10

(176)

-: HAND WRITTEN NOTES:-

OF

CIVIL ENGINEERING

(1)

-: SUBJECT:-

SURVEYING

10

2

Introduction:->

Earth:-> Earth is an oblate spheroid.
(Flatted on poles)

(3)

Diameter - polar axis = 1271.80 km.
Equatorial axis = 12756.75 km.
difference = 42.95 km (0.34% less)

Types:->

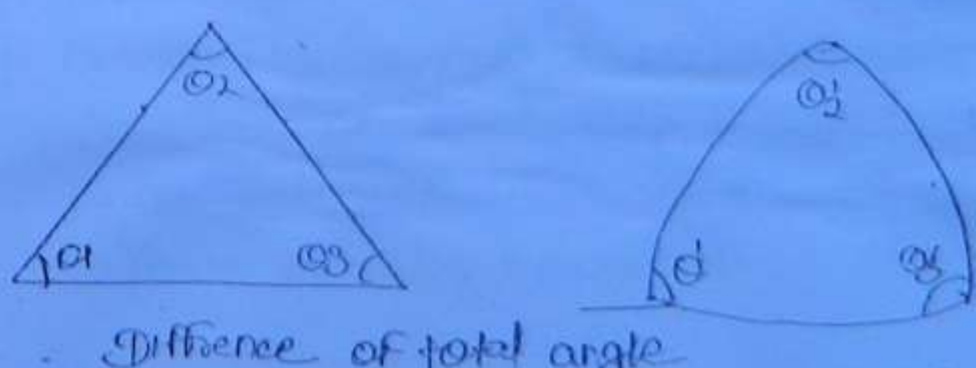
1) **plain Surveying:->** at earth curvature is not considerd (Suitable for small area)

2) **Geodetic Survey:->** It earth curvature is considerd (Suitable for large area)

(1)

difference for 12 km length = 1 cm

(5)



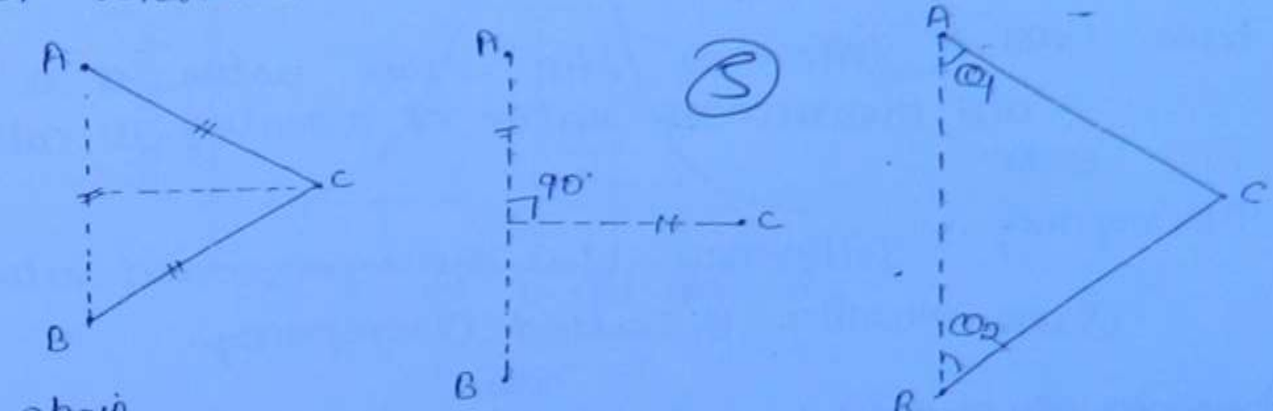
Difference of total angle

$(\theta_1' + \theta_2' + \theta_3') - (\theta_1 + \theta_2 + \theta_3)$ = 1 Second = $0^\circ 0' 1''$

4

(3) Principal of Surveying :->

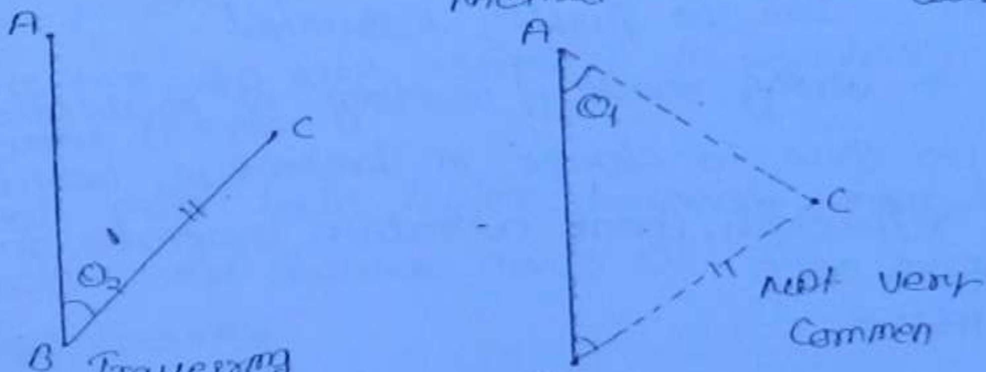
(a) Location of a point by measurement from two point of referance.



Chain Survey

Offset method

Compass Survey



Traversing

Not very Commen

(b) Working from whole to part :-> first major control points repre -senting whole are fixed and distance are mesured with higher accuracy then minor details can be taken even with less precision Error involved in ~~can be taken~~ own measument will not be accumulated.

* Accuracy and Errors :->

(I) Definitions

(i) Accuracy :-> Degree of persection obtained in measurm of a quantity is called accurcy. By using prices instrument correct mearurment and correct manner of taking measurment.

(2) Precision :→

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Degree of perfection used in the measurement is called precision.

(3) True Error :→ Difference b/w true value of a quantity and measurement value of a quality is called true error.

(4) Discrepancy :→ Differency b/w two measured value of same quantity is called Discrepancy.

★ Source of Errors :→

① Instrument :- Due to faulty instrument.

② Personal → Wrong reading/ writing of measurement.

③ Nature → Due to change in Temperture, humidity, wind, refraction, local attraction megnatic declimantion.

★ Kind of Errors :→

① Mistakes :→ Human error's due to less knowledge, carelessness, Confusion in experience.

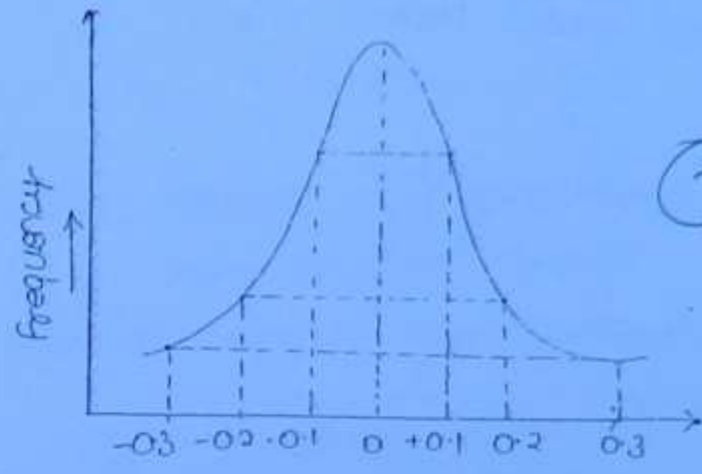
② Systmatic Error :→ (Commulative error)

Always's have same size and directions under same condition of measurement may be either (+)ive or (−)ive

③ Accidental Error's → (Componsating error) :→

These error's occur's same times in one direction and same times in opposit time and (−)ive error's compensante each others.

A Theory OF probability :->



(7)

-> Accidental error's Followed a definite rule method law OF probability.

As per this law according to possibility distribution curve of error.

(1) Small error have higher frequency than large errors.

(2) positive and negative error's OF Same magnitude have Same frequency.

A True Value :-> Exact value OF a quantity.
(Almost impossible to measure)

A Most probable value :-> The value of measurement which ... Chanes of being the correct OF a quantity than other measurement is called most probable value.

A Principal OF least Square :->

Most probable value of quantity is 1 for which Sum of a Square of a residual error is min.

Ex:-> when all measurement have equal weight x_1, x_2, x_3 ------ x_n (equal weight = 1.0)

Residual error:→

If most proable value = x.

$x = x_1$

$x = x_2$

(8)

- - - - -

- - - - -

Square $(x-x_1)^2$

$(x-x_2)^2$

- - - - -

- - - - -

As per principal of least square

$$y = (x-x_1)^2 + (x-x_2)^2 + \cdots = \min^m$$

$$\Rightarrow \frac{dy}{dx} = 2(x-x_1) + 2(x-x_2) + \cdots = 0$$

$$nx = (x_1 + x_2 + \cdots x_n) = 0$$

$$n \cdot x = (x_1 + x_2 + \cdots x_n) = 0$$

$$x = \left(\frac{x_1 + x_2 + \cdots + x_n}{n} \right) = \text{Mean of all}$$

Case (II) Unequal weights

Squares	measurement	weight	M.P.V	Residual error
$(x-x_1)^2 \times \omega_1$	x_1	w_1	↑	$x-x_1$
$(x-x_2)^2 \times \omega_2$	x_2	w_2	x	$x-x_2$
- - - - -	- - -	- - -		- - -
$(x-x_n)^2 \times \omega_n$	x_n	w_n	↓	$(x-x_n)$

Sum of Square of residual error.

$$y = \omega_1 (x-x_1)^2 + \omega_2 (x-x_2)^2 + \cdots + \geq \min^m.$$

$$\frac{dy}{dx} = 2\omega_1(x-x_1) + 2(\omega_2)(x-x_2) + \cdots = 0$$

$$\text{mpv} \Rightarrow x = \frac{\omega_1 x_1 + \omega_2 x_2 + \cdots}{\omega_1 + \omega_2 + \cdots} = \frac{\Sigma \omega x}{\Sigma \omega}$$

☆ The probable error of a single observation.

$$E_S = \pm 0.6745 \sqrt{\frac{\Sigma V^2}{(n-1)}}$$ (9)

V = difference b/w any single observation and mean of the series.

☆ The probable error of the mean:-

$$E_m = \pm 0.6745 \sqrt{\frac{\Sigma V^2}{n(n-1)}}$$

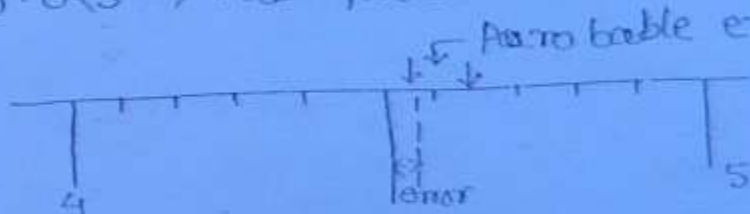
$$E_m = \frac{E_S}{\sqrt{n}}$$

☆ Significant Figures:→ / max. error / Most probable error:→

4.6

error 0.05 ← max. error

0.025 → Most probable error



→ No. of significant figures shows the accuracy of measurement

→ If there are n significant figure in a measure (n-1) figure are called - certain figure

least figure is called - Uncertain figure.

→ There are two types of error

Example	Max. error	probable error
4.6	0.05	0.025
5.86	0.005	0.0025

Accumulation of error :→

(1) For max. error :→

Total error = Algebric Sum of all errors...

$$e_T = \pm e_1 \pm e_2 \pm e_3$$

(2) For probable error :→

Sum = Root mean Square value

$$e_T = \pm \sqrt{e_1^2 + e_2^2 + e_3^2 + ---}$$

Error's in Computed Result :→

(1) Addition :→

If x and y are two measured value

$$S = x + y$$

$$\boxed{ds = dx + dy} \quad \text{—— (1)}$$

if max. error's are $= \pm \delta x$ and $\pm \delta y$

max. error

$$S \pm \delta_S = (x + \delta x) + (y + \delta y)$$

$$\Rightarrow S \pm \delta_S = (x + y) \pm (\delta x + \delta y)$$

$$\delta_S = (\delta x + \delta y) \text{ max. error in } S$$

Probable error :-

are e_x and e_y sum of probable error's

$$e_S = \sqrt{e_x^2 + e_y^2}$$

Range of $S = (S + e_S)$ to $(S - e_S)$

(ii) Sub-Traction :→

$$S = x - y$$
$$dS = dx - dy$$

Max. error if $\pm \delta x$ and $\pm \delta y$ are max. error

For (S) ⇒ $\delta_S = (+\delta x) - (-\delta y)$

$$\delta_S = +(\delta x + \delta y)$$

or

$$= (-\delta x) - (+\delta y)$$
$$= -(\delta x + \delta y)$$

$$\delta_S = \pm (\delta x + \delta y)$$

Range of S

$$S = (S + \delta_S) \text{ to } (S - \delta_S)$$

Probable error

$$e_S = \pm \sqrt{(e_x)^2 + (e_y)^2}$$

Range $= (S + e_S)$ to $(S - e_S)$

(iii) Multiplication :→

$$S = x \cdot y$$
$$dS = x\,dy + y\,dx$$

max. error

Respective error of x and y → δx and

For S in $x \to y \cdot \delta x$

in $y \to x \cdot \delta y$

$$\delta = x \cdot \delta_y + y \cdot \delta x \quad \text{—— (1)}$$

Range $(S + \delta_S)$ to $(S - \delta_S)$

Probable error :→

Respective error of x and y → e_x and e_y.

for S. error in $x = y\,e_x$

$$y = x \cdot e_y$$

$$\text{Sum} = e_s = \sqrt{(y e_x)^2 + (x e_y)^2}$$ (12)

$$\Rightarrow \frac{e_s}{s} = \frac{1}{xy} \cdot \sqrt{(y \cdot e_x)^2 + (x \cdot e_y)^2}$$

$$\Rightarrow \frac{e_s}{s} = \sqrt{\left(\frac{e_x}{x}\right)^2 + \left(\frac{e_y}{y}\right)^2}$$

$$\Rightarrow e_s = s \times \sqrt{\left(\frac{e_x}{x}\right)^2 + \left(\frac{e_y}{y}\right)^2}$$

(4) Division: $\rightarrow s = x/y$

$$ds = \frac{y\,dx - x\,dy}{y^2}$$

$$ds = \left(\frac{dx}{y}\right)^2 - \left(\frac{x}{y^2}\right)dy$$

max error:- Respective error of x and $y \rightarrow \delta x$ and δy

For s in $x \rightarrow \frac{1}{y}\delta x$

in $y \rightarrow \frac{x}{y^2}\delta y$

$$\boxed{\delta_{os} = \frac{\delta x}{y} + \frac{x}{y^2} dy}$$

Range $(s + ds)$ to $(s - ds)$

Probable error:-

Respective error of x and $y \rightarrow e_x$ and e_y

For s error in $x = \frac{1}{y} e_x$

$$y = \frac{x}{y^2} e_y$$

$$\text{Sum } e_s = \sqrt{\left(\frac{e_x}{y}\right)^2 + \left(x \cdot \frac{e_y}{y^2}\right)^2}$$

$$\Rightarrow \frac{e_s}{s} = \frac{y}{x}\sqrt{\left(\frac{e_x}{y}\right)^2 + \left(\frac{x}{y^2} e_y\right)^2}$$

$$\Rightarrow \boxed{\frac{e_s}{s} = \sqrt{\left(\frac{e_x}{x}\right)^2 + \left(\frac{e_y}{y}\right)^2}} \text{ — B}$$

Que ① A quantity S is equal to sum of two measured quantities x and y.

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$S = 5.68 + 3.648$

Find out probable error, max. error & most probable limits max. limits of S.

$x = 5.68$	$0.005\ \delta x$	$0.0025\ lx$
$y = 3.648$	$0.0005\ \delta y$	$0.00025\ ly$
	max. error	probable error.

Solution: → ① max. error

(For S) $\delta_S = \delta x + \delta y$

$\delta_S = 0.005 + 0.0005$

$\delta_S = 0.0055$

Range max. range $= 8\,(S + \delta_S)$ to $(S - \delta_S)$

$= 9.328 + 0.0055$ to $\begin{array}{r} 9.328 \\ -0.0055 \\ \hline 9.3225 \end{array}$

② most probable error:-

$e_S = \sqrt{e_x^2 + e_y^2}$

$e_S = \sqrt{(0.0025)^2 + (0.00025)^2}$

$e_S = 0.002512$

probable range of S

$= S + e_S$ to $S - e_S$

$= 9.328$ to 9.328

$= 9.33051 \quad - 0.002512$

$= 9.3255$ Ans

Ques(2) Calculated the max. & probable error & range of a computed quantity.

(14) $S = \frac{9.58}{4.6}$

Solution:->

		max^m	probable
x	9.58	$\delta x = 0.005$	$e_x = 0.0025$
y	4.60	$\delta y = 0.05$	$e_y = 0.025$

$S = 2.0826$

$ds = \frac{y\,dx - x\,dy}{y^2}$

$ds = \frac{dx}{y} - \frac{x}{y^2}dy$

max^m error.

$\delta s = \frac{\delta x}{y} + \frac{\delta y}{y^2}x$

$\delta s = \frac{0.005}{4.6} + \frac{9.58 \times 0.05}{4.6^2}$

$\delta s = 0.0237$

Range of s.

$$\begin{array}{r} 2.0826 \\ +0.0237 \\ \hline 2.1063 \end{array} \quad \text{to} \quad \begin{array}{r} 2.0826 \\ -0.0237 \\ \hline 2.0589 \end{array}$$

Probable error

$\Rightarrow \frac{e_s}{s} = \sqrt{\left(\frac{e_x}{x}\right)^2 + \left(\frac{e_y}{y}\right)^2}$

$\Rightarrow e_s = 2.0826\sqrt{\left(\frac{0.0025}{9.58}\right)^2 + \left(\frac{0.025}{4.6}\right)^2}$

$\Rightarrow e_s = +0.0113$

Range of S

$$\begin{array}{r} 2.0826 \\ +0.0113 \\ \hline 2.0939 \end{array} \qquad \begin{array}{r} 2.0826 \\ -0.0113 \\ \hline 2.0713 \end{array}$$

Ans

* Fundamental definition :→
(Linear measurement)

Scale :→ Scale is ratio of distance plotted on drawing to distance on the ground.

Ex = 1 cm = 1 Km

1 cm = 1000 m

1 cm = 1000 × 100 cm

$$R.F = \frac{1}{100000} = \text{Representative fraction}$$

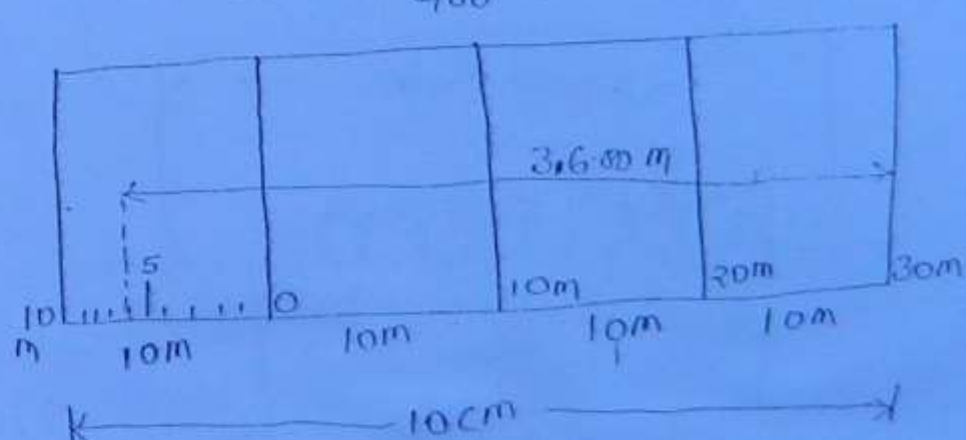
Types :→

1. plane scale.
2. Diagonal Scale.
3. Vernier scale.
4. chord Scale.

(1) plane Scale :→ It measures upto two dimension only

A scale 1cm = 4 m to be prepared

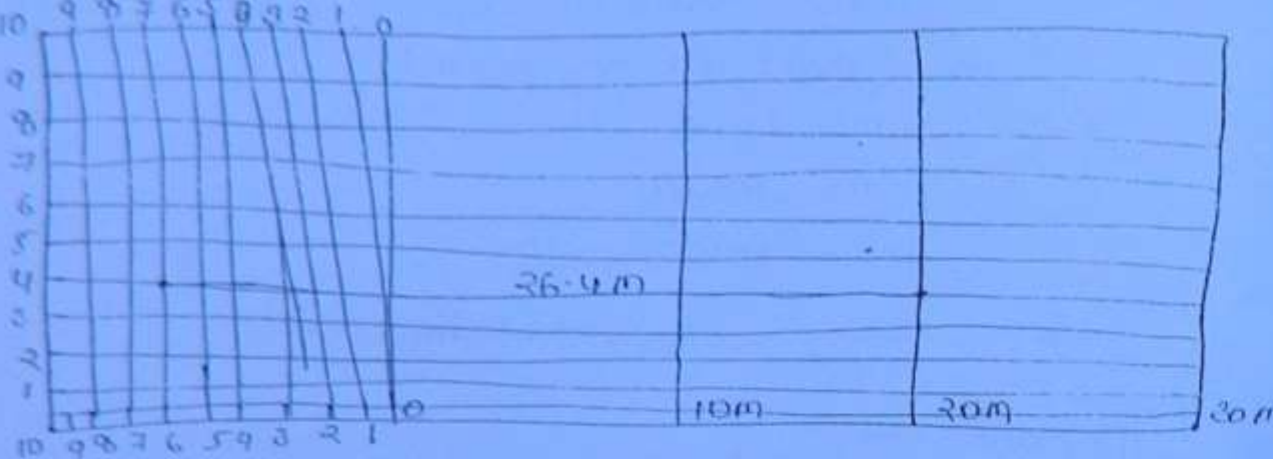
$$R.F = \frac{1}{400}$$



→ In this case, 10m and meter are the two dimention that can be measured.

(2) Diagonal Scale :-> It can measured upto 3 dimension. Similar triangle theory is used in diagonal scale.

(16)

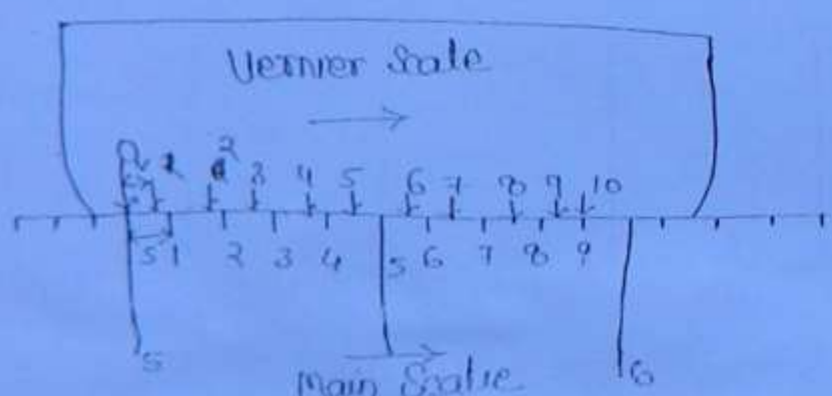


In three diamention in above case

(1) 10m
(2) meter
(3) decimeter

(3) Vernier Scale :->

(a) Direct vernier Scale -> In this case also upto 3 diamention can be read.



In case of direct vernir scale,

(i) Vernier scale moves in same direction as of main scale.

(ii) (n-1) parts of main scale is equal to n divisions (parts) of vernier scale.

$$n \cdot v = (n-1)s$$

S = mean scale
v = vernier scale

$$V = \frac{(n-1)}{n} \cdot s$$

Least count ⇒ minimum value that can be used using a scale is called least count.

$$L.C. = S - V$$

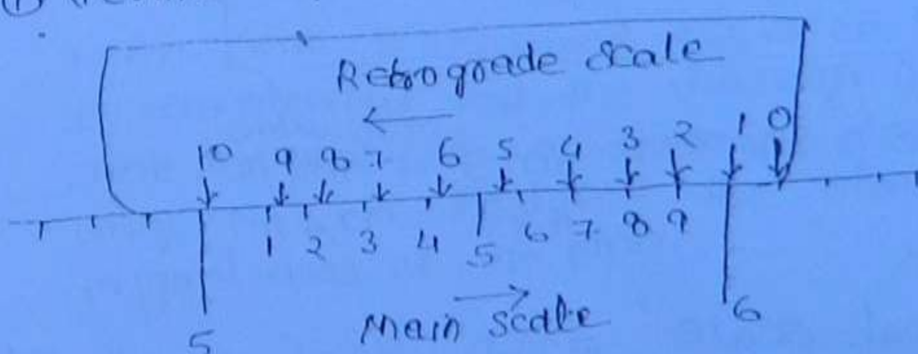
$$L.C. = S - \frac{n-1}{n} \cdot s$$

$$L.C. = \frac{ns - ns + s}{n}$$

$$\boxed{L.C. = \frac{s}{n}}$$ — least count of this vernier scale.

(b) Retrograde Scale :-> In case of Retrograde scale

(1) Vernier scale moves in opposite direction as the main scale.



(2) (n+1) parts of main scale is equal n division (parts) of vernier scale.

$$n \cdot v = (n+1)s$$

$$V = \frac{(n+1)}{n} \cdot s$$

Least count ⇒ minimum value that can be read using a scale is called least count

$$L.C. = V - S$$

$$L.C. = \frac{(n+1)}{n} \times S - S$$

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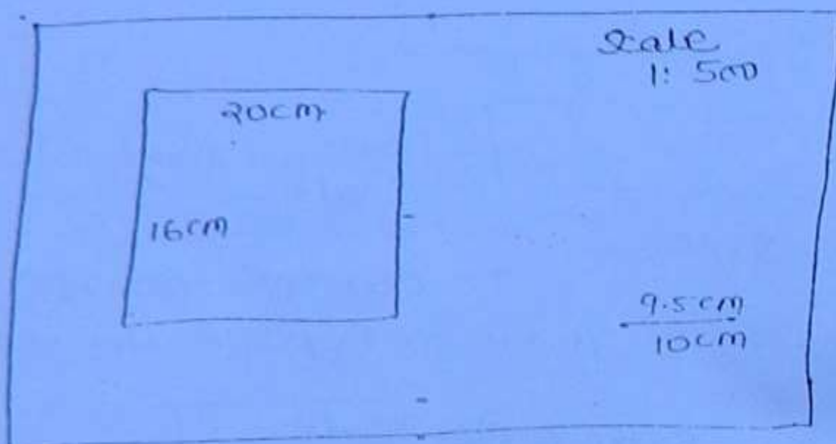
$$L.C. = \frac{nS + S - nS}{n}$$

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

Shrink Scale :→
(and Shrinkage factor)



1: 500
1cm = 500 cm
1cm = 5m

This line is represent $20 \times 5 = 100$ m (scale value)
$16 \times 5 = 80$ m

original Scale
1 : 500
10cm = 5000 cm

Now
present Scale
9.5 cm = 5000 cm

$$1\,cm = \frac{5000}{9.5}\,cm$$

1 cm = 526.316 cm $\boxed{1 : 526.316}$

→ Shrinkage factor :- It is the ratio of shrunk length to orignal length of the ...

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$$S.F. = \frac{\text{Shrunk length}}{\text{orignal length}}$$

→ Shrunk Scale = shrinkage factor x orignal scale.

Ex. for given example.

$$SF = \frac{9.5}{10}$$

$$SF = 0.95$$

Shrunk scale = shrinkage factor x orignal scale

$$= 0.95 \times \frac{1}{500}$$

$$= \frac{1}{526.316}$$

problem:→ Area of a plan in a drawing plotted to a scale 1 cm = 50 m is measured 250 sq. cm by planimeter. It was observed that the drawing has shrunk and line originally 10 cm drawn on drawing measured only 9.20 cm. Find out the shrunk scale and original area of the plan.

Solution:→ Shrunk length = 9.2 cm

orignal length = 10 cm

$$\text{Shrinkage factor} = \frac{\text{Shrunk length}}{\text{orignal length}}$$

$$= 9.2/10$$

$$= 0.92$$

orignal scale = 1 cm = 50 m

1 cm = 5000 cm

$= 1/5000$

Shrunk scale $= S.F. \times 0.5$

$= 0.92 \times \frac{1}{5000}$

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$= \frac{1}{5434.78}$

Scale $1 cm = 54.35 m$

original area $= 250 \, cm^2 \times (54.35)^2$

$= 738490.6 \, m^2$

Ans :-

Error due to wrong length of chain / Tape :→

l = length (Designated) length of Tape / chain

l' = wrong length of Tape / chain [actual length]

L' = wrong Measured (written) length of a line

L = True of line measured

$$\boxed{\begin{array}{l} \text{True} \times \text{True} = \text{wrong} \times \text{wrong} \\ L \times l = l' \times L' \end{array}}$$

True length of line $L = \left(\frac{l'}{l}\right) \times L'$

Ex:→ If a 30 m chain is actually 30.20 m long, what will be the actual length of a line which is measured 3052 m using above tape.

Solution :→

$l = 30 m$

$l' = 30.20 m$

$L' = 3052 m$

$L = ?$

$l \times L = l' \times L'$

$L = \left(\frac{l'}{l}\right) \times L'$

$L = \frac{30.20}{30} \times 3052 = \boxed{3072.35 m}$

Formula

① $l = \left(\frac{L'}{L}\right) \times l'$ for length

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② For Area

$$A = \left(\frac{L'}{L}\right)^2 \times A'$$

③ For volume

$$V = \left(\frac{L'}{L}\right)^3 \times V'$$

☆ Tape Correction :→

ⓐ Correction due to standardization. [Due to wrong length of chain / Tape].

Total Correction required

$$Ca = \frac{\text{Total length of line } (l')}{L} \times c$$

$$Ca = \frac{l'}{L} \times c$$

∗ Ca = Total correction

c = Correction required per chain length

L = Designated length of tape / chain

this correction may be (+) or (−)

② Measured length	③ written noted length	④ Error	⑤ Correction	① Case
More 30·50	less 30·0	(−)ve −0·50m	(+)ve +0·50m	Tape is long
less 29.5m	More 30.0m	(+)ve +0·50m	(−)ve −0·50m	Tape is short

(b) Correction due to slope (C_s)

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In case of chaining along a sloping area we need to measured the horizontal distance.

Slope correction (C_s) $= L - l$

$$C_s = L - (\sqrt{L^2 - h^2})$$

$$C_s = L - L\left[1 - h^2/L^2\right]^{1/2}$$

$$C_s = \cancel{L} - \cancel{L} + \frac{h^2}{2L} + \cdots$$

$$\boxed{C_s = \frac{h^2}{2L}}$$

Errors always positive (+)ve correction is alway (−) ve.

(c) Correction due to alignment :→ (C_{al}) :→

If h is error in alignment

L = length of line measured

correction due to alignment

$$C_{al} = \frac{h^2}{2L}$$ ← Same as slope correction

(Error always (+) ve) (correction always (−) ve)

(d) Correction due to Temperature :→ The correction required C_T

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$$C_T = L(T_m - T_0) \times \alpha$$

here L = length of line measured

T_m = Temperature at the time of measurement

T_0 = Temperature at the time of Standardization

Case (1) - If T_m is more than T_0

$(T_m > T_0)$

Tape length is increase.

error = (-)ve

Correction = (+)ve

Case (2) = If $(T_m < T_0)$

Tape length is decrease

error = (+)ve

correction = (-)ve

(e) Pull Correction :→

If L = length of line measured.

P_m = Pull applied at the time of measurement.

P_0 = Pull applied at the time of Standardization

Pull Correction

$$C_P = \frac{(P_m - P_0) \cdot L}{AE}$$

A = c/s area of Tape/chain

E = young's modulus of elasticity of Tape/chain

Case (1) $P_m > P_0$ length increases

Error = (-) ve

Correction = (+) ve

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Case (2) $P_m < P_0$

length is less

Error = (+) ve

Correction = (-) ve

(F) Sag correction :->

Sag correction $C_{sag} = \frac{W^2 l}{24 P_m^2} = \frac{(w l_1)^2 l}{24 P_m^2}$

∀ W = Total weight of chain

= $w l_1$

w = weight per meter

l_1 = length of chain/Taper

P_m = Pull applied at the time of measured.

Error - always = (+) ve

Correction - always = (-) ve

(ii) Normal Tension :→

If ($P_m > P_0$) Pull correction is (+)ve
Sag correction is (−)ve

Pull correction and Sag correction neutralize each other

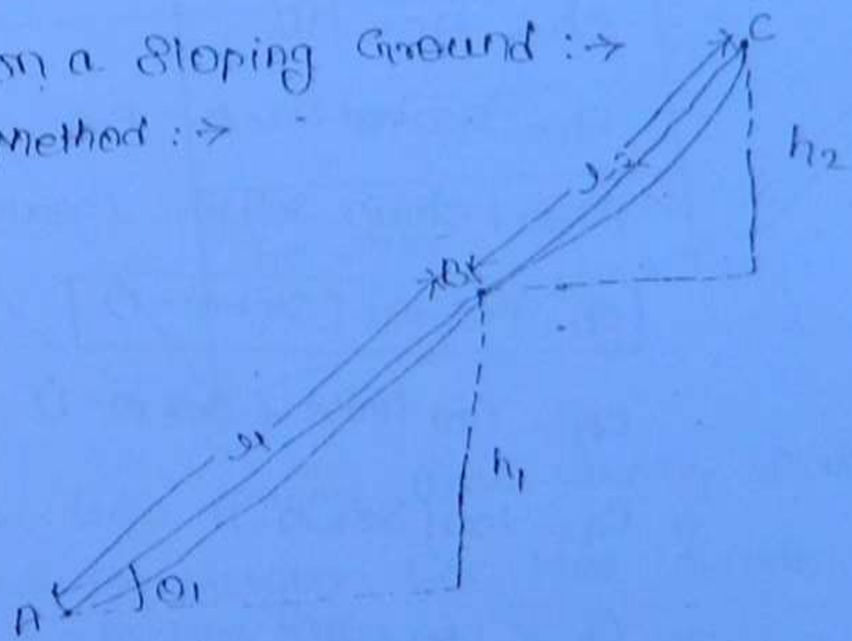
→ the value of pull (P_m) for which pull correction is equal to Sag correction is called Normal tension

$$\boxed{\frac{(P_m - P_0)L}{A \cdot E} = \frac{W^2 L}{24 P_m^2}}$$

This eq. can be solved : trial and error for (P_m)

(iii) Chaining on a Sloping Ground :→

(1) Indirect Method :→



Horizontal distance A to C

$$= l_1 \cos\theta_1 + l_2 \cos\theta_2 + \cdots$$

(2) Measuring difference of level :→

Horizontal distance $= \sqrt{l_1^2 - h_1^2} + \sqrt{l_2^2 - h_2^2} + \cdots$

(3) Hypotenusal correction :→

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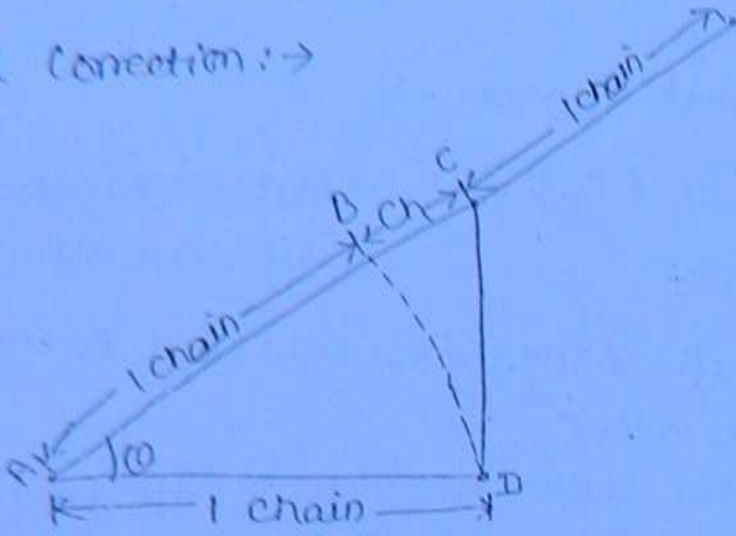


Hypotenusal correction $Ch = BC$

$$\frac{AD}{AC} = \cos\theta$$

$$Ch = AC - AB$$

$$Ch = AD\ \sec\theta - AB$$

$$Ch = 1\text{ chain } \sec\theta - 1\text{ chain}$$

$$\boxed{Ch = 1\text{ chain }(\sec\theta - 1)}$$

$$Ch = 100\text{ links }(\sec\theta - 1)$$

$$\Rightarrow Ch = 100(\sec\theta - 1)$$

$$\Rightarrow Ch = 100 \times \frac{\theta^2}{2}$$

$$\Rightarrow \boxed{Ch = 50\theta^2}\text{ links}$$

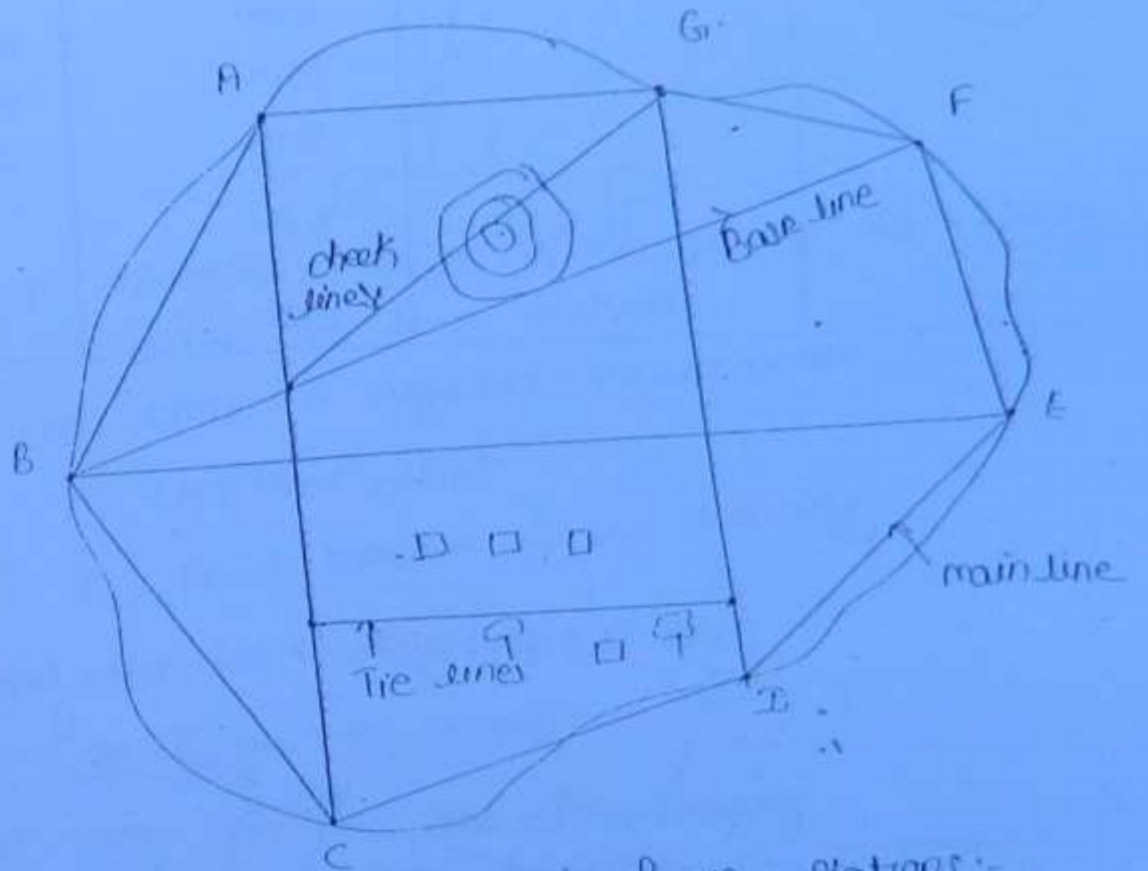
This correction is applied after each chain, and next chaining is started after correction.

