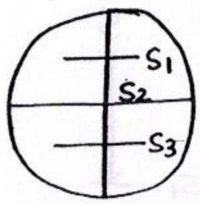
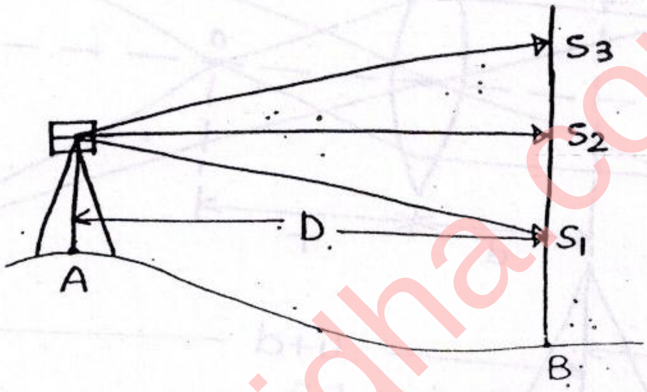
TACHEOMETER SURVEYING

→ Using a tacheometer staff reading can be read to calculate the R.L of a point as well as the distance of the staff location from the instrument.

→ Three staff readings are taken.



Cross-hair



S_2 = Used for R.L

$S_3 | S_1$ = Used for Distance

Staff Intercept

$$s = (S_3 - S_1)$$

Distance of staff from Instrument –

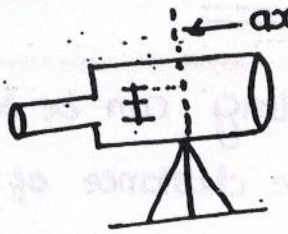
$$\boxed{D = ks + C}$$

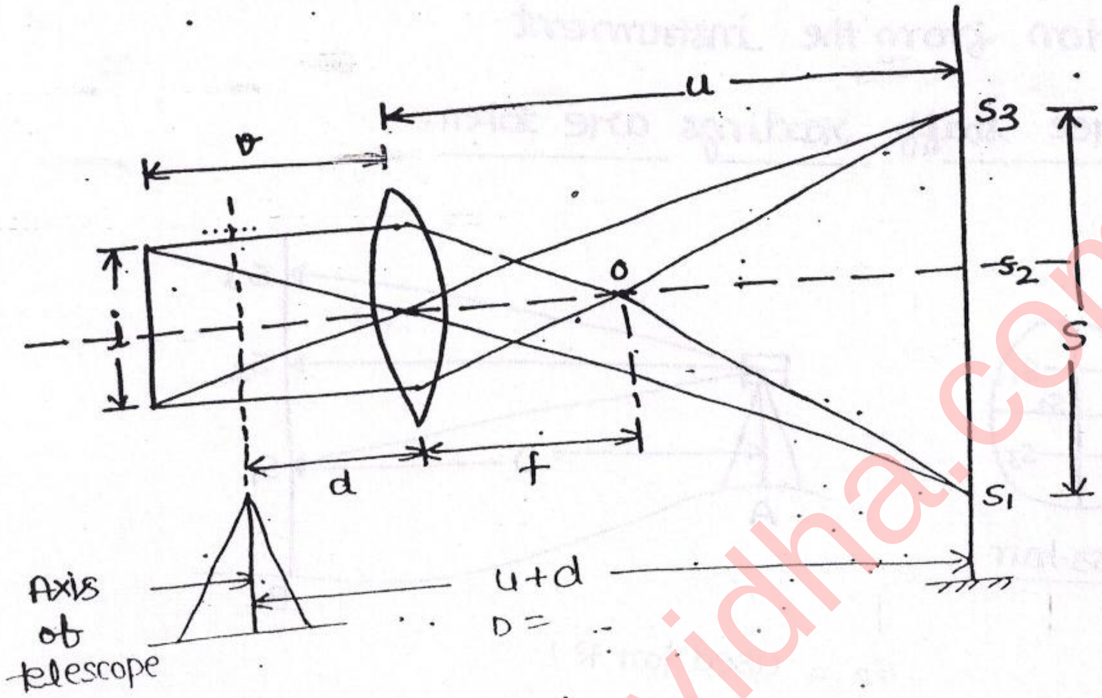
where

k = multiplying constant (generally – 100)

