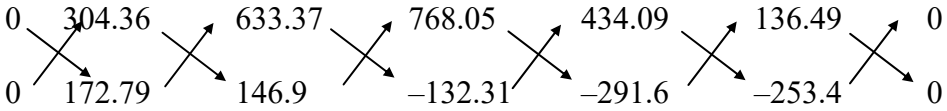
Conventional Practice Solutions

01.

Sol:

Line	L	D	Station	X-coordinates	Y-coordinates
AB	172.79	304.37	A	0	0 (assume)
BC	–25.89	329	B	304.37	172.79
CD	–279.21	134.68	C	633.37	146.9
DE	–159.29	–333.96	D	768.05	–132.31
EF	37.86	–297.6	E	434.09	–291.6
FA	253.74	–136.49	F	136.49	–253.74

Area by co-ordinates



$$A = \frac{1}{2}[(304.36\times146.9)-(172.79\times633.37)]+[(633.37\times-132.31)-(146.9\times768.05)]+$$
$$[(-768.05\times291.6)+(132.31\times434.09)]+[(434.09)\times(-253.4)+(291.6\times136.49)]$$
$$=\frac{1}{2}[-64729.52-196627.73-1,66,528.93-70,197.92]=(-)249042.05\ m^2$$

Meridian Dist. Method:

	L	D	D/2	m	mL
AB	172.79	304.37	152.18	152.18	26,295.18
BC	–25.89	329	164.5	468.86	–12,138.78
CD	–279.21	134.68	67.34	700.7	–195,642.45
DE	–159.29	–333.96	–166.98	601.06	–95,742.85
EF	37.86	–297.6	–148.8	285.28	10,800.7
FA	253.74	–136.49	–68.25	68.23	17,312.68

$A = \Sigma mL = 249,115.52\ m^2$

02.

Sol:

Chainage	G.L	R.L of formation	Depth of cutting (h)	bh	nh^2	A
0	214.5	212.93	1.57	9.42	4.93	14.35
20	215.1	213.43	1.67	10.02	5.58	15.60
40	215.4	213.93	1.47	8.82	4.32	13.14
60	216.4	214.43	1.97	11.82	7.76	19.58
80	217.2	214.93	2.27	13.62	10.30	23.92
100	217.7	215.43	2.27	13.62	10.30	23.92
120	218.5	215.93	2.57	15.42	13.21	28.63

Given: b = 6 m; n = 2

$A = [b + nh]\, h = bh + nh^2$

Calculation of volume

(i) Trapezoidal Rule: $V = 20\left[\left(\frac{14.35 + 28.63}{2}\right) + 15.60 + 13.14 + 19.58 + 23.92 + 23.92\right] = 2353\ m^3$

(ii) Prismodial Rule

$$V = \frac{20}{3}\left[(14.35 + 28.63) + 4(15.60 + 19.58 + 23.92) + 2(13.14 + 23.92)\right] = 2356.67\ m^3$$

Error = 0.15%

03.

Sol:

Contour	Area (m^2) × 1000
260	40 × 2 × 2 = 160
258	36.5 × 2 × 2 = 146
256	32.5 × 2 × 2 = 130
254	31 × 4 = 124
252	27.5 × 4 = 110
250	24.5 ×4 = 98
248	20.5 × 4 = 82
246	17.5 × 4 = 70
244	14.5 × 4 = 58
242	11.5 × 4 = 46
240	0

Scale 1:2000

$\therefore$ 1 cm = 20 m

(i) Trapezoidal Rule:

$$V = 2\left[\left(\frac{160 + 0}{2}\right) + 146 + 130 + 124 + 110 + 98 + 82 + 70 + 58 + 46\right]1000$$

$= 1.888 \times 10^6$

(ii) Prismoidal Rule:

$$V = \frac{2}{3}[(160+0)+4(146+124+98+70+46)+2(130+110+82+58)]$$

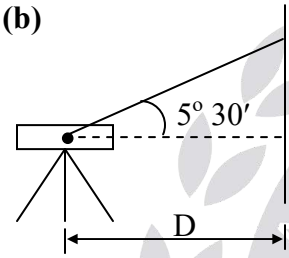
$= 1.904 \times 10^6$

% Error = 0.84

11. Tacheometry

01. Ans: (b)

Sol:



$\Rightarrow$ With an allactic lens

k = 100 C = 0

$D_1 = ks \cos^2 \theta + C \cos \theta$

$D_1 = 100 \times 1.750 \times \cos^2 5^\circ 30'$

$D_1 = 173.39$ m

$\Rightarrow$ With K = 101 & C = 0.6

$D_2 = KS \cos^2 \theta + C \cos \theta$

$D_2 = 101\ (1.75) \cos^2 (5^\circ 30') + 0.6 \cos (5^\circ 30')$

$D_2 = 175.72$ m

$$\% \text{ age of error} = \frac{D_1 - D_2}{D_1} \times 100$$

$$= \frac{175.72 - 173.39}{173.39} \times 100$$

% age of error = 1.35%

02. Ans: (a)

Sol: L = KS + C

50 = 0.495 K + C

80 = 0.795 K + C

K = 100, C = 0.5

03. Ans: (d)

Sol: f = 25 cm = 250 mm, i = 5 mm

$$\text{m.c} \Rightarrow K = \frac{f}{i} = \frac{250}{5} = 50$$

A.C $\Rightarrow$ C = f + d = 250 + 15 cm = 40 cm

$= 40 \times 10^{-2}$ m

C = 0.40 m

04. Ans: (a)

Sol: Horizontal distance, $D = Ks \cos^2\theta + C \cos\theta$

K = 100; C = 0

$= 100 \times (2.985 - 2.225) \cos^2 (7°54')$

= 74.564 m

05. Ans: (d)

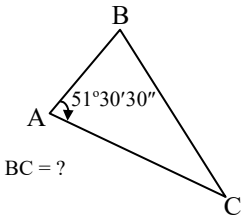
Sol: D = KS + C

K = 95, S = 2.65 – 0.65

D = 95(2.65 – 0.65) + 0.5 = 190.5 m

06. Ans: (27.746 m)

Sol:



$AB = 100 \times 0.35 + 0.2 = 35.2$ m

$AC = 100 \times 0.25 + 0.2 = 25.2$ m

$$\cos 51^\circ 30'30'' = \frac{AB^2 + AC^2 - BC^2}{2AB \times AC}$$

$BC = 27.746$ m

07. Ans: (b)

Sol:

$$D = \frac{S}{\tan\alpha_1 + \tan\alpha_2} = \frac{2}{\tan(1^\circ 12') + \tan(1^\circ 30')}$$

$= 42.43$ m

$V = D \tan\alpha_2 = 42.43\tan(1^\circ 30') = 1.112$

R.L of A = 100 – 1.12 – 0.5= 98.39 m

08. Ans: (a)

Sol: $D = (206265)\frac{S}{\beta}$

$\beta = (30 \times 60) + 15 = 1815$

$$D = (206265)\frac{1.25}{1815} = 142.06 \text{ m}$$

09. Ans: (d)

Sol: $D = \frac{KS}{m}\cos^2\theta + C\cos\theta$

$$= \frac{1000 \times 2}{m}\cos^2 6^\circ + 0.5\cos 6^\circ$$

$\therefore$ m = 19.88

Conventional Practice Solutions

01.

Sol: Staff held normal to the Line of sight

$D = (KS + C)\cos\theta + r\sin\theta;$

$V = (KS + C)\sin\theta$

Observations from A to P

Staff intercept = 2.85 – 1.35 = 1.5

$D = AP = (100 \times 1.5 + 0.3)\cos 3^\circ 30' + 2.1$

$\sin 3^\circ 30' = 150.15$ m

$V = (100 \times 1.5 + 0.3)\sin 3^\circ 30' = 9.175$ m

Observations from A to Q

S = 3.76 – 1.95 = 1.81 m

$D = AQ = (100 \times 1.81 + 0.3)$

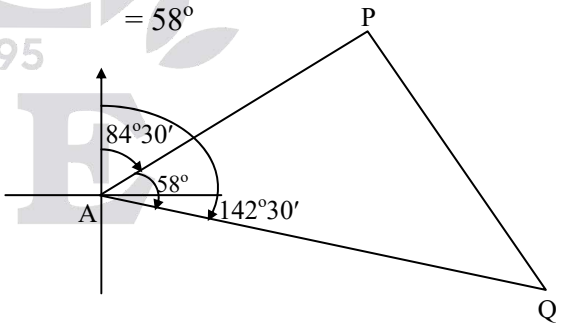
$\cos 2^\circ 45' + 2.87 \sin 2^\circ 45'$

$= 181.23$ m

$V = (100 \times 1.81 + 0.3)\sin 2^\circ 45' = 8.698$ m

$\angle PAQ = 142^\circ 30' - 84^\circ 30'$

$= 58^\circ$



Cosine Rule

$PQ^2 = AP^2 + AQ^2 - 2AP \times AQ\cos 58^\circ$

$= 150.15^2 + 181.23^2 - 2 \times 150 \times 181.23\cos 58^\circ$

$\therefore$ PQ = 162.94 m

Assume the Horizontal Line of sight is reference

RL. of P = V – rcos θ

Elevation of 'P' = 9.175 –2.10 cos 3° 30′

= 7.079 m

Elevation of 'Q' = 8.698 – 2.87 × cos2° 45′

= 5.831

∴ Difference in elevation = 7.075

∴ P is higher level than 'Q'

∴ Gradient from P to Q

$$= \frac{\text{R.L Difference}}{\text{Horizontal Distance}}$$

$$= \frac{(7.079 - 5.831)}{162.94} = 1 \text{ in } 130.56$$

02.