[redacted]

☆ Chain Surveying :->

☆ Limiting length of offset :-> (27)

Important terms :->



Lines joining main survey stations :-

① Main line :-> Lines joining main survey stations :-

② Base line :-> The longest line that devide the whole area in two part.

③ Tie line :-> A line drawn to collect the information or detail of objects nearly.

④ check line :-> To check the accuracy of survey work

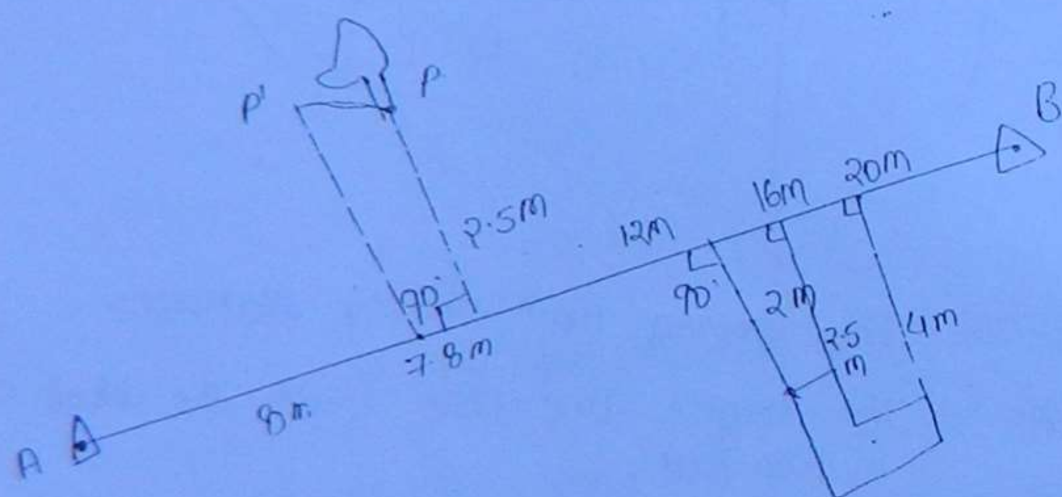
⑤ well condition traingle -> A traingle having no angle < 3…

⑥ Off Sets and field book :->

Types
→ Right angle off Sets (Square offset) (at 90°)
→ Oblique. off Sets → at an angle with survey line
≠ 90°

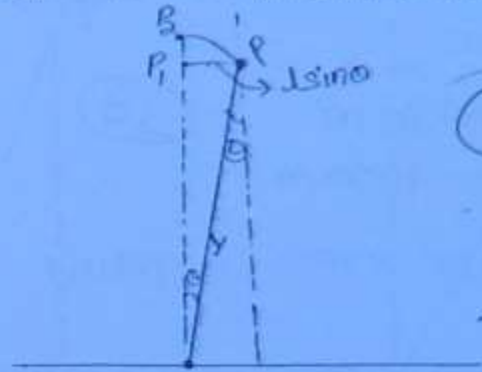
Field book:→

28		20m	4
		16m	2.5
		12m	2m
	2.5m	8m	
		ΔA	



Limiting length of offset :→

Case (2) When error is in measurement of direction only



P = Location of point on the ground for which offset has been taken.

θ = Error in angular measurement

l = Length of offset.

P_2 = Point marked on the drawing.

Total error due to wrong angle is PP_2

$\Rightarrow PP_2 \approx PP_1 = l\sin\theta$

If 1cm = S m is a scale of a drawing

Length of error on drawing = $\boxed{\dfrac{l\sin\theta}{S}\text{ cm}}$

If error on the drawing is not more than 0.25mm (error shall not be reflected on the drawing)

$$\frac{l\sin\theta}{S}\text{ cm} = 0.025\text{ cm}$$

$$l = \frac{0.025\times S}{\sin\theta}$$

$\boxed{l = 0.025\times S\times \operatorname{cosec}\theta}$ → Limiting length of offset

Exe(1) What is the limiting length of offset for a angular error in offset measurement of 3° and scale of drawing

(30)

(1) 1cm = 50 m
(2) 1cm = 1000 m

Solution :> length of error on ground = $l\sin\theta$ m

length of error on drawing = $\frac{l\sin\theta}{S} \geq 0.025$ cm

$l = 0.025 \times S \times \sin\theta$

(1) for Scale 1cm = 50m

$l = 0.025 \times 50 \times \operatorname{cosec} 3^\circ$

$l = 23.80$ m

(2) for Scale 1cm = 1000 m

$l = 0.025 \times 1000 \times \operatorname{cosec} 3^\circ$

$l = 477.7$ m

Note :> for a 23.80m offset on ground

length of error on ground

$= l\sin\theta$

$= 23.80 \times \sin 3^\circ$

$= 1.245$ m

length of error on drawing

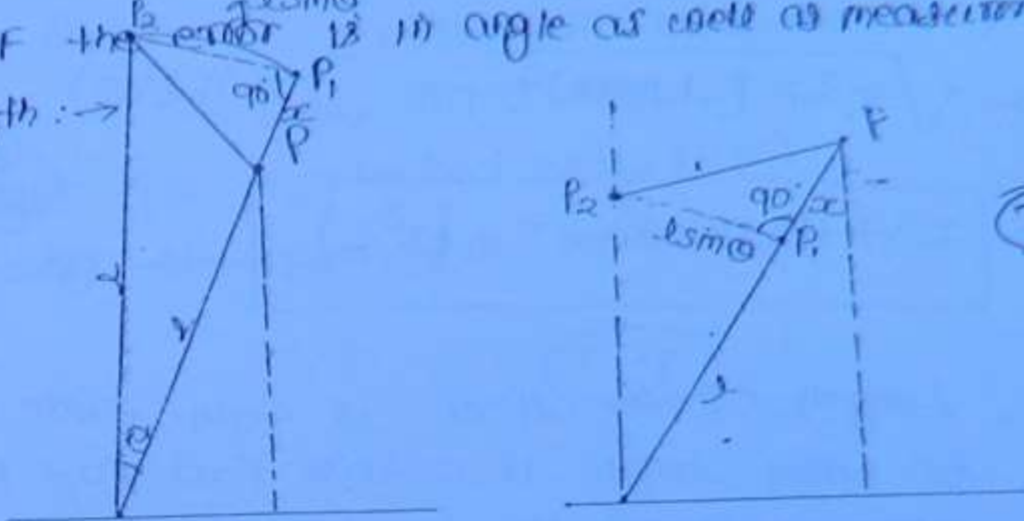
Scale = 1cm = 50m

$= \frac{1.245}{50} = 0.0249$ cm

R.F. = 1cm = 5000 cm

= 1 : 5000

Case ③ If the error is in angle as well as measurement of length :→



(31)

P = Point on the ground for which offset is being taken

l = length of offset with error.

PP_1 = Error in length measurement.
$= x$

θ = Error in angular measurement.

P_2 = Point marked on the drawing

P_1P_2 = Error due to angular measurement
$= l\sin\theta$

Assumption :→ in both case
$\angle PP_1P_2 = 90°$

So total error (length on ground)

$$PP_2 = \sqrt{PP_1^2 + P_1P_2^2}$$

$$\Rightarrow PP_2 = \sqrt{x^2 + (l\sin\theta)^2}$$

If scale is 1 cm = S m

length of error on the drawing

$$PP_2 = \frac{\sqrt{x^2 + (l\sin\theta)^2}}{S} \ngtr 0.025\text{ cm}$$

$$\Rightarrow \sqrt{x^2+(l\sin\theta)^2} = (0.025S)$$

$$\Rightarrow \boxed{x^2+(l\sin\theta)^2 = \left(\frac{S}{40}\right)^2} \quad \text{—— (A)}$$

Que:→ Length of an offset is 20m. Error in measurment of offset length is 0.20m. Find max. permissible error in laying the direction of offset If scale of the drawing is 1cm = 40m

Solution:⇒ $l = 20\ m$

$x = 0.20m$

$1cm = 40m$ scale

$\therefore S = 40m$

$\theta = ?$

$$\Rightarrow x^2+(l\sin\theta)^2 = \left(\frac{S}{40}\right)^2$$

$$\Rightarrow (0.20)^2+(20\sin\theta)^2 = \left(\frac{40}{40}\right)^2$$

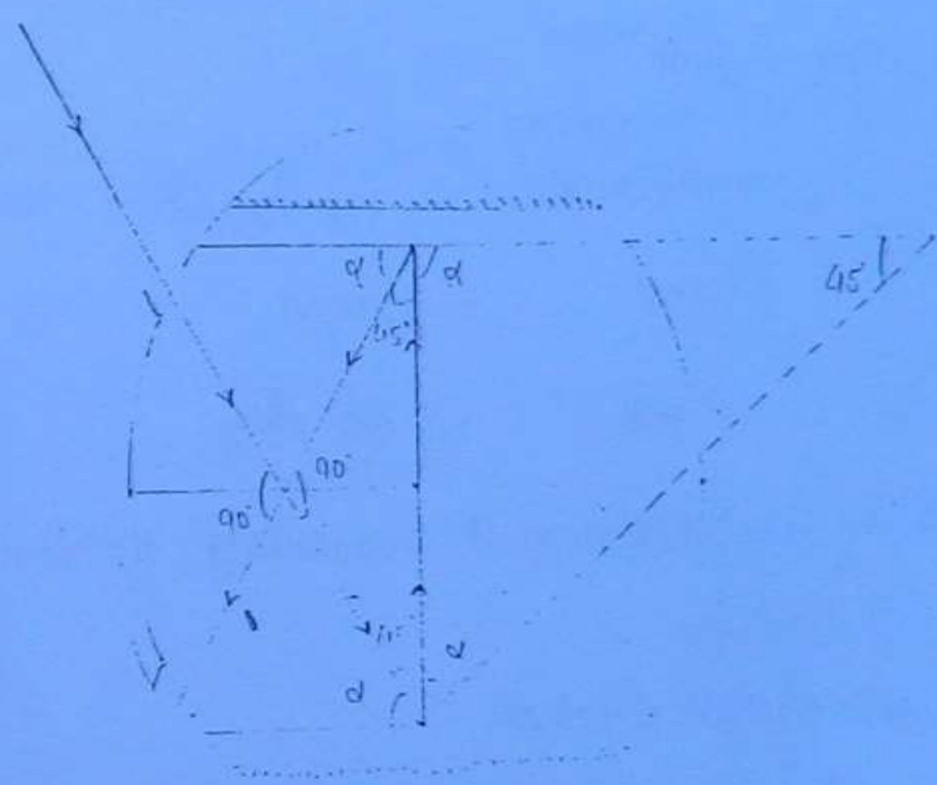
$$\Rightarrow 0.04 + 400\sin^2\theta = 1$$

$$\Rightarrow \boxed{\theta = 2^0\ 49'\ 29''}$$ Ans

(7) Optical Square:→ Instrument used to set perpendi-cular on a line

→ Angle b/w reflected rays (90°)
→ Twice of angle b/w mirrors (45°)

33



★ Compass Survey :->

System of angle measurment :->

(1) Most worldly used System

(34)

1 circumference = 360° degree

1 degree = 60 min

1 minute = 60 sec

(2) Hour System

1 circumference = 24 hours.

1 hour = 60 min

1 min = 60 sec.

Note-> 1 circumference is according to the earth rotation.

(3) Centesimal System

1 circumference = 400 grade

1 grade = 100 centigrade.

1 centigrade = 100 centi- centi grade

Important terms :->

(1) Bearing :-> the direction of a line w.r. to a given meridian. It is the angle b/w given meridian and the line.

(2) True meridian :-> line joining true North and true South pole the earth is called True meridian.

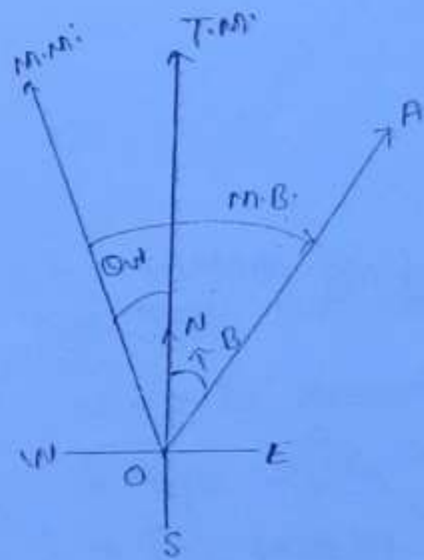
True north or south point are the point about which earth is rotating.

(3) True bearing:→ Bearing measured from true meridian.

(4) Magnetic Meridian:→ Line joining magnetic North and South poles. - (35)

Magnetic bearing :→ Bearing measured from magnetic meridian.

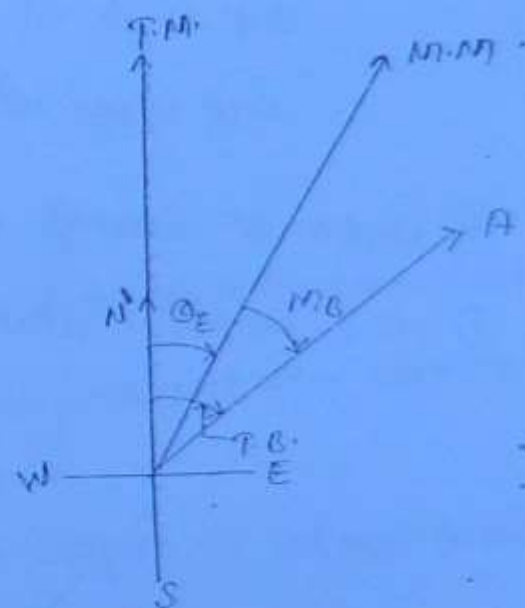
(5) Magnetic declination:→ Horizontal angle b/w true meridian and magnetic meridian at a particular place is called magnetic declination.



(Western Declination)

$M.B = T.B + \theta_W$

$T.B. = MB - \theta_W$



(Eastern declination)

$M.B. = T.B - \theta_E$

$T.B. = MB + \theta_E$

(7) Variation in Declination :→

Types :→

(1) Diurnal variation (Daily)

(2) Annual variation (Annualy)

(3) Secular variation (Due to the moment of moon)

(4) Irregular variation.

⑥ Angle of Dip:→ If a magnet is hanged freely from it's C.G. It align line it set in the direction of magnetic flux in that area, angle made with horizontal direction of magnet is called dip angle.

36

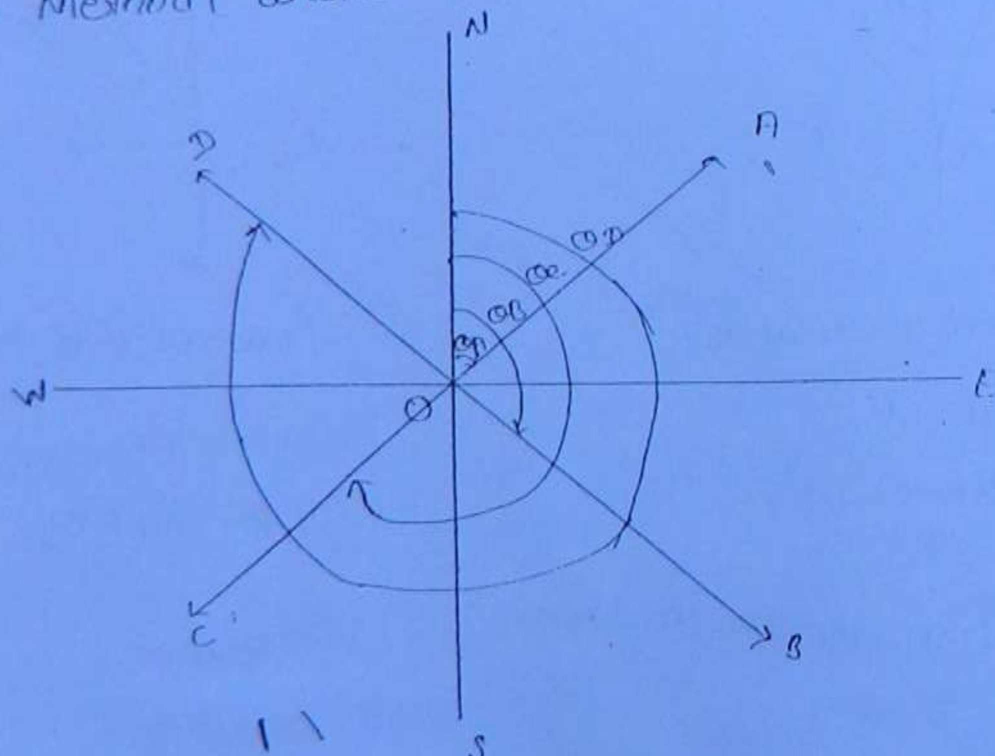
Dip angle at any point on earth is the angle b/w horizontal and direction of magnetic flux.

Dip angle at equator = 0

Dip angle at poles = 90°

⑦ System of Bearing Measurement:→

① WCB Method (whole circle bearing method):→

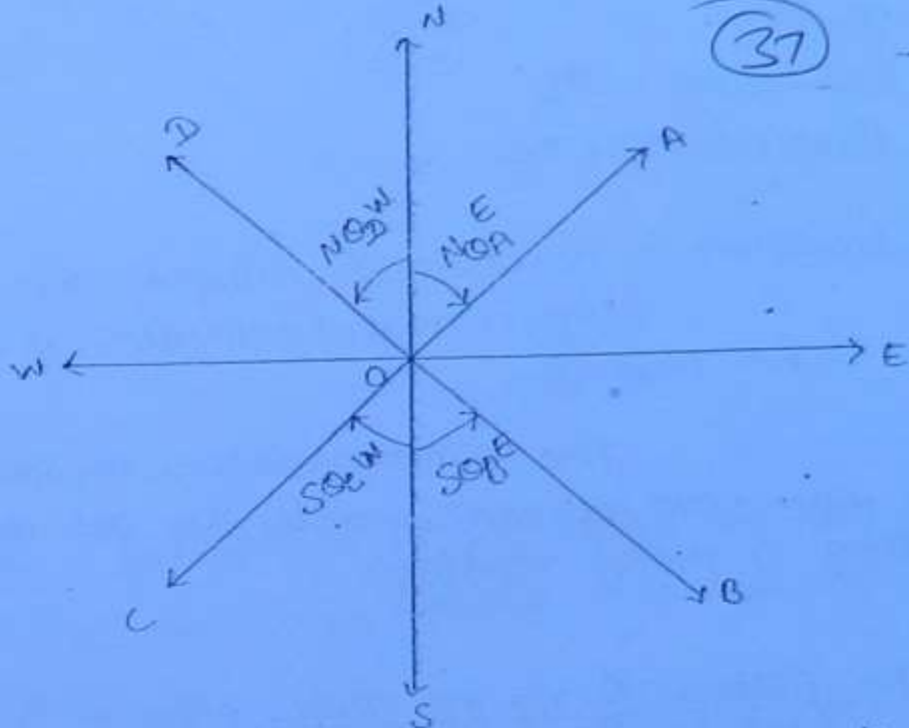


→ All angle are measured from north.

→ always in clockwise direction.

(2) Q.S.B Method :->
(Quadrantal System of bearing)

(37)



-> Angle are measured either from North or from South.
-> Can be measured in clockwise/anticlock wise direction.
-> Angle with direction are shown.
-> This bearing System is also known as reduced bearing

(iii) Fore bearing and Back bearing :->

-> For line AB
Angle at 1st point A = θA = Fore bearing.

angle at 2^{nd} point B = θ_B = Back bearing

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→ for line BA

Fore bearing = θ_B

Back bearing = θ_A

★ Local Attraction :→ Bearings of diffrent line are measured using a magnetic needle. (in case of magnetic bearing)

Due to the presence of some iron objects near instrument, magnetic needle may get deflected, resulting in wrong readings.

ES-2002

Problem :→ The following reading were noted in a closed traverse

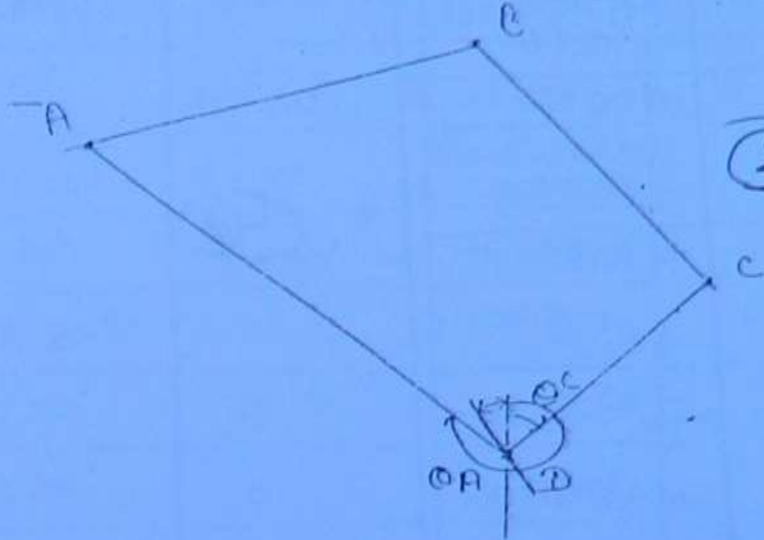
	Fore bearing	Back bearing	
AB	32°	212°	→ 180
BC	77°	262°	→ 185
CD	112°	287°	→ 175
DE	122°	302°	→ 180
EA	265°	85°	→ 180

This station is correct from local attraction

at what station do you suspect local attraction. find correct bearing of the lines. what will be the true bearings (as reduced bearing is magnetic declination was (2°W)

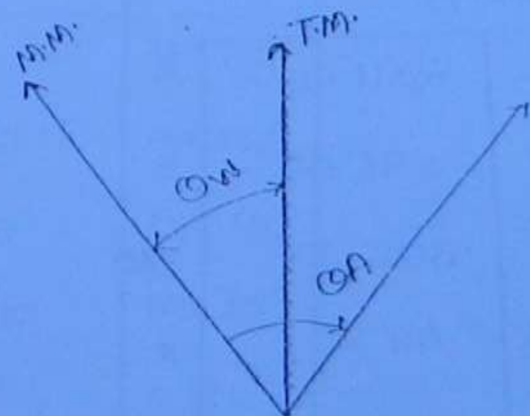
Solution :→

Line	Bearing	Correction	Corrected bearing
AB	32	0	32°
BA	212	0	212°
BC	77	0	77°
CB	262	−5°	77 + 180 = 257°
CD	112	−5°	112° − 5° = 107°
DC	287	0	107 + 180 = 287°
DE	112	0	112°
ED	302	0	302°



→ Here all differences of FB/BB are 180, except for line BC and CD so station 'C' is affected form local attraction.

EA	265	0	265
AE	85	0	85



$T.B. = M.B. - \theta.W.$

T.B. in WCB Method	T.B in Q.CB
20	N20E
200	S20W
65	N65E
245	S65W
95	S85E
275	N85W
110	S70E
290	N70W
253	S73W
73	N73E

(40)

Problem → Following bearing were taken using a compass. find out the correct bearing

AB	75° 5'	254° 20'	x
BC	115° 20'	296° 35'	x
CD	165° 35'	345° 35'	180°
DE	224° 50'	44° 5'	x
EA	304°	125° 5'	x

Solution:- when station C and D are free from local attraction

Lines	Bearings	Correction	Corrected bearing
AB	75° 5'	+(0° 30')	75° 35'
BA	254° 20'	+1° 15'	(75° 35' + 180°) = 255° 35'
BC	115° 20'	+1° 15'	116° 35'
CB	296° 35'	0	116° 35' + 180 = 296° 35'
CD	165° 35'	0	165° 35' → Starting Point
DC	345° 35'	0	345° 35'
DE	224° 50'	0	224° 50'
ED	44° 5'	+0° 45'	224° 50' − 180° = 44° 50'
EA	304° 50'	+0° 45'	305° 35'
AE	125° 5'	+0° 30'	305° 35' − 180° = 125° 35'

(41)

Problem:→ Following are the bearing of a closed traverse.

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

Considered AB value as correct find out the correct bearing of all other lines.

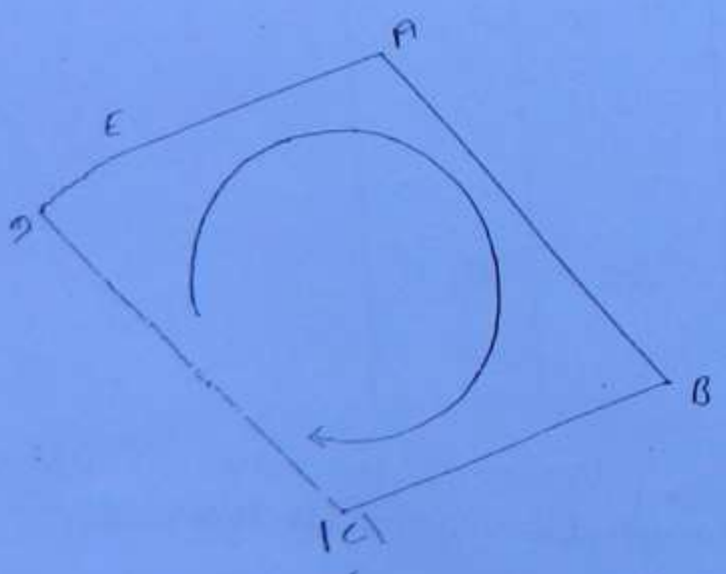
Solution:→

Lines	Bearing	Correction	Correct Bearing
AB	142° 30'	0	142° 30'
BA	322° 30'	0	322° 30'
BC	223° 15'	0	223° 15'
CB	44° 15'	−1° 0'	(223° 15' − 180°) = 43° 15'
CD	287°	−1° 0'	286°
DC	107° 45'	−1° 45'	106°
DE	12° 45'	−1° 45'	11°
ED	193° 15'	−2° 15'	191° 15'
EA	60°	−2° 15'	57° 45'
AE	239	≠ not equal	237° 45'

(42)

(ii) Method of Internal angle :->

(I) Draw the traverse.



② Draw a clock wise circular direction.

③ Internal angles

$A = \overset{before}{AE} - \overset{after}{AB} = 237 - 142^\circ 30' = 96^\circ 30'$

$B = BA - BC = 322^\circ 30' - 223^\circ 15' = 99^\circ 15'$

$C = CB - CD = 44^\circ 15' - 287 + 360 = 117^\circ 0' 15'$

$D = DC - DE = 107^\circ 45' - 12^\circ 45' = 95'$

$E = ED - EA = 193^\circ 15' - 60 = 133^\circ 15'$

$\overline{541^\circ 15'}$

④ IF any angle is 360 deduct 360°

⑤ IF any angle is negative add 360°

Sum of all internal angles $= (2n-4) \times 90^\circ$

$= (2 \times 5 - 4) \times 90^\circ$

$= 540^\circ$

Diffrence in sum of internal angle $= 1^\circ 15'$

Error in each angle $= \frac{1^\circ 15'}{5} = 0^\circ 15'$

than correction in each angle $= (-) 0^\circ 15'$

corrected internal angle.

96° 15'

99°

117°

194° 45'

133°

$\overline{540^\circ}$

$A = AE - AB = 96^\circ 15' = \angle A$

$B = BA - BC = 99^\circ = \angle B$

44

$C = CB - CD + 360 = 117^\circ$

$D = DC - DE = 94^\circ 45'$

$E = ED - EA = 133' = \angle E$

Corrected bearing of line :->

$AB = 142^\circ 30'$
$+ \angle A = + 96^\circ 15'$
$AE = 238^\circ 45'$
$- 180^\circ$
$EA = 58^\circ 45'$
$+ \angle E = 133^\circ$
$ED = 191^\circ 45'$
$- 180^\circ$
$DE = 11^\circ 45'$
$+ \angle D = + 94^\circ 45'$
$DC = 106^\circ 30'$
$+ 180^\circ$
$CD = 286^\circ 30'$
$+ \angle C = 117^\circ$
$- 360^\circ$
$CB = 43^\circ 30'$

$CB = 43^\circ 30'$
$- 180$
$BC = 223^\circ 30'$
$+ \angle B = 99^\circ$
$BA = 322^\circ 30'$
$- 180^\circ$
$AB = 142^\circ 30'$

Ans

$A = AB - AE = 191^\circ 30' - 53^\circ = 138^\circ 30'$

$B = BC - BA = 69^\circ 30' - 13^\circ = 56^\circ 30'$

$C = CD - CB = 32^\circ 15' - 246^\circ 30' = 145^\circ 45'$
$+360^\circ$

$D = DE - DC = 262^\circ 45' - 210^\circ 30' = 52^\circ 15'$

$E = EA - ED = 230^\circ 15' - 80^\circ 45' = 149^\circ 30'$

$\overline{542^\circ 30'}$

46

Total error $= 2^\circ 30'$

Error in each angle $= \frac{2^\circ 30'}{5}$

$= 0^\circ 30'$

Correction in each angle $=$ $(-)\ 0^\circ 30'$

Corrected angle

138°

56°

145° 15'

51° 45'

149°

AB has mini error

Corrected bearing $AB = 191^\circ 30' - 0^\circ 45' = 190^\circ 45'$

" " $BA = 13^\circ + 0^\circ 45' =$ — this value is range than

Corrected bearing $AB = 191^\circ 30' + 0^\circ 45' = 192^\circ 15'$

" " $BA = 13^\circ - 0^\circ 45' = 12^\circ 15'$

$AB = 192° 15'$

$\angle A = -138°$

$AE = 54° 15'$

$+180°$

$EA = 234° 15'$

$\angle E = -149°$

$ED = 85° 15'$

$+180°$

$DE = 265° 15'$

$-\angle D = -151° 45'$

$213° 30'$

$DC = -180°$

$CD = 33° 30'$

$\angle C = -145° 15'$

$+360$ → Because the value is negative than add 360.

(47)

$CB = 248° 15'$

$-180°$

$BC = 68° 15'$

$-\angle B = -56°$

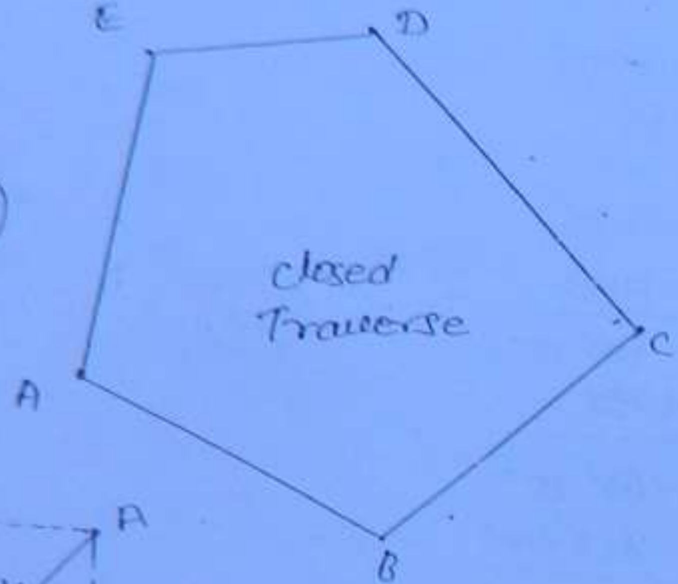
$BA = 12° 15'$

$+180°$

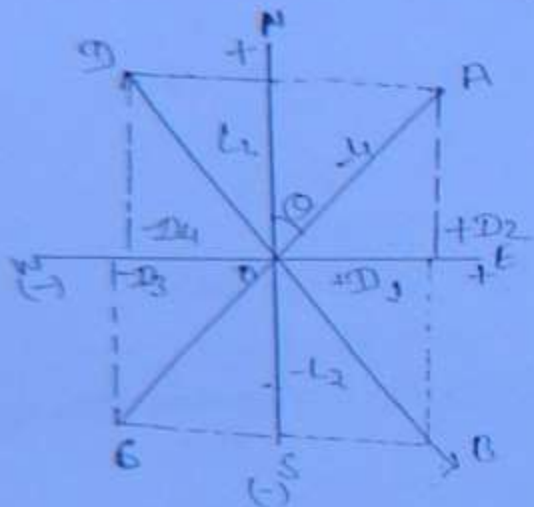
$AB = 192° 15'$

[redacted]

Traverse :→ Latitude and departure of different lines of a traverse.



(48)



→ Latitude is the projection of a line on N-S direction

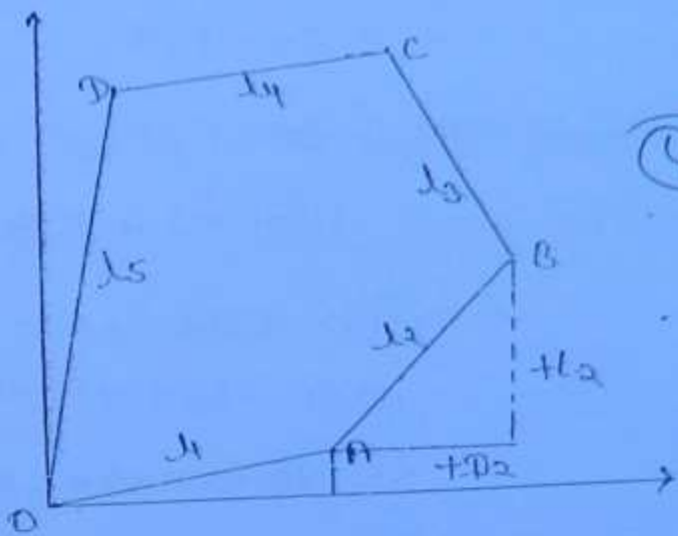
$$L = l\cos\theta$$

→ Departure is the projection of line on E-W direction

$$D = l\sin\theta$$

Line	WCB	Latitude	Departure
l_1	$0<\theta<90°$	$N\theta_1E$ $+l_1\cos\theta_1$	$+l_1\sin\theta_2$.
l_2		$S\theta_2E$ $-l_2\cos\theta_2$	$+l_2\sin\theta_2$
l_3		$S\theta_3W$ $-l_3\cos\theta_3$	$-l_3\sin\theta_3$
l_4		$N\theta_4W$ $+l_4\cos\theta_4$	$-l_4\sin\theta_4$

(ii) Independent co-ordinate :->



(49)

If co-ordinate of diffrent points are measured w.r. to a fixed origin is called independent co-ordinate.

Ex Properties of a closed travers :->

Sum of all latitude and departure should be zero

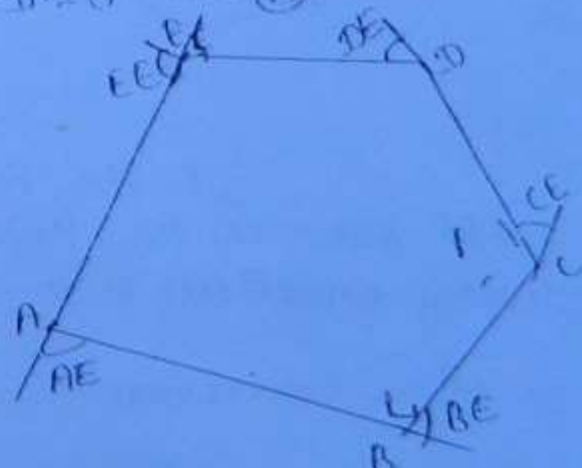
① Sum of all latitude

$l_1 \cos\theta_1 + l_2 \cos\theta_2 + ----$

$\Sigma L = 0$ — (1)

$l_1 \cos\theta_1 + l_2 \cos\theta_2 + ----$

$\Sigma D = 0$ — (2)



② Sum of all internal angle of a closed travers

$$= (2n-4)\,90^\circ$$

③ Sum of External angle of a closed traverse

$$AE + BE + \cdots = (180 - A) + (180 - B) + \cdots$$

$$= n \times 180 - (A + B + \cdots)$$

$$= 2n \times 90 - (2n-4) \times 90$$

$$= 2n \times 90 - 2n \times 90 + 4 \times 90$$

$$= 360^\circ$$

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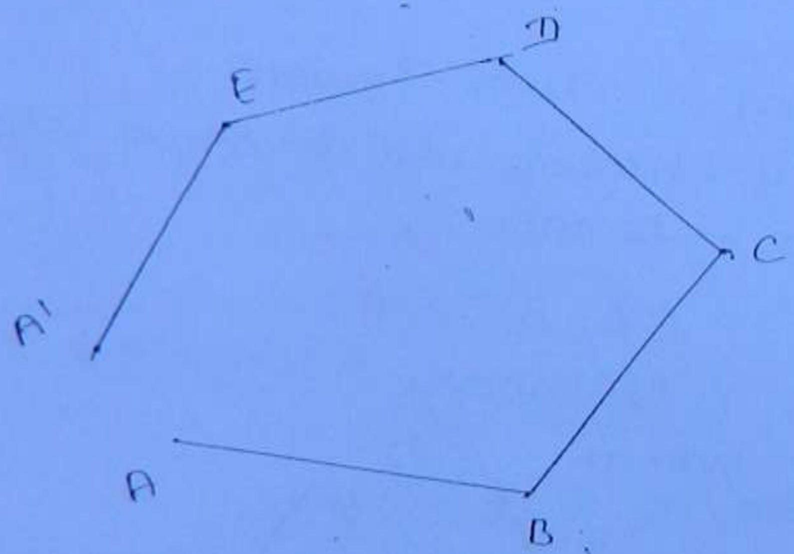
Close Error :→ In case of a closed traverse



If the first point of the closed traverse is not same as the that point. the error is called closing error. AA' is the error

$\therefore$ A'A = Correction

* Adjustment of closing error :→

(1) $\Sigma L = 0$

$\Sigma D = 0$

(2) Sum of all internal angle = $(2n-4) \times 90°$

Method for balancing a closed traverse.