C = Additive constant (generally – zero)

Principle of Tacheometer :-





(ii) For the object piece

$$\frac{1}{f} = \frac{1}{v} + \frac{1}{u} \quad \text{--- (1)}$$

Ratio $\frac{s}{i} = \frac{u}{v}$ $\quad\Big\|\quad$ $v = \frac{ui}{s}$ --- (2)

Put in (1)

$$\frac{1}{f} = \frac{1 \cdot s}{u \cdot i} + \frac{1}{u} = \frac{1}{u}\left(\frac{s}{i} + 1\right)$$

$$u = f\left(\frac{s}{i} + 1\right) = \left(\frac{f}{i} \cdot s + f\right) \quad \text{--- (3)}$$

Total distance D : from instrument (axis of telescope) to staff

$$D = u + d$$

$$D = \frac{f}{i} s + f + d$$

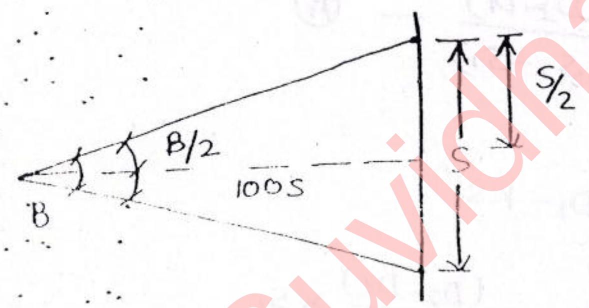
$$D = \left(\frac{f}{i}\right) s + (f + d)$$

$$\boxed{D = KS + C}$$

Multiplying constant $K = (f/i)$ = generally = 100

Additive constant $C = (f+d)$ = generally = 0

When $K = 100$, $C = 0$ | The telescope is called Anallactic telescope.



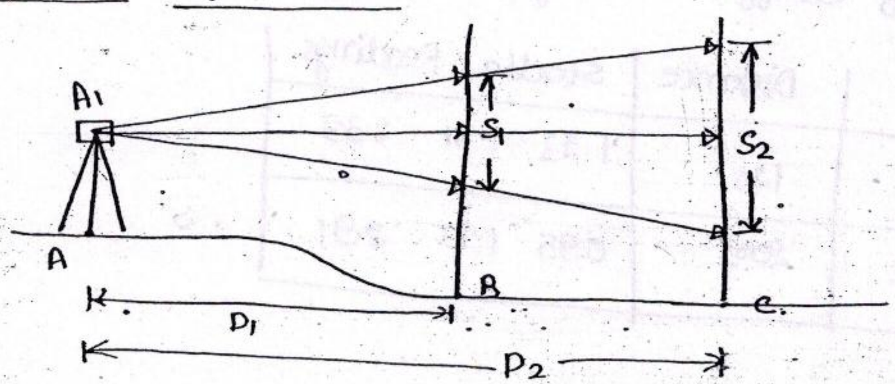
$$\tan B/2 = \frac{S/2}{100S} = \frac{1}{200}$$

$$B/2 = \tan^{-1}\left(\frac{1}{200}\right) = 0° 17' 11.32''$$

$$B = 2 \times 0° \times 17' 11.32'' = 0° 34' 22.63''$$

for anallactic telescope.

Determination of K and C :- 04/01/14



The staff readings are taken at 2 location of known distances from instrument say D_1 & D_2.

If staff Intercept –

at B $= S_1$

at C $= S_2$

$$D_1 = K \cdot S_1 + C \quad \text{—— (I)}$$

$$D_2 = K \cdot S_2 + C \quad \text{—— (II)}$$

<u>Solve for K & C</u>

(2) - (1)

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

$$C = D_1 - KS_1$$

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

$$= \frac{D_1 S_2 - D_1 S_1 - D_2 S_1 + D_1 S_1}{S_2 - S_1}$$

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

<u>Ques:</u> (1) If staff readings taken on B & C are –

	Distance	Stadia Readings		
B	120	1.23	1.81	2.39
C	200	0.95	1.93	2.91

$D = u + d$

$D = \frac{f}{i} s + f + d$

$D = \left(\frac{f}{i}\right) s + (f + d)$

$$\boxed{D = KS + C}$$

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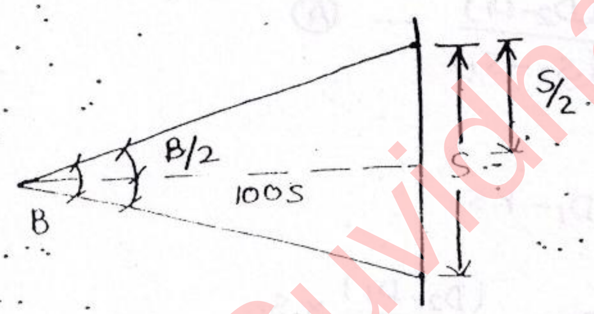