Sol: F.S.H.M

$D = KS\cos^2\theta + C\cos\theta$

S = 3.335 – 1.335 = 2 m ; θ = 5.5°

D = 100 × 2 ×cos² 5° 30′ + 0.5 cos 5° 30′ = 198.66 m

$$V = \frac{KS\sin 2\theta}{2} + C\sin\theta$$

$$= \frac{100 \times 2 \times \sin 11^\circ}{2} + 0.5\sin 5^\circ 30' = 19.128\text{m}$$

∴ PQ = 198.66 m

RL of Q = 1030.50 + 2.355 + 19.128 – 2.335

= 1049.648 m

M.H.M

$$D = \frac{K'S}{m}\cos^2\theta + C\cos\theta$$

$$198.66 = \frac{K' \times 3}{14.95}\cos^2 5^\circ 30' + 0.5\cos 5^\circ 30'$$

∴ K′ = 996.66

12. Horizontal & Vertical Curves

01. Ans: (c)

Sol: D = 2°

Chord length = 30 m

Δ = 30°

$$\ell = \frac{30\Delta}{2} \qquad \ell = \frac{30 \times 30}{2}$$

$$\ell = 450 \text{ m} \qquad \ell = \frac{\pi R\Delta}{180}$$

$$\frac{450 \times 180}{\pi \times 30} = R$$

R = 859.44 m

Apex distance = R [sec Δ/2–1]

$$= 859.44\left[\sec\frac{30}{2} - 1\right] = 30.32 \text{ m}$$

02. Ans: (a)

Sol: $l = 2R\sin\Delta/2$

$$341.6 = 2 \times R\sin\left(\frac{42}{2}\right)$$

R = 476.61 m

$$\ell = \frac{\pi \times R\Delta}{180}$$

$$\ell = \frac{\pi \times 476.61 \times 42}{180}$$

$$\ell = 349.4\,\text{m}$$

03. Ans: (c)

Sol: Offset = $R - \sqrt{R^2 - x^2}$

$= 500 - \sqrt{500^2 - 20^2}$

$= 0.4$ m

04. Ans: (c)

Sol: $O_o = R - \sqrt{R^2 - \left(\frac{L}{2}\right)^2}$

$= 80 - \sqrt{80^2 - \left(\frac{100}{2}\right)^2} = 17.5\,m$

05. Ans: (b)

Sol: $L = 2R \sin\frac{\Delta}{2}$

$= 2 \times 600 \times \sin 30^o$

$= 600$ m

Mid ordinate = $R\left(1 - \cos\frac{\Delta}{2}\right)$

$= 600\ (1 - \cos 30)$

$= 80.38$ m

06. Ans: (c)

Sol: Tangent length = $R \tan\frac{\Delta}{2}$

$= 200 \times \tan 30°$

$= 115.47$ m

07. Ans: (92.82 m)

Sol: Apex distance = $R\left(\sec\frac{\Delta}{2} - 1\right) = 92.82$ m

08. Ans: (a)

Sol: Tangent length = 600 tan15°

= 160.77 m

Length of curve = $\frac{\pi R\Delta}{180} = 314.15\,m$

Change of point of curve = 1650–160.77

= 1489.23 m

Point of tangency = 1489.23+314.15

= 1803.39 m

09. Ans: (d)

Sol: $\ell = \frac{30\Delta}{D} = \frac{30 \times 60}{3} = 600$ m

10. Ans: (b)

Sol: $L = \frac{g_1 - g_2}{r} = \frac{-1.5 - (-3.7)}{\left(\frac{0.1}{30}\right)}$

= 660 m

11. Ans: (a)

Sol:

$L = \frac{0.80 - (-0.70)}{\left(\frac{0.05}{1}\right)}$

= 30 chains

12. Ans: (c)

Sol: L = nh

$= 200 \times 100$

= 20000 mm

= 20 m

13. Ans: (c)

Sol: n = 40 mm

h = 100 mm

V = 20 m/sec

$$L = \frac{hV}{x} = \frac{100 \times 20 \times 1000}{40}$$

= 50000 mm

= 50 m

14. Ans: (88.88 m)

Sol: V = 20 m/sec

a = 0.3

r = 300 m

$$L = \frac{v^3}{R\alpha} = \frac{20^3}{300 \times 0.3}$$

= 88.88 m

15. Ans: (a)

Sol: $\frac{V^2}{Rg} = \frac{1}{8}$

$\Rightarrow R = 2 \times 78.67$

= 157.34 m

16. Ans: (61.75 kmph)

Sol: $h = \frac{GV^2}{Rg}$

$$\Rightarrow V = \sqrt{\frac{hRg}{G}} = \sqrt{\frac{0.100 \times 300 \times 9.61}{}}$$

= 17.155 m/s

$$\text{Velocity} = 17.155 \times \frac{18}{5}$$

= 61.75 kmph

Conventional Practice Solutions

01.

Sol: Radial offset = $O_x = \sqrt{R^2 + x^2} - R$

Perpendicular offset = $O_x = R - \sqrt{R^2 - x^2}$

Approximate formula = $O_x = \frac{x^2}{2R}$

For 20 m ; Radial offset

$= \sqrt{300^2 + 20^2} - 300$

= 0.666 m

Perpendicular offset

$= 300\ \sqrt{300^2 - 20^2} = 0.667$

Approximate = $\frac{20^2}{2 \times 300} = 0.666\text{m}$

Tabulated as below

Distance along tangent (x)	Radial offset (Exact)	Perpendicular offset (Exact)	Offset (Approximate)
20	0.666	0.667	0.666
40	2.655	2.678	2.667
60	5.941	6.061	6.0
80	10.483	10.863	10.667
100	16.227	17.157	16.667
120	23.11	25.045	24

02.