(1) Bowditch method.

(2) Transit method.

(3) Graphical method

(4) Axis method.

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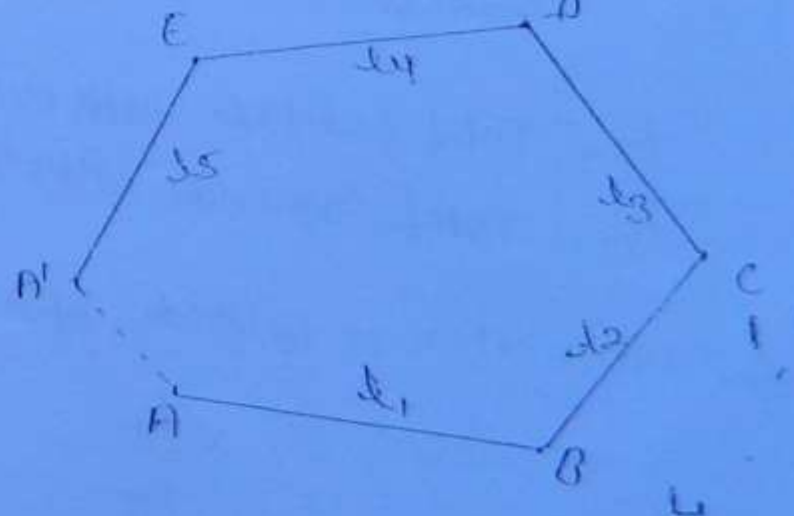
(1) Bowditch method :→ This method is suitable when linear and angular measurements having been measured with equal precision. Changes of error are same in lineal angular measurements.

As per bowditch

(1) Error in linear measurement ∝ $\sqrt{l}$.

(2) Error in angular measurement ∝ $1/\sqrt{l}$



If

ΣL = Total error in latitude.
(Sum of all latitude with singe)

ΣD = Total error in Depertude
(sum of all deperture with singe)

Σl = Sum of all length of diffrent line

Correction in latitude of a particular line

52

$$C_L = \Sigma L \times \frac{l_1}{\Sigma l} \quad \text{--- (1)}$$

Correction in Departure

$$C_D = \Sigma D \times \frac{l_1}{\Sigma l} \quad \text{--- (2)}$$

(2) Transit Method :→ this Method is suitable when angular measurement are more prease than linear measurement.

Error $\begin{cases} \Sigma L - \text{Sum of all latitudal (with sing)} \\ \Sigma D : \text{Sum of all departure (with sing)} \end{cases}$

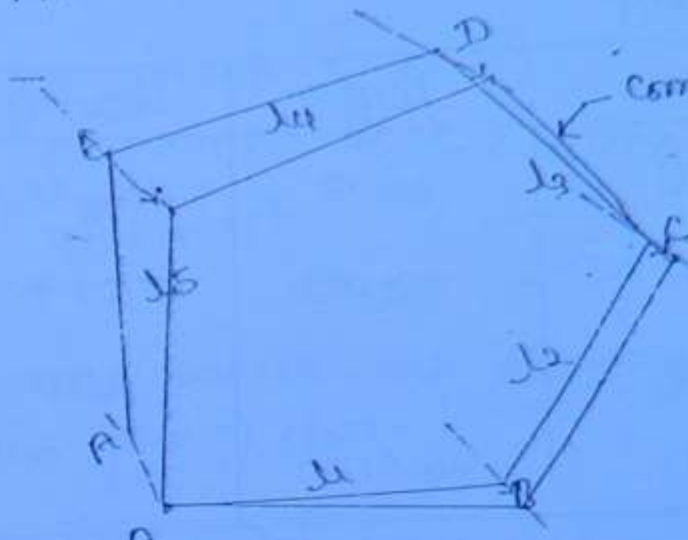
L_T = Total latitude with out sing
D_T = Total Departure with out sing

than correction in latitude of a part line

$$C_L = \Sigma L \times \frac{L_1}{L_T}$$

$$C_D = \Sigma D \times \frac{D_1}{D_T}$$

(c) Graphical method:→



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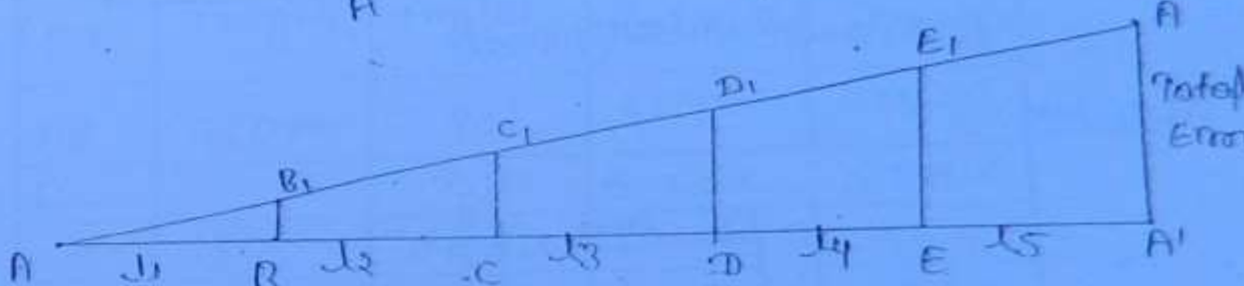


all this corection is makerd and the mark point is same direction.

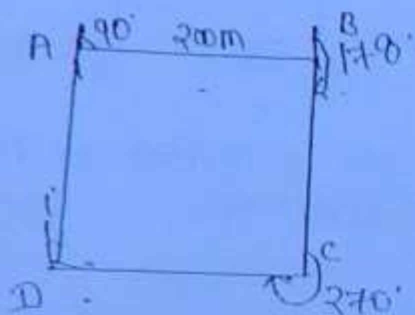
Que:→ A closed traverse has the following length and bearing

Line	length	bearing
AB	200 m	Rughly East
BC	98 m	178°
CD	—	270°
DA	84.6 m	1°

(54)

Find out missing data

Solution:→



Bearing	Latitude	Departure
Rughly	$200\cos\theta$	$200\sin\theta$
178°	$= -97.94$	$= 3.42$
	$x\cos 270 = 0$	$x\sin 270 = -x$
270		
84.6	86.39	$= 1.509$

$\Sigma L = 0$ $\Sigma D = 0$

From $\Sigma L = 0$

$200\cos\theta = 11.55$

$\cos\theta = 0.05775 \Rightarrow \theta = 86^\circ 41' 22''$ Ans.

$\Sigma D = 0$

$200 \sin\theta + 3.42 + 1.508 - x = 0$

$x = 200 \sin 86° 41' 22'' + 4.928$

$\boxed{x = 204.60\,m}$ Ans

55

Problem:→ A closed traverse has following readings. Find out the missing data.

Line	Length	Angles WCB	Latitude	Departure
AB	250 m	85°	21.79	249.05
BC	x	40°	0.766x	0.643x
CD	150	320°	114.907	-96.418
DE.	220	295°	92.976	-199.39
EF	140	θ - 160°	140 cos θ	140 sin θ
FA	200		-187.94	68.404

Solution:→ $\Sigma L = 0$

$\Rightarrow 0.766x + 140\cos\theta + 41.733 = 0$ —(1)

$\Sigma D = 0$

$0.643x + 140\sin\theta + 21.646 = 0$ —(2)

from eq. (1)

$\Rightarrow 140\cos\theta = -0.766x - 41.733$ —(3)

from eq (2)

$\Rightarrow 140\sin\theta = -0.643x - 21.646$ —(4)

$$\Rightarrow 140^2(\cos^2\theta + \sin^2\theta) = (0.766x + 41.733)^2 + (0.643x + 21.646)^2$$

$$\Rightarrow 19600 = x^2 + 91.77x + 2210.192 = 0$$

$$\Rightarrow x^2 + 91.77x - 17389.8 = 0$$

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$$\boxed{x = 93.74}\ m$$

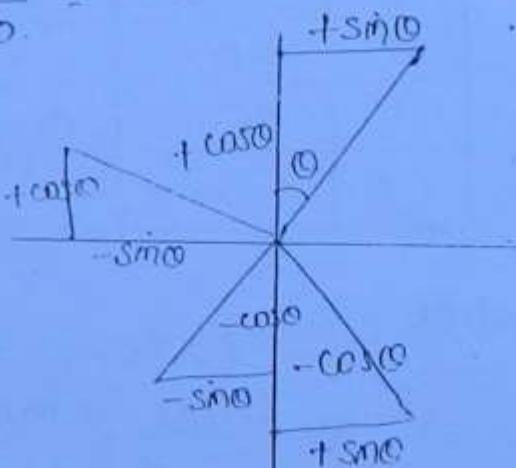
Ans

From eq. (3)

$$\cos\theta = -\frac{173.54}{140} = -0.81098$$

From eq (4)

$$\sin\theta = -\frac{81.92}{140} = -0.58515$$



$$\tan\theta = \frac{\sin\theta}{\cos\theta} = 0.7215$$

$$\theta = 35^\circ 45' 52''$$

Bearing of Line (Line is in 3rd Q)

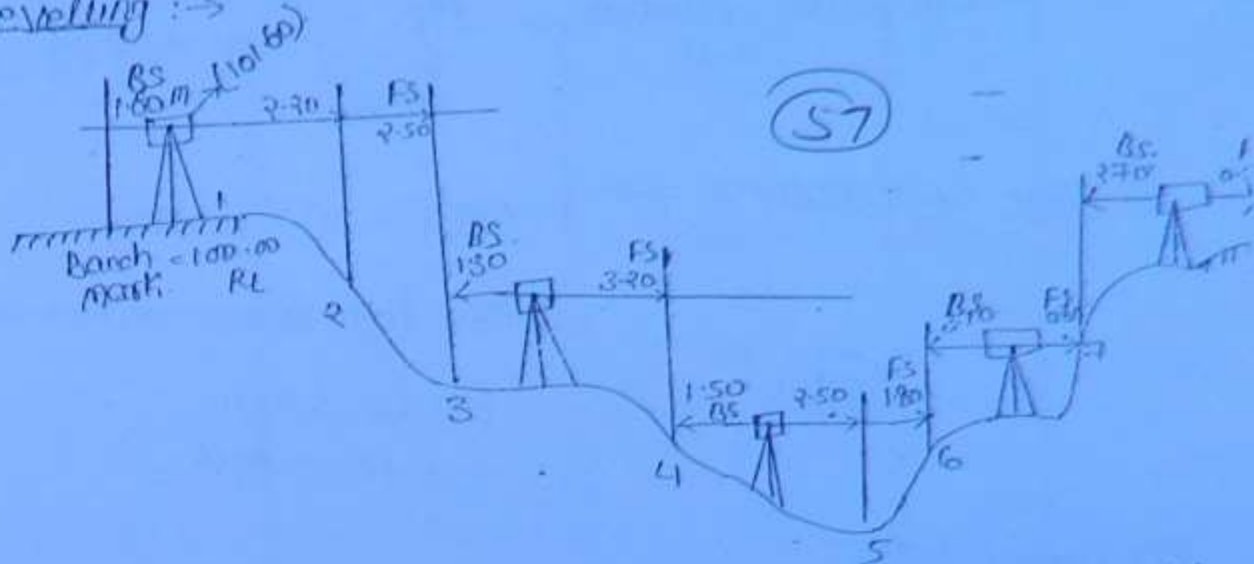
$$= 180 + \theta$$

$$= 180 + 35^\circ 48' 41.52''$$

$$\boxed{= 215^\circ 48' 41.52''}$$

Ans

Levelling :→



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Terms:→

(1) Reduced level :→ Reduced level of point on earth surface is the elevation of that point w.r.t. to a fixed location (Mean see level) or w.r.t. length of certain Bench marks.

(2) Back Sight (Reading) :→ First reading taken after sett up the instrument (Leveling Instr.) at a particular location.

(3) Fore Sight Reading :→ Last reading taken from an Instrument location after which position of Instrument is being changed is called fore sight reading.

Last reading after which survey work is closed is also a fore sight

(4) Intermediate Sight :→ All other reading than BS and FS are intermediate sight.

(5) Hight of Instrument :→ The elevation of line of sight at perticular Instriment location.

H.I of 1th location = RL OF BM + BS(1)

H.I of next Station = $HI_{p} - FS_{(3)} + BS_{(3)}$
Previous

⑥ <u>Rise and Fall</u> :→ I^{st} reading − 2^{nd} reading

(taken from Same instrument Station)

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(+) ve → Rise
(−) ve → Fall

⑦ <u>Level Book</u> :→

Point	Back Side (BS)	Intermidiat Side (IS)	Fore Side (FS)	Height of Instrument (HI)	R.L
1 BM	1.60			101.60	100.00 Given
2		2.20			99.40 = 101.60 − 2.20
3	1.30		2.50	99.10 + 1.30 = 100.40	99.10 = 101.60 − 2.50
4	1.50		3.20	97.20 + 1.50 = 98.70	97.20
5		2.50	[illegible]		96.20 = 98.70 − 2.5
6	3.10		1.80		
7	2.70		0.60		
8			0.70		

Rise and Fall Method :->

Level Book	Rise	Fall	R L
	—	—	100.00
		0.60	99.40
	59	0.30	99.10
			10

(#) Check :-> add All Back side reading =

add All Fore Side reading =

the calculated difference b/w two reading

than add All rise =

add All Fall =

diffrence b/w rise and Fall

Note $\Sigma BS - \Sigma FS$ = last RL − 1st R.L.

= ΣRise − ΣFall

2000 — (73)

Problem:-> In running fly levels from a BM of RL 120.750 the following reading were obtained

BS = 0.85 ~~0~~ 1.285 1.182 0.965 0.49

FS = 0.555 1.150 1.945 1.755 —

(60) From the last position of the instrument seven page at 10m, interval are to be set out on a uniform descending gradient of 1 m 50. the first page is at RL 120.00 m. Work out the staff readings for setting the top of pages. Fall the level book and carry out arithmetic checks

Solution:-

Points	BS	IS	FS	Rise	Fall	RL
1	0.85		—			120.750
2	1.285		0.555	0.295		121.045
3	1.182		1.150	0.135		121.180
4	0.965		1.945		0.763	120.417
5	0.49		1.755		0.790	119.627
6		0.117		0.373		120.00
7		0.117 + 0.20 = 0.317			0.20	119.80
8		0.517			0.20	119.60
9		0.717			0.20	119.40
10		0.917			0.20	119.20
11		1.117			0.20	119.00
12			1.317		0.20	118.80
check	ΣBS = 4.792	1.95 / 2.00	ΣFS = 6.782			

Seven pegs are to set

each at distance = 10m (61)

at gradient b/w two pegs

$$= 10 \times \frac{1}{150} = (-)\ 0.20\ m$$

the 1st pegs R.L = ~~~~ 120.0 m

Check (1) $IS = \Sigma FS - \Sigma BS = 6.722 - 4.772$

$= 1.95m$

(2) RL = 1st RL - Last RL.

$= 120.750 - 119.20$

$= 1.95$

(3) $\Sigma Rise + \Sigma Fall =$

$-0.803 + 2.75 = 1.95\ m$

than ok Ans

— o —

1444 (2-a) (same as 2008 (a))
Problem
(HW)

Problem :-> Fill the missing data of a level book

point	BS	IS	FS	Rise	Fall	R.L.
1	3.125			x	x	123.68 (J)
2	(A) 2.265		(B) 1.80	1.325		125.005
3		2.32			0.055	124.95 (K)
4		(C) 1.92		0.40 (F)		125.350
5	(D) 1.04		2.655	(G)	0.735	124.615 (L)
6	1.620		3.205		2.165	122.45 (M)
7		3.625		(H)	2.005	120.445 (N)
8			(E) 1.48	2.145 (I)		122.590
	ΣBS = 8.05		ΣF = 9.14	ΣR = 3.87	ΣF = 4.96	

Solution

$J = 125.005 - \text{Rise}\ (1.325)$

$J = 123.68$

$B = 3.125 - 1.325 = 1.80$

$A = 2.32 - 0.055 = 2.265$

$K = 125.005 - 0.055 = 124.95$

$F = 125.350 - 124.95 = 0.40$
Rise

$C\quad 2.32 - 0.40 = 1.92$

$G = 1.92 - 2.655 = -0.735$ (Fall)

$L = 125.35 - 0.735 = 124.615$

$D = 3.205 - 2.165 = 1.04$

$M = 124.615 - 2.165$

$M = 122.45$

$H = 1.620 - 3.625 = -2.005$ (Fall

$N = 122.45 - 2.005 = 120.445$

$I =$ (Rise) $122.59 - 120.445 = 2.145$ G3

$E = 3.625 - 2.145 = 1.48$

Check =

① $EFs - EBs \Rightarrow 9.14 - 8.05$
$= 1.09$

② $EF - ER \Rightarrow 4.96 - 3.87$
$= 1.09$

③ 1^{st} RL $-$ Last RL $= 123.68 - 122.590$
$= 1.09$

than ok Ans

Problem :-> following consective reading wer taken from dumpy level.

BS $\boxed{6.25}$, 4.92, 6.52, 9.85 Fs

A BS

BS 4.62, 3.50, $\boxed{4.23}$, 3.97

B 6.30, 4.83 BS 3.52, 2.30

B 1.50, 2.40 4.25, 3.50 FS

BS

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level was shifted after 4th, 6th 9th and 13th reading. IF R.L. of 1st point BM = 100.00 Fill the level book and find out R.L. of different point

Solution :->

Point	BS	IS	FS	Rise	Fall	R.L.
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						

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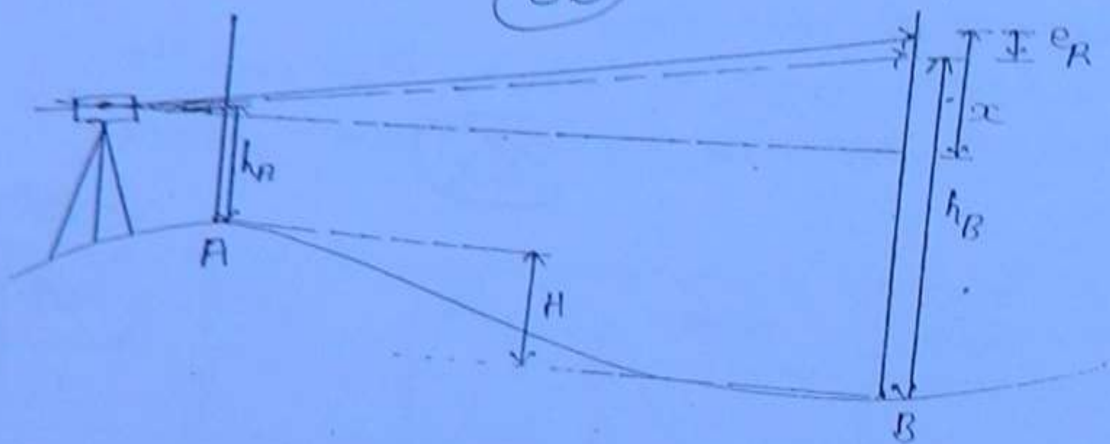
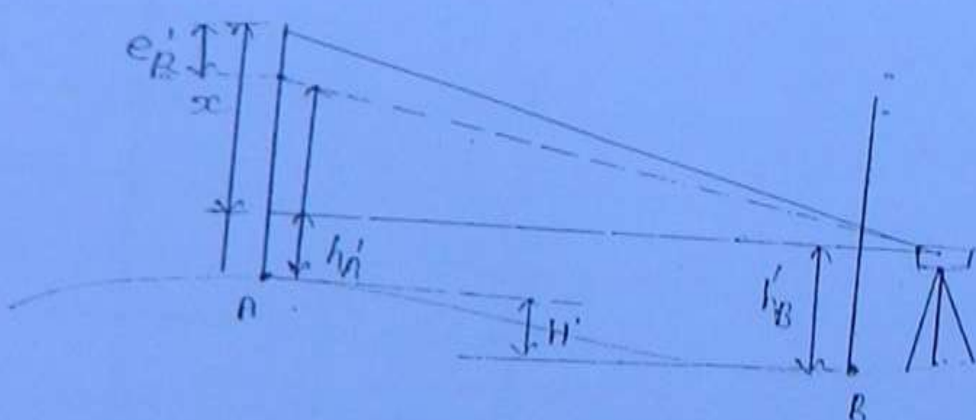
★ Reciprocal leveling:-> Reciprocal leveling is used -

(1) Find out any error in the leveling instrument. (Line of sight may not be in horizontal direction, even with bubble in the centre.)

(2) To eliminate the effect of earth curvature and refraction.

(66)





In case of reciprocal leveling, two point A and B at a distance about 100 - 200m. is selected staff reading are noted keeping. Instrument first first near A and than e near B.

When Instrumen is at A
Reading at A = h_F

Reading at $B = h_B$

When Instrument is at B

reading at $A = h_A'$

Reading at $B = h_B'$

If instrument is Faulty

$h_B - h_A \neq h_B' - h_A'$ (67)

When Instrument is at A

h_A = Correct reading

Correct reading at B should be $= h_B + e_R - x$

Correct difference of Level b/w A and B

$$H = (h_B + e_R - x) - h_A \quad \text{—(1)}$$

When Instrument is at B

h_B' = Correct reading

Correct reading at A should be $= h_A' + e_R' - x$

Correct difference of level b/w B and A

$$H' = h_B' - (h_A' + e_R' - x) \quad \text{—(2)}$$

$$e_R' = e_R \quad \text{or} \quad H' = H$$

Add eq. (1) and (2)

$$H + H' = h_B + \cancel{e_R} - \cancel{x} - h_A + h_B' - h_A' - \cancel{e_R} + \cancel{x}$$

$$\Rightarrow 2H = (h_B - h_A) + (h_B' - h_A')$$

Correct difference of level b/w A and B

$$\Rightarrow \boxed{H = \frac{(h_B - h_A) + (h'_B - h'_A)}{2}}$$

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Problem: → For a reciprocal leveling following reading was taken

Instrument	Reading A	Reading B	difference	Correct diff.
A	1.95 h_A	$\boxed{2.82}$ 2.76 h_B	0.91	
B	0.925 $\boxed{0.9705}$ h'_A	1.955 h'_B	1.03	0.97

Distance b/w point 1 and 2 is 250 m. If R.L. of A is 120.50 m. Find out correct R.L. of B. Find out the error in line of sight of instrument. Neglected error due to curvature and refraction.

Solution: ⇒ Difference of reading when instrument is at A

$$\Rightarrow h_B - h_A = 2.76 - 1.95 = 0.91$$

⇒ Difference of reading when instrument is at B

$$h'_B - h'_A = 1.955 - 0.925 = 1.03$$

⇒ Correct difference of level b/w A and B

$$H = \frac{(h_B - h_A) + (h'_B - h'_A)}{2} = \frac{0.91 + 1.03}{2}$$

$$H = 0.97 \text{ m}$$

⇒ Correct Reading at A = 1.85

when Instrument is at A)

At B should be $= 1.85 + 0.97 = 2.82$ m

where reading taken $= 2.76 < 2.82$

So line of sight is inclined downward

R.L. of A = 120.50 m

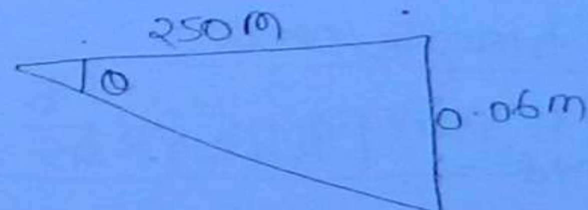
R.L. of B = 120.50 m
$\quad - 0.97$ m
$\overline{\quad 119.53 \text{ m}}$

(B is at lower elevation than A)

Error in line of Collimation

$= 2.82 - 2.76$

$= 0.06$



$\tan\theta = \frac{0.06}{250} = 2.4 \times 10^{-4}$

$$\boxed{\theta = \frac{1}{4166.67}}$$

(7) Correction due to curvature and refraction :→

(i) Correction due to Curvature (Earth curvature) :→

→ Level line ⇒ A line parallel to earth surface (curved line)

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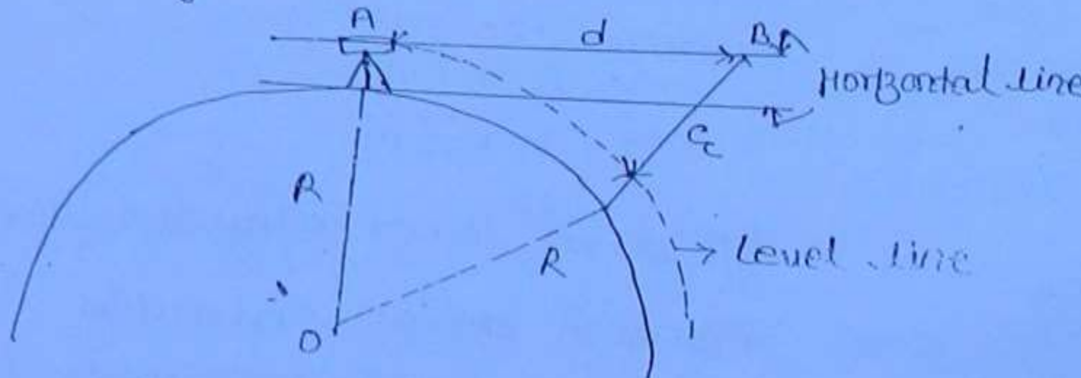
→ Horizontal line → Tangent line at earth surface at any point.



In triangle OAB

$$\Rightarrow R^2 + d^2 = (R + C_c)^2$$

$$\Rightarrow \cancel{R^2} + d^2 = \cancel{R^2} + C_c^2 + 2RC_c$$

$$\Rightarrow d^2 = C_c(2R + C_c)$$

$\because 2R + C_c \approx 2R$

⇒ Correction due to curvature

$$\boxed{C_c = \frac{d^2}{2R}}$$

∀ R = Radius of Earth or Radius of curvature (6370 km)

Correction due to earth curvature

$$C_C = \frac{d^2}{2 \times 6370} \times 1000 = \text{meter}$$

$$\Rightarrow \boxed{C_C = 0.07849\, d^2\ m} \quad (71)$$

here d = distance in. Km.

(#) for staff reading

Error = (+) ve

Correction = (-) ve

(#) For reduced levels calculated using wrong staff read.

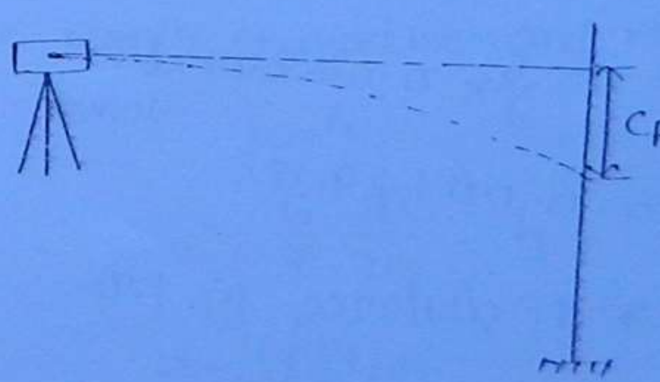
error = (-) ve

Correction = (+) ve

Generally

$$\boxed{C_C = (-)\frac{d^2}{2R} = 0.07849\, d^2}$$

(2) Correction due to refraction :→



This correction is required due to refraction. The value is (1/7) of curvature

$$C_R = \frac{1}{7} \times \text{Correction due to curvature}$$

$$\Rightarrow C_R = \frac{1}{7} \times \frac{d^2}{2R} \quad (72)$$

$$\Rightarrow C_R = \frac{d^2}{14R}$$

$$\Rightarrow C_R = \frac{1}{7} \times 0.07849\, d^2$$

$$\Rightarrow \boxed{C_R = 0.01121\, d^2}$$

C_R = is always (+) ve

) Combined correction :→

Due to curvature and refraction

$$= -\left(\frac{d^2}{2R}\right) + \frac{1}{7}\left(\frac{d^2}{2R}\right)$$

$$= -\frac{6}{7} \times \frac{d^2}{2R}$$

$$= -\frac{6}{7} \times 0.07849\, d^2$$

$$= 0.06728\, d^2$$

$\ast$ d = distance in km.

Note $C_c = (-)\frac{d^2}{2R} = (-)0.07849d^2$

$$C_R = (+)\frac{1}{7}\times\frac{d^2}{2R} = (+)0.01121d^2$$

$$C = (-)\frac{6}{7}\times\frac{d^2}{2R} = (-)\ 0.06728d^2$$

$$\boxed{R = 6370}$$

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(4) Distance of Visible horizon →

A person at h height from sea level can see the point at sea surface upto a distance d.

Combined formula for correction due earth curvature and refraction is used

hence $C = h$

$$C = \frac{6}{7}\frac{d^2}{2R} = h$$

$$d = \sqrt{\frac{14}{6}Rh}$$

$$C = 0.06728d^2$$

$$d = \sqrt{\frac{h}{0.06728}}$$

$$d = 3.855\sqrt{h}$$

Y h = in meter

d = in km

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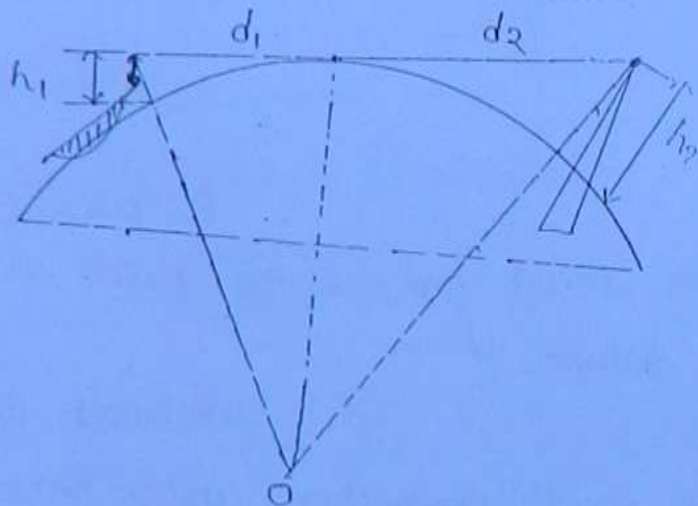
ES-1998

Problem → 06

An observer standing on the deck of a ship just see a light house. The top of light house is 49m above sea level and the height of observaber eye is 9m above sea level.

Find the distance of observer from light house.

Solution →



Distance of observation to light house = $d_1 + d_2$

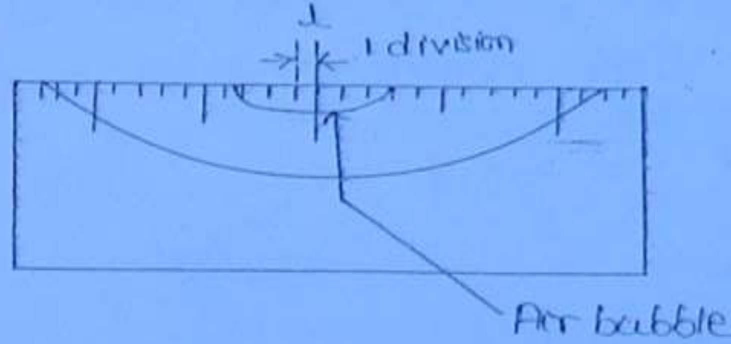
$= 3.855\sqrt{h_1} + 3.855\sqrt{h_2}$

$= 3.855(\sqrt{9} + \sqrt{49})$

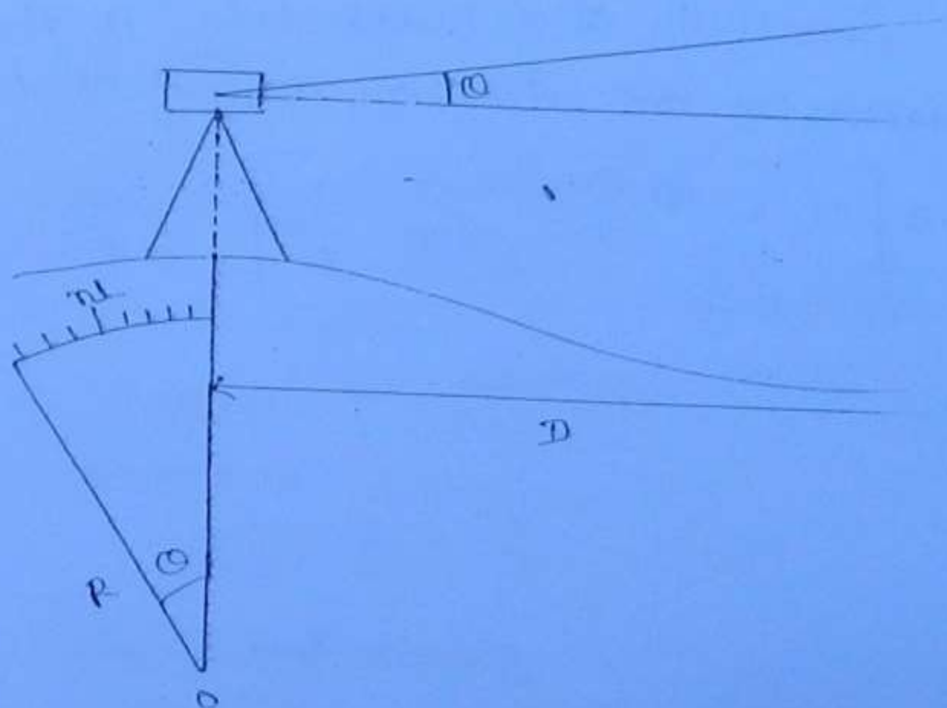
$= 3.855 \times (3+7)$

$= 38.55$ km Ans

* Sensitiveness of a bubble Tube:→



(75)



Experiment:→

① fix the instrument at a location take bubble in the centre at on a staff key

② Now rotated the telescope such that bub n division.

if l = length of one division.

Total moment of bubble $= nl$

(3) Radius of curvature of bubble tube $= R$

(4) Staff reading after rotation $= S_2$

(5) Staff intercept $S = S_2 - S_1$

total angle

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$$\boxed{\theta = \frac{S}{D} = \frac{nl}{R}} \quad \text{— (A)}$$

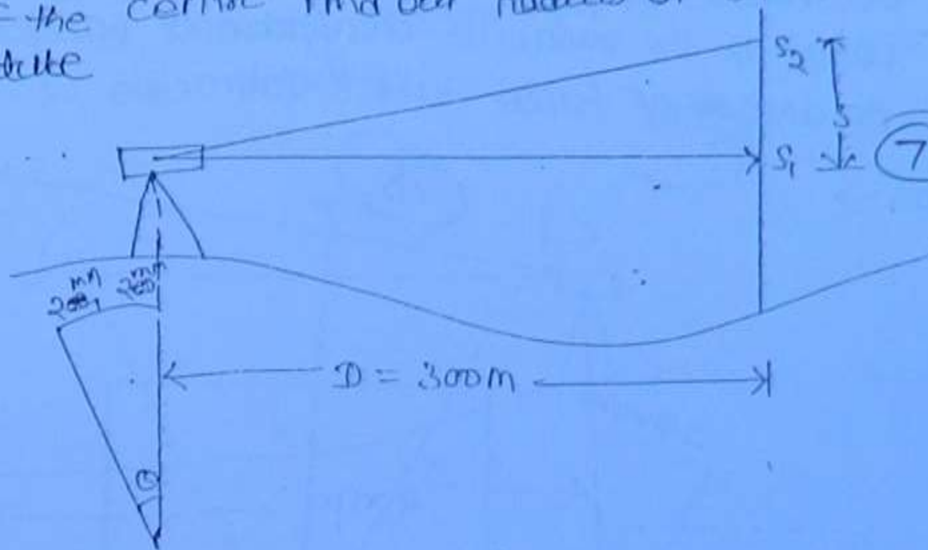
Sensitivity of a bubble tube is the angle of rotation for one division moment of bubble

$$\Rightarrow \boxed{\alpha = \frac{\theta}{n} = \frac{S}{nD} = \frac{l}{R}} \quad \text{— (B)}$$

Problem :-> If a bubble tube has sensitivity of 25 sec [11/01/201]

length of one division of bubble tube is 2 mm. Find out the error in staff reading on a staff kept at 300m distance caused due to bubble 2-division out of the centre. Find out Radius of curvature of bubble tube

Solution:-



Sensitivity of bubble tube

$$\alpha = 25 \text{ sec} = \frac{25}{60\times60}\times\frac{\pi}{180} = \frac{25}{206265}\text{ rad.}$$

$$n = 2$$

length of one division $l = 2\,mm$

Sensitivity

$$\alpha = \frac{\theta}{n} = \frac{S}{nD} = \frac{l}{R}$$

Error in staff reading

$$S = n\alpha D = 2\times\left(\frac{25}{206265}\right)\times300$$

$$S = 0.0727\,m$$

$$\boxed{S = 7.27\,m} \text{ Ans}$$

$$\Rightarrow \alpha = l/R \quad R = l/\alpha = \frac{2\,mm}{25/206265}$$

Radius of curvature of the $\boxed{R = 16.502\,m}$ mm

Problem:→ The reading taken on a staff kept at 200 m from an instrument with bubble at centre was 1.85m. Bubble is then moved by 5 division out of the centre and an staff reading observed was 1.986m. Find the sensitivity of bubble tube & what is the radius of curvature of bubble tube. length of one division of bubble tube is 3mm

Solution:→

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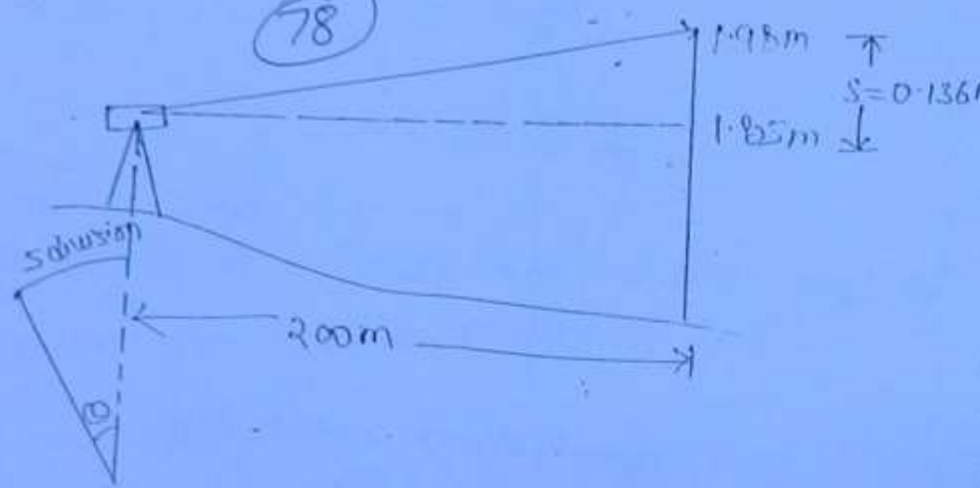

$S_1 = 1.85m$

$S_2 = 1.986m$ (after 5 division movement)

$S = S_2 - S_1$

$S = 1.986 - 1.85$

$\boxed{S = 0.136m}$

$n = 5$

$l = 3mm$

Sensitivity of bubble tube $\alpha = \frac{\theta}{n} = \frac{S}{nD} = \frac{l}{R}$

$\Rightarrow \alpha = \frac{S}{nD} = \frac{0.136}{5\times200} = 1.36\times10^{-4} = 1.36\times10^{-4}\times\frac{60\times60\times180}{\pi}$

$= 28.05\ sec$

Radius of curvature

$R = \frac{l}{\alpha} = \frac{3}{1.36\times10^{-4}} \Rightarrow \boxed{22058.5\ mm}$

* Plane Table Surveying :->
There are Four method.