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04/01/14

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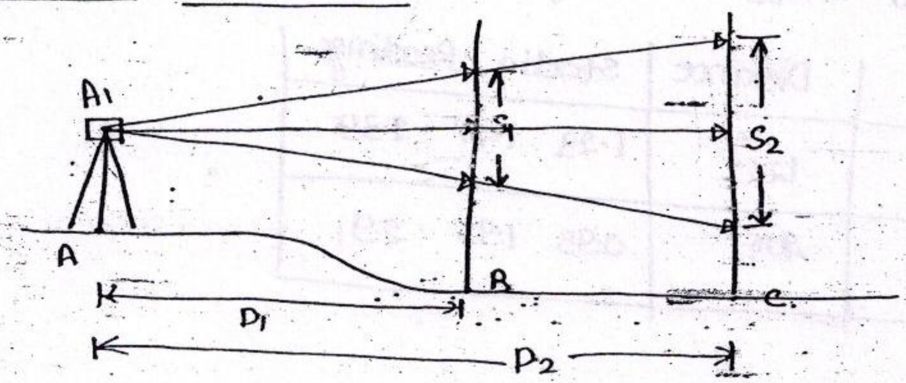

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Solve for k & C

(2) − (1)

$$k = \frac{(D_2 - D_1)}{(S_2 - S_1)} \quad \text{— (A)}$$

$$C = D_1 - kS_1$$

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

$$= \frac{D_1 S_2 - D_1 S_1 - D_2 S_1 + D_1 S_1}{S_2 - S_1}$$

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

Ques: (1) If staff readings taken on B & C are —

	Distance	Stadia	Readings	
B	120	1·23	1·81	2·39
C	200	0·95	1·93	2·91

⇒ Calculate K & C :

$D_1 = 120m$

$S_1 = 2.39 - 1.23$

$S_1 = 1.16$

$D_1 = K \times S_1 + C$

$120 = K \cdot 1.16 + C$ —— ①

$D_2 = 200m$

$S_2 = 2.91 - 0.95$

$S_2 = 1.96$

$D_2 = K \cdot S_2 + C$

$200 = K \times 1.96 + C$ —— ②

② − ①

$200 - 120 = K(1.96 - 1.16)$

$K = \frac{80}{0.80} = 100$

$C = 120 - K \cdot S_1$

$C = 120 - 100 \times 1.16$

$C = 4$

Staff Readings :- (on angle of elevation or angle of depression

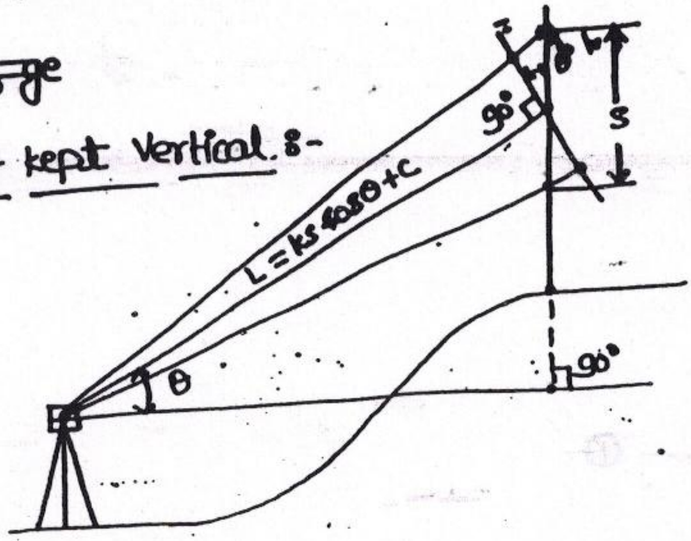
(1) Vertical Staff

(2) Staff kept Normal

(⊥cular to line of sight)