Sol: $Q_1 = \dfrac{C_1^2}{2R}$

Degree of a curve with 20 m chord

$R = \dfrac{1145.9}{D};\ D = \dfrac{1145.9}{400} = 2.864^\circ = 2^\circ\ 52'$

Half the central angle = $\dfrac{45^\circ}{2} = 22^\circ 30'$

Let full chords = 7 Nos

$= 7 \times 2.864^\circ = 20.048^\circ$

Left angle = $22.5^\circ - 20.048 = 2^\circ 27'$

First chord length = $C_1 = \dfrac{2^\circ 27'}{2^\circ 52'} \times 20$

$= 17.09$ m

$O_1 = \dfrac{C_1^2}{2R}$

$O_2 = \dfrac{C_2}{2R}(C_1 + C_2)$

$O_3 = \dfrac{C_3}{2R}(C_2 + C_3)$

$C_1 = 17.09$

$C_2 = C_3 = 20$

$O_1 = 0.36$

$O_2 = 0.927$

$O_3 = O_4 = 1$ m

03.

Sol: $L = \dfrac{g_1 - g_2}{r} = \dfrac{0.6 - (-0.8)}{\left(\dfrac{0.05}{20}\right)} = 560$ m

Chainage of Apex (A) = 950.5 m

Chainage of 'O' = 950.5 – 280 = 670.5 m

Chainage of 'B' = 950.5 + 280 = 1230.5 m

RL. of 'A' = 858.75 m

$e_1 = \dfrac{g_1}{100} \times \ell = \dfrac{0.6}{100} \times 20 = 0.12$m

$e_2 = \dfrac{g_2}{100} \times \ell = \dfrac{0.8}{100} \times 20 = 0.16$m

RL of 'O' = RL of A – ne_1

$= 858.75 - 14 \times 0.12$

$= 857.07$ m

RL of 'B' = RL of A – ne_2

$= 858.75 - 14 \times 0.16$

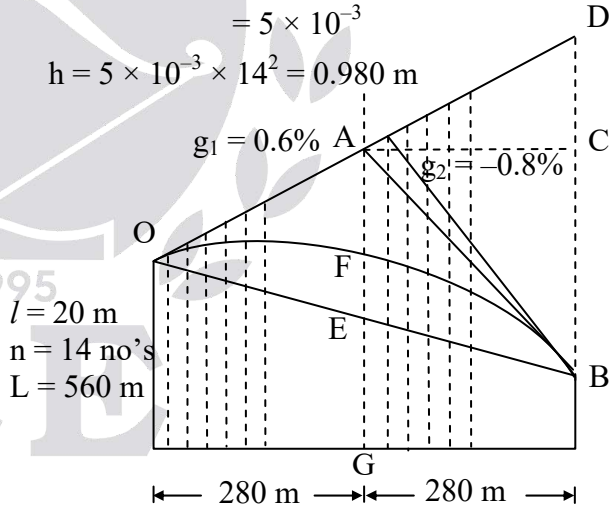
$= 856.51$ m

Tangent correction = $h = kN^2$

$K = \dfrac{(e_1 - e_2)}{4n} = \dfrac{0.12 - (-0.16)}{4 \times 14}$

$= 5 \times 10^{-3}$

$h = 5 \times 10^{-3} \times 14^2 = 0.980$ m



RL of E = $\dfrac{1}{2}$[RL of 0 + RL of B]

$= 856.79$ m

RL of F = $\dfrac{1}{2}$ [RL of E + RL of A]

$= \dfrac{1}{2}[856.79 + 858.75] = 857.77$ m

Check: RL of F

= RL of A – tangent Correction

= 858.75 – 0.980 = 857.77 m

$n = 1; h_1 = k \times 1^2 = 5 \times 10^{-3} \times 1 = 0.005$ m

$\rightarrow 20$ m

$n = 2; h_2 = k \times 2^2 = 5 \times 10^{-3} \times 2^2 = 0.020$ m

$\rightarrow 40$ m

$n = 3; h_3 = 5 \times 10^{-3} \times 3^2 = 0.045$ m $\rightarrow 60$ m

$n = 4; h_4 = 5 \times 10^{-3} \times 4^2 = 0.080$ m $\rightarrow 80$ m

.. ..

.. ..

.. ..

$n = 14; h_{14} = 5 \times 10^{-3} \times 14^2 = 0.98$ m

(Tangent correction)

$n = 15; h_{15} = 5 \times 10^{-3} \times 15^2 = 1.125$ m

.. ..

.. ..

$n = 28; h_{28} = 5 \times 10^{-3} \times 28^2 = 3.92$ m (Last pt)

Elevation of Points on the tangent

$e_1 = \frac{0.6}{100} \times 20 = 0.12$m

RL of a pt '0' = 857.07 m

RL of a pt '1' = 857.07 + 0.12 = 857.19

RL of a pt '2' = 857.07 + 2 × 0.12 = 857.31

.. ..

.. ..