(1) Radiation Method.
(2) Intersection method. } for collecting the objects details.
(3) Traversing. } for locating the position of instrument Statio
(4) Resection } over drawing.

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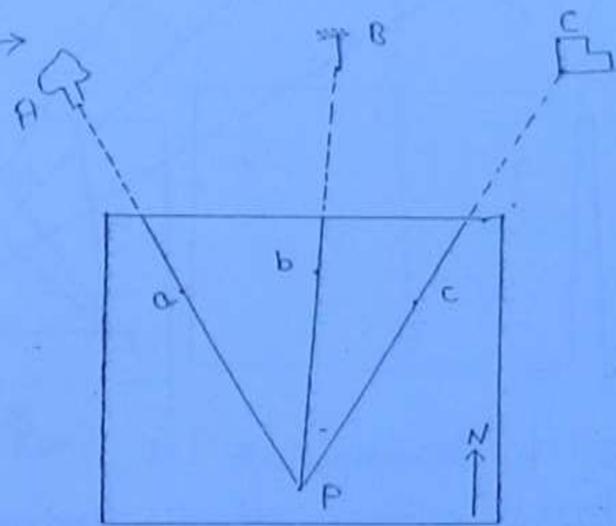
(1) Radiation :->



-> Orient the table in correct direction (N-S) using a line drawn on the drawing

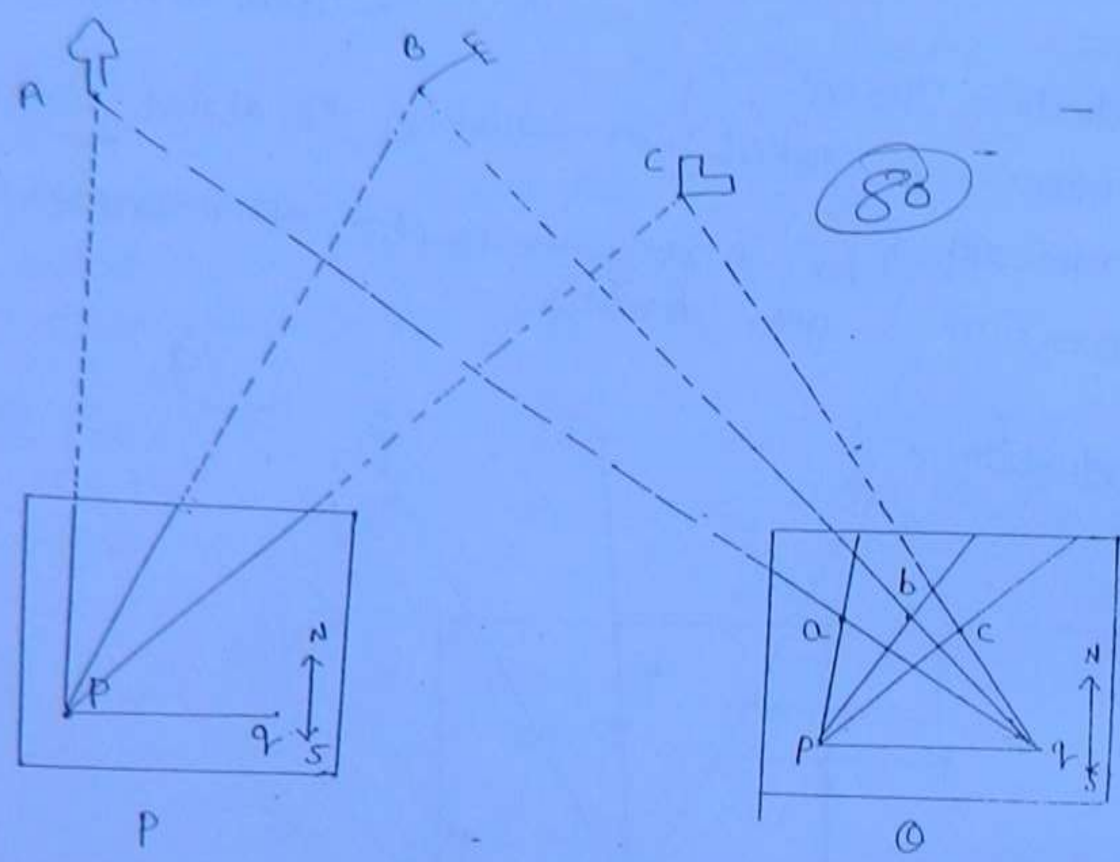
-> Position of instrument station P is marked over drawing

-> For location object position, distances are measured by using any other instrument

-> Lines are drawn towards different objects A, B and C and position of objects are marked by using a suitable scale

(2) Intersection :-> First the instrument at is set up at a Station P and after orienting the table.

Lines are drawn towards different objects. i.e. A B and C



→ Then another Station Q is marked by measuring PQ distance and by drawing a line PQ distance and by drawing a line from p towards Q.

→ The instrument is charged to Q and after orienting the table by either compass or back orientation line are again drawn toward A, B and C.

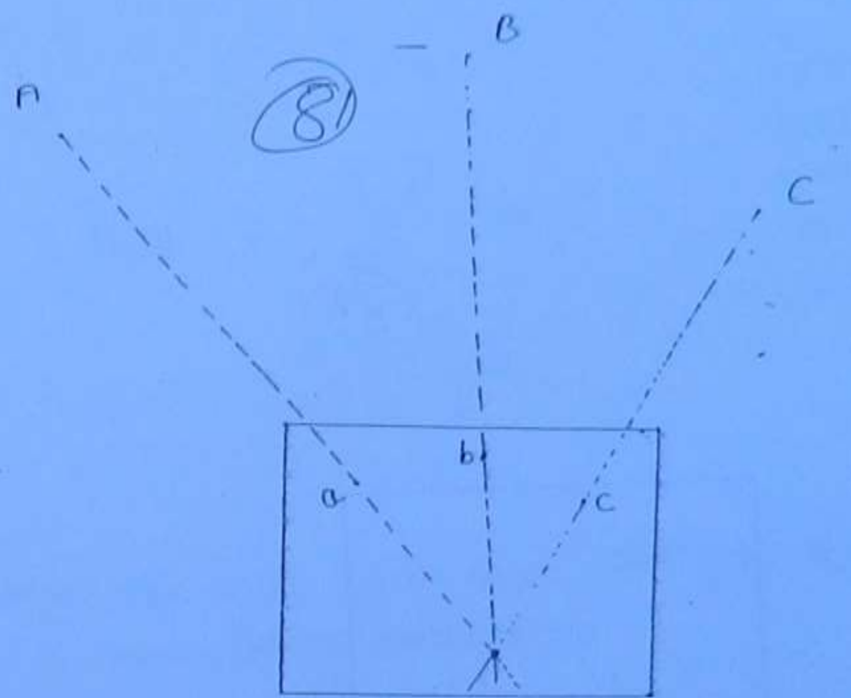
→ Intersection points are the location of objects.

③ Traversing:→

→ Different station of a closed traverse are marked by distance and orientation of table by back orientation.

→ Other details are collected either by radiation / Intersection

(4) Resection:→



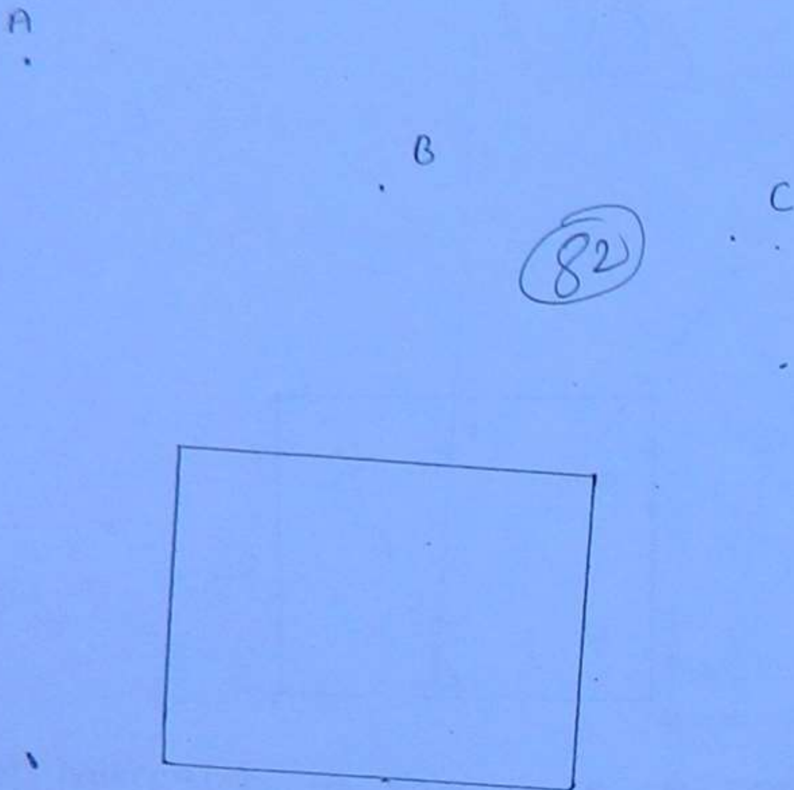
→ Resection is the process of determining position of instrument station after orienting the table in correct direction.

→ Methods
① Orientation by campass. (N S)
② Orientation by back sighting.
③ Three point problem.
④ Two point problem.

⇒Three point problem:→ (using the known location of three points on the drawing)

① By Traping paper method.
② By Bassel's graphicaly method.
③ By Lehman's rule method.

① Tracing paper method:→



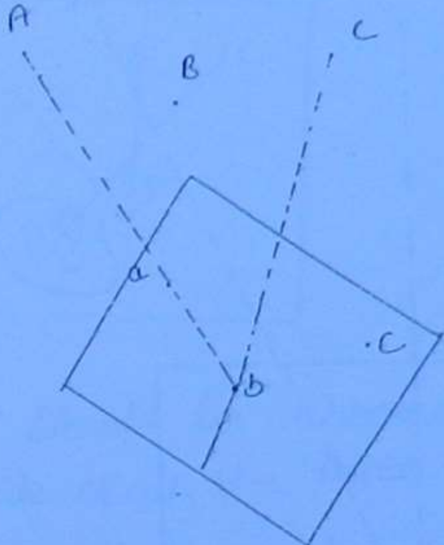
→ Fixed a Tracing paper on the drawing. Select any point on the tracing paper and draw three lines to-wards A, B and C.

→ Now rotated the tracing paper over drawing such that the marked position a, b and c comes directly over the three lines drawn in tracing paper.

→ Transfer the location of intersection point on the tracing drawing. this is the correct position of Instrument Station. Orient any one line towards the corresponding object. this is the correct orientation.

(2) Bessel's Graphical Method :->

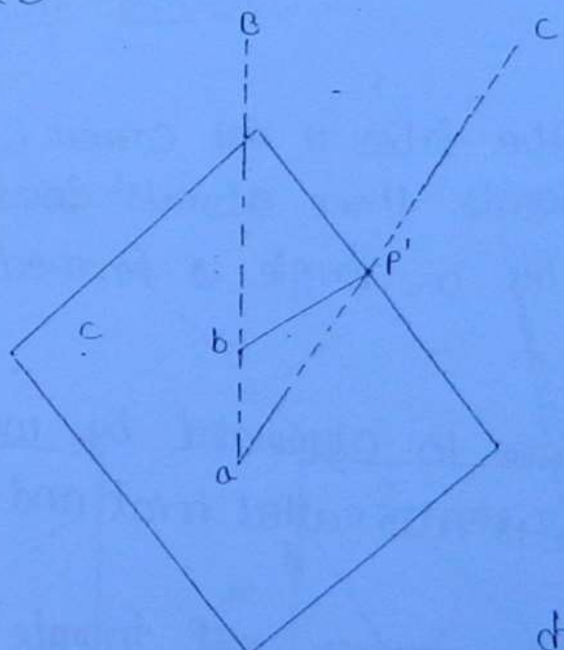
Step (1)



(83)

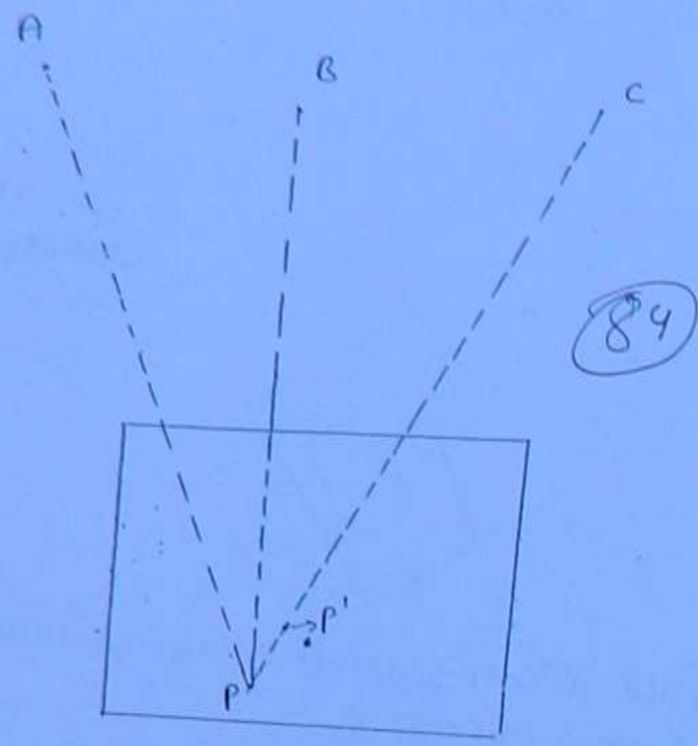
-> After at setting the table at station P. rotating the table to make line $\vec{ba}$ from b toward C. Rotatin

(2) Rotating the table such that line $\vec{ab}$ is now towards B draw a line from a toward C.



(3) Intersection point of two lines drawing is P'

(4) Now rotating the table and make line P'C towards C. This is the correct orientation of the table, draw line from A, B and B. that intersect line P'C at a point P that is the location of Instrument Station.



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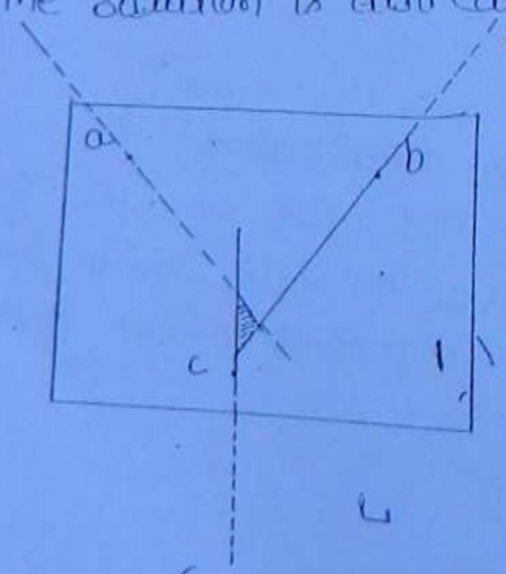
③ Lehman's method :→

→ If orintation of the table is not correct, the three lines draw towards three objects does not intersect at a single point. this a traingle is formed called traingle of error.

This traingle of error to eleminated by using lehman's Rules. the solution is also called trial and error solution.

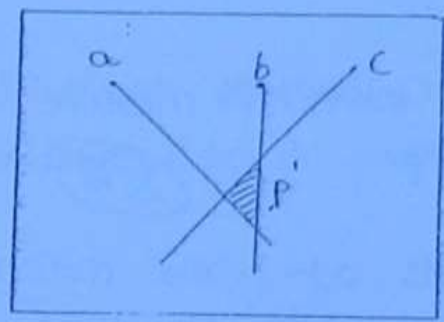
Rules→

①



→ If triangle of error is within the major triangle possible location of point is with in the triangle.

(3)



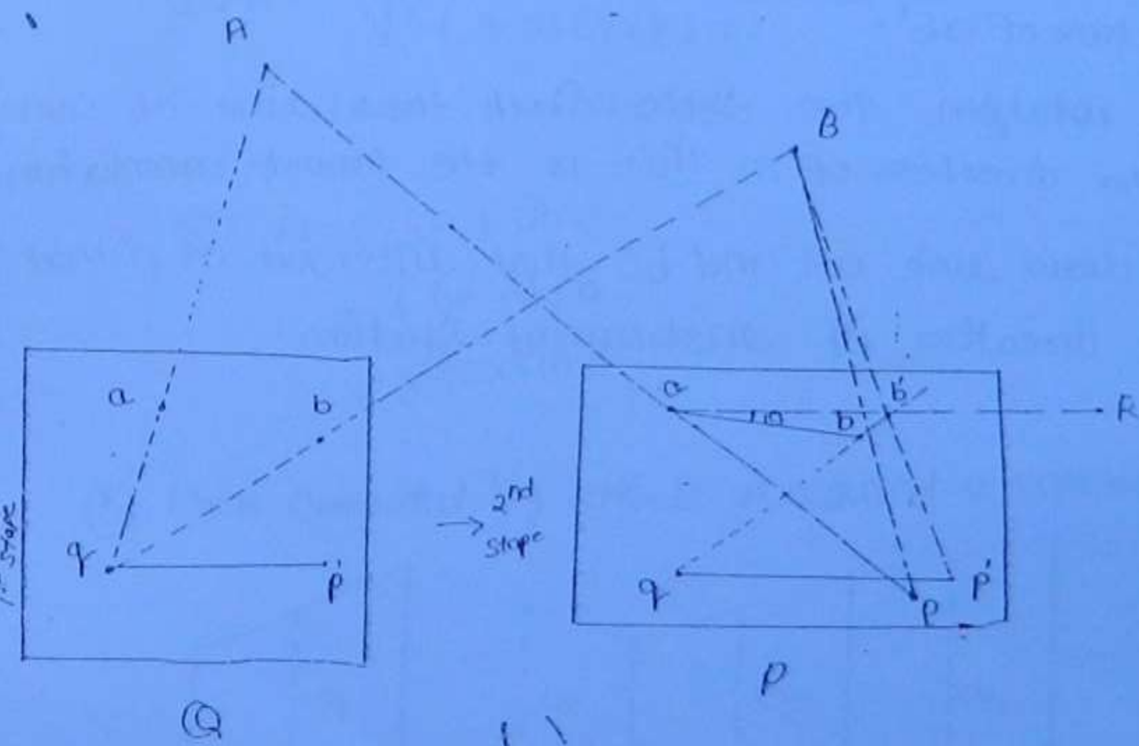
→ The point p' should be choosen such that, Its distance from a, b and c are propotional to p'A, p'B and p'C

(85)

→ The point p' should be choosen such that, it is to the same side of all the three rays pa, pb and pc.

→ The p' should be opposite the triangle.

(4) Two point problem:→



Procedure:→

(1) A and B are two point with which location are marked as a and b.

(2) Fixed the table at a station near P. Overnting the tab

approximatly. draw line aA and bB & that intersect at q.

(3) From q draw line toward P mesure distance PQ and plot the position OF P'. (86)

(4) Now bring the table at p and orient the table by back orientation toward Q. In this position orientation OF table is same as it was at Q.

(5) Now draw a line from p' toward B that cut line qb at b' ∠Qab' is the error in orientation.

(6) To correct the error fix a flag at R near P in the direction of ab'.

(7) Now rotation the table such that line ab comes in the direction OF R. this is the correct orientation.

(8) Now draw line aA and bB that intersect at p' that is the direction of instrument station.

[redacted]

☆ Area / Volume :→

① Area :→

Diffrent Methods are

ⓐ Dividing into a number of Triangles.

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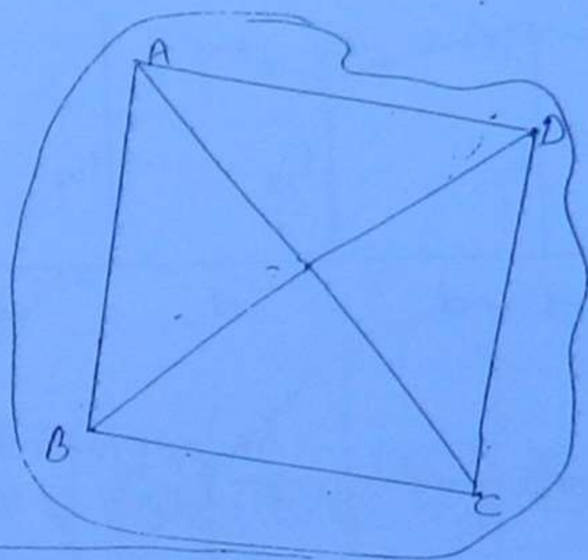


① $A = \sqrt{S(S-a)(S-b)(S-c)}$

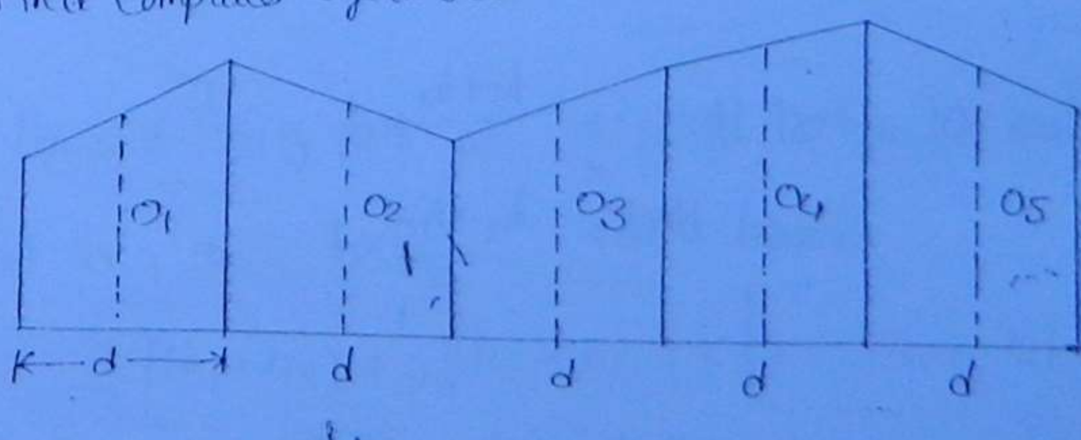
where $S = \dfrac{a+b+c}{2}$

② $A = \frac{1}{2} a \cdot b \sin C$

$= \frac{1}{2} bc \sin A$

$= \frac{1}{2} ac \sin B$

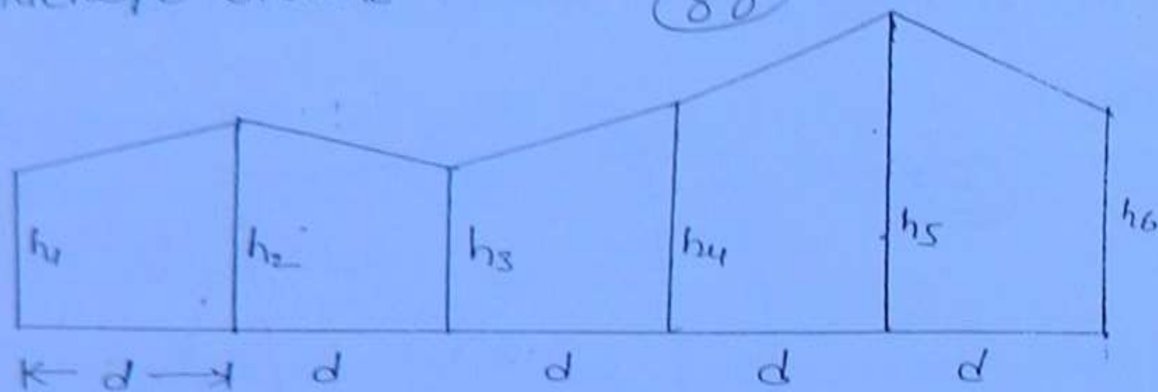
ⓑ Area computed by offsets measured a equaal intervals.



(1) Mid ordinate method:-

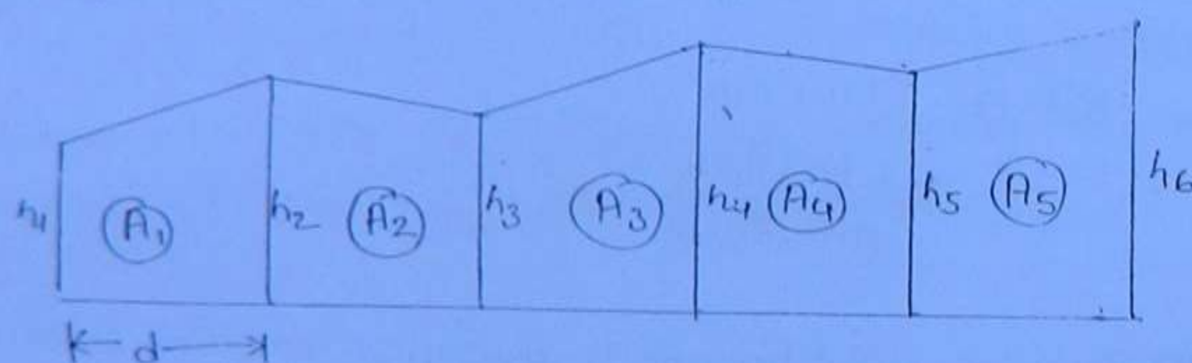
$$Area = d(O_1 + O_2 + O_3 + O_4 ---- + O_n)$$

(2) Average ordinate rules:-> 88



$$A = \left(\frac{h_1 + h_2 + h_3 + -- h_n}{n}\right) \times (n-1).d$$

(3) Trapezoidal Rule:->



Area of First block = $\frac{h_1 + h_2}{2} \times d$

Second block = $\frac{h_2 + h_3}{2} \times d$

Last block = $\frac{h_{n-1} + h_n}{2} \times d$

Total Area

$$A = \frac{d}{2}\left[(h_1 + h_n) + 2(h_2 + h_3) + \cdots h_{n-1}\right]$$

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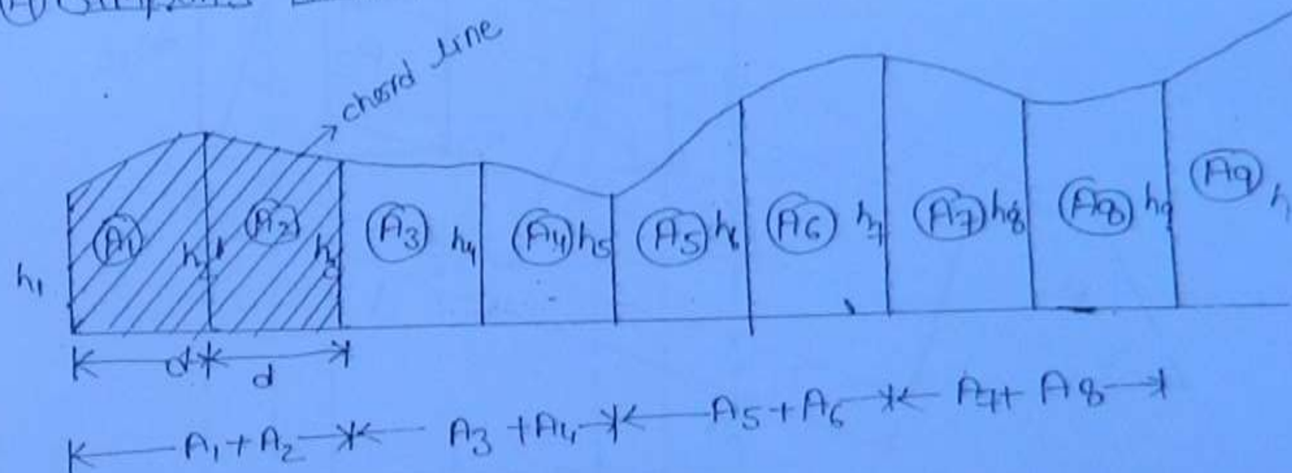
Trapezoidal Formula

$$A = d\left[\frac{h_1 + h_n}{2} + (h_2 + h_3 + h_4 + \cdots h_{n-1})\right]$$

(4) Simpson's Rule:→



Area of one pair $(A_1 + A_2) = \frac{d}{3}(h_1 + 4h_2 + h_3)$

Second Pair $(A_3 + A_4) = \frac{d}{3}(h_3 + 4h_4 + h_5)$

- - - - - - - - - - - - - - - -

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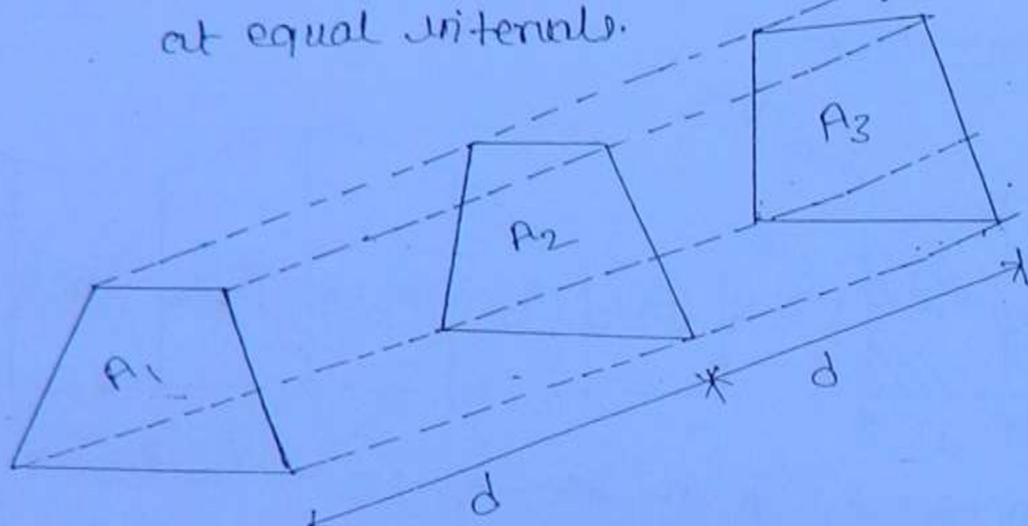
$A_{(n-2)} + A_{(n-1)}$ pair $= \frac{d}{3}(h_{n-2} + 4h_{n-1} + h_n)$

Total area:→

$$A = \frac{d}{3}\left[(h_1 + h_n) + 4(h_2 + h_4 + h_6 + \cdots) + 2(h_3 + h_5 + h_7 + \cdots)\right]$$

Note:→ Above formula can be used for Odd Number OF offsets only. If there are even No. of offsets either First block/last block area is calculated using trapezoidal rule and simply added. 90

★ Volume:→ If there are different parallel areas available at equal intervals.



(1) Trapezodial formula:→ (Method of End Area)

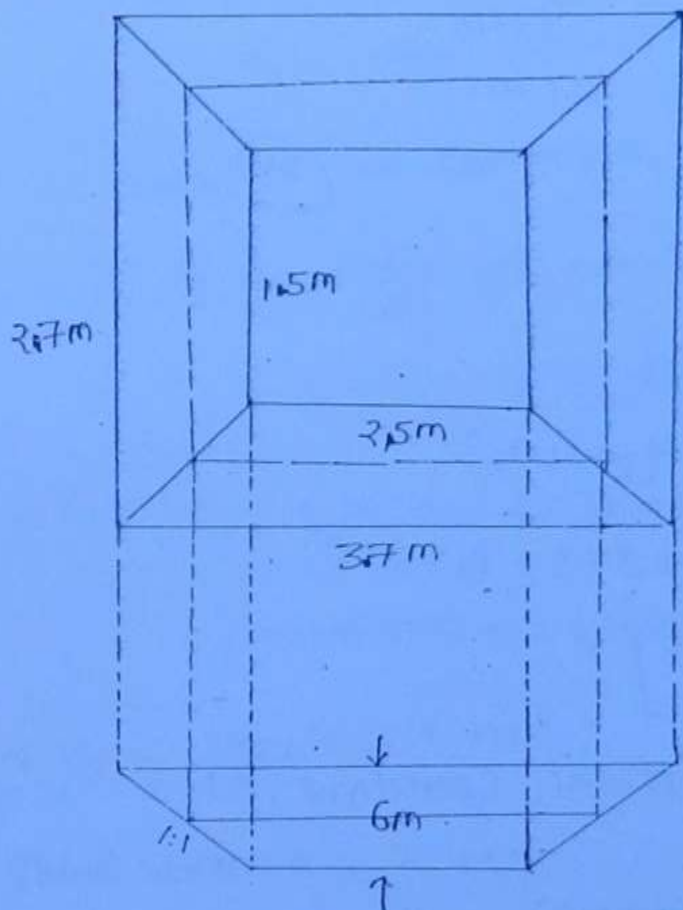
$$V = d\left[\frac{A_1 + A_n}{2} + (A_2 + A_3 + \cdots A_{n-1})\right]$$

(2) Simpson Rule:→

$$V = \frac{d}{3}\left[(A_1 + A_n) + 4(A_2 + A_4 + \cdots) + 2(A_3 + A_5 + \cdots)\right]$$

Note→ The line joint in curved line then Simpson Rules is best and the line is joint in a strait line than Trapezoidal formula is best.

<u>Problem</u>:→ An excavation has shape as shown in fig. calculated volume of the excavation earth by
(1) Trapezoidal Rule (2) Simpson's Rule.



(9)

<u>Solution</u>:- Trapezoidal Rule

$\frac{37\times 27}{}$ ↑ 6 ↓ $\frac{}{25\times 15}$

$A_1 = 37\times 27 = 999\ m^2$

$A_2 = 25\times 15 = 375\ m^2$

$d = 6m$

Volume

$$V = \frac{A_1 + A_2}{2}\times d = \frac{999+375}{2}\times 6$$

$$\boxed{V = 4122\ m^3}$$

(3) Simpsion's Rule:→

Considerd another area at centre.

$A_1 = 37 \times 27 = 999\,m^2$

$A_2 = 31 \times 21 = 651\,m^2$

$A_3 = 25 \times 15 = 375\,m^2$

(92)

$d = 3m$

Volume

$$V = \frac{d}{3}(A_1 + A_3 + 4A_2)$$

$$V = \frac{3}{3}(999 + 375 + (4 \times 651))$$

$$\boxed{V = 3978\ m^3}$$

Problem:→ Area of different countors of a reservior area :-

Countors	Area (m^2)
104	→ 4000 (A_0)
105	→ 15500 (A_1)
106	→ 90000 (A_2)
107	→ 160000 (A_3)
108	→ 850,000 (A_4)
109	→ 13,50,000 (A_5)
110	→ 19,40,000 (A_6)
111	→ 20,30,000 (A_7)

V_1 V_2

Calculate volume of resetvior by Simpsion's formula. Volume below 104m may be neglected.

Solution:→ Volume b/w Contoure 104 and 105 using Trapezoidal formula.

$$V_1 = \frac{4000 + 15500}{2} \times 1$$

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$$V_1 = \cancel{950}\ 9750\ m^3$$

Volume b/w Countors 105 to 111

$$\Rightarrow V_2 = \frac{d}{3}\left[(A_1 + A_7) + 4(A_2 + A_4 + A_6) + 2(A_3 + A_5) \right]$$

$$\Rightarrow V_2 = \frac{1}{3}\left[(15500 + 20{,}30{,}000) + 4(98000 + 950{,}000 + 1840000) + 2(160{,}000 + 1350000) \right]$$

$$\Rightarrow V_2 = 5405833.3\ m^3$$

Total volume $= V_1 + V_2$

$$V = 9\overset{7}{5}0 + 5405833.3\ m^3$$

$$\boxed{V = 5415583.33\,m^3}$$ Ans

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Problem:→ In a proposed reservoir the area containing with in the contours are

Contors.	Area (ha)
100 →	32
95 →	26
90 →	24
85 →	19
80 →	15
75 →	13
70 →	7
65 →	2

9Y

Using the method of end areas, calculate
(1) capacity of reservoir when it is full at 100 m level.
(2) Elevation of water when it is 60% full.
Ignore the volume below 65 m R.L.
Given your remarks about method of end area.

Solution:→

Countor	Area (ha)	Avg. Area	Volume (ha-m)	Commulative Volume
100	32	29	145	600
95	26	25	125.	455
90	24	21	105	330
85	19	16.5	82.5	225
80	15	14.0	70.0	142.5
75	13	10.0	50.0	72.5
70	7	4.5	22.5	22.5
65	2	0	0	0

① Capacity of reservoir when it is full at 100m level

$$V = d\left[\frac{A_1 + A_n}{2} + A_2 + A_3 + \text{----}\right]$$

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$$V = 5\left[\frac{32+2}{2} + (7+13+15+19+24+26)\right]$$

$\boxed{V = 600 \text{ ha-m}}$

② Volume when reservoir is 60% Full

$$V = \frac{60}{100} \times 600 = 360 \text{ ha-m}$$

water level should be b/w 90 to 95 m

$90\,m \rightarrow 330$ ha-m

$95\,m \rightarrow 455$ ha m

by interpolation water level for 360 ha-m volume

$$= 90 + \frac{(95-90)}{(455-330)} \times (360-330)$$

$$= \boxed{91.20\ m}$$ Ans

Remarks: → End area method is used trapezoidal formula for calculation of volume b/w two different area at equal interval and parallel to each others.