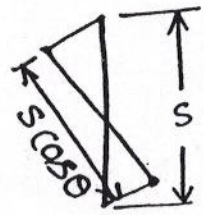
~~(1) Staff ge~~

(1) Staff kept Vertical :-



Inclined length

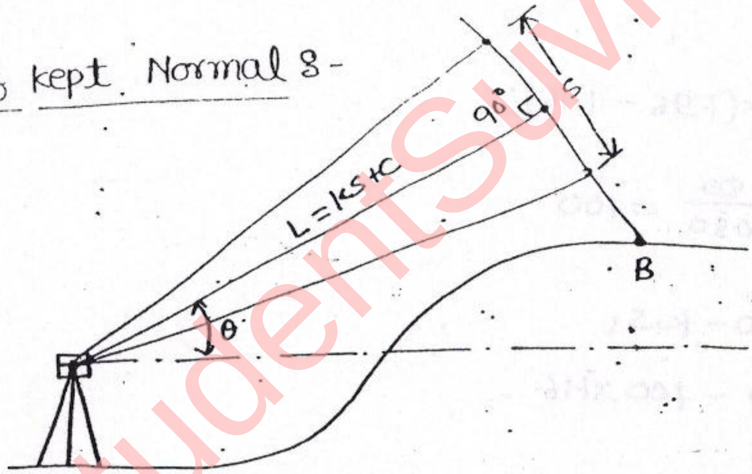
L = K S cosθ + C



Staff intercept ⊥cular to line of sight = S cosθ

$$L = K(S\cos\theta) + C$$

(2) Staff kept Normal :-



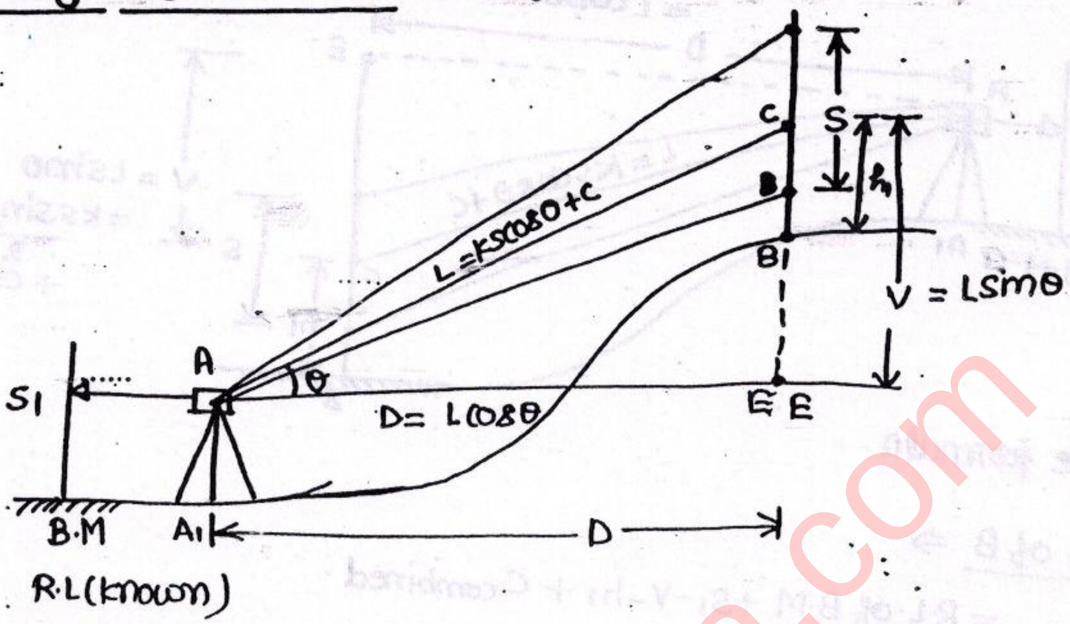
In this case the staff is kept inclined (⊥cular to line of sight) The inclined distance from instrument to central reading of staff.

$$L = KS + C$$

S = staff intercept

There are four cases :

(1) Angle of Elevation (staff kept Vertical)