Station	Chainage	Tangent Elevation	Tangent Correction (–)	R.L of curve
0	670.5	857.07	0.000	857.07
1	690.5	857.19	0.005	857.185
2	710.5	857.31	0.020	857.29
3	730.5	857.43	0.045	857.385
4	750.5	857.55	0.080	857.47
5	770.5	857.67	0.125	857.545
6	790.5	857.79	0.180	857.61
7	810.5	857.91	0.245	857.665
8	830.5	858.03	0.320	857.71
9	850.5	858.15	0.405	857.745
10	870.5	858.27	0.500	857.77
11	890.5	858.39	0.605	857.785
12	910.5	858.51	0.720	857.79
13	930.5	858.63	0.845	857.785
14	950.5	858.75	0.980	857.77
15	970.5	858.87	1.125	857.745
16	990.5	858.99	1.280	857.71

17	1010.5	859.11	1.445	857.665
18	1030.5	859.23	1.620	857.61
19	1050.5	859.35	1.805	857.545
20	1070.5	859.47	2.000	857.47
21	1090.5	859.59	2.205	857.385
22	1110.5	859.71	2.420	857.29
23	1130.5	859.83	2.645	857.185
24	1150.5	859.95	2.880	857.07
25	1170.5	860.07	3.125	856.945
26	1190.5	860.19	3.380	856.81
27	1210.5	860.31	3.645	856.665
28	1230.5	860.43	3.920	856.51

13. Errors & Adjustments

01. Ans: (48^o 16′ 22.87″)

Sol: $\angle A + \angle B + \angle C = 179^\circ 59' 50.6''$

$d = +9.4''$

$$C_c = \left[\frac{e_c^2}{e_A^2 + e_B^2 + e_c^2}\right] d$$

$$= \left[\frac{2^2}{4^2 + 6^2 + 2^2}\right] 9.4''$$

$C_c = 0.67''$

Corrected angle = [48^o, 16′ 22.2″] +0.67″

= 48^o 16′ 87″

02. Ans: (a)

Sol: $A \rightarrow 5$

$$\frac{\text{wt of } 3A}{\text{wt of } A/4} = \frac{5/9}{80} = \frac{5}{720}$$

03. Ans: 22500 ± 3 m^2

Sol: Given, side of square (a) = 150 m

Error (e_a) = ± 0.010 m

Area = $a^2 = (150)^2 = 22500\ m^2$

$e_A = 2a.\ e_a$

$= 2 \times 150 \times 0.010$

$= \pm 3\ m^2$

Probable value = 22500 ± 3m^2

04. Ans: (d)

Sol: Most probable value

$$= \frac{42°12'35" + 84°25'15" + 168°50'23"}{7}$$

$= 42°12'36"$

05. Ans: (d)

Sol: As per laws of weights, "If a quantity of given weight is divided by a factor, the weight of the result is obtained multiplying its given weight by the square of the factor".

$3^2 \times 5 = 45$

06. Ans: (b)

Sol: MPV or WAM

$$= 40° + \frac{20\times2 + 30\times3 + 45\times9}{2+3+4}$$

$= 40°\ 34'\ 26.67''$

07. Ans: (a)

Sol: $\angle A = 47°32'30'' \pm 2'' - e_A$

$\angle B = 24°\ 16'40'' \pm 3'' - e_B$

$E_C = \pm\sqrt{e_A^2 + e_3^2} = \pm\sqrt{2^2 + 3^2} = \pm 3.605''$

08. Ans: (d)

Sol: $e_B = \pm\sqrt{e_a^2 + e_b^2 + e_c^2}$

$= \pm\sqrt{1^2 + 1^2 + 1^2} = \pm\sqrt{3}''$

09. Ans: (c)

Sol: Radius, r = 12.25

$e_r = \pm 0.03$ m

$A = \pi r^2$

$e_A = 2\pi r\, e_r$

$= \pm 2.309\ m^2$

10. Ans: (c)

Sol: r = 80 m Diameter = 160 m

$e_d = 0.05$ m

$$A = \frac{\pi}{4}d^2$$

$$e_A = \frac{\pi}{4}(2d)(e_d)$$

$$= \frac{\pi}{2}\times d \times e_d$$

$= \pm 12.56\ m^2$

11. Ans: 471.4352 ± 2.309 m^2

Sol: MPV of an area

$= A \pm e_A$

$= (\pi \times 12.25^2) \pm 2.309$

$= 471.4352 \pm 2.309\ m^2$

12. Ans: (± 1.32 m)

Sol: $C = 2\pi r$ $e_c = 2\pi e_r$

$= \pm 2 \times \pi \times 0.21$

$= \pm 1.32$ m

13. Ans: (d)

Sol: $\angle A = 20°\ 10' \pm 0.2$

$\angle B = 100°\ 40' \pm 0.1$

$\angle C = 59°\ 10° \pm 0.2$

$e_s = \pm\sqrt{0.2^2 + 0.1^2 + 0.2^2} = \pm 0.3$

14. Ans: 3.162 m^2

Sol: $e_a = \pm 0.02$ m $e_b = \pm 0.01$ m

$A = ab$

$$e_A^2 = \left(\frac{\partial A}{\partial a}\right)^2 .e_a^2 + \left(\frac{\partial A}{\partial b}\right)^2 e_b^2$$

$$\frac{\partial A}{\partial a} = b = 150$$

$$\frac{\partial A}{\partial b} = a = 100$$

$$e_A^2 = 150^2(0.02)^2 + 100^2(0.01)^2$$

$\Rightarrow e_A = \pm 3.162\ m^2$

MPV = $15000 \pm 3.162\ m^2$

15.