☆ Area enclosed within a closed Traverse :→

① M.D. Method :→ (Meridian Distance Method) :→

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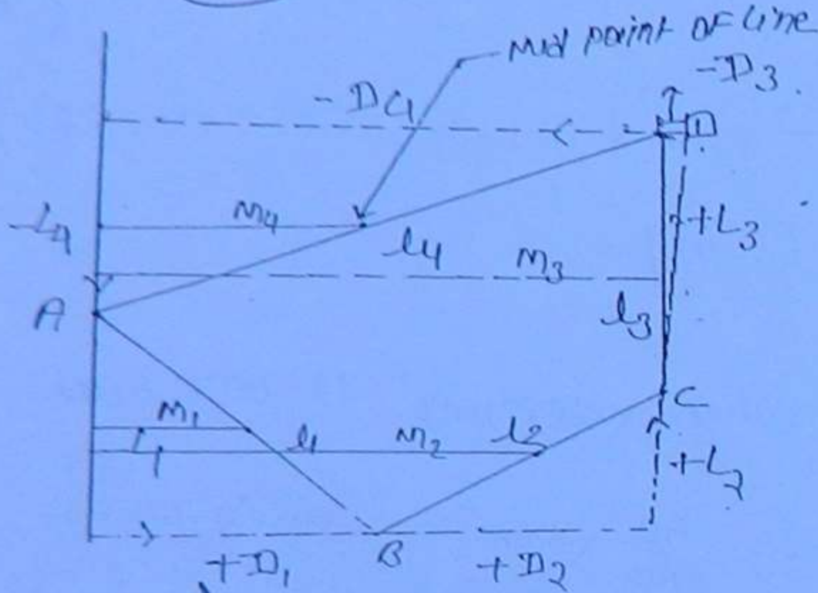

→ Meridian distance ~~method~~ is the distance of mid point of a line from a given meridian.

Meridian distance of

line $AB = m_1 = +\frac{D_1}{2}$

line $BC = m_2 = +D_1 + \frac{D_2}{2}$

$= \frac{D_1}{2} + \frac{D_1}{2} + \frac{D_2}{2}$

$= m_1 + \left(\frac{D_1}{2} + \frac{D_2}{2}\right)$

line $CD = D_1 + D_2 - \frac{D_3}{2}$

$= D_1 + D_2 + \left(-\frac{D_3}{2}\right)$

$$= \left(\frac{D_1}{2} + \frac{D_1}{2} + \frac{D_2}{2}\right) + \frac{D_2}{2} + \left(-\frac{D_3}{2}\right)$$

$$= m_2 + \left(\frac{D_2}{2} + -\frac{D_3}{2}\right)$$

M.D of a line = (M.D. of previous line) + ($\frac{1}{2}$ Departure of previous line) + ($\frac{1}{2}$ Dep. this line)

$$\text{M.D. of line } AD = m_3 + \left[\left(-\frac{D_3}{2}\right) + \left(-\frac{D_4}{2}\right)\right]$$

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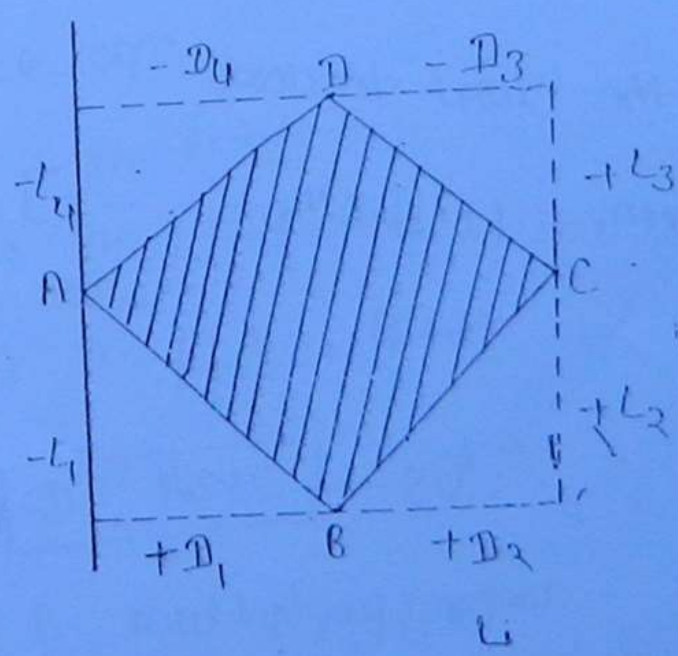
Area with in closed travers.

$$A = (\pm L_1) \times m_1 + (\pm l_2)\, m_2 + \cdots$$

$$A = \Sigma (L \times m)$$

☆ DMD Method :→
(Double Meridian Distance method)



Double meridian distance is the sum of the meridian distance of two extreme points of a line.

DMD of line

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$AB = M_1 = 0 + D_1$

$M_1 = D_1$

for $BC = M_2 = D_1 + (D_1 + D_2)$

$M_2 = M_1 + (D_1 + D_2)$

$$\text{DMD of a line} = \begin{pmatrix}\text{DMD of} \\ \text{Previous} \\ \text{line}\end{pmatrix} + \begin{pmatrix}\text{Departure} & & \text{Dep. of} \\ \text{of Pories} & + & \text{this} \\ \text{line} & & \text{line}\end{pmatrix}$$

for $CD = M_2 + [(+D_2) + (-D_3)]$

$DA = M_3 + [(-D_3) + (-D_4)]$

Area within the closed traverse

$$A = \frac{1}{2}[(\pm L_1) \times M_1 + (\pm L_2) \times M_2 + \text{------}]$$

$$A = \frac{1}{2} \Sigma LM$$

$$\Rightarrow \frac{1}{F} = \frac{1}{u} + \frac{1}{v} \quad \text{— (1)}$$

$$\frac{1}{u} = \frac{1}{F} - \frac{1}{v}$$

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$$\frac{S}{u} = \frac{i}{v}$$

$$\boxed{v = \frac{ui}{S}} \quad \text{— (2)}$$

$$\Rightarrow \frac{1}{u} = \frac{1}{F} - \frac{S}{ui}$$

$$\Rightarrow \frac{1}{u}\left(1 + \frac{S}{i}\right) = \frac{1}{F}$$

$$\Rightarrow F\left(1 + \frac{S}{i}\right) = u$$

$$\Rightarrow \boxed{u = F + \frac{F}{i}S} \quad \text{— (3)}$$

The distance of object from axis of telescope

$$D = u + d$$

$$\Rightarrow D = F + \frac{F}{i}S + d$$

$$\Rightarrow D = \left(\frac{F}{i}\right)S + (F + d)$$

$$\boxed{D = KS + C} \quad \text{— (A)}$$

$\forall$ K: multiplying constant

$$K = \frac{F}{i} \approx 100 \text{ (generally)}$$

C = Additive Constant = (f+d) ≈ 0 (generally)

→ A telescope which have $K = 100$, and $C = 0$ is called Anallactic telescope.

S = Staff intercept

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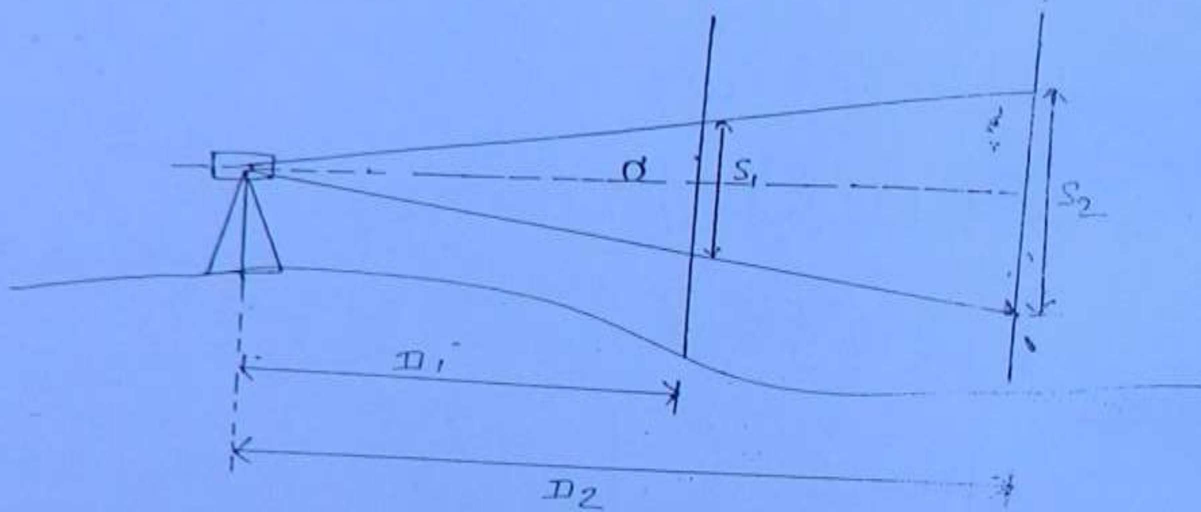
Determination of K and C for a telescope :→



Instrument is fixed at a station and staff readings are taken at two location, at distance D_1 and D_2, where staff intercept are S_1 and S_2.

$$D_1 = KS_1 + C \quad -(1)$$
$$D_2 = KS_2 + C \quad -(2)$$

Solve this two eq

$$\Rightarrow (D_1 - D_2) = K(S_1 - S_2)$$

$$\boxed{K = \frac{(D_1 - D_2)}{(S_1 - S_2)}} \quad -(A)$$

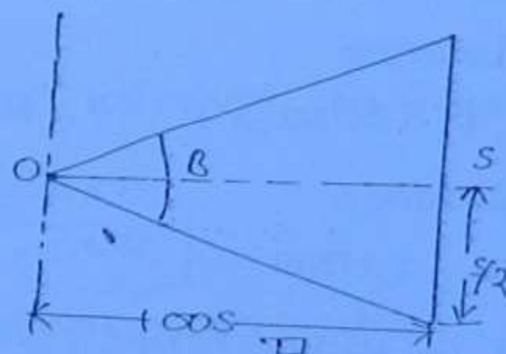
$$\Rightarrow C = D_1 - KS_1$$

$$C = D_1 - \frac{(D_1 - D_2)}{(S_1 - S_2)} \cdot S_1$$

$$\Rightarrow C = \frac{\cancel{D_1 S_1} - D_1 S_2 - \cancel{D_1 S_1} + D_2 S_1}{(S_1 - S_2)}$$

$$\boxed{C = \frac{D_2 S_1 - D_1 S_2}{S_1 - S_2}} \quad \text{--- (B)}$$

⇒ For Anallatical Telescope.

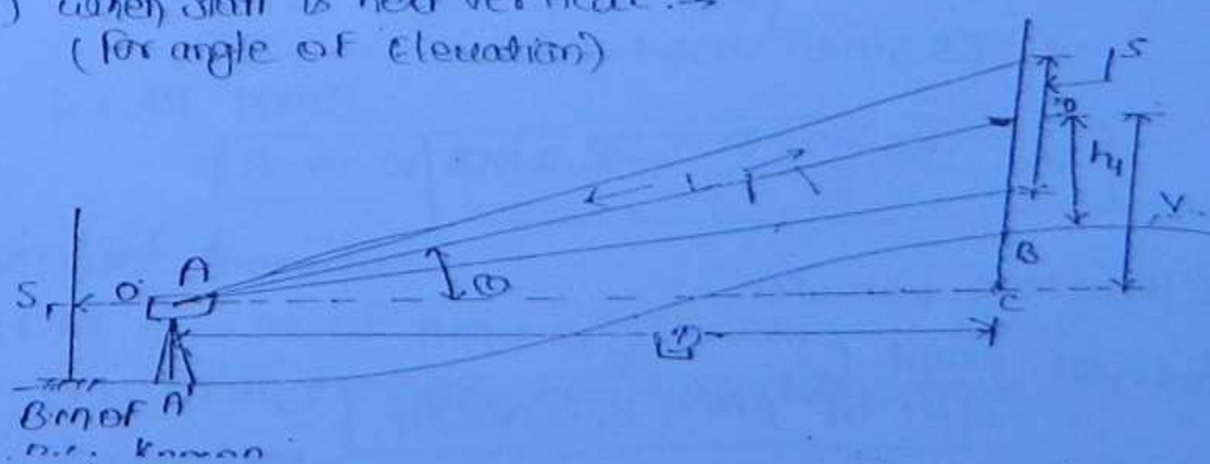


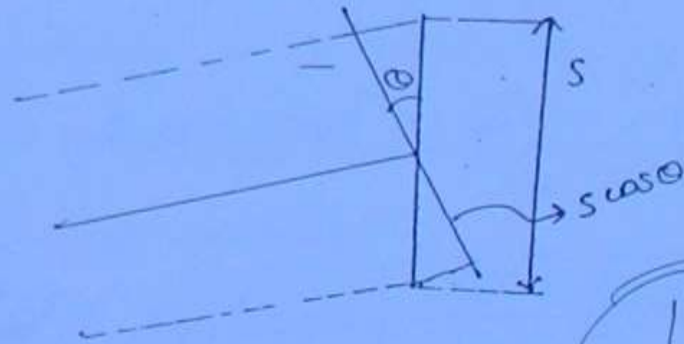
$$\tan \beta/2 = \frac{S/2}{100S} = \frac{1}{200}$$

$$\therefore \boxed{\beta = 0°34'22.63''}$$

⇒ Distance and Elevation Formula :→

Case (I) when staff is held vertical :→
(For angle of Elevation)





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☆ When Staff act vertical:→

Staff intercept for distance = $S\cos\theta$

Inclined distance

$\Rightarrow L = K \cdot S\cos\theta + C$

Horizontal distance

$AC = D = L\cos\theta$

$D = (KS\cos\theta + C)\cos\theta$

Distance formula $\boxed{D = KS\cos^2\theta + C\cos\theta}$ — A

Vertical distance

$V = L\sin\theta$

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

$V = KS\sin\theta \cdot \cos\theta + C\sin\theta$

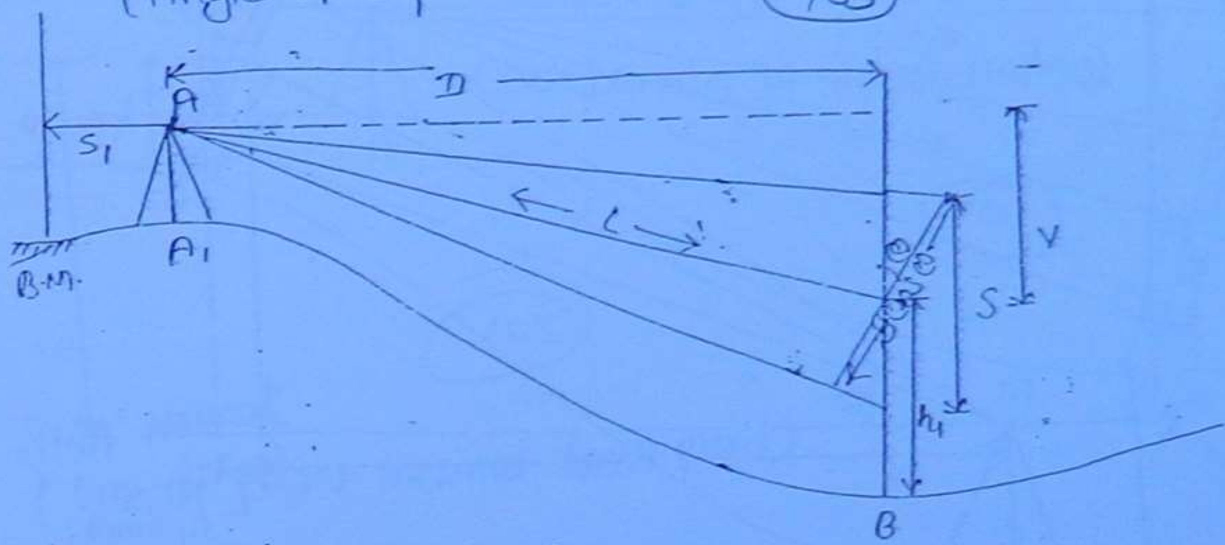
$$\boxed{V = \frac{KS\sin 2\theta}{2} + C\sin\theta} \quad \text{— B}$$

Elevation formula

R.L. of point B

$= \boxed{RL \text{ of } BM + S_1 + V - h_1}$ L

case (2) Staff held vertical
(Angle of depression)



Staff intercept for distance = $S\cos\theta$

Inclined distance

$$\boxed{l = ks\cos\theta + C}$$

Horizontal distance formula

$$D = l\cos\theta$$

$$\boxed{D = ks\cos^2\theta + c.\cos\theta}$$

Elevation formula

$$V = l\sin\theta$$

$$\boxed{V = k.s.\frac{\sin 2\theta}{2} + c\sin\theta}$$

R.L of point B

$$\boxed{= RL\ of\ BM + S_1 - V - h_1}$$

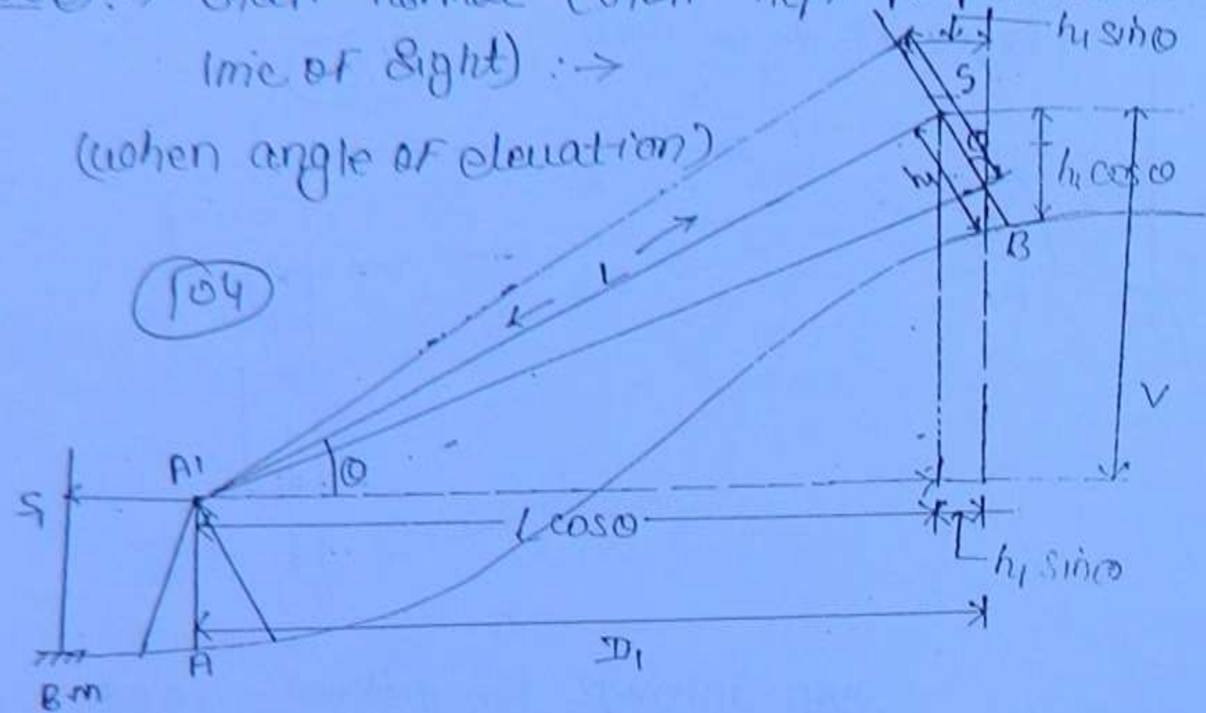
Combine formula.

R.L of B = RL of BM + $S_1 \pm V - h_1$

We (+)ve for angle of elevation, (-)ve for angle of depression.

case③ :→ Staff normal (staff kept perpendicular to line of sight) :→

(when angle of elevation)



Staff intercept for Distance $l = S$

Inclined length

$$\boxed{l = ks + c}$$

Horizontal Distance

$$D = l\cos\theta + h_1 \sin\theta$$

$$\boxed{D = (ks+c)\cos\theta + h_1 \sin\theta} \quad \text{—(A)}$$

Elevation formula.

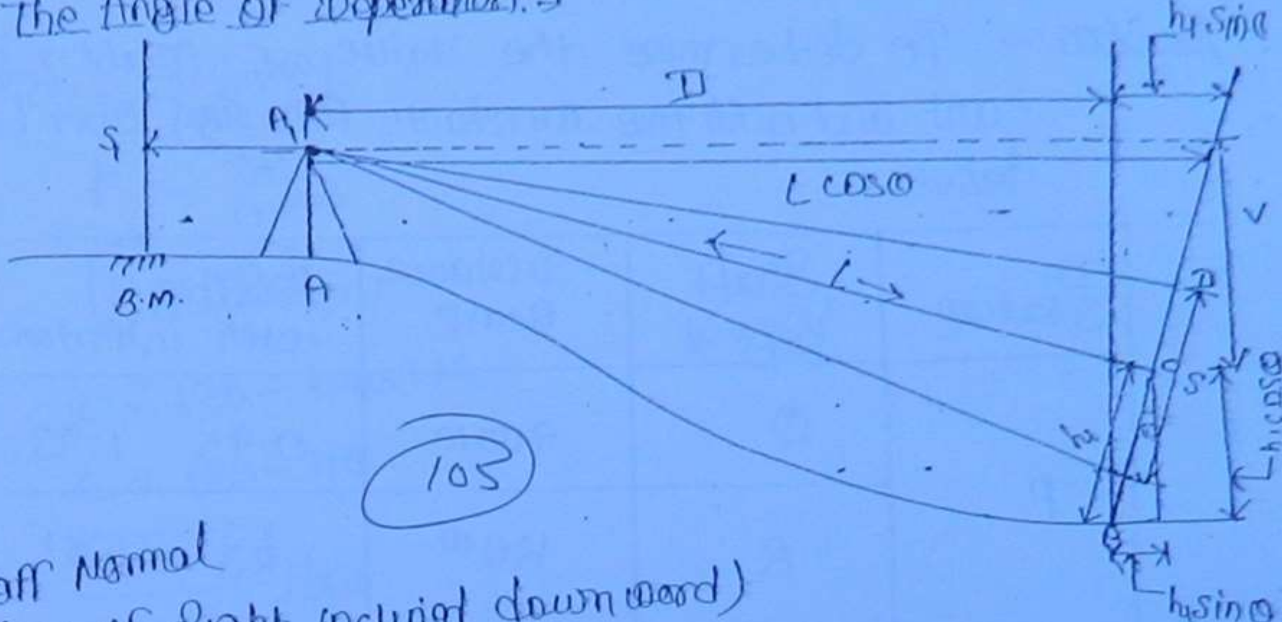
$$V = l\sin\theta$$

$$\boxed{V = (ks+c)\sin\theta}$$

R.L of point B

$= \text{RL of BM} + S_1 + V - h_1 \cos\theta$

Case (4) The Angle of Depression:→



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Staff Normal
(Line of Sight inclined downward)

Staff intercept = S
Inclined length $\boxed{L = KS + C}$

Horizontal Distance formula

$$D = L\cos\theta - h_1 \sin\theta$$

$$\boxed{D = (KS + C)\cos\theta - h_1 \sin\theta}$$

Elevation formula

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

∴ R.L of B

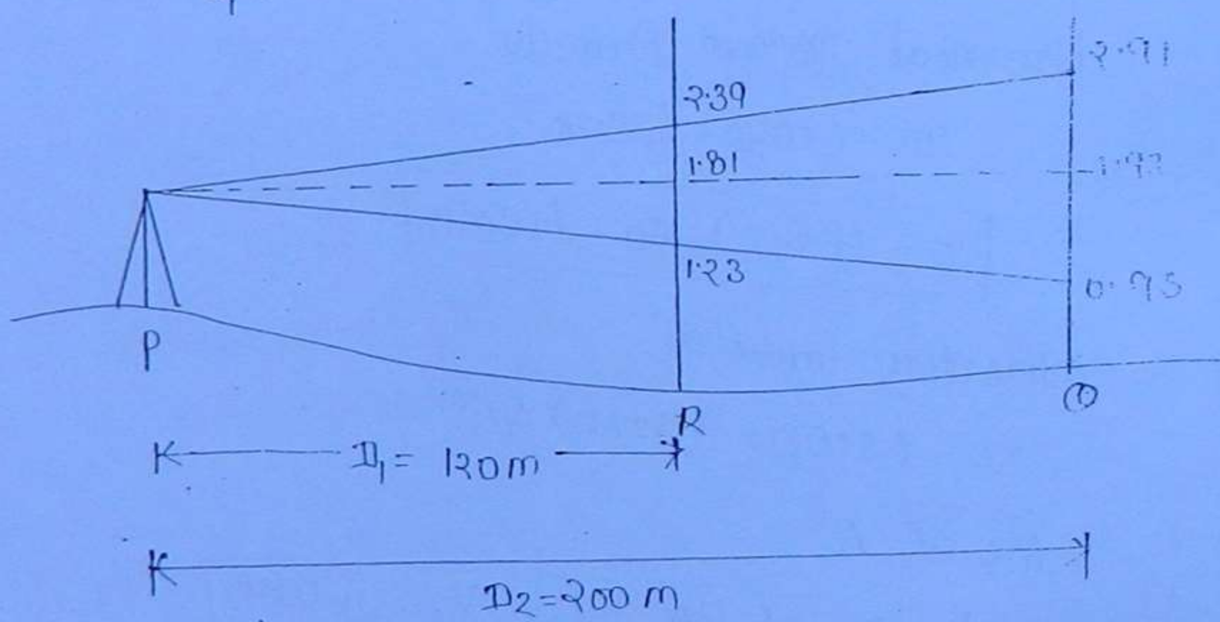
$$\boxed{= \text{RL of BM} + S_1 - V - h_1 \cos\theta}$$

Problem:→ To determine the value of multiplying constant and additive constant. following observation were taken.

Ins. station	Staff kept at	Distance from P	Reading with inclination 0°0"		
P	Q	200 m	0.95	1.93	2.91
	R	120 m	1.23	1.81	2.39

Solution:→ $S_1 = 2.39 - 1.23$ | $S_2 = 2.91 - 0.95$ (106)

$S_1 = 1.16$ | $S_2 = 1.96$



$D_1 = KS_1 + C$

$\Rightarrow 120 = K \times 1.16 + C$ — (1)

$\Rightarrow D_2 = K \cdot S_2 + C$

$\Rightarrow 200 = K \times 1.96 + C$ — (2)

of (2)-(1)

$\Rightarrow 80 = 0.80 \times K$

$K = \frac{80}{0.80}$

$\boxed{K = 100}$ Ans

$C = 120 - 100 \times 1.16$

$C = 120 - 116$

$\boxed{C = 4}$ Ans

Problem:→ From a Tacheometer set up a Station A, reading were taken as in Staff kept at Station B and Bench mark M.

Instrum. Station	Staff location	Angle	Staff position	Readings
A	B	$+15^{\circ}30'$ (upward)	Kept vertical	2.35, 2.60, 2.85
A	M B.M RL 200.52 m	−15 (downward)	Kept normal	1.32, 1.55, 1.78

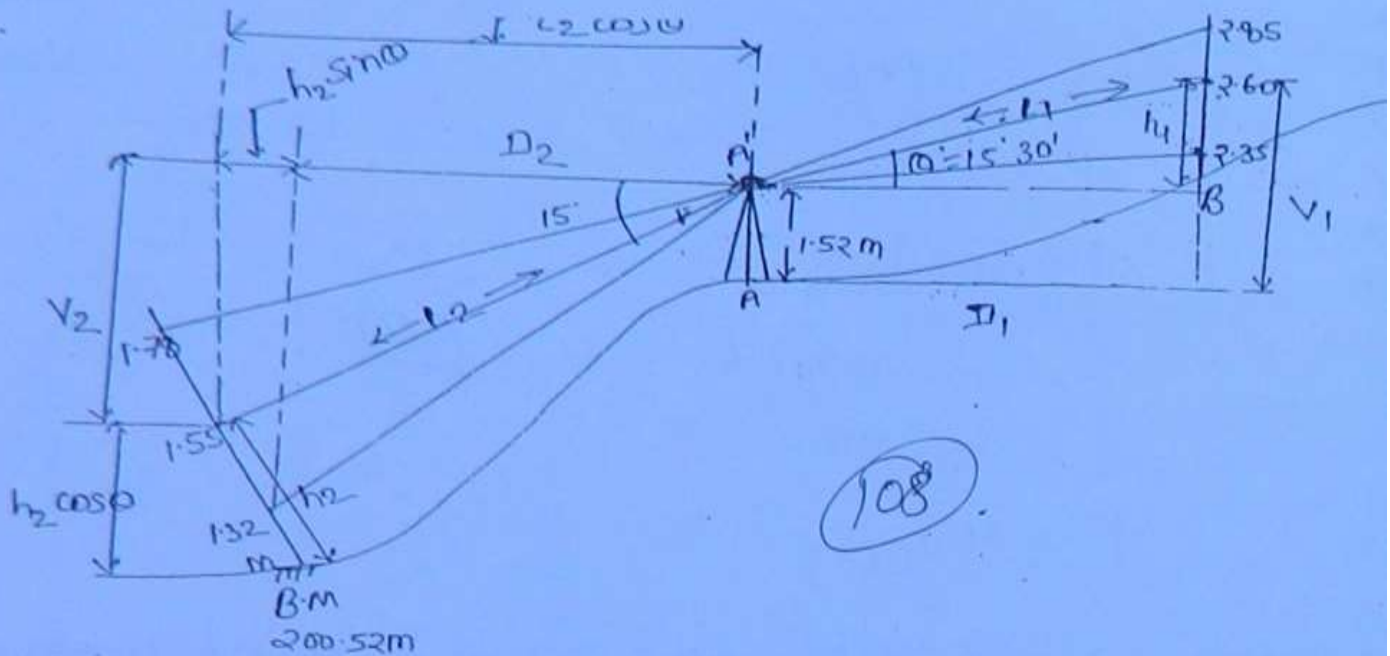
If k = 100, C = 0 height of instrument at A = 1.52 m, find out R.L of A at B. Also find out distance of B and M from A.

Solution:→ A to B

$S = 2.85 - 2.35 = 0.50$

Staff is vertical

Staff intercept $= S\cos\theta$
$= 0.50\cos 15^{\circ}30'$



Distance formula.

$$D_1 = Ks\cos^2\theta + \cancel{C}\cos\theta$$

$$D_1 = 100 \times 0.50 \times \cos^2 15°30'$$

$$\boxed{D_1 = 46.43\,m}$$

Elevation formula.

$$V_1 = Ks\frac{\sin 2\theta}{2} + \cancel{C}\sin\theta$$

$$V_1 = 100 \times 0.50 \times \frac{\sin 31}{2}$$

$$\boxed{V_1 = 12.876\,m}$$

From A towards M

$$S = 1.78 - 1.32$$

$$\boxed{S = 0.46}$$

Distance formula:→

$$D_2 = (Ks+C)\cos\theta - h_2 \sin\theta$$

$$D_2 = 100 \times 0.46 \times \cos 15^\circ - 1.55 \sin 15^\circ$$

$$\boxed{D_2 = 44.03\ m}$$

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Elevation formulas →

$$V_2 = L_2 \sin\theta$$

$$V_2 = (ks+c)\sin\theta$$

$$V_2 = 0.46 \times 100 \times \sin 15^\circ$$

$$\boxed{V_2 = 11.91\ m}$$

R.L. of A

$$= \text{RL of BM} + h_2 \cos\theta_2 + V_2 - 1.52$$

$$= 200.52 + 1.55 \times \cos 15^\circ + 11.91 - 1.52$$

$$= \boxed{212.41\ m}$$

R.L. of B

$$= \text{R.L of A} + 1.52 + V_1 - h_1$$

$$= 212.41 + 1.52 + 12.876 - 2.60$$

$$= \boxed{224.20\ m}$$

Problem: → To determine the gradient b/w two points A and B, a tacheometer was set up at another station C, and the following observation were made.

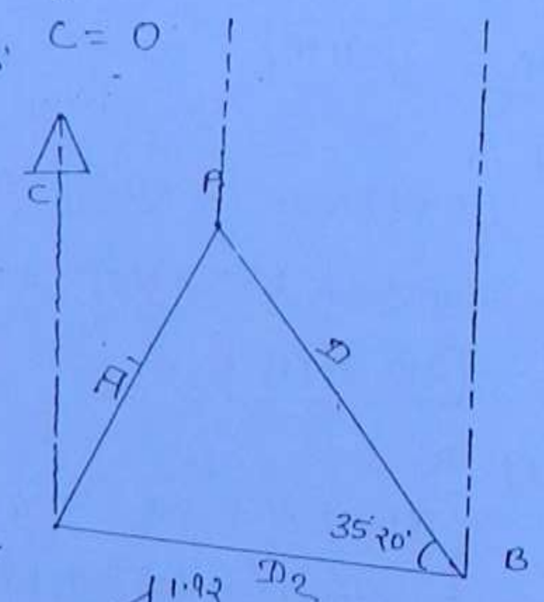
In	Staff	Vertical angle	Staff reading Kept Vertical
C	A	+4°20'0"	1.30, 1.61, 1.92
	B	+0°10'40"	1.10, 1.41, 1.72

110

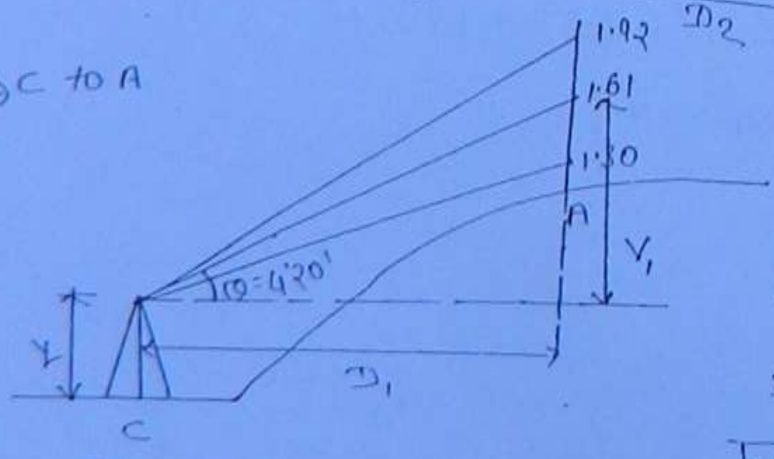
If horizontal angle ABC = 35°20'. Determine average gradient b/w A and B.

K = 100, C = 0

Solution: →



⇒ C to A



RL of C = x

$S = 1.92 - 1.30 = 0.62$

$D_1 = Ks\cos^2\theta + \cancel{C}\cos\theta$

$D_1 = 100 \times 0.62 \times \cos^2 4°20'$

$\boxed{D_1 = 61.646\,m}$

$$V_1 = Ks\frac{\sin 2\theta}{2} + C \sin\theta$$

$$\Rightarrow V_1 = 100 \times 0.62 \times \frac{\sin 2 \times 4^\circ 20'}{2}$$

$$\Rightarrow \boxed{V_1 = 4.67\ m}$$

(iii)

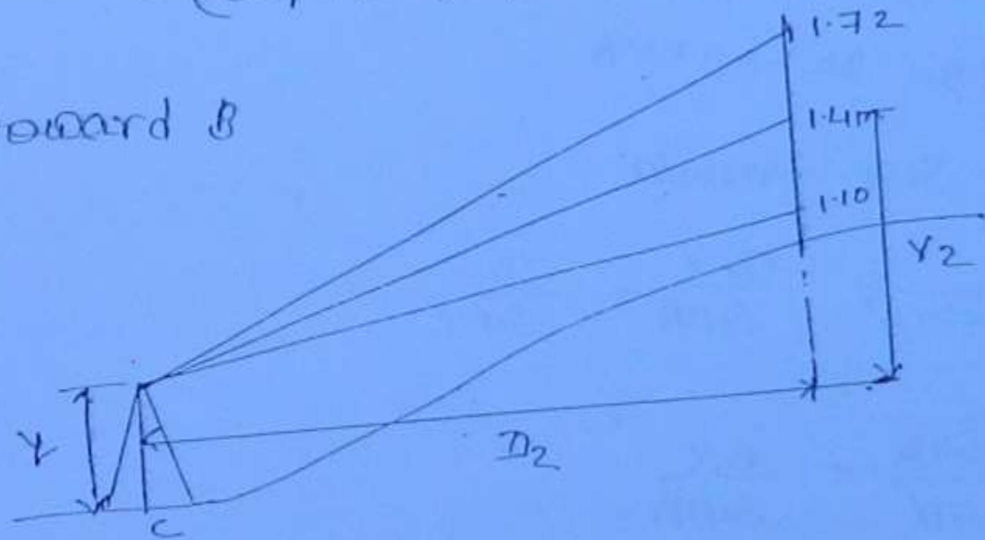
R.L. OF A

$= x + y + V_1 - h_1$

$= x + y + 4.67 - 1.61$

$= (x + y + 3.06)\ m$

$\Rightarrow$ C toward B



$s = 1.72 - 1.10$

$s = 0.62$

Distance $D_2 = Ks\cos^2\theta + C\cos\theta$

$D_2 = 100 \times 0.62 \cos^2 0^\circ 10' 40''$

$$\boxed{D_2 = 62\ m}$$

$V_2 = Ks\frac{\sin 2\theta}{2} = 100 \times 0.62 \times \frac{\sin 2 \times 0^\circ 10' 40''}{2}$

$$\boxed{V_2 = 0.192\ m}$$

$$R.L. \text{ OF } B = RL \text{ OF } C + 4 + V_2 - h_2$$
$$= (x+4) + 0.192 - 1.41$$
$$= (x+4) - 1.218$$

112

Difference of R.L. b/w A and B

A is higher

$$= R.L \text{ OF } A - R.L \text{ OF } B$$
$$= \cancel{x+4} + 3.06 - \cancel{x+4} + 1.218$$
$$= \boxed{4.278\,m}$$

Distance from A to B

Apply Sine-formula

$$\Rightarrow \frac{D_1}{\sin 35°20'} \quad \frac{D_2}{\sin A} = \frac{D}{\sin C}$$

$$\Rightarrow \frac{61.646}{\sin 35°20'} = \frac{62}{\sin A}$$

$$\Rightarrow A = 35°34'0.9''$$

$$\text{Angle } c = 180 - (35°34'0.9'' + 35°20')$$

$$c = 109°5'59.10''$$

$$D = \frac{D_1 \xrightarrow{} 61.646}{\sin 35°20'} \times \sin 109°5'59.10''$$

$$\boxed{D = 100.72m}$$

$$\text{Gradient} = \frac{4.278}{100.72}$$

$$\boxed{= \frac{1}{23.541}}$$ Ans

(113)

Es- 1989

problem (3)(a)

114

Curve :→

(1) Simple Curve :→

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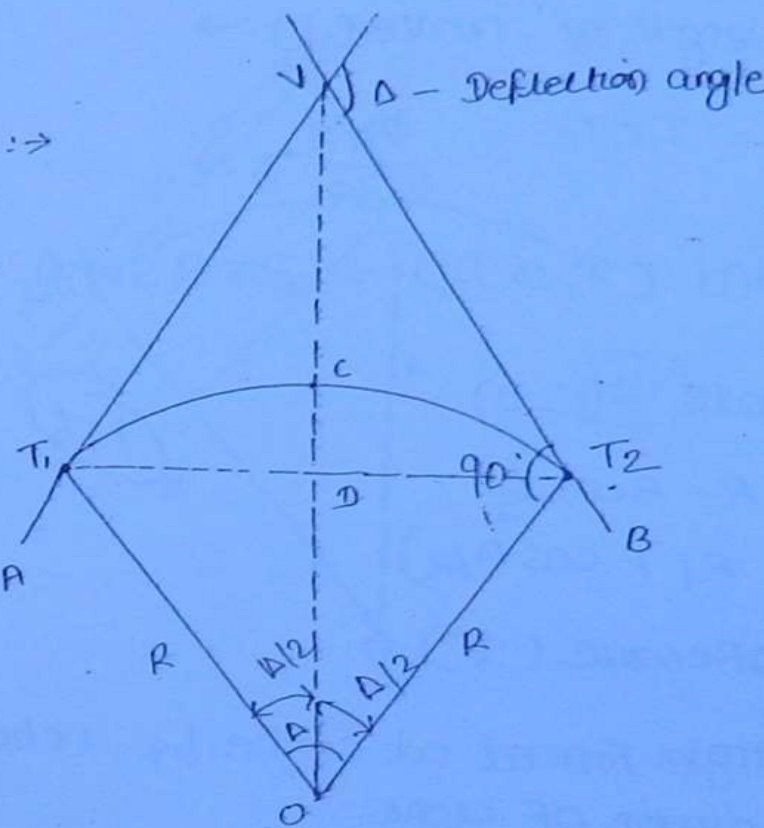


[redacted]

Important Terms :→

(1) Back tangent → AT_1

(2) Forward tangent → BT_2

(3) Point of curve → Point T_1

(4) Point of tangency → Point T_2

(5) Deflection ~~and~~ angle (or intersection angle) Δ.