Staff Intercept = S

Inclined length, $L = KS\cos\theta + C$

(i) For Horizontal distance,

$$D = L\cos\theta$$

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

$$\boxed{D = K\cdot S\cos^2\theta + C\cos\theta} \quad \text{— (A)}$$

(ii) Vertical Height :-

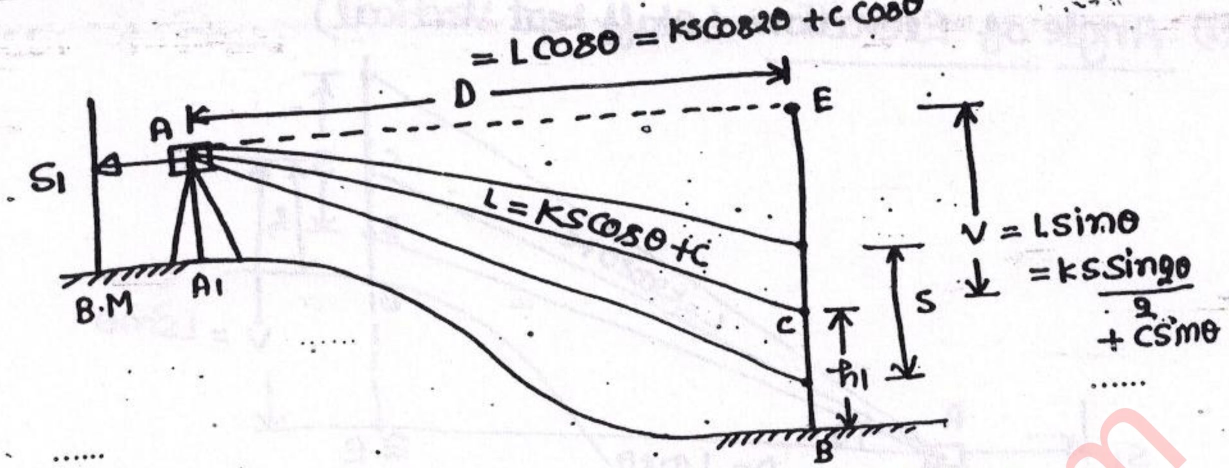
$$V = L\sin\theta = (KS\cos\theta + C)\sin\theta$$

$$= \frac{K\cdot S\sin 2\theta}{2} + C\sin\theta$$

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

R.L. of B = R.L of B.M + S_1 + V − h_1 + Combined

(2). Angle of Depression: (Staff is kept vertical)

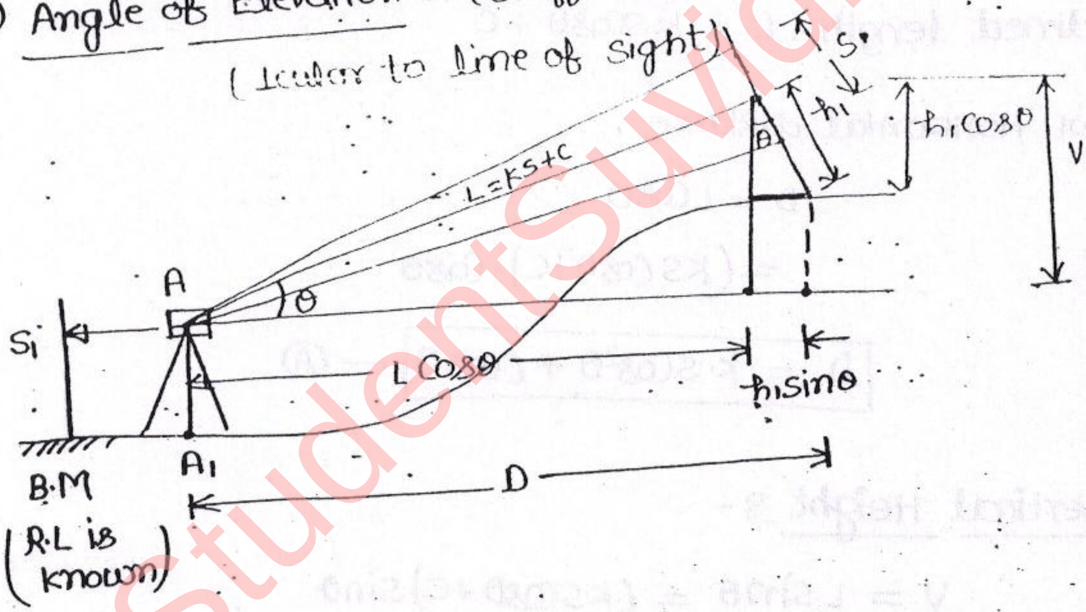


⇒ Same formula.