Sol: MPV = $15000 \pm 3162\ m^2$

16. Ans: (d)

Sol: $E\alpha\sqrt{\ell}$

$$\frac{E_1}{E_2} = \sqrt{\frac{\ell_1}{\ell_2}} \quad \text{(or)} \quad \frac{0.09}{E_2}$$

(or) $E_2 = \pm 0.08$ m

17. Ans: (c)

Sol: $V = ab\,c$

$e_A^2 = (4 \times 3)^2\ 0.02^2 + (3\times 3)^2\ (0.01)^2 + (3\times 4)^2\ (0.02)^2 = \pm 0.35$ m

18. Ans: (d)

Sol: $$\frac{1}{\frac{1}{3}+\frac{1}{2}} = \frac{6}{5}$$

Conventional Practice Solutions

01.

Sol: Observations are of equal weight

$A + B + C = 180^o$

$\therefore A + B = 180^o - C = 180^o - 64^o\ 02'\ 15''$

$= 115^o\ 57'\ 45''$

Normal equations

$A = 59^o\ 32'\ 46'' \rightarrow$ (i)

$B = 56^o\ 12'\ 18'' \rightarrow$ (ii)

$A + B = 115^o\ 57'\ 45'' \rightarrow$ (iii)

Since they are of equal weight, coefficient being '1'

$\therefore$ Normal equation for A

(i) + (iii) $\Rightarrow 2A + B = 175^o\ 30'\ 31'' \rightarrow$ (iv)

Normal equation for B

(ii) + (iii) = $A + 2B = 172^o\ 10'\ 3'' \rightarrow$ (v)

$2A + B = 175^o\ 30'\ 31''$

$2A + 4B = 344^o\ 20'\ 6''$

$3B = 168^o\ 49'\ 35''$

$\therefore B = 56^o\ 16'\ 31.67''$

$\therefore A = 59^o\ 36'\ 59.67''$

$\therefore C = 180 - (A + B)$

$= 180 - 115^o\ 53'\ 31.3''$

$= 64^o\ 6'\ 28.66''$

Observations are of unequal weights

$A = 59^o\ 32'\ 46'' \rightarrow$ (Wt (2) $\rightarrow$ (1))

$B = 56^o\ 12'\ 18'' \rightarrow$ (wt (4) $\rightarrow$ (2))

$A + B = 115^o\ 57'\ 45'' \rightarrow$ (wt (3) $\rightarrow$ (3))

Multiply (1) $\times$ 2 = $119^o\ 5'\ 32'' = 2A \rightarrow$ (3)

Multiply (2) $\times$ 4 = $224^o\ 49'\ 12'' = 4B \rightarrow$ (4)

Multiply (3) × 3 = 347° 53′ 15″ = 3A + 3B →(5)

∴ Normal equation for 'A' (3) + (5)

5A + 3B = 466° 58′ 47″ → (6)

Normal equation for B (4) + (5)

3A + 7B = 572° 4′ 24″ → (7)

15A + 9B = 1400° 56′ 21″

(–) 15A + 35 B = 2863° 32′ 15″

26 B = 1462° 35′ 54″

B = 56° 15′ 13.62″

A = 59° 38′ 37.23″

∴ C = 180° – (A + B)

= 180° – 115° 53′ 50.8″

= 64° 6′ 9.28″

02.

Sol: Sum of all angles A + B + C = 76° 14′ 25′ + 54° 34′ 35″ + 49° 10′ 48″ = 179° 59′ 48″

= 180°

Correction = 180° – 179°59′ 48″= +12″

∴ Error = – 12″

∴ $e_a + e_b + e_c = 12''$ → (1)

From the principle of least squares taking the weights into account

$3e_a^2 + 4e_b^2 + 2e_c^2$ is minimum → (2)

Difference (1) & (2) we get

$\delta e_a + \delta e_b + \delta e_c = 0$ → (3)

$3e_a\,\delta e_a + 4e_b\,\delta e_b + 2e_c\,\delta e_c = 0$ → (4)

∴ Multiply (3) by correlate (– λ)

Adding equation (3) and (4) we get

$\delta e_a (3e_a - \lambda) + \delta e_b(4e_b - \lambda) + \delta e_c (2e_c - \lambda) = 0$

∴ Co-efficient must separately vanish

$3e_a - \lambda = 0;\ \lambda = 3e_a;\ e_a = \frac{\lambda}{3}$

$4e_b - \lambda = 0;\ \lambda = 4e_b;\ e_b = \frac{\lambda}{4}$

$2e_c - \lambda = 0;\ \lambda = 2e_c;\ e_c = \frac{\lambda}{2}$

∴ Substituting in the equation (1)

$e_a + e_b + e_c = \frac{\lambda}{3} + \frac{\lambda}{4} + \frac{\lambda}{2} = 12''$