(6) Radius = R

(7) of curve centre is at O

(8) Tangent distances $= VT_1 = VT_2 = R \cdot \tan\frac{\Delta}{2}$

(9) External distances = (VC) → (Apex distance) —

$$VC = R\sec\frac{\Delta}{2} - R$$

$$\boxed{VC = R\left(\sec\frac{\Delta}{2} - 1\right)}$$

(10) Total length of curve (l) :→

$$l = T_1 C T_2 = \frac{2\pi R}{360} \times \Delta$$

(11) Long Cord ($T_1 D T_2$) $= 2 \times R \sin\frac{\Delta}{2}$

(12) Midordinate :- (C D)

116

$$CD = R - R\cos\frac{\Delta}{2}$$

$$CD = R(1 - \cos\Delta/2)$$

(13) Degree of curve (D°) ⇒

Angle formed at centre by 1 chain length is called degree of curve.

(1) chain = 30 m

$$D = \frac{1720}{R} \quad \Big| \quad R = \frac{1720}{D}$$

(2) chain = 20 m

$$D = \frac{1146}{R}$$

$$R = \frac{1146}{D}$$

(14) Setting out a Simple curve on Ground :→

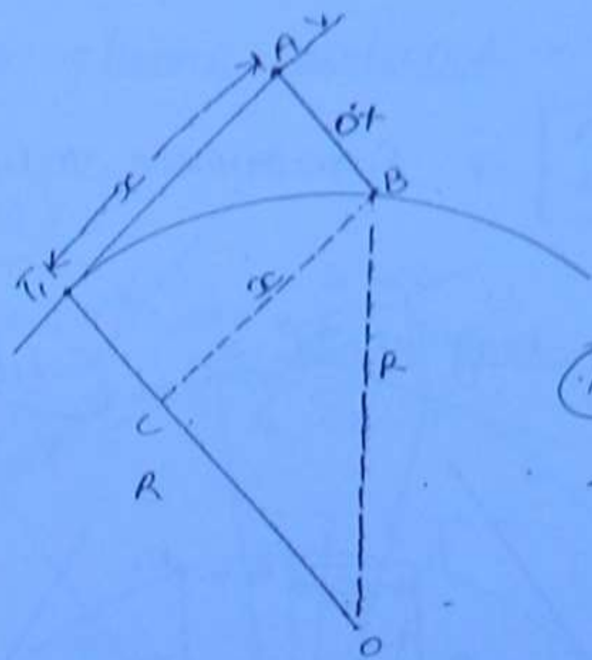
(I) Offset method :→

(1) Perpendicular offsets :→

$$O_x = AB = T_1C = OT_1 - OC$$

$$\boxed{O_x = R - \sqrt{R^2 - x^2}} \text{ — (A)}$$

→ Exact formula

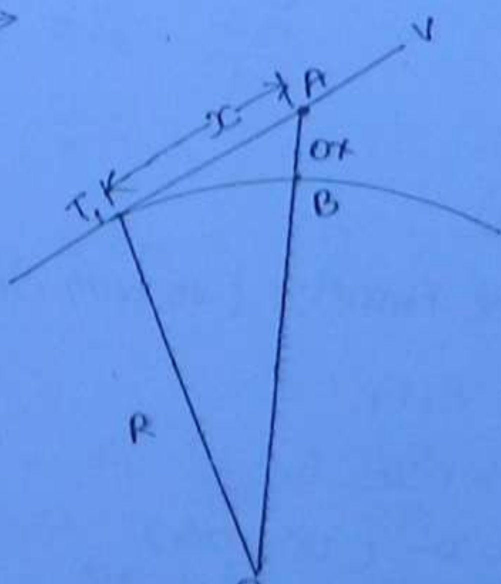


(117)

Expanding

$$\boxed{O_x = \frac{x^2}{2R}} \rightarrow \text{approximate value}$$

(b) Radial off set →



$OX = AB = OA - OB$

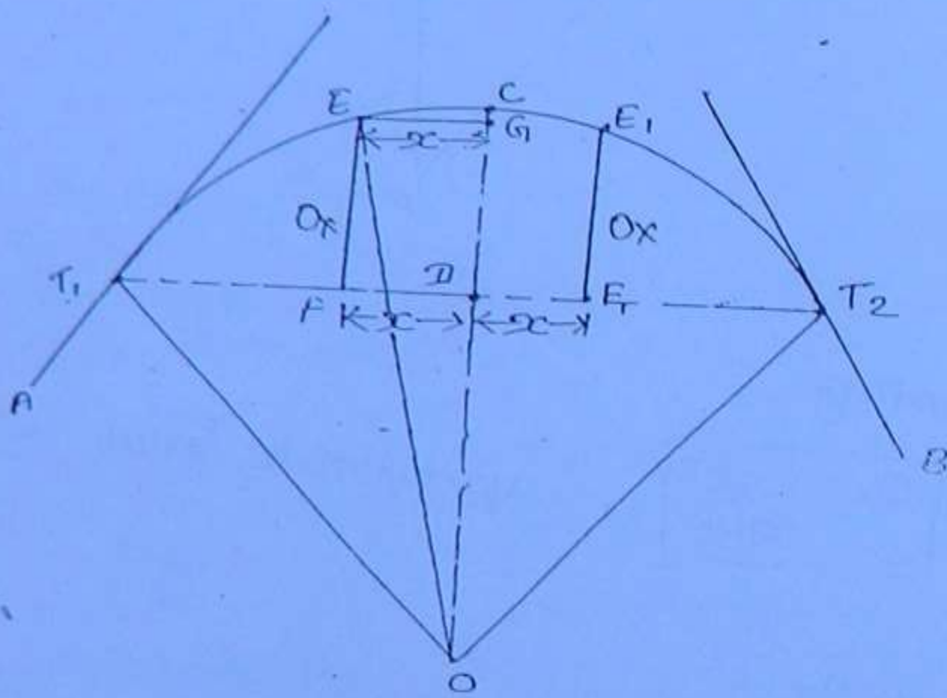
$$\boxed{OX = \sqrt{R^2 + x^2} - R} \rightarrow \text{exact Formula}$$

Expanding

$$\boxed{O_x = \frac{x^2}{2R}} \rightarrow \text{Approximate value}$$

(2) Offset from long chord: →

(118)



⇒ CD = Mid ordinate

$CD = R(1 - \cos \Delta/2)$

Offset at x distance from D (on both side)

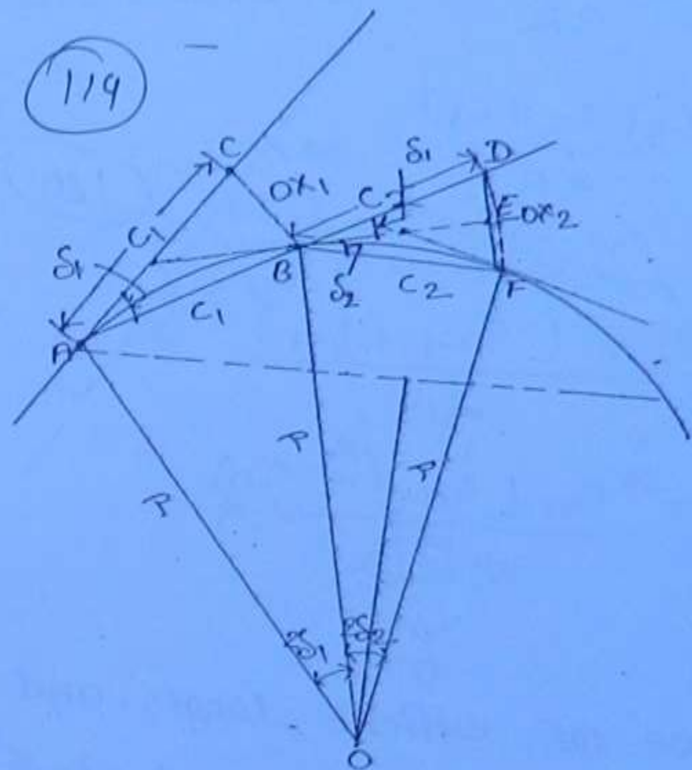
$$O_x = EF = E_1F_1$$

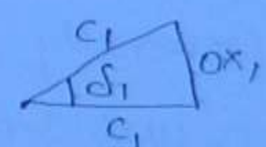
$$O_x = GD = CD - GC$$

$$O_x = CD - (OC - OG)$$

$$\boxed{O_x = R(1 - \cos \Delta/2) - \left(R - \sqrt{R^2 - x^2}\right)}$$

(d) Offset from chord produced:→





$\delta_1 = \frac{Ox_1}{C_1}$

$Ox_1 = \delta_1 C_1$

$\Rightarrow \delta_1 = \frac{C_1}{2R} \Rightarrow 2\delta_1 = \frac{C_1}{R}$

$\Rightarrow \delta_2 = \frac{C_2}{2R} \Rightarrow 2\delta_2 = \frac{C_1}{R}$

-- -- -- -- -- -- -- --

-- -- -- -- -- -- -- --

$\Rightarrow \delta_n = \frac{C_n}{2R} \Rightarrow 2\delta_n = \frac{C_n}{R}$

Offset

$Ox_1 = C_1\delta_1 = C_1 \cdot \frac{C_1}{2R} = \frac{C_1^2}{2R}$

$Ox_2 = DF = DE + EF$

$Ox_2 = C_2\delta_1 + C_2\delta_2$

$Ox_2 = C_2\frac{C_1}{2R} + C_2\frac{C_2}{2R}$

$$\Rightarrow OX_2 = \frac{c_2(c_1+c_2)}{2R}$$

$$\Rightarrow OX_3 = \frac{c_3(c_2+c_3)}{2R}$$

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$$\Rightarrow OX_r = \frac{c_r(c_{r-1}+c_r)}{2R}$$

$$\Rightarrow OX_n = \frac{c_n(c_{n-1}+c_n)}{2R}$$

Generally

c_1 and c_n are of diffrent length. and all other chords $c_2 = c_3 = c_4 = \cdots c_{n-1} = 1$ chain length

$$OX_1 = \frac{c_1^2}{2R}$$

$$OX_2 = \frac{c(c_1+c)}{2R}$$

$$OX_3 = \frac{c(c+c)}{2R} = \frac{c^2}{R}$$

$$OX_3 = OX_4 \cdots OX_{n-1}$$

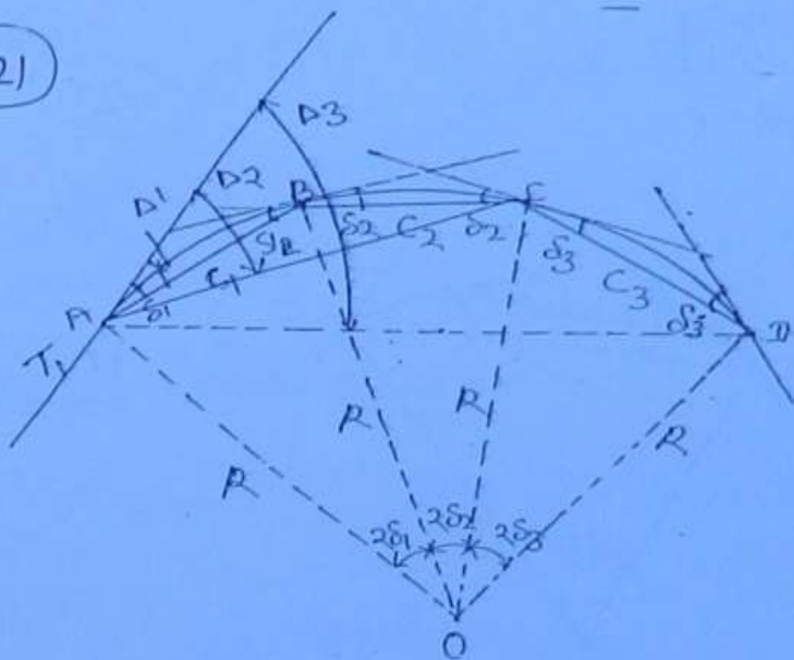
$$OX_n = \frac{c_n(c+c_n)}{2R}$$

IMP

Rankine Method :→

(1) One theodolite method :→

(121)



$$\frac{c_1}{2\pi R} = \frac{2\delta_1}{360^\circ}$$

$$\delta_1 = \frac{360\, c_1}{4\pi R} \text{ degree}$$

$$\delta_1 = \frac{360\, c_1 \times 60}{4\pi R} \text{ minute}$$

$$\delta_1 = 1718.9\, \frac{c_1}{R} \text{ minute}$$

$$\delta_2 = 1718.9\, \frac{c_2}{R} \text{ minute}$$

$$\delta_3 = 1718.9\, \frac{c_3}{R} \text{ minute}$$

-- ---

$$\delta_n = 1718.9\, \frac{c_n}{R} \text{ minute}$$

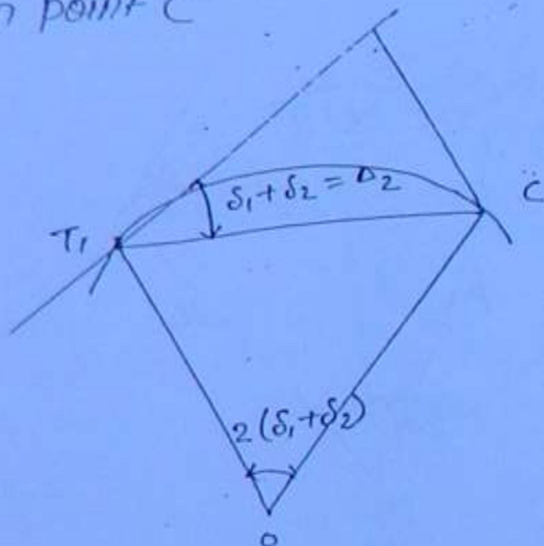
Total deflection angle:→

For point B

$$\boxed{\Delta_1 = \delta_1}$$

From point C

(122)



$\Delta_2 = \delta_1 + \delta_2$

$$\boxed{\Delta_2 = \Delta_1 + \delta_2}$$

From point D

$\Delta_3 = \delta_1 + \delta_2 + \delta_3$

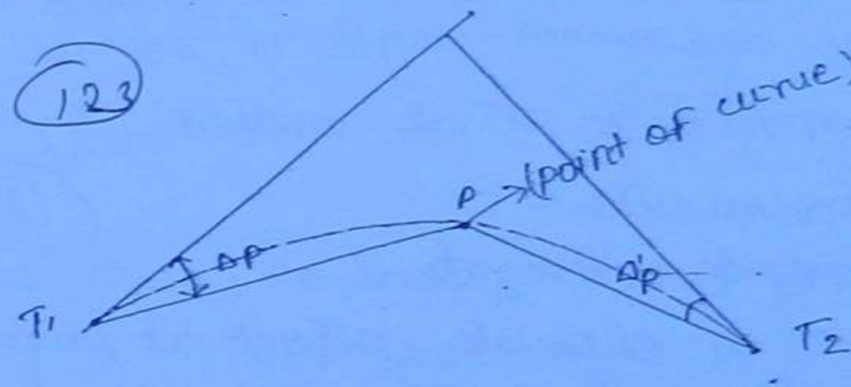
$$\boxed{\Delta_3 = \Delta_2 + \delta_3}$$

- - - - - -

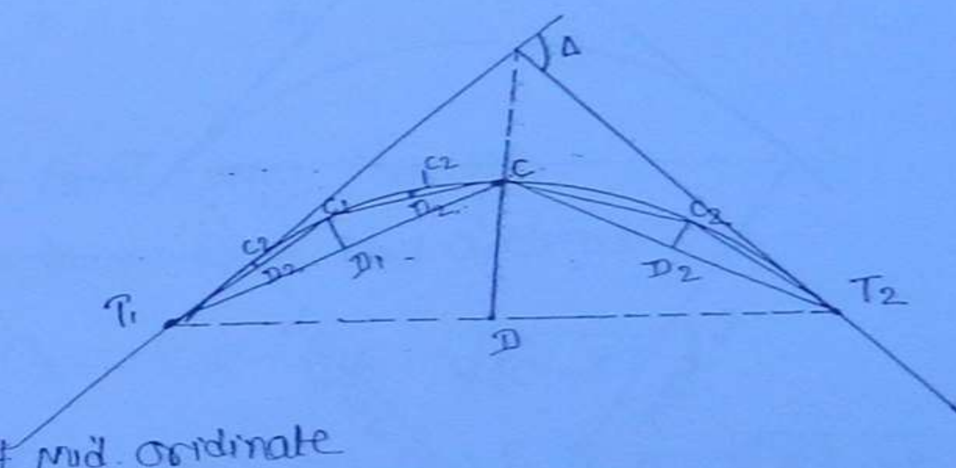
- - - - - -

$$\boxed{\Delta_n = \Delta_{n-1} + \delta_n}$$

(b) Two Theodolite Method :→



☆ By Bisection of chord :→



First Mid ordinate

$$CD = R(1 - \cos \Delta/2)$$

$$C_1 D_1 = R(1 - \cos \Delta/4)$$

$$C_2 D_2 = R(1 - \cos \Delta/8)$$

Problem :→ For a circular curve of Radius 300m, calculate data required to set out a simple curve, if total deflection angle is 75°

use :- ① Perpendicular offset method.

② Radial offset

③ offset from Long chord.

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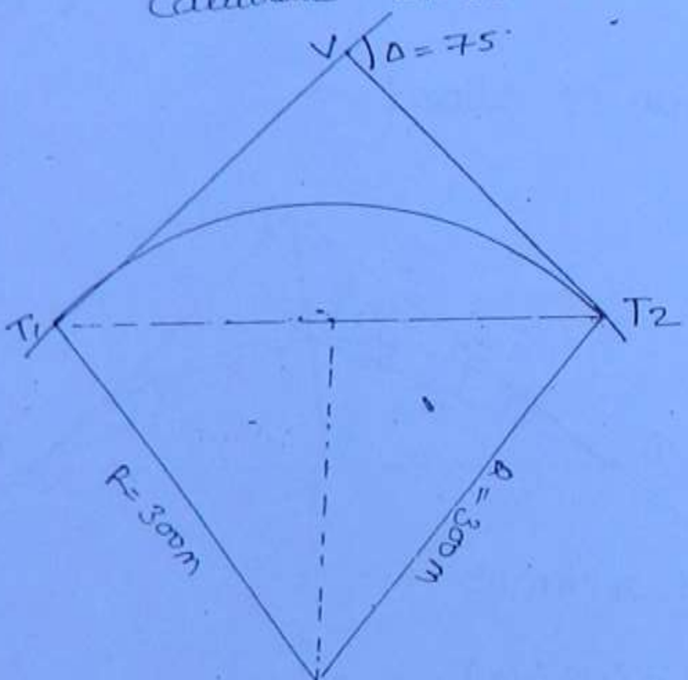
Calculate offset at every 20m distance

Solution:-



$\Rightarrow VT_1 = VT_2 = R \tan \Delta/2$

$= 300 \times \tan \frac{75°}{2}$

$= 230.19 \, m$

① Perpendicular offset

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

$O_x = 300 - \sqrt{300^2 - x^2}$

x	0	20	40	60	80m
O_x	0	0.67	2.68	6.06	

② Radial offset

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

$$O_x = \sqrt{300^2 - x^2} - 300$$ 125

x	0	20	40	60	80 m
Ox	0	0.67 m	2.65 m	5.94 m	10.48 m
using approximate formula	0	0.667 m	2.67	6.60	10.67

③ offset from long chord:→

Distance from mid ordinate = x

$$O_x = CD - (R - \sqrt{R^2 - x^2})$$

$$O_x = R(1 - \cos \Delta/2) - (R - \sqrt{R^2 - x^2})$$

$$O_x = 61.99 - (300 - \sqrt{300^2 - x^2})$$

x	0	20	40	60	80	upto 182
Ox	61.99	61.32	59.01			

$$O_x = \sqrt{300^2 - x^2} - 238.01$$

Problem:→ ES-1998 (5b)

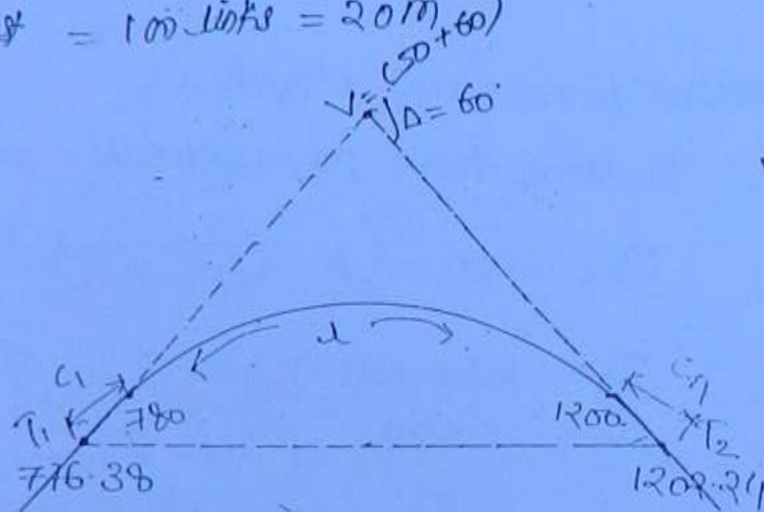
Two tangent intersect at chainage 50·60 (50 chain and 60 links) (126)

deflection angle being 61°, Calculate the necessary data to set out a circular curve of 20 Chain radius to connect the two tangents point by method of offset from chords. Take peg. interval equal to 100 links with length of chain being 20m (100 links)

Solution:→ C = All chord length except 1st and last = 100 links = 20 m

$C_1 = ?$

$C_n = ?$



chainage of point of intersection

$V = 50 + 60$

$V = 50 \text{ chains} + 60 \text{ chains}$

$V = 50 \times 20 + 60 \times 20$

$V = 1012 \text{ m}$, $R = 20 \text{ chains}$

$R = 20 \times 20 = 400 \text{ m}$

Tangent length $VT_1 = VT_2 = R \tan \frac{\Delta}{2}$

$VT_1 = 400 \tan \frac{61°}{2}$

$\Rightarrow \boxed{VT_1 = 235.62\,m}$

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Length of curve

$l = \frac{2\pi R}{360} \times \Delta$

$l = \frac{2\pi \times 400}{360} \times 61$

$\boxed{l = 425.86\,m}$

chainage of T_1 = chainage of V − VT_1

$T_1 = 1012 - 235.62$

$\boxed{T_1 = 776.38\,m}$

chainage of T_2

T_2 = chainage of $T_1 + l$

$T_2 = 776.38 + 425.86$

$\boxed{T_2 = 1202.24\,m}$

Exact multiple of 20 m

after T_1 = 780 m

So first chord $C_1 = 780 - 776.38$

$C_1 = 3.62\,m$

Exact multiple of 20m

before T_2 = 1200 m

So last chord $C_n = 1202.24 - 1200 = 2.24\,m$

All other chord length

$c = 20\ m$

Offsets from chord:

$O x_1 = \frac{c_1^2}{2R} = \frac{3.62^2}{2 \times 400}$ (128)

$O x_1 = \cancel{0.59\ m}$ 0.016 m

$O x_2 = \frac{c\,(c_1 + c)}{2R} = \frac{20\,(3.62 + 20)}{2 \times 400}$

$O x_2 = 0.59\ m$

$O x_3 = O x_4 = \text{---}\ O x_{n-1}$

$= \frac{c^2}{R} = \frac{20^2}{400} = 1\ m$

$O x_n = \frac{c_n\,(c_n + c_{n-1})}{2R}$

$O x_n = \frac{2.24\,(20 + 2.24)}{2 \times 400}$

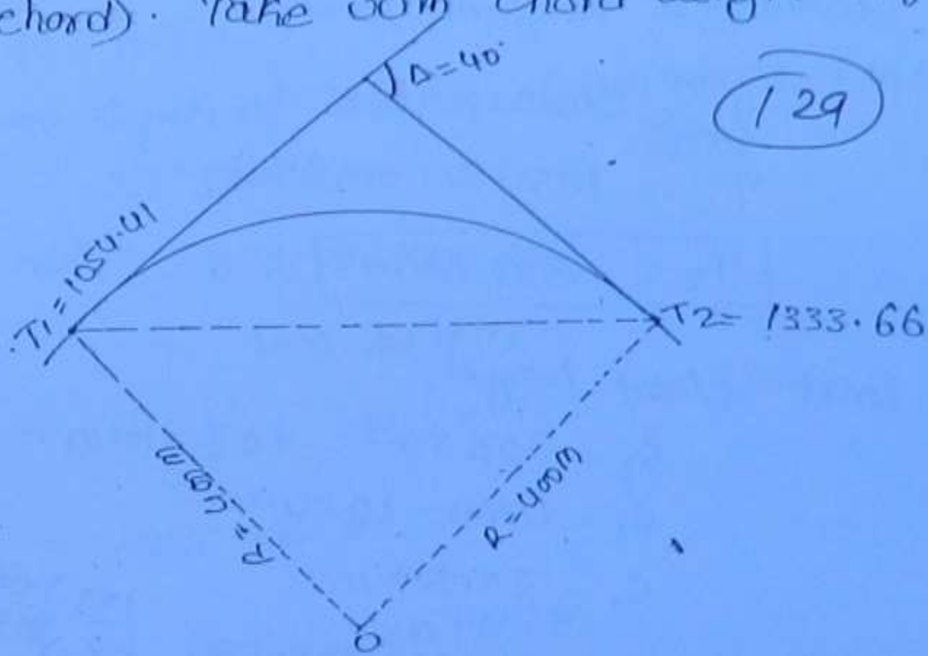
$O x_n = 0.062\ m$

Problem:→ 1990 6(b)

Two Tangents intersect at chainage 1200m, deflection angle = 40°, compute the data for setting out a 400m radius curve by deflection angle and offset (chord). Take 30m chord length in general case.

129

Solution:→



All other chord length

$C = 30m$

$C_1 = ?,\ C_n = ?$

(1) Radius $R = 400m$

$\Delta = 40°$

Tangent length

$VT_1 = VT_2 = R \tan \Delta/2$

$= 400 \times \tan 40/2 = 145.59\ m$

length of curve

$$l = \frac{2\pi R}{360} \times \Delta = \frac{2 \times \pi \times 400}{360} \times 40$$

$\boxed{l = 279.25m}$

chainage of tangent point T_1

T_1 = chainage $V - VT_1$

$T_1 = 1200 - 145.59$

$\boxed{T_1 = 1054.41\ m}$

130

chainage of tangent point T_2

T_2 = Chainage $T_1 + l$

$T_2 = 1054.41 + 279.25$

$\boxed{T_2 = 1333.66\ m}$

First chord length

$C_1 = 30 \times 36 = 1080.00\ m$

$C_1 = 1080 - 1054.41$

$C_1 = 25.59\ m$

$C_n = 1333.66 - 1320 \rightarrow \frac{1333.66}{30}$

$C_n = 13.66\ m$

All other chord length $c = 30\ m$

$\delta_1 = 1718.9 \frac{C_1}{R} = 1718.9 \times \frac{25.59}{400} = 1°49'58''$

$\delta_2 = \delta_3 = \cdots = \delta_{n-1} = 1718.9 \times C/R = 1718.9 \times \frac{30}{400} = 2°8'55''$

$\delta_n = 1718.9 \frac{C_n}{R} = 1718.9 \times \frac{13.66}{400} = 0°58'42''$

Points	δ	Δ
T_1	1°49'58''	1°49'58''
1	2°8'55''	3°58'53''
2	2°8'55''	6°7'48''
3	2°8'55''	
4	2°8'55''	

Last 0°58'42'' 20

[redacted]

PCC

Problem → Solve last one

Solution: → Loss of prestress = 20%. (131)

$$K = 1 - \frac{20}{100}$$

$$K = 0.80$$

Assume depth of slab (considered 1 m width of slab)

$$D = 500 \, mm$$

⇒ Self wt $= 0.50 \times 1 \times 1 \times 25$

$= 12.5 \, kN/m$

$$M_d = \frac{w_d l^2}{8} = \frac{12.5 \times 12^2}{8}$$

$$M_d = 225 \, kN\text{-}m$$

⇒ Live load $w_l = 20 \, kN/m$

$$M_l = \frac{20 \times 12^2}{8}$$

$$M_l = 360 \, kN\text{-}m$$

(1) Section modulus req.

$$Z = \frac{(1-K) M_d + M_l}{F_c}$$

$$Z = \frac{(1 - 0.80) \times 225 \times 10^6 + 360 \times 10^6}{19}$$

$$Z = 20928571.4 \, mm^3$$

Depth required

$$D = \sqrt{\frac{6 \times 20928571.4}{b}} = 416.62$$

Provide 420 mm

Self wt = $0.42 \times 1 \times 1 \times 25$

$= 10.5$ kN/m

$$Md = \frac{10.5 \times 12^2}{8}$$

$Md = 189$ kN-m

132

(2) Prestressing force

$$P = \frac{A \cdot f_c}{2K} = \frac{1000 \times 420 \times 14}{2 \times 0.80}$$

$P = 3675$ kN

No. of cable $\frac{3675}{225} = 16.33 \simeq 17$ nos

(3) Eccentricity

$$e = \frac{(1+K)\,Md + ml}{2PK}$$

$$e = \frac{(1+.80)\,189 \times 10^6 + 360 \times 10^6}{2 \times 0.80 \times 3675 \times 10^3}$$

$e = 119$ mm

ES- 2007

Problem:→ A post tensimed prestressed concrete beam of rectangular section 240 mm wide, is to be designe for 25 kN/m live load u.d.l over an eff. span of 12 m. The stress in concrete ⊁

17 mpa in compression

1.4 mpa in Tension

Considerd loss of prestress = 15%.

133

(1) calculated minimum possible depth of beam.

(2) calculated P and e.

Solution:→ Assume depth of beam.

$D = 800 \text{ mm}$

Self wt:

$w_d = 0.8 \times 0.24 \times 1 \times 25$

$w_d = 4.8 \text{ kN/m}$

$m_d = \dfrac{w_d l^2}{8}$

$m_d = \dfrac{4.8 \times 12^2}{8} = 86.4 \text{ kN-m}$

$m_l = \dfrac{m_l l^2}{8} = \dfrac{25 \times 12^2}{8}$

$m_l = 450 \text{ kN.m}$

Section modulus required

$$z = \frac{(1-K)\,m_d + m_l}{(K f_c - f_t)}$$

$$z = \frac{(1-0.85)\,86.4 + 450 \times 10^6}{K\ 0.85 \times 17 - (-1.4)}$$

$z = 29208052.8$

Depth required

$$D = \sqrt{\frac{6Z}{B}}$$

$$D = \sqrt{\frac{6 \times 29209032.8}{B}}$$

134

$$D = 859.50 mm$$

Considerd $D = 900 mm$

$$wd = 0.24 \times 0.90 \times 25$$

$$wd = 5.4$$

$$Md = 5.4 \times \frac{12^2}{8}$$

$$Md = 97.2$$

$$Z = \frac{0.15 \times 97.2 \times 10^6 + 450 \times 10^6}{(0.85 \times 17 + 1.4)}$$

$$Z = 29311041 \ mm^3$$

Depth required

$$D = \sqrt{\frac{6Z}{B}}$$

$$D = 856.00 mm$$

Take minimum possible depth = 860 mm

$$wd = 0.24 \times 0.86 \times 25$$

$$wd = 5.16$$

$$Md = 5.16 \times 12^2 / 8$$

$$Md = 92.88 \ kN-m$$

(2) Prestressing Force P/e

$$F_{sup} = \left(F_t - \frac{M_d}{Z}\right)$$

$$F_{sup} = \left(-1.4 - \frac{92.88 \times 10^6 \times 6}{240 \times 860^2}\right)$$

$$F_{sup} = -4.56 \ N/mm^2$$

135

$$F_{inf} = \frac{F_t}{K} + \frac{M_d + M_L}{KZ}$$

$$F_{inf} = \frac{-1.4}{0.85} + \frac{(92.88 + 450) \times 10^6 \times 6}{0.85 \times 240 \times 860^2}$$

$$F_{inf} = 19.94 \ N/mm^2$$

Prestressing force

$$P = \frac{A(F_{inf} + F_{sup})}{2}$$

$$P = \frac{240 \times 860(-4.56 + 19.94)}{2}$$

$$P = 1587 \ kN$$

eccentricity :→

$$e = \frac{Z(F_{inf} - F_{sup})}{A(F_{sup} + F_{inf})}$$

$$e = \frac{240 \times 860^2}{6 \times 240 \times 860} \left(\frac{19.94 - (-4.56)}{19.94 + (-4.56)}\right)$$

$$\underline{e = 228 mm}$$

work Book
chaper - 7

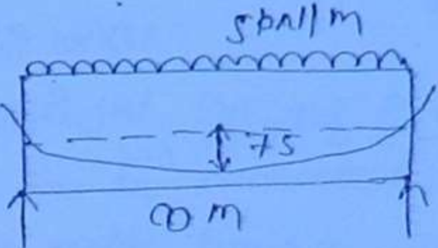
que (1) - b
que (2) a
que (3) a
que (4) d
que (5) c
que (6) c
que (7) b
que (8) c
que (9) b
que (10) a
que (11) c -
que (12) ~~b~~ d
que (13) c
que (14) d
que (15) a
que (16) b
que (17) b
que (18) a
que (19) b
que (20) c

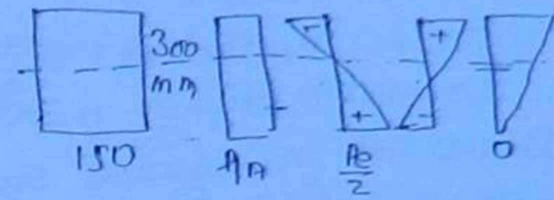
(136)

que (21) b
que (22) c
que (23) c
que (24)
que (25)
que (26)
que (27)
que (28)
que (29)
que (30)
que (31)
que (32)
que (33)
que (34)
que (35)
que (36)
que (37)
que (38)
que (39)
que (40)

Que (4)

(137)





Dead load = $0.15 \times 0.30 \times 1 \times 24$
$= 1.125$ kN
Live load 5 kN
6.125 kN

$M = \frac{wl^2}{8} = \frac{6.125 \times 8^2}{8}$
$= 49$ kN

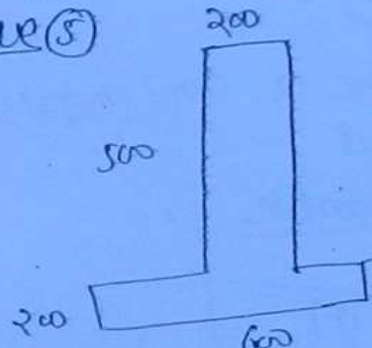
$\frac{P}{A} + \frac{Pe}{Z} - \frac{M}{Z} = 0$

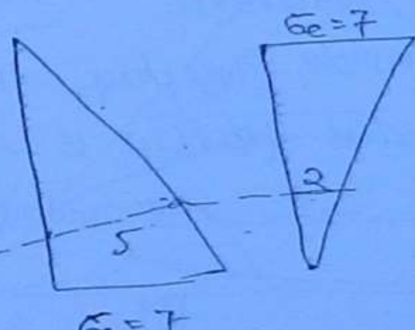
$P\left(\frac{1}{A} + \frac{e}{Z}\right) = \frac{M}{Z} = P\left(\frac{Z + e}{AZ}\right) = \frac{M}{Z}$

$P = \frac{AM}{Z + Ae} = \frac{150 \times 300 \times 49 \times 10^6}{150 \times \frac{300^2}{6} + 150 \times 300 \times 75}$

$P = 392$ kN

Que (5)





$P = 200 \times 500 \times \frac{5}{2} +$
$200 \times 600 + \left(\frac{5+7}{2}\right)$

$P = 970$ kN

$P = 200 \times 500 \times \left(\frac{2+7}{2}\right) + 200 \times 600 \times \frac{2}{2}$

$P = 570$ kN

Que (6) 40 mm
5 mm plus max size of aggregate

Que (7) $V_D = 0.67\, BD \times \sqrt{f_t^2 + 0.8 f_{cp} \cdot f_t} + V_p$

$f_t = 0.24\sqrt{f_{ck}} = 0.24\sqrt{45} = 1.61$

$f_{cp} = \frac{P}{BD} = \frac{200 \times 10^3}{150 \times 300} = 4.44$

$V_p = 200 \sin\theta = 200 \times \frac{75 \times 4}{8000}$

$200 \times \frac{4 \times 47}{x} = 7.5$ kN

$V_D = 0.67 \times 150 \times 300 \sqrt{(1.61)^2 + 0.8 \times 4.44 \times 1.61} + 7.5$

$V_D = 94.40$ kN

Que (12) final $P = 500 kN$

Losses = 15%.