⇒ R.L. of B ⇒

$= R.L. \text{ of } B.M + S_1 - V - h_1 + C_{combined}$

(3) Angle of Elevation :- (Staff kept Normal) (⊥cular to line of sight)



Staff Intercept = S

Inclined length

$L = KS + C$

(i) Horizontal Distance -

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

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

(2) Vertical Ht. :-

$$V = L\sin\theta$$

$$\boxed{V = (KS+C)\sin\theta} \quad —(B)$$

(3) R.L. of B = R.L. of BM + S_1 + V − $h_1\cos\theta$ + $C_{combined}$

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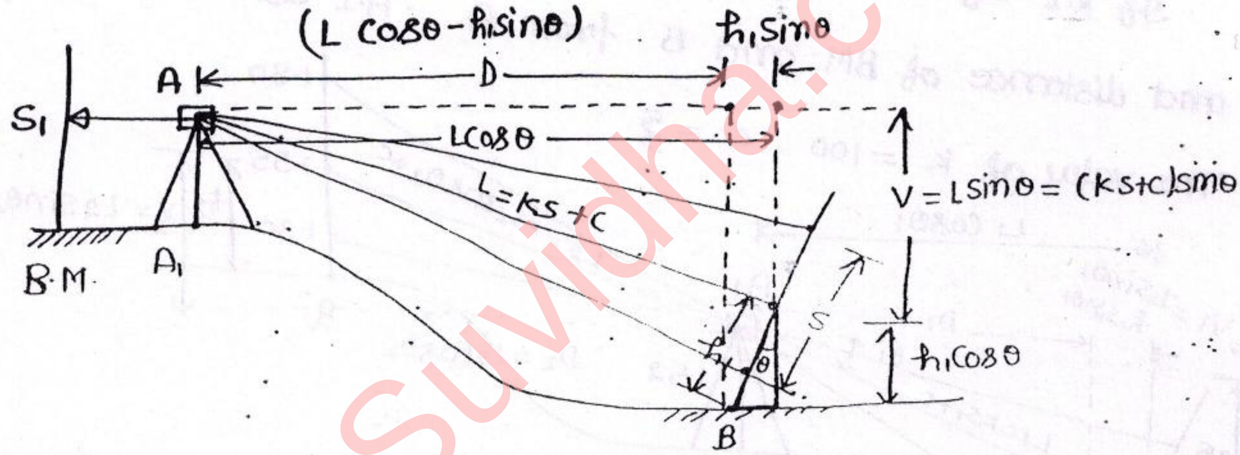
(4) Angle of depression (staff is kept Normal)



staff Intercept = S

Inclined length

$$L = ks + c$$

(i) Horizontal distance :

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

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

(ii) Vertical height :