∴ λ = 11.08″

∴ $e_a = 3.69''$; $e_b = 2.77''$; $e_c = 5.54''$

∴ A = 76° 14′ 28.69″

B = 54° 34′ 37.77″

C = 49° 10′ 53.54″

15. Photogrammetry

01. Ans: (d)

Sol: r = 86 mm

$$d = \frac{rh}{H} = \frac{86\times10^{-3}\times600}{4500}$$

= 0.011466 m

= 11.466 mm

02. Ans: (c)

Sol: $S = \frac{f}{H-h}$

$$= \frac{152\times10^{-3}}{1800-300} = \frac{1}{9868}$$

03. Ans: (a)

Sol: $\frac{\text{Photo scale}}{\text{Map scale}} = \frac{\text{P.D.}}{\text{M.D.}}$

$$\Rightarrow PS = \frac{188\times10^{-3}}{120\times10^{-3}} \times \frac{1}{20{,}000}$$

$$= \frac{1}{12766}$$

04. Ans: 406

Sol: $N_i = \left[\frac{L_1}{L} + 1\right]$

$$N_2 = \left[\frac{W_1}{W} + 1\right]$$

$$L = (1-0.6) \times \frac{230\times10^{-3}}{\frac{1}{10{,}000}} = 0.92 \text{ km}$$

$$W = (1-0.3)\frac{230\times10^{-3}}{\frac{1}{10{,}000}} = 1.61 \text{km}$$

$$N_1 = \frac{L_1}{L} + 1 = \frac{25}{0.92} + 1 = 28.17$$

$$N_2 = \frac{W_1}{W} + 1 = \frac{20}{1.61} + 1 = 13.42$$

$$N = N_1 \times N_2 = 406$$

05. Ans: (c)

Sol: H = 1500 m

h_1 = 250 m

d = 115.4 × 10^{-3}

r = 190 × 10^{-3} m

$$d = \frac{r_2 h_2}{H - h_1} = 996.05 \text{ m}$$

06. Ans: (a)

Sol: focal length = 21.5 cm

= 21.5 × 10^{-2} m

$$S = \frac{1}{45{,}000}$$

P.D = 11 × 10^{-2} m

M.D = 3 × 10^{-2} m

h = 350 m

H = ?

$$S = \frac{f}{H - h}$$

$$\frac{\text{Photo scale}}{\text{Map scale}} = \frac{11\times10^{-2}}{3\times10^{-2}}$$

$$\Rightarrow \frac{21.5\times10^{-2}}{\frac{4-350}{1}} = \frac{11\times10^{-2}}{3\times10^{-2}} \Rightarrow H = 2988.637 \text{ m}$$

$$\frac{}{45{,}000}$$

07. Ans: (a)

Sol: $V = \frac{L}{t} \times 3600 = 216$ kmph

08. Ans: 620

Sol: R =?

h_a = 650 m, h_b = 250 m

f = 250 × 10^{-3}

H = 2700

X_A = 299.3 m

Y_B = 547.82

Y_A = +208.28 m

X_B = –220.5 m

$$\sqrt{(X_A - X_B)^2 + (Y_A - Y_B)^2} = 620 \text{ m}$$

09. Ans: (a)

Sol: $S_d = \frac{f}{H} \Rightarrow \frac{1}{8000} = \frac{25\times10^{-3}}{H}$

$\therefore$ H = 2000 m

$$d = \frac{r_1 h_1}{(H - h_1)}$$

$$= \frac{7.50\times10^{-2}\times350}{2000-350}$$

= 0.015 m

= 15.9 mm

10. Ans: (d)

Sol: $d = r_2 - r_o$

= 112.5 –82.40= 30.1 mm

$$h_2 = \frac{d(H-h_1)}{r_2}$$

$$= \frac{30.1}{112.5}\times(700-250)$$

= 120.4 m

Conventional Practice Solutions

01.

Sol: Relief displacement = d = 10 – 8.75

= 1.25 cm

H = 1250 m ; r = 25 cm

$\therefore$ $d = \frac{rh}{H} \Rightarrow h = \frac{dH}{r} = \frac{1.25\times1250}{25}$

= 62.5 m

02.

Sol: Scale of photograph = $S = \frac{f}{H-h} = \frac{1}{10,000}$

$$\frac{0.25}{H-1875} = \frac{1}{10000} \Rightarrow H = 4375\,m$$

03.

Sol: Shutter speed = $\frac{1}{150}$ sec

Distance moved by air craft in $\frac{1}{150}$ sec

$$L = \frac{V}{\varepsilon}\times t = 360\times\left(\frac{5}{18}\right)\times\frac{1}{150} = \frac{2}{3}\,m$$

Scale of photograph = $S = \frac{f}{H}$

$$= \frac{\text{Distance moved by image}}{\text{Distance moved by plane}}$$

$$\frac{180}{H} = \frac{0.075}{(2/3)} \Rightarrow H = 1600\,m$$

If the equivalent angular displacement

$= \theta$

$$\therefore \tan\theta = \frac{\text{Distance moved}}{\text{Flying height}}$$

$$= \frac{\left(\frac{2}{3}\right)}{(1600)} = \frac{1}{2400}$$

$\therefore$ $\theta = 0^o\ 1'26''$

04. (i) Flying height of aircraft (H)

Scale of photograph = $S = \dfrac{f}{H - h_{avg}}$

$$\frac{1}{12000} = \frac{0.375}{H - 500} \Rightarrow H = 5000\ m$$

(ii) Number of photographs in each flight line

Effective length covered per photograph

$$L = \left[(1 - 0.6) \times \frac{(25 \times 10^{-2})}{1} \right] \times 10^{-3}$$

$$= 1.20\ km$$

$$N_1 = \left[\frac{L_1}{L} + 1 \right] = \frac{37.5}{1.2} + 1$$

$$= 32.25 \text{ say}$$

$$= 33$$

(iii) Number of flights

Effective ground width covered per photograph

$$= \left[(1 - 0.3) \times \frac{(25 \times 10^{-2})}{\left(\frac{1}{12000}\right)} \right] \times 10^{-3}$$

$$= 2.1\ km$$

$$N_2 = \left[\frac{W_1}{W} + 1 \right] = \frac{30}{2.1} + 1 = 15.28 \text{ say} = 16$$