$0.85 P_0 = P$

$P_0 = P/0.85$

Initial $P_0 = \frac{500}{0.85} = 588.24 kN$

$e = 75$

$\Rightarrow \frac{P}{A} \mp \frac{Pe}{Z} \Rightarrow \frac{588.24 \times 10^3}{250 \times 300} \mp \frac{588.24 \times 10^3 \times 75}{250 \times 300^2}$

$\Rightarrow 7.84 \mp 11.76$

Top = -3.92

bottom = $19.60 N/mm^2$

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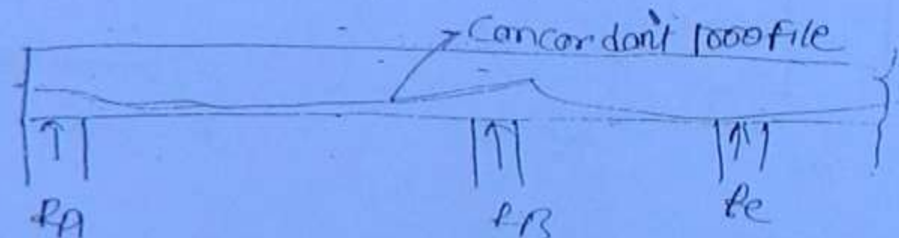
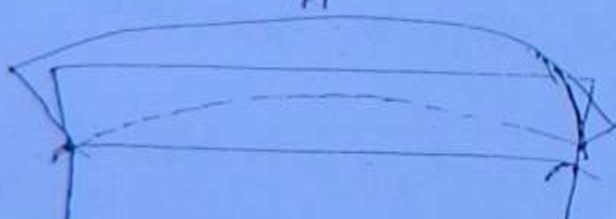
Que (13) (C) load balancing concept is applied only for determinate structure

for indeterminate structure like a continuous beam, concordant profile is used



continuous beam

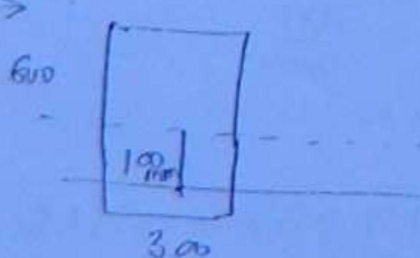


If in is case prestress cable is provided to this B.M.D

→ Concordant profile is a particular shape of cable used

for an indeterminate structure like continuous beam such that support reaction does not changes. This will reduced the calculation of BM at different stage

Que (14) :->

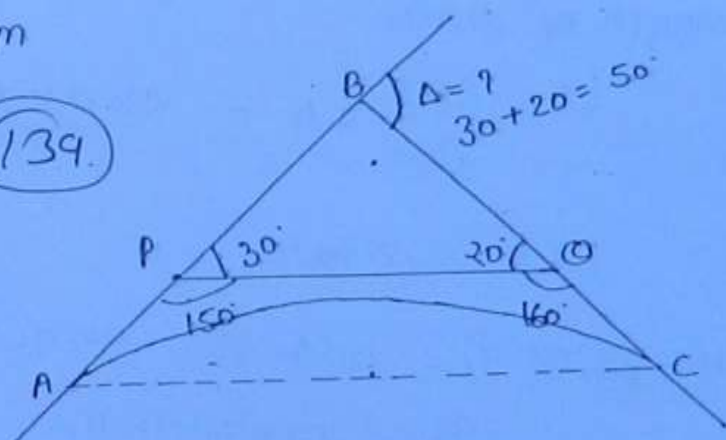


$P = 1000 kN$

Survey:→ ⑤6- ES- 1991

Problem:→ Two Straight AB and BC meet in an in accessible point B, and to be connected by a simple curve of R = 600m. Two points P and Q were selected on AB and BC such that ∠APQ = 150', ∠CPQ = 160' than PQ = 150m make necessary calculation to set out curve by deflection angle method. Chainage of P = 1600 m. Take chord length = 30 m

Solution:→ (139)



In Tangent BPQ

Apply Sin formula

$$\Rightarrow \frac{150}{\sin 130} = \frac{BP}{\sin 20}$$

$$\Rightarrow BP = \frac{\sin 20}{\sin 30} \times 150$$

$$\Rightarrow BP = 66.97 \text{ m}$$

Chainage of B = 1600 + 66.97

= 1666.97 m

$R = 600\ m$

$\Delta = 50^\circ$

140

(1) Tangent length

$VT_1 = R \tan \Delta/2 = 600 \times \tan \frac{50}{2}$

$VT_1 = 279.78\ m$

length of curve

$l = \frac{2\pi R}{360} \times \Delta = \frac{2 \times \pi \times 600}{360} \times 50$

$l = 523.60\ m$

chainage of $T_1 = 1666.97 - 279.78$

$T_1 = 1387.19\ m$

chainage of $T_2 = 1387.19 + 523.60$

$T_2 = 1910.79\ m$

First chord length

$c_1 = 1410 - 1387.19\ m$

$\boxed{c_1 = 22.81\ m}$

$c_n = 1910.79 - 1890$

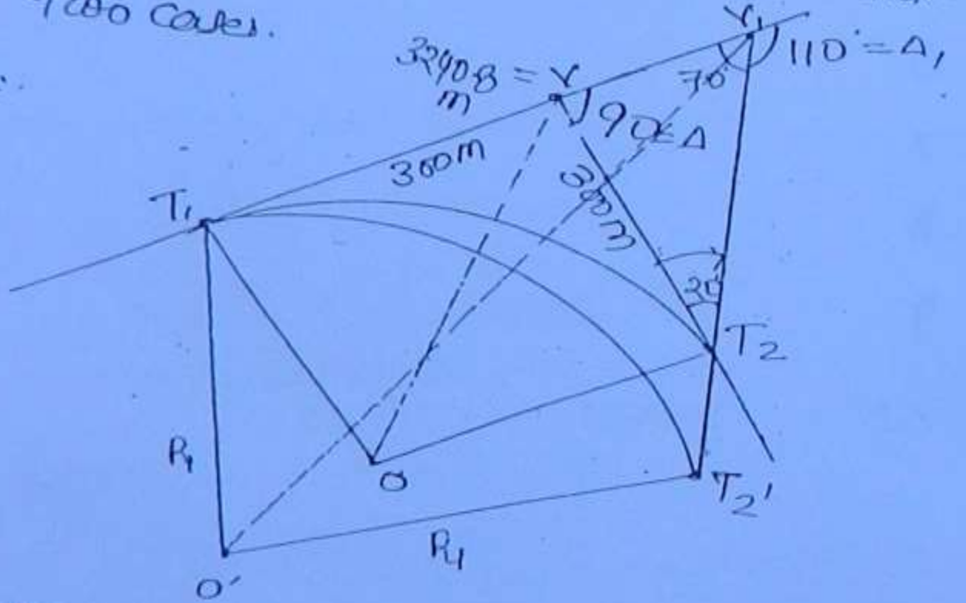
$c_n = 20.79\ m$

Points	C	$\delta \rightarrow 1718.87 \times \frac{c}{R}$	Δ
T_1	0	0	0
1 →	22.81	1° 5' 29"	1° 5' 21"
2	30	1° 25' 57"	2° 31' 18"
3	30	1° 25' 257"	
4	30		
5	30		
6			
7			
8			
9			
22	20.79	0° 59' 34"	25°

Problem:- Two Tangents of a circular curve of 300m have a deflection angle 90°. If change the position of forward tangent it through 20°, such that deflection 110° (forward tangent it is rotated of tangency). Calculated the radius of
(1) Point of curve is not changed.
(2) Point of tangency is not changed
If chainage of original P
Calculated chainage of important poi
two cases.

(142)

Solution:



$R = 300m$

$\Delta = 90°$

Tangent length $VT_1 = VT_2 = 300 \tan \frac{90}{2}$

$= 300m$

Case (1) If point of curve is not changed.

The New point of intersection is

IN Triangle VV_1T_2

Apply sin

$$\Rightarrow \frac{VV_1}{VT_2} = \tan 20^\circ$$

T43

$$\Rightarrow VV_1 = VT_2 \tan 20^\circ$$

$$\Rightarrow VV_1 = 300 \tan 20^\circ$$

$$\Rightarrow VV_1 = 109.19 m$$

$$\frac{V T_2}{V_1 T_2} = \cos 20^\circ$$

$$\Rightarrow V_1 T_2 = \frac{VT_2}{\cos 20}$$

$$\Rightarrow V_1 T_2 = \frac{300}{\cos 20^\circ}$$

$$\Rightarrow V_1 T_2 = 319.25 m$$

New Tangent length

$$V_1T_1 = VT_1 + VV_1 = 300 + 109.19$$

$$V_1T_1 = 409.19 m$$

$$V_1T_1 = V_1T_2$$

$$R_1 \tan\frac{\Delta_1}{2} = 409.19$$

$$\Rightarrow R_1 = \frac{409.19}{\tan\frac{110}{2}}$$

$$\Rightarrow \boxed{R_1 = 286.51 m}$$

Chainage of $T_1 = 3240.8 - 300$

$= 2940.8\,m$

Chainage of $V_1 = 3240.8 + 109.19$

144

$= \cancel{3240}\ 3349.99\,m$

length of curve $= \frac{2\pi R_1}{360} \times D_1$

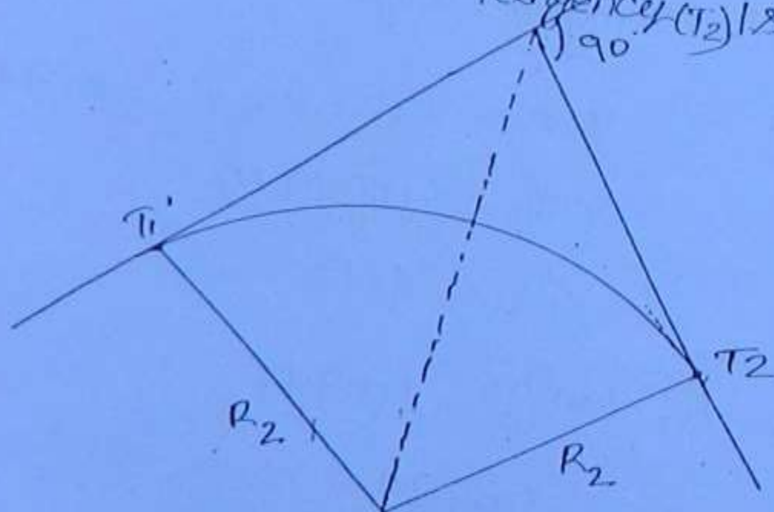
$= \frac{2\times\pi\times 286.51}{360} \times 110$

$= 550.06\,m$

Chainage of $T_2 = 2940.80 + 550.06\,m$

$= 3490.86\,m$

Case (2) If point of ~~A~~ Tangency (T_2) is not chang



V_1 = New point of intersection

So New Tangent length $= V_1T_2$

$V_1T_2 = 319.25$

$V_1T_2 = V_1T_1'$

$R_2 \tan \frac{\Delta_1}{2} = 319.25$

$R_2 = \dfrac{319.25}{\tan 110/2}$ 145

$R_2 = 223.54\,m$

chainage of T_1' = chainage of V_1 - V_1T_1'

$= 3349.99 - 319.25$

$= 3030.74\,m$

length of curve $l = \dfrac{2\pi R_2}{360} \times \Delta_1$

$= \dfrac{2 \times \pi \times 223.54}{360} \times 110$

$= 429.16\,m$

chainage of $T_2 = 3030.74 + 429.16$

$= 3459.90\,m$

☆ Compound Curve :→

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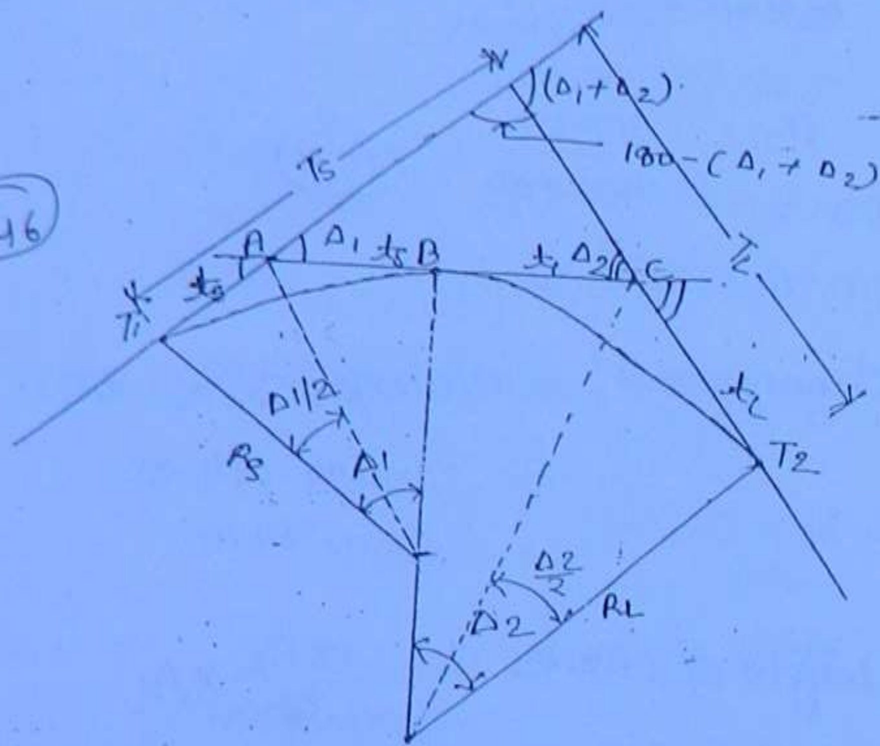


Components

① R_s ② R_L ③ t_s ④ t_L ⑤ T_s ⑥ T_L ⑦ Δ_1 ⑧ Δ_2 ⑨ $\Delta = (\Delta_1+\Delta_2)$

case① Given values are

① Δ_1 ② Δ_2 ③ R_s ④ R_L

Find out ① t_s ② t_2 ③ t_s ④ T_L

Solution :→ $t_s = R_s \tan \frac{\Delta 1}{2}$

$t_L = R_L \tan \Delta 2/2$

Value of AC = Common tangent = $t_s + t_L$

$= R_s \tan \frac{\Delta 1}{2} + R_L \tan \frac{\Delta_2}{2}$

In triangle VAC, Apply Sine formula

$$\Rightarrow \frac{VA}{\sin\Delta_2} = \frac{Vc}{\sin\Delta_1} = \frac{AC}{\sin(180-\Delta)} = \frac{(t_s+t_L)}{\sin\Delta}$$

$$\Rightarrow V_A = \frac{\sin\Delta_2}{\sin\Delta}(t_s+t_L)$$ 147

$$\Rightarrow V_C = \frac{\sin\Delta_1}{\sin\Delta}(t_s+t_L)$$

Total tangent length

$$\left.\begin{aligned} T_s &= t_s + (t_s+t_L)\frac{\sin\Delta_2}{\sin\Delta} \\ T_L &= t_L + (t_s+t_L)\frac{\sin\Delta_1}{\sin\Delta} \end{aligned}\right\} - (A)$$

Problem:→ The following data refer to a compound curve

Total deflection angle = 93°

degree of first curve = 4°

degree of second curve = 5°

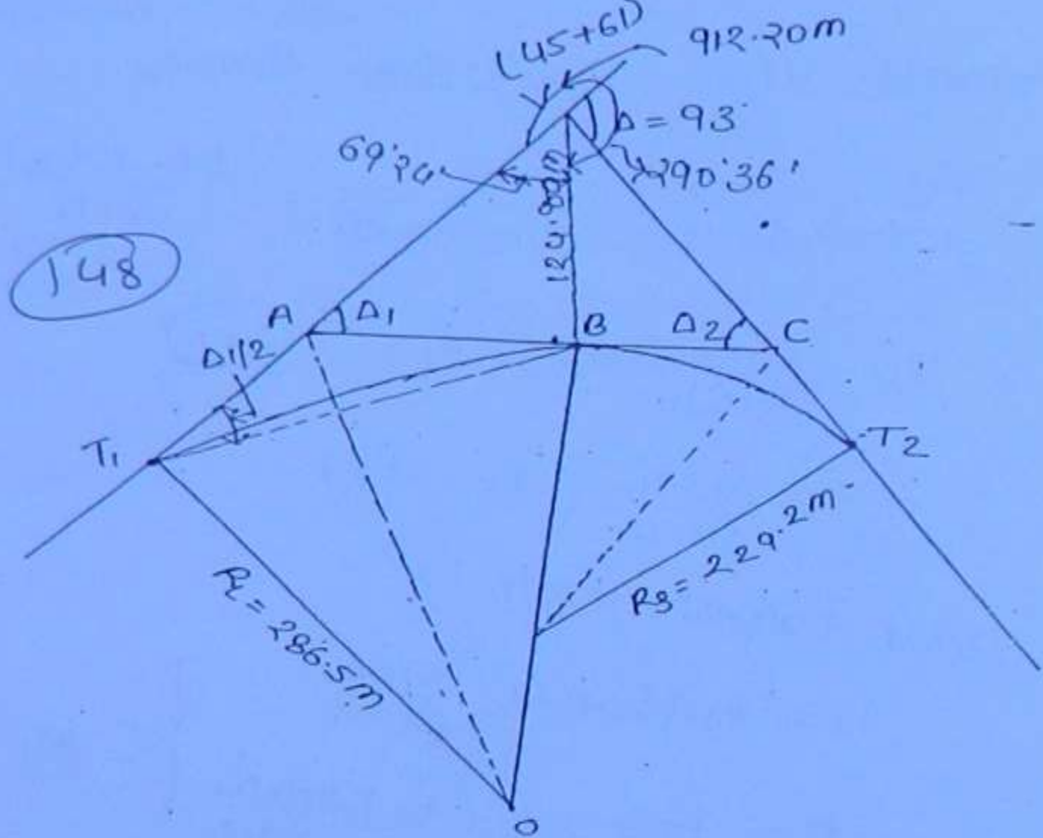
point of intersection = (45+61)

(20m chain used)

Determine the running distance to tangent point and point of compound curve, given that the latter point is (6+24) from point of intersection at back angle of 290°36 from first tangent.

Solution:→ $R_1 = \frac{1146}{40} = 286.5m = R_L$

$R_2 = \frac{1146}{50} = 229.2\,m = R_S$



chainage of P.C. $= 45 \times 20 + 61 \times 0.20$

$= 912.20\,m$

$VB = (6+24)$

$= 6 \times 20 + 24 \times 0.20$

$= 124.80\,m$

$\angle AVB = 360 - 290°36'$

$\angle AVB = 69°24'$

$AB = 286.50 \tan \frac{\Delta_1}{2}$

Apply Sin Formula

$$\Rightarrow \frac{AB}{\sin 69°24'} = \frac{124.80}{\sin \Delta_1}$$

$$\Rightarrow \frac{286.50 \sin \Delta_1/2}{\sin 69^\circ 24' \cos \Delta_1/2} = \frac{124.80}{\sin \Delta_1}$$

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$$\Rightarrow \frac{286.50 \sin \Delta_1/2}{\sin 69^\circ 24' \cancel{\cos \Delta_1/2}} = \frac{124.80}{2 \sin \frac{\Delta_1}{2} \cancel{\cos \Delta_1/2}}$$

$$\Rightarrow \sin^2 \Delta_1/2 = \frac{124.8}{2} \times \frac{\sin 69^\circ 24'}{286.50}$$

$$\Delta_1 = 53^\circ 40' 59.25''$$

$$\Delta_2 = 93^\circ - \Delta_1$$

$$\Delta_2 = 93^\circ - 53^\circ 41'$$

$$\Delta_2 = 39^\circ 19'$$

$$T_S = t_S + (t_S + t_L)$$

$$t_L = R_C \tan \frac{\Delta_1}{2}$$

$$\Rightarrow t_L = 286.50 \times \tan \frac{53^\circ 41'}{2}$$

$$\Rightarrow \boxed{t_L = 144.98 m}$$

$$t_S = 229.20 \times \tan \frac{39^\circ 19'}{2}$$

$$\boxed{t_S = 81.88 m}$$

$$\Rightarrow t_L + t_S = 226.85 m$$

$$T_L = t_L + (t_S + t_L) \frac{\sin \Delta_2}{\sin \Delta}$$

$$T_L = 144.98 + 226.86 \times \frac{\sin 39^\circ 19'}{\sin 93^\circ}$$

$T_L = 288.92\ m$

$$T_S = 91.88 + 226.86 \times \frac{\sin 53°41'}{\sin 93°}$$

$T_S = 264.92\ m$

150

length of curve

$$\Rightarrow l_1 = \frac{2\pi R_L}{360} \times \Delta_1 = \frac{2\pi \times 286.50}{360} \times 53°41'$$

$$\boxed{l_1 = 268.44\ m}$$

$$\Rightarrow l_2 = \frac{2\pi R_S}{360} \times \Delta_2 = \frac{2\pi \times 229.20 \times 39°19'}{360}$$

$\Rightarrow l_2 = 157.28\ m$

chainage $V = 912.20$

$\Rightarrow -(T_L) = (-) 288.92$

chainage $T_1 = 623.28$

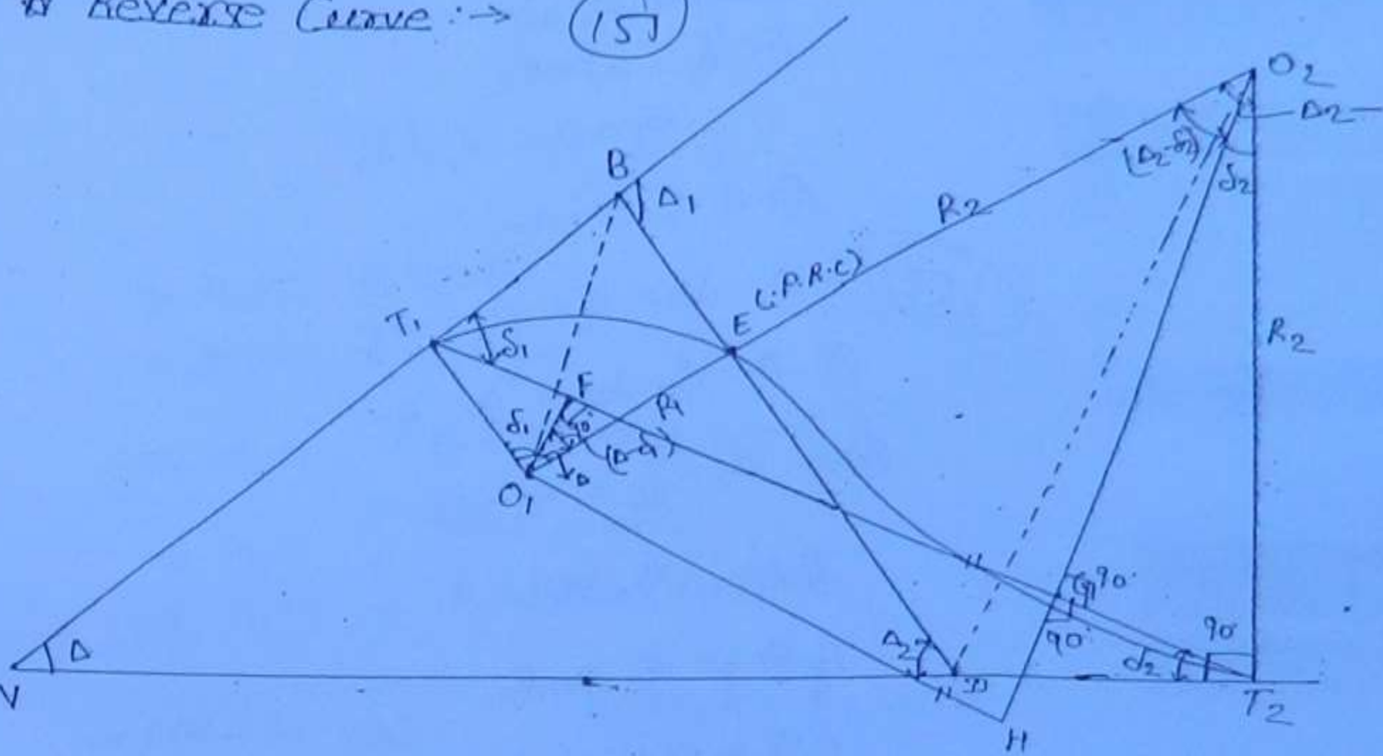
$+ l_1 = + 268.44$

chainage (B) 891.72

$+ l_2 = 157.28$

chainage (C) $1049\ m$

☆ Reverse Curve :→ (151)



R_1 = first radius $\qquad$ $(FG \parallel O_1H)$

R_2 = Second radius

E = point of Reverse curve

V = Point of intersection.

Line O_1H is parallel to T_1T_2

$O_1F \perp T_1T_2$

$O_2H \perp T_1T_2$

$\angle T_1O_1F = \delta_1$

$\angle T_2O_2G = \delta_2$

$\angle EO_1F = \Delta_1 - \delta_1$

$\angle EO_2F = \Delta_2 - \delta_2$

Relation: →

(1) $\delta_1 = \Delta + \delta_2$

So $\Delta = \delta_1 - \delta_2$

(2) $\Delta_1 = \Delta + \Delta_2$

152

So $= \Delta = \Delta_1 - \Delta_2$

(3) $\Delta = \delta_1 - \delta_2 = \Delta_1 - \Delta_2$

(4) ⇒ $\Delta_2 - \delta_2 = \Delta_1 - \delta_1$.

$T_1F = R_1 \sin\delta_1$

$T_2G = R_2 \sin\delta_2$

$FG = O_1H = O_1O_2 \sin(\Delta_2 - \delta_2)$

$FG = (R_1 + R_2)\sin(\Delta_2 - \delta_2)$

Total length

$\Rightarrow T_1T_2 = l = T_1F + FG + T_2G$

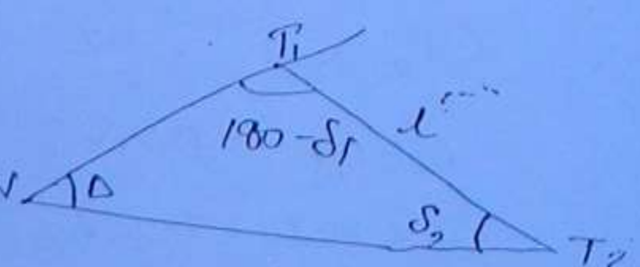
$\Rightarrow T_1T_2 = R_1\sin\delta_1 + R_2\sin\delta_2 + (R_1+R_2)\sin(\Delta_2-\delta_2)$

$\Rightarrow l = R_1\sin\delta_1 + R_2\sin\delta_2 + (R_1+R_2)\sin(\Delta_1$

Tangent length :→

Apply Sine formula

$$\Rightarrow \frac{VT_1}{\sin\delta_2} = \frac{VT_2}{\sin(180-\delta_1)} = \frac{T_1T_2}{\sin\Delta}$$



$$VT_1 = \frac{\sin \delta_2}{\sin \Delta} \cdot l$$

$$VT_2 = \frac{\sin \delta_1}{\sin \Delta} l$$

153.

$\Rightarrow O_1F = R_1 \cos \delta_1$

$\Rightarrow O_2G = R_2 \cos \delta_2$

$\Rightarrow O_2H = (R_1 + R_2) \cos(\Delta_2 - \delta_2)$

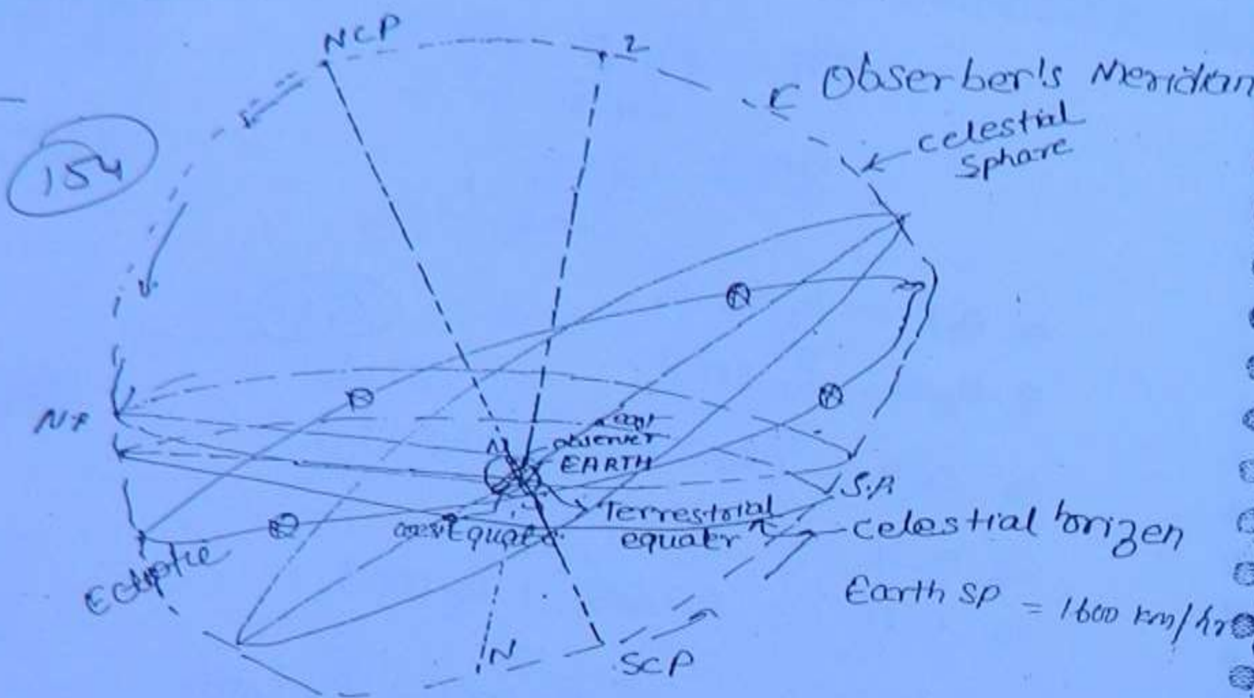
$\Rightarrow O_2H = O_1F + O_2G$

$\Rightarrow O_2H = R_1 \cos \delta_1 + R_2 \cos \delta_2$

$$\Rightarrow \cos(\Delta_2 - \delta_2) = \frac{R_1 \cos \delta_1 + R_2 \cos \delta_2}{(R_1 + R_2)}$$

$$\Rightarrow \boxed{\cos(\Delta_2 - \delta_2) = \cos(\Delta_1 - \delta_1)}$$

* ASTRONOMY :->



① The celestial sphare :-> The imaginary sphare on which all heavenly bodies like stars, sun, moon, plates etc. appear to us is called celestial sphare.

② Zenith :-> The point on celestial sphare exactly above the observer (apposite to centre of earth) is called zenith point.

③ Nadir point :-> point on celestial sphare exactly below the observer position is called Nadir point.

④ zenith, Nadir line :-> Line joining zenith and Nadir point.

⑤ Poles (on celestial sphare) :- If NP/SP of earth is extended to celestial sphare, we get two point called poles

(1) NCP - North celestial pole.
(2) SCP - South Celestial pole.

(6) Celastrial horigen :-> The great circle (that is passing centre as cente of earth) perpendicula to zenith Nadir line is called celestial horgen.

(155)

(7) Sensible horigen :-> It is a circle having centre a obserber's position. this circle is are parallel perpendicular to zenith Nadir line. this cirle is parallel to celestial horign at R distance (R = radius of earth.)

(8) Terrestrial Equator :-> Equator on earth surface.

(9) Celestial Equator :-> Equator extended on celestial sp (great circle) is called celestial equator. It is perpenduoler to Nort and South pole. than it is not change.

(10) Vertical circle :-> All those great circles passing through zenith and nadir point are called verticle circle.

(11) Obserber's meridian :-> The great (vertical) circle, that is pasing through north/Sou pole is called oberseberss meridian

(12) Prime. Vertical :-> The great circle (vertical) passing through zenith/Nadir points and perpen-calar, to obserber's meridians is called prime Vertical.

(13) North and South points :-> Junction of obserber's meridian with celestial horgon are north/ South point.

(14) East / west point :→ Junction of prime vertical with celestial horizon are earth / west points.

(15) Ecliptic :→ The great circle of celestial sphere, on which the Sun appears to lie in its movement in one year is called ecliptic w.r.to earth as centre.

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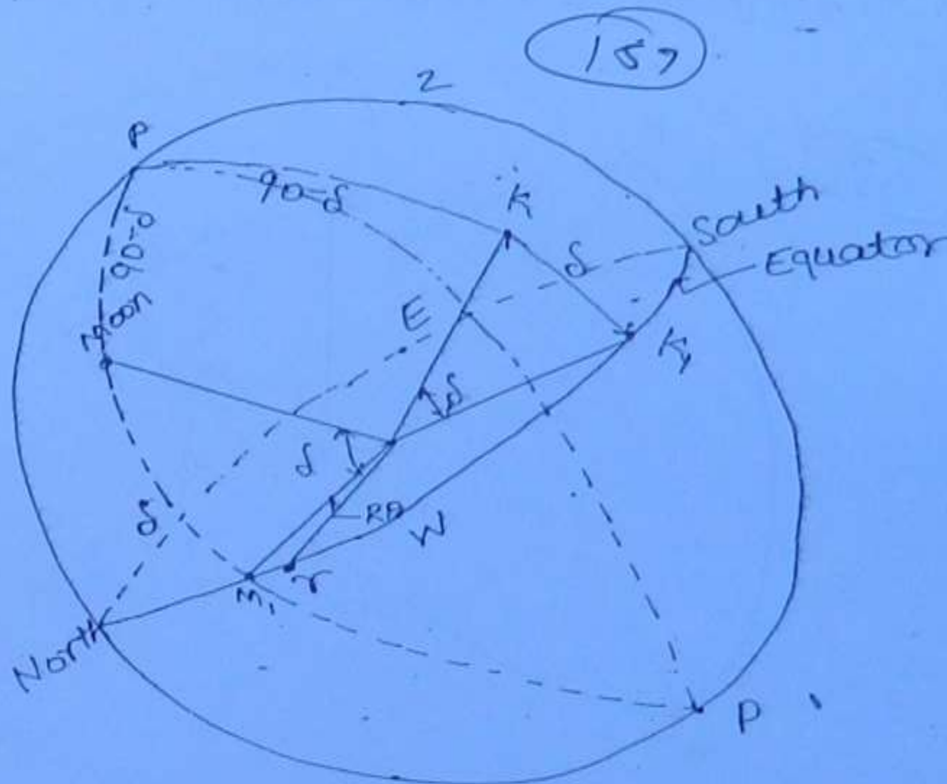
(16) First point of Aries / First point of Libra :→

(Vernal equinox) (Autumnal Equinox)

(2) Indepentent Equatorial System :→
(Declination and Right Ascension System) :→



Two point of reference
(1) Pole.
(2) Equator.
Angle are measure with respect to
(1) Equator.
(2) First point of aries
(1) Declination :→ Angle above or below equator, along declination circle is called declination
(2) Right Ascension :→ Angle mesured along equator, from first point of Aries towards east.

(2) Co-declination Angle from pole to star = 90-δ

(3) Dependent equitorial System :->
(Declination and hour angle)

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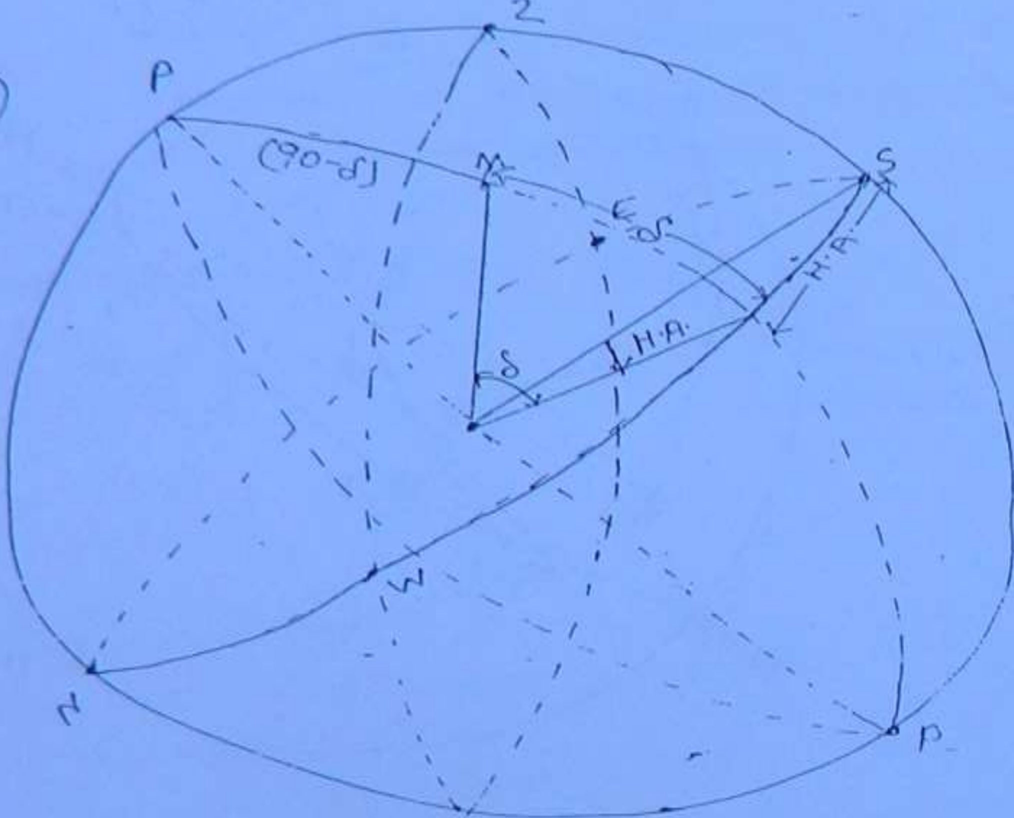

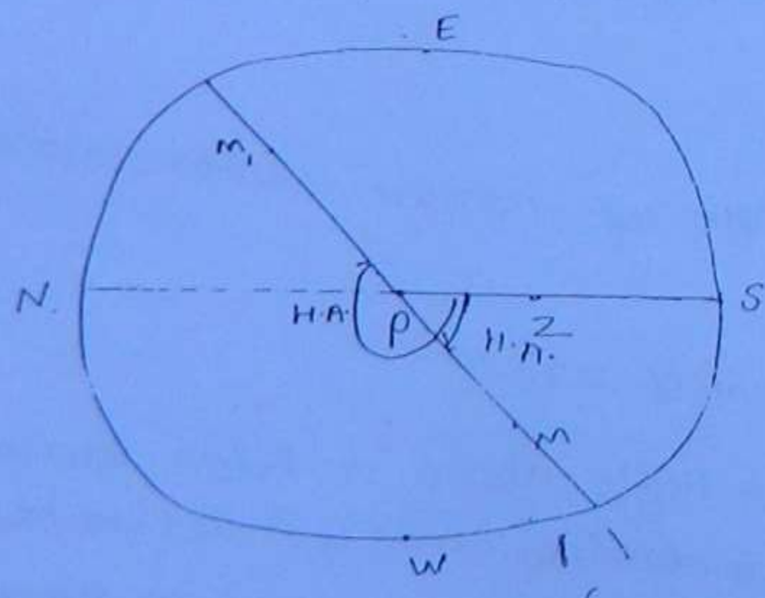

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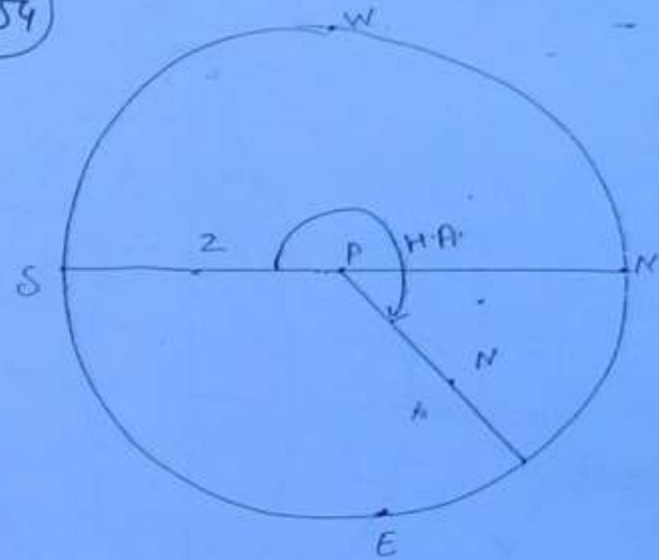


Two point of reference :-

(1) pole

(2) South point

Two planes :-

(1) Equator

(2) Observer's meridian(point for South)

Angle measured :-

(1) declination - Same as above.