$$V = L\sin\theta$$

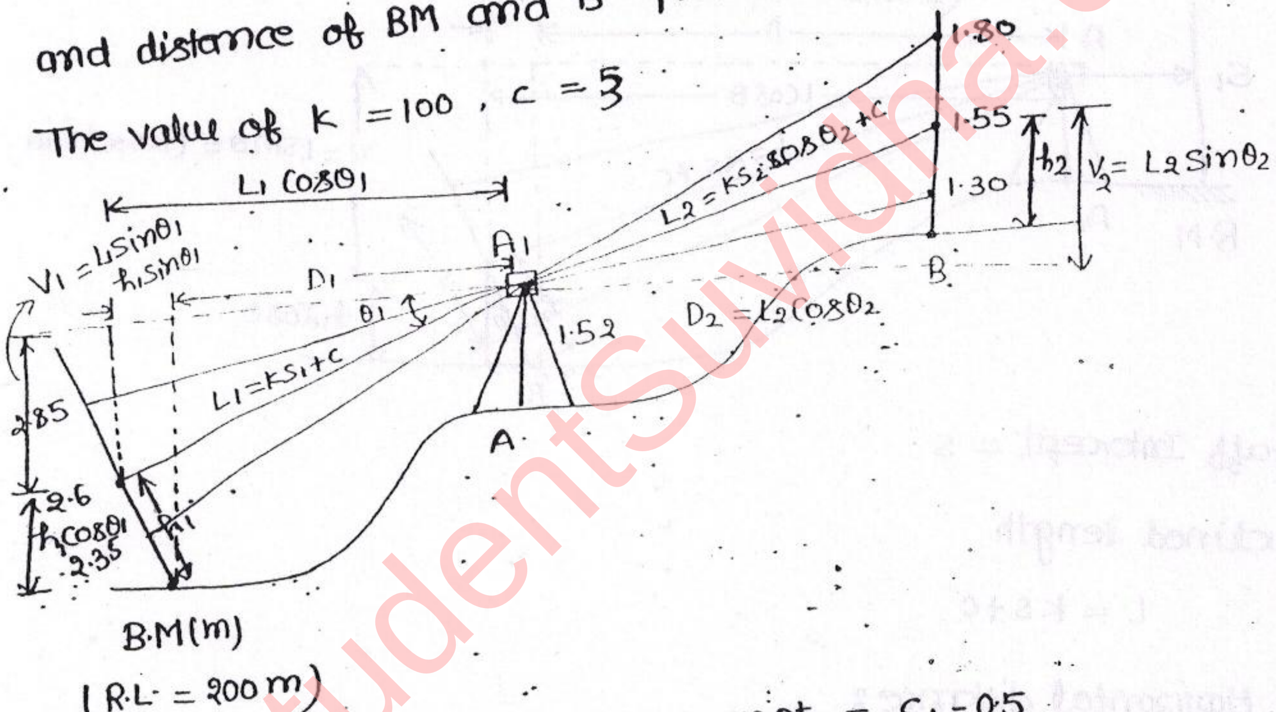
$$\boxed{V = (KS+C)\sin\theta}$$

R.L. of B = R.L. of BM + S_1 − V_1 − $h_1\cos\theta$ + $C_{combined}$.

Ques (1) From a tacheometer set up at station 'A' readings were taken on a B.M. M, and another station B.

Reading from	Staff Reading at	Staff Position	Angle	Stadia Reading
(A)	BM (M)	Inclined (normal to L.O.S)	-15°	2.35, 2.6, 2.85
	B	Vertical	$+20^\circ$	1.30, 1.55, 1.80

If R.L. of B.M (M = 200.00 m. Find out the R.L. of A & B from A. H.I. at A = 1.52 m. and distance of BM and B from A. The value of K = 100, c = 5



Staff intercept $= S_1 = 0.5$

⇒ from A to B.M.

Inclined length (Staff is normal to L.O.S)

$L_1 = KS_1 + C$

$S_1 = 0.5$

$\therefore L = 100 \times 0.5 + 5$

$\boxed{L = 55 m}$

Horizontal distance :-

$\Rightarrow D_1 = L_1 \cos\theta_1 - h_1 \sin\theta_1$

$D_1 = 53 \cos 15° - 2.60 \times \sin 15°$

$\boxed{D_1 = 50.52 m}$

Vertical ht :-

$V_1 = L_1 \sin\theta_1$

$= 53 \sin 15°$

$\boxed{V_1 = 15.72 m}$

R.L. of A

$= R.L of B.M + h_1 \cos\theta_1 + V_1 - 1.52$

$= 200 + 2.6 \cos 15° + 13.72 - 1.52$

$= 214.71 m$

From A to B :

Staff intercept $S_2 = 1.8 - 1.3$
$= 0.5 m$.

Inclined length :-

$L_2 = k \cdot S_2 \cos\theta_2 + C$

$= 100 \times 0.5 \times \cos 20 + 3$

$\boxed{L_2 = 49.98 m}$

Vertical ht :