(iv) $N = N_1 \times N_2$

$$= 33 \times 16 = 528$$

(v) Exposure interval (sec) = $\dfrac{L}{v}$

$$= \frac{1.2}{\left(\frac{250}{60 \times 60}\right)} = 17.28 \text{ sec}$$

By taking exposure interval = 17 sec = t

$\therefore$ The adjusted ground distance between exposures

$$L = v \times t = \left(250 \times \frac{5}{18}\right) \times 17 = 1180.5 m$$

16. Triangulation

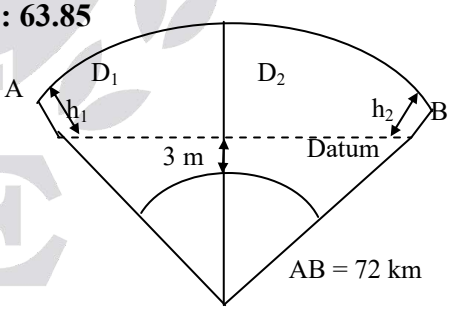
01. Ans: (c)

Sol: $\alpha = \dfrac{r \cos^2 \theta/2}{D}$

$$= 206265 \times \frac{7.5 \times 10^{-2} \times \cos^2 60/2}{10 \times 10^3}$$

$$= 1.16''$$

02. Ans: 63.85



Minimum elevation of line of light

= 328 + 3 = 331 m

(Take as a reference)

Height of A = 372 – 331 = 41 m

If line of right from A strike the ground at D_1

$$D_1 = \sqrt{\frac{h_1}{0.06735}} = 24.673\ km$$

$\therefore D_2 = 47.327$ km

$h_2 = 0.06735\ D_2^2 = 150.85$ m

Elevation of signal at B

331 + 150.85 = 481.85 m

$\therefore$ Signal @ B to be required to elevate

= 481.85 m – 418 = 63.85

03. Ans: (b)

Sol: D = 8560 m

$$r = \frac{140}{2} = 70\text{mm}$$

$\theta = 50^o$

$$\propto = \frac{206265 \times 70 \times 10^{-3} \times \cos^2\left(\frac{50}{2}\right)}{8560}$$

$= 1.53''$

21. Field Astronomy

01.

Sol:

(i) Time into degree system

(a) 4h 12 m 48 s

$$48 \times 15 = \frac{720''}{60} = 12'$$

$$12 \times 15 = \frac{180'}{60} = 3^o$$

$$4 \times 15 = 60^o$$

$\therefore 63^o\ 12'\ 0''$

(b) 16 h 32 m 24s

$$24 \times 15 = \frac{120''}{60} = 6'$$

$$32 \times 15 = \frac{480'}{60} = 8^o$$

$$16 \times 15 = 240^o$$

$\therefore 248^o\ 6'$

(ii)

(a) $12^o\ 32'\ 48''$

$$\frac{12^o}{15} = 0 \text{ hr}$$

$$(12^o \times 60 + 32) = \frac{752}{15} = 50 \text{ m}$$

$$(2' \times 60 + 48) = \frac{168}{15} = 11.25 \text{ sec}$$

$\therefore$ 0h 50 m 11.2 secss

(b) $124^o\ 12'\ 36''$

$$\frac{124^o}{15} = 8\text{h}$$

$$\left(4^o \times 60 + 12\right) = \frac{252'}{15} = 16\text{m}$$

$$12' \times 60 + 36'' = \frac{756''}{15} = 50.4\,\text{sec}$$

$\therefore$ 8 h 16 m 50.4 sec

02.

Sol:

(i) At upper culmination as $\delta < \theta$;

The star is on the south side of zenith

$\therefore$ Zenith distance = $\theta - \delta = 50^o - 20^o = 30^o$

(ii) At lower culmination

Zenith distance = $180^o - \theta - \delta$

$= 180^o - 45^o\ 30' - 22^o\ 30' = 112^o$

03.

Sol:

(a) Standard time 9 am

Longitude = 72^o 30′ E

Difference in longitude

= 82^o 30′ – 72^o 30′ = 10^o

10^o = 0h 40 m

LMT @ a place = 9 h – 0h 40 m = 8 h 20 m

GMT = 9 h – 82^o 30′ in time

= 9 h – 5h 30 m = 3 h 30 m

82^o 30′ = 5h 30m

(b) Local time = 10 pm = 22 h

Difference in longitude

= 82^o 30′ – 72^o 30′

= 10^o = 40 m

Local mean time @ place

= 22 h 0m – 0h 40 m

= 21 h 20 m

Corresponding Greenwhich mean time

= 21 h 20 m – 4 h 50 m (or 72^o 30′)

= 16h 30 m

Or 22h –5h 30 m (or 82^o 30′)

= 16 h 30 m