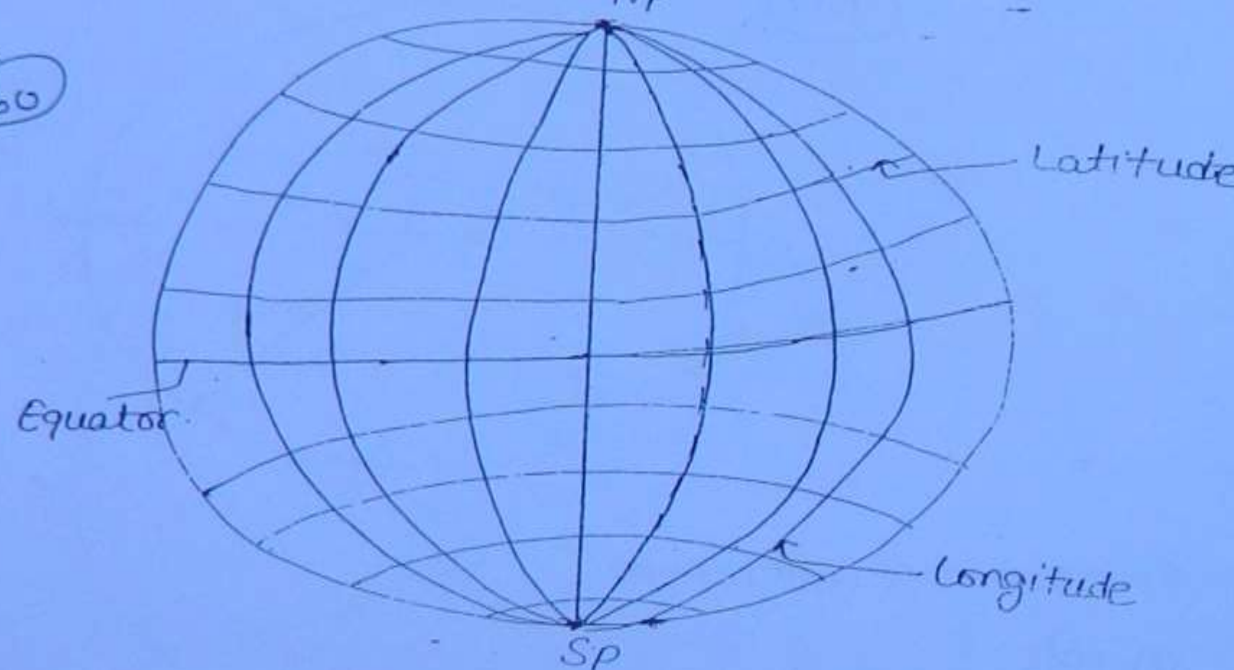
(2) Hour Angle :-> Measured along equator from South going forward west.

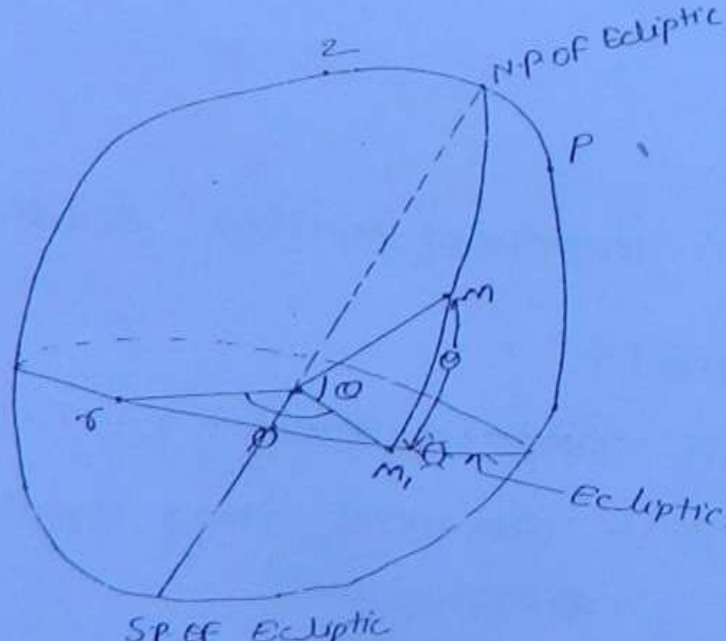
(3) Co-declination :-> $(90-\delta)$ Same as above

(4) Celestial Latitude and Longitude System:

Terrestrial Latitude and Longitude

(160)





Two point of reference

(1) N.P. of ecliptic

(2) First point of Aries

Two planes :-

(161)

① Ecliptic

② plane, passing through first point of Aries.

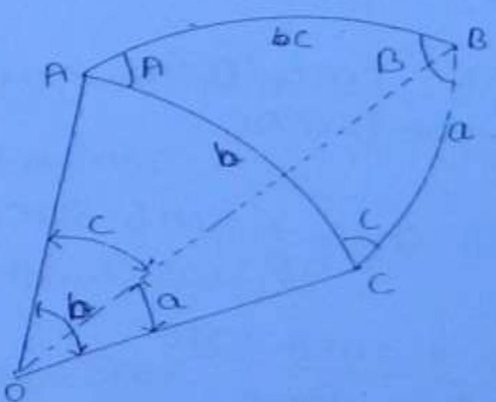
Two angles :-

① Celestial latitude :- Angle above or below Ecliptic

② Celestial longitude :→ Angle measured along ecliptic starting from First point of Aries.

As per this System latitude of Sun is always zero.

☆ Spherical Triangle :→



Angles :→ Angle b/w two planes

Sides :→ Angle b/w any two edge formed at centre of Sphere.

Properties :→

① Any angle is less than 2×90 (π)
<180.

② 180 ≤ A+B+C ≤ 540

(3) Sum of any two side > third side

(162)

$a+b > c$

$a+c > b$

$b+c > a$

(4) If sum of any two side = 180°, sum of opposite two angle = 180°.
If $a+b = 180°$, $A+B = 180°$

(5) The smaller angle is opposite the smaller side.

Formula :→

(1) $\frac{\sin a}{\sin A} = \frac{\sin b}{\sin B} = \frac{\sin c}{\sin C}$

(2) $\cos A = \frac{\cos a - \cos b \cdot \cos c}{\sin b \cdot \sin c}$

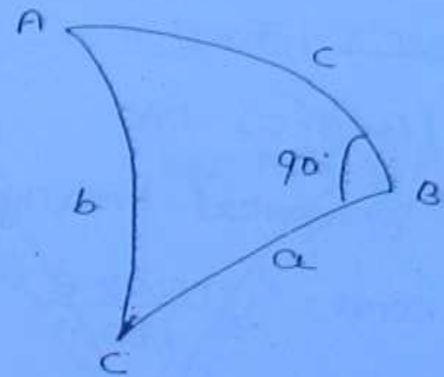
$\cos a = \cos b \cdot \cos c + \sin b \cdot \sin c \cdot \cos A$

(3) $\cos a = \frac{\cos A + \cos B \cdot \cos C}{\sin B \cdot \sin C}$

$\cos A = -\cos B \cdot \cos C + \sin B \cdot \sin C \cdot \cos a$

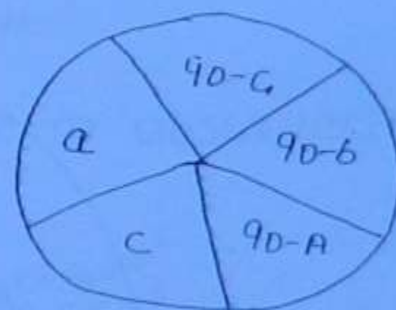
Napier's Rule :→ This is for a right angle spherical triangle.

If any one angle = 90° (A, B, or C)
(not side)



$a,\ C,\ b,\ A,\ c$

$a \rightarrow a$, $C \rightarrow (90-C)$, $b \rightarrow (90-b)$, $A \rightarrow (90-A)$, $c \rightarrow c$



(1) $\sin c = \tan(90-A)\tan a$

$= \cot A \tan a$

(2) $\sin c = \cos(90-b)\cos(90^\circ-c)$

$= \sec b \cdot \sec c$

$\sin(\text{middle}) = \tan(\text{adjacent}_1) \times \tan(\text{adjacent}_2)$

$\sin(\text{middle}) = \cos(\text{opp.}_1) \times \cos(\text{opp.}_2)$

(3) $\sin(90-b) = \tan(90-C)\tan(90-A)$

$\cos b = \cot C \cdot \cot A$

(4) $\sin(90-b) = \cos a \cdot \cos c$

$\cos b = \cos a \cdot \cos c$

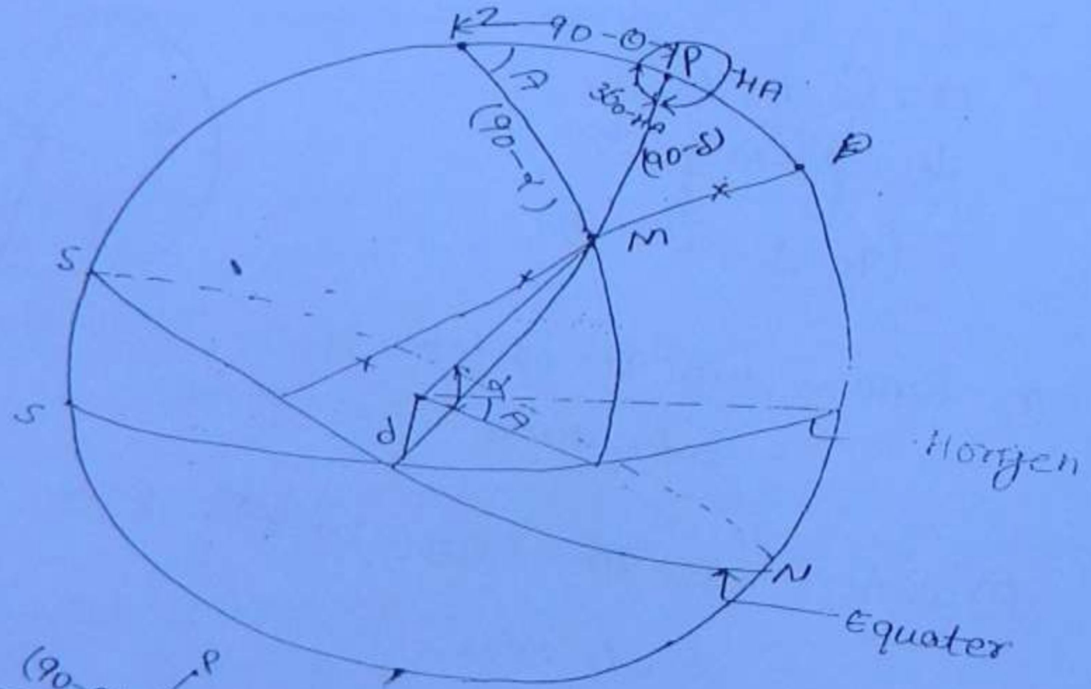
Total 10 Secoh equation can be formed.

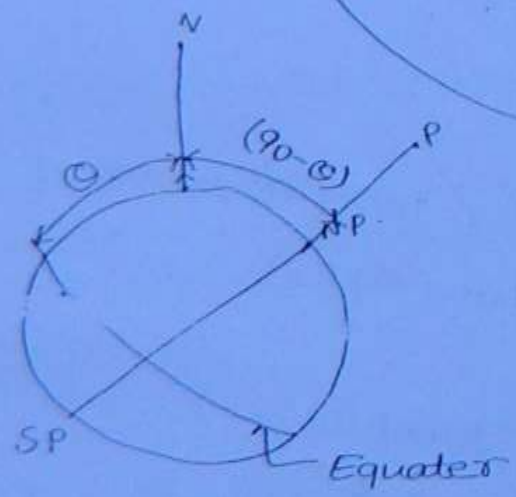
Spherical Excesses formed

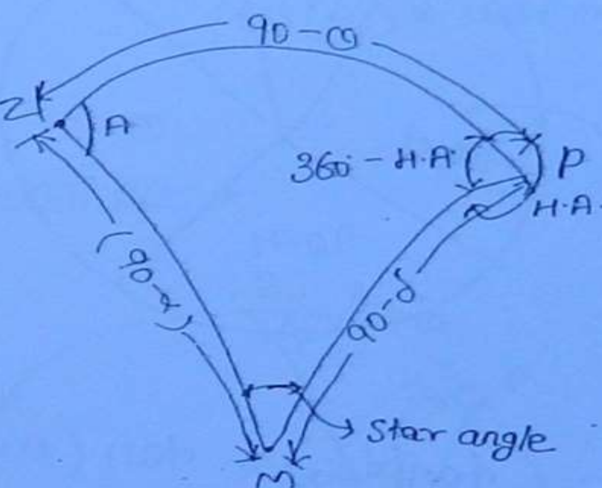
(164) $E = (A+B+C) - 180$

area of spherical triangle

$$\Delta \text{ area} = \frac{\pi R^2 \times E}{180}$$







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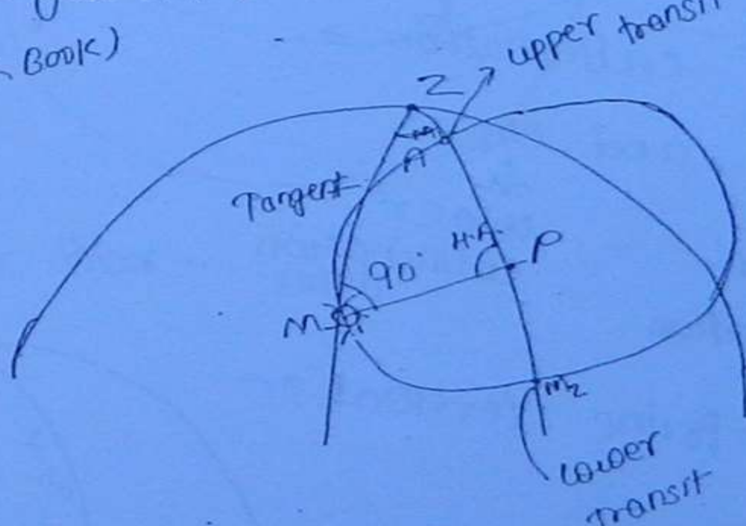
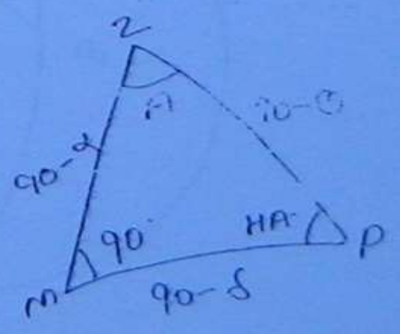
★ Different position of Star w.r. to observer's merid:

(i) Star at Elongation:→

(work Book)





Angle – (90-α), A, (90-φ), H, (90-δ)

(90-α) (90-A) φ (90-M) (90-δ) ——

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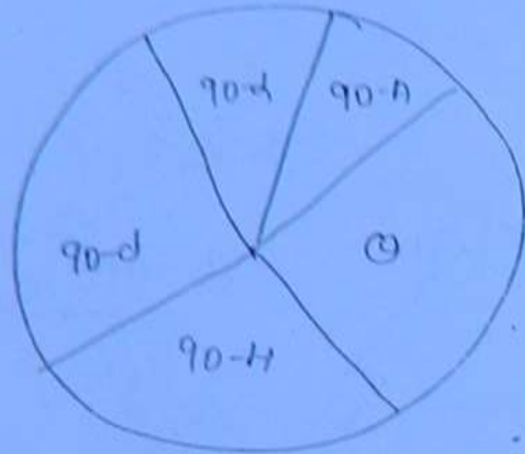


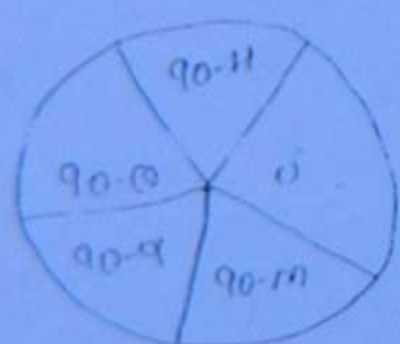
Sin(middle) = tan(adj.) x tan (adj2)

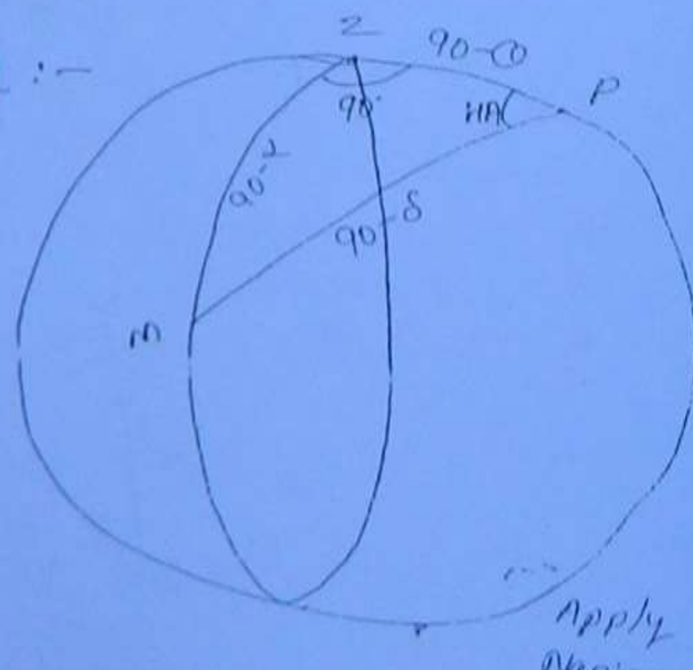
sin (middle) = cos (opp1) x cos (opp2)

(2) Star of culmination :->

M1 and M2
↓ ↓
upper lower
culmination culmination

(3) Star at Prime Vertical :-





90-φ, H, 90-d, m, 90-α
(90-φ) (90-H) δ (90-m) (90-α)

Apply Napier rule

$$\sin(\text{middle}) = \tan(\text{adj}_1) \times \tan(\text{adj}_2)$$
$$\cos(O_1) \times \cos(O_2)$$

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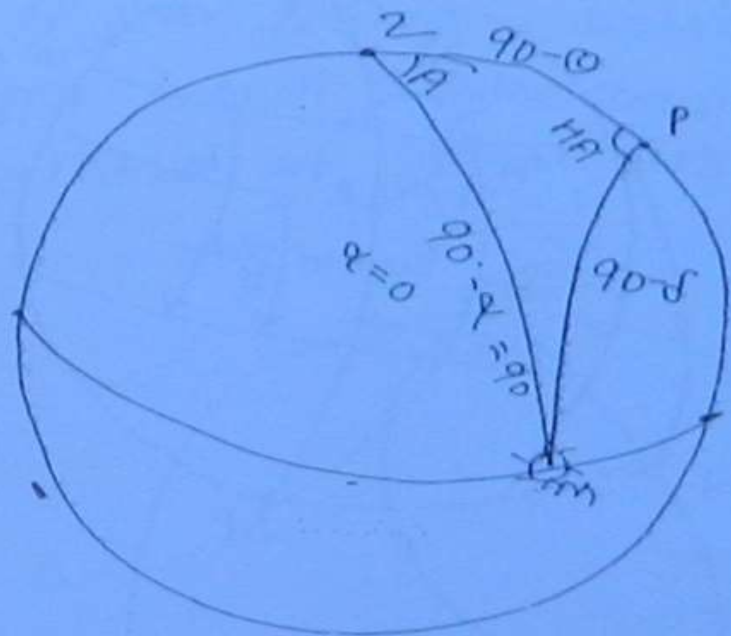
(4) Star at Horizon: →



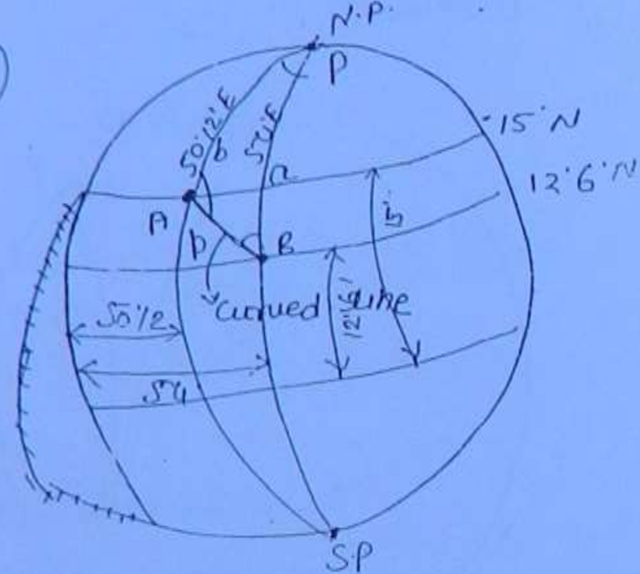
(5) Circumpolar Star :- Book-

Problem. ES-1994

(1) Find the shortest distance b/w two points A and B on earth surface, given that latitude of A and B are 15°N and 12°6'N, and their longitudes are 50°12'E and 54°E, R = 6370 km

Solution :→

(168)



$a = 90° - 12°6' = 77°54'$

$b = 90 - 15° = 75°$

$P = 54 - 50°12'$

$P = \cancel{3°48'}\ 3°48'$

$p = ?$

$$\cos P = \frac{\cos p - \cos a \cos b}{\sin a \sin b}$$

$\cos p = \cos a \cos b + \sin a \sin b \cdot \cos P$

$\cos p = \cos 77°54' \cdot \cos 75° + \sin 77°54' \sin 75 \times \cos 3°48'$

$\Rightarrow \cos p = 4°41'46''$

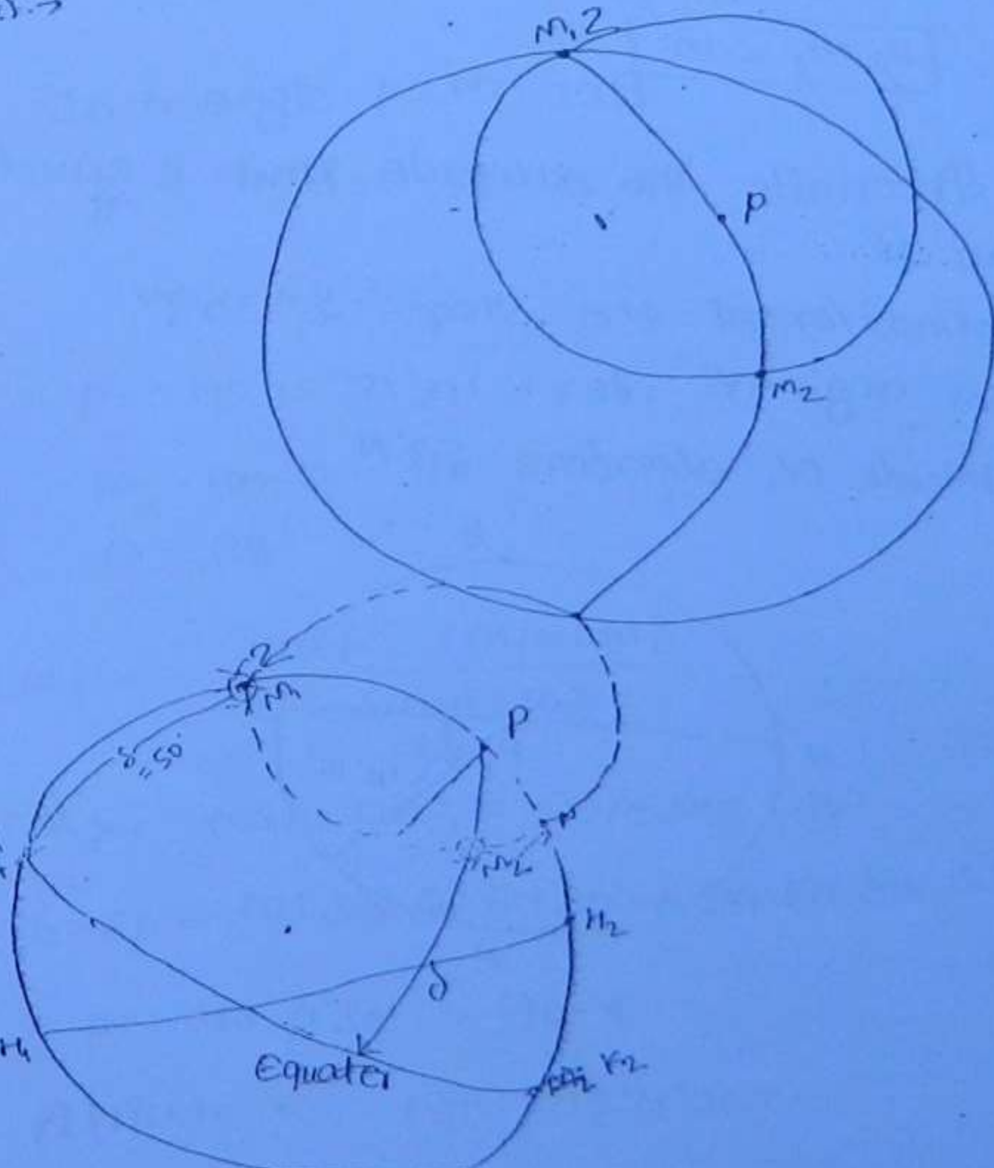
Distance AB $= \dfrac{2\pi R}{360^\circ} \times p$

769 $\quad = \dfrac{2 \times \pi \times 6370}{360^\circ} \times 4^\circ 41' 46''$

$= \boxed{522.1 \text{ km}}$ Ans

Problem:→ A star having a declination of 50°N has its upper transit in the zenith of the place. Find the altitude of Star at it's lower transit.

Solution:→



Declination at upper transit

$M_1 = 50 = ZH_1 = M_1H_1$

So $Zp = 90 - 50 = 40^\circ$

at lower transist

$PM_2 = 40^\circ$

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Altitude of star at lower transit $= H_2M_2 =$

$ZH_2 - Zp - PM_2$

$H_2M_2 = 90 - 40 - 40$

$\boxed{H_2M_2 = 10^\circ}$

Ans

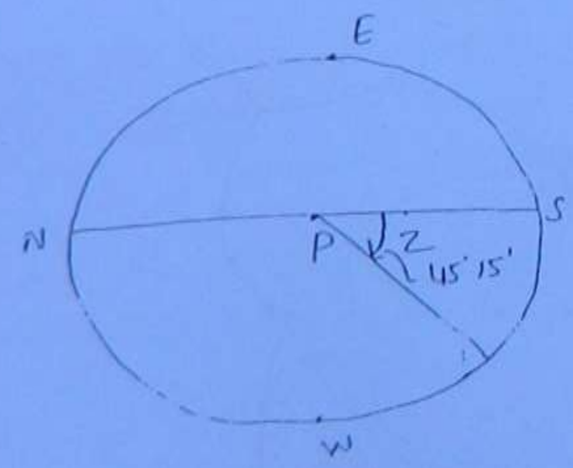
Problem:- Determine the altitude and azimuth of a star if

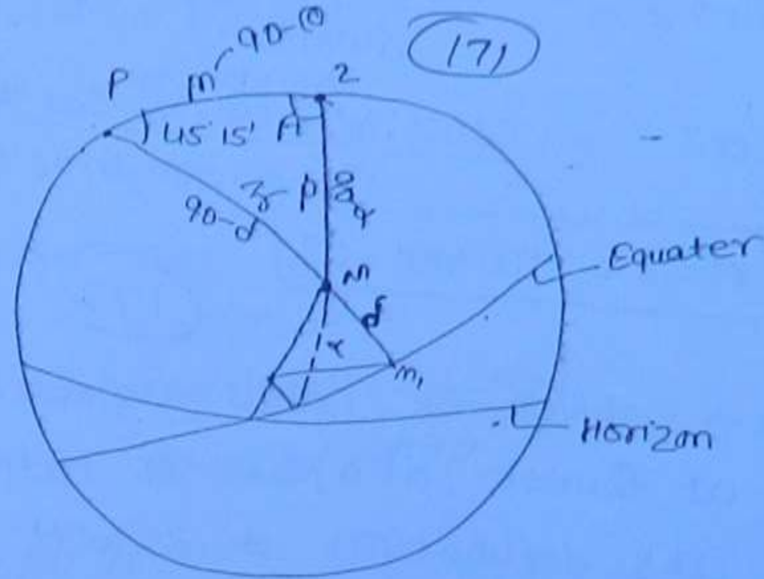
(1) Declination of the star $= 25^\circ 30' N$

(2) Hour angle of star $= 45^\circ 15'$

(3) latitude of observer $= 52^\circ N$

Solution:→





In triangle PZM

$z = 90 - d = 90 - 35°30'$

$z = 64°30'$

$p = 45°15'$

$m = 90 - \theta = 90 - 52°$

$m = 38°$

$$\cos P = \frac{\cos p - \cos m \cos z}{\sin m \sin z}$$

$\cos p = \cos m \cos z + \sin m \sin z \cos P$

$\cos p = \cos 38° \cos 64°30' + \sin 38° \sin 64°30' \cos 45°15'$

$p = 43°4'30'' = 90 - \alpha$

Altitude $\alpha = 90 - 43°4'30''$

$\alpha = 46°55'30''$

$$\cos Z = \frac{\cos z - \cos m \cos p}{\sin m \cdot \sin p}$$

$$\cos Z = \frac{\cos 64^\circ 30' - \cos 38^\circ \cos 43^\circ 4' 30''}{\sin 38^\circ \sin 43^\circ 4' 30''}$$

$$\boxed{A = Z = 110^\circ\ 11'\ 14''}$$

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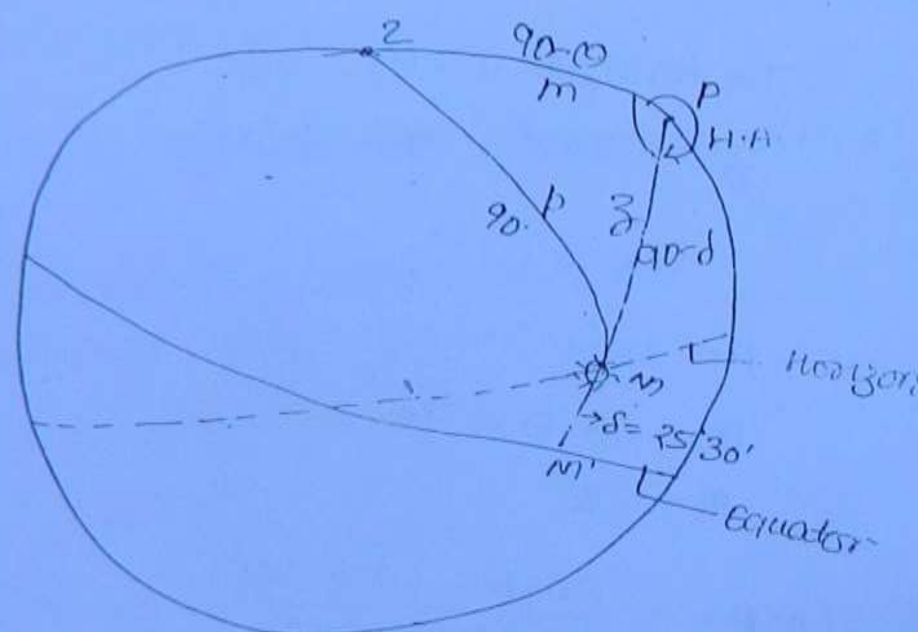
Problem:→ Calculate the Sun's azimuth and hour angle at Sunset, at a place of latitude 42°30', when it's declination is 25°30' N.

Solution:→



At Sunset

altitude of Sun = 0

ZM = 90 − d = 90 − 0 = 90°

Declination $MM_1 = 25°30'$ N

PM = 90 − d = 90 − 25°30'

= 64°30' = d

ϕ = latitude = $42°30'$

$zp = 90 - \phi = 90 - 42°30'$

$= 47°30' = m$

$$\cos z = \cos A = \frac{\cos z - \cos m \cdot \cos p}{\sin m \cdot \sin p}$$

$$A = \frac{\cos 64°30' - \cos 47°30' \cos 90}{\sin 47°30' \sin 90}$$

$A = 54°16'34''$ 173

$$\cos p = \frac{\cos P - \cos m \cdot \cos z}{\sin m \cdot \sin z}$$

$$\cos p = \frac{\cos 90 - \cos 47°30' \cos 64°30'}{\sin 47°30' \sin 64°30'}$$

$p = 115°55'1''$

$H.A. = 360 - 115°55'1''$

$\boxed{HA = 244°4'59''}$ Ans

Time :→

① Express following angle into time

$85^\circ\ 30'\ 45''$ (174)

$85^\circ = \frac{85}{15} =$ 5 hours 40 min 0 sec

$30' = \frac{30}{15} =$ 0 hour 2 min 0 sec

$45'' = \frac{45}{15} =$ 0 hr 0 min 3 sec

5 hour 42 min 3 sec

② 18 hr. 26 min 46 sec Convert into angle

18 hr = $18 \times 15 = 270^\circ\ 0'\ 0''$

26 min = $\frac{26 \times 15}{60} = 6^\circ\ 30'\ 0''$

46 sec = $\frac{46 \times 15}{60} = 0^\circ\ 11'\ 30''$

$276^\circ\ 41'\ 30''$

Day = Night = 21 September

Day = Night = 21 March

Nort east direction _ Summer

Sout east direction - Rainne, Winter

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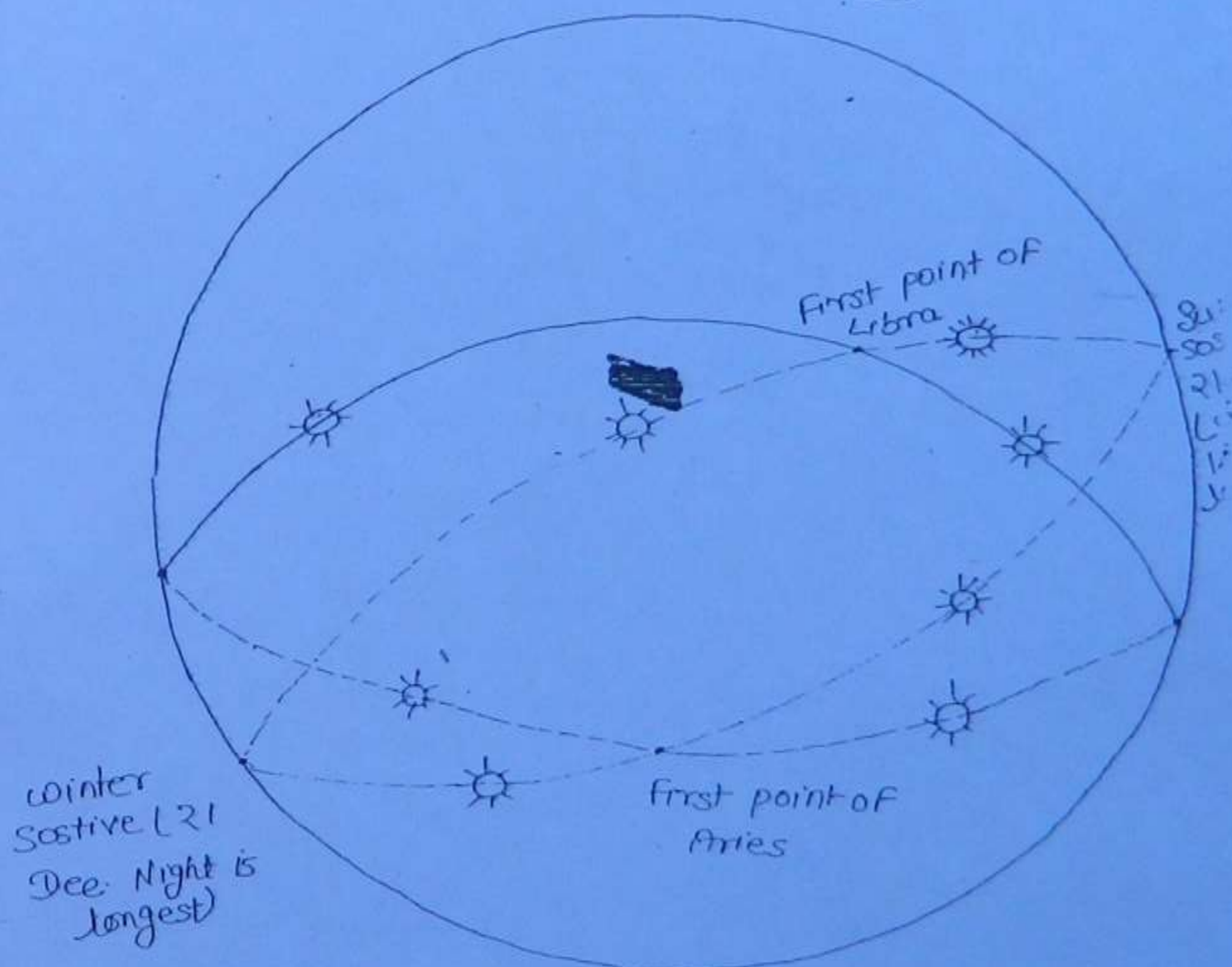

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The end [redacted]

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