$V_2 = L_2 \sin\theta_2$

$= 49.98 \cdot \sin 20°$

$\boxed{V_2 = 17.10 m}$

Horizontal distance :-

$D_2 = A \text{ to } B = L_2 \cos \theta_2$

$= 49.98 \times \cos 20$

$\boxed{D_2 = 46.97 m}$

R.L. of B

$= R.L. \text{ of } A + 1.52 + V_2 - h_2$

$= 214.71 + 1.52 + 17.10 - 1.55$

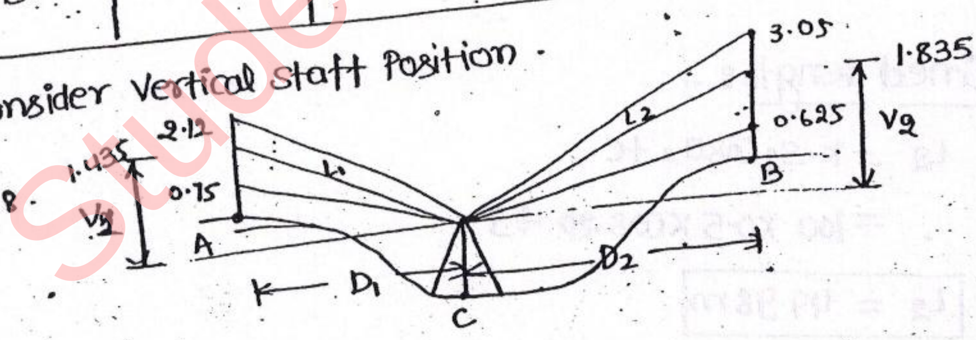
$= \underline{231.78 m}$

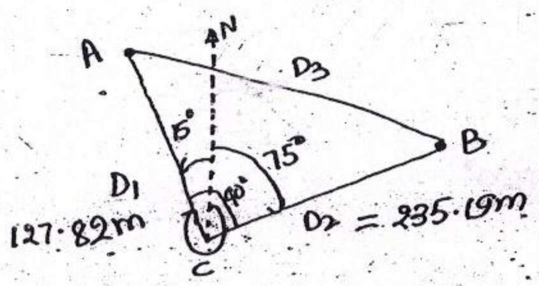
Ques:(2) 2(d) ES-2012 Determine the gradient from A to B from the following observations made with a fixed hair tacheometer fitted with anallactic lense. of K = 100

Reading	Bearing	Reading on stadia hair		Reading on axial hair	Vertical angle
to A	345°	0.75	2.12	1.435	+15°
to B	75°	0.625	3.05	1.835	+10°

Consider Vertical Staff Position.

Solun:





① From C to A

Staff intercept

$S_1 = 2.12 - 0.75 = 1.37 m$

Inclined length

$L_1 = K \cdot S_1 \cos\theta_1 + C$

$= 100 \times 1.37 \times \cos 15° + 0$

$= 132.33 m$

Horizontal Distance :

$D_1 = L_1 \cos\theta_1 = 132.33 \cdot \cos 15°$

$D_1 = 127.82 m$

Vertical Height :

$V_1 = L_1 \sin\theta_1 = 132.33 \times \sin 15°$

$V_1 = 34.25 m$

If R.L. of C = x

H.I at C = y

R.L. of A

$= x + y + V_1 - h_1$

$= x + y + 34.25 - 1.435$

$= x + y + 32.815$

② From C to B

Staff intercept

$S_2 = 3.05 - 0.625$

$= 2.425 m$

Inclined length

$L_2 = K \cdot S_2 \cos\theta_2 + C$

$= 100 \times 2.425 \cos 10° + 0$

$L_2 = 238.82 m$

Horizontal distance

$D_2 = L_2 \cos\theta_2$

$= 238.82 \cos 10^\circ$

$D_2 = 235.19\,m$

Vertical Ht :-

$V_2 = L_2 \sin\theta_2$

$= 238.82 \times \sin 10$

$V_2 = 41.47\,m$

R.L. of B $= x + y + V_2 - h_2$

$= x + y + 41.47 - 1.835$

$= x + y + 39.635\,m.$

(3) Difference of R.L. from A to B

$= R.L.\ B - R.L.\ A$

$= x + y + 39.635 - x - y - 32.815$

$= 6.82\,m.$ (B is higher)

In Horizontal angle ΔABC

$\angle C = 75^\circ + (360 - 345^\circ)$

$= 90^\circ$

$D_3 = \sqrt{D_1^2 + D_2^2} = \sqrt{(127.82)^2 + (235.19)^2}$

$D_3 = 267.68\,m$

gradient from A to B

$= \dfrac{\text{difference of R.L}}{\text{Horizontal distane}} = \dfrac{6.82}{267.68} = \dfrac{1}{39.25}$ (upward)