

Methods of Tacheometry:- There are two methods.

- 1) Stadia Tacheometry
- 2) TAO
- 2) Tangential Tacheometry.

1) Stadia Tacheometry:- In this method, the stadia diaphragm of the tacheometer is provided with two stadia hairs one upper hair & another lower hair, looking through the telescope the stadia hair readings are taken and noted. The difference between upper hair and lower hair readings is known as staff intercept  $[S]$ . To determine the distance between instrument station and staff, the staff intercept is multiplied by the multiplying constant  $[K/i]$ . The stadia method is further divided into two types.

- (a) Fixed Hair Method
- (b) Movable Hair Method

(a) Fixed Hair Method:- This is most commonly used method of tacheometry. In this method, the stadia hairs are kept at fixed interval and the value of intercept ~~varies~~ varies with the distance from instrument station.

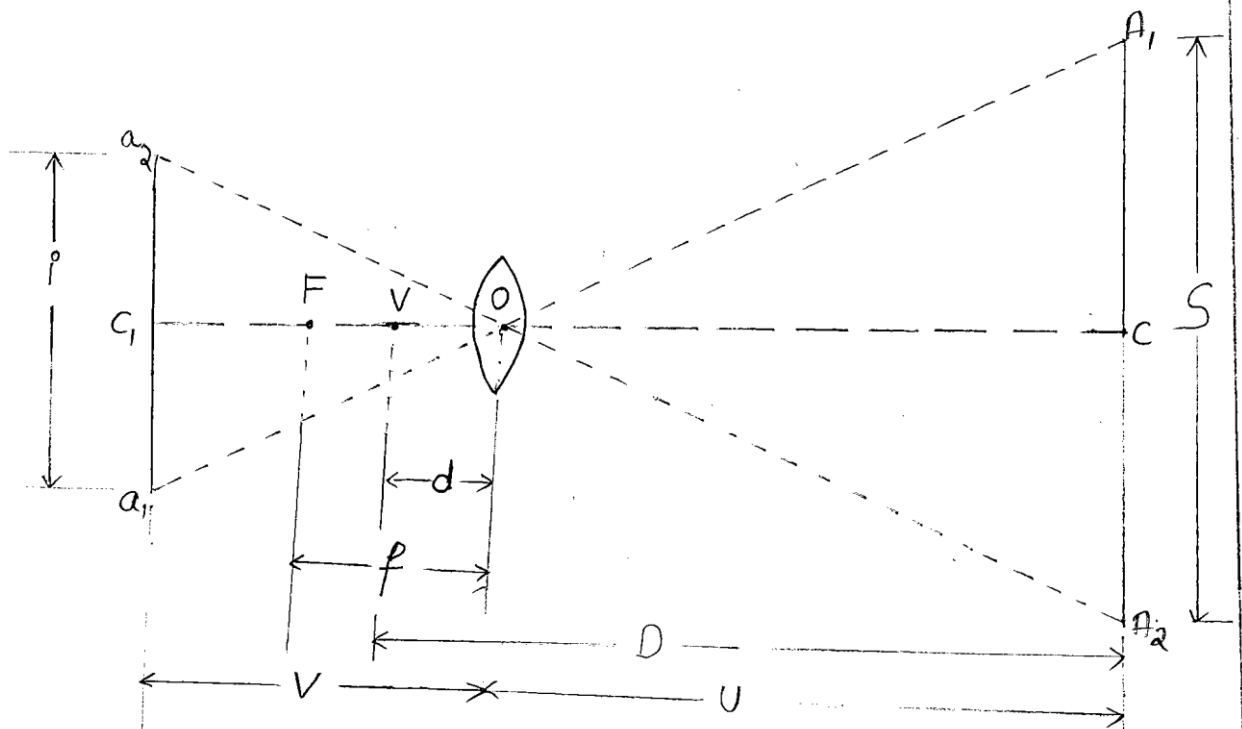
It contains of two cases.

Case-1: When line of sight is horizontal & staff held vertical

Case-2: When line of sight is inclined & staff held vertical

- (a) By considering angle of elevation.
- (b) By considering angle of depression.

Theory of Stadia Tacheometry (a) Determination of horizontal distance between instrument & staff when the line of sight is horizontal & staff held vertical (a) Determination of General tacheometric equation:-



In the above figure,  $a_1, a_2$  &  $c_1$  are the bottom, top & central hairs of diaphragm.  $A_1, A_2, C$  are readings on staff cut by three hairs.

$a_1, a_2 = i =$  Stadia Intercept (or) length of image.

$A_1, A_2 = S =$  Staff intercept.

$O =$  Optical centre of object glass

$F =$  focus

$V =$  Vertical axis of instrument.

$f$  = focal length of object glass

$d$  = Distance between optical centre & vertical axis of instrument.

$u$  = Distance between optical centre & staff

$v$  = Distance between optical centre & image

$D$  = Horizontal distance between vertical axis of instrument & staff.

$$\therefore D = u + d \rightarrow (1)$$

From triangles  $OA_1A_2$ ,  $OA_2A_1$  all similar triangles

$\therefore$  from property of similar triangles,

$$\frac{i}{s} = \frac{v}{u} \Rightarrow v = \frac{iu}{s} \rightarrow (2)$$

From property of lenses, we know that

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v} \rightarrow (3)$$

By substituting eq (2) in eq (3), we get

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{\frac{iu}{s}}$$

$$\frac{1}{f} = \frac{1}{u} + \frac{s}{ui}$$

$$\frac{1}{f} = \frac{1}{u} \left[ 1 + \frac{s}{i} \right]$$

$$u = f \left[ 1 + \frac{s}{i} \right]$$

but from eq (1),

$$D = u + d$$

$$D = f \left[ 1 + \frac{s}{i} \right] + d$$

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

$$D = \frac{f}{i}(s) + [f+d] \rightarrow (4)$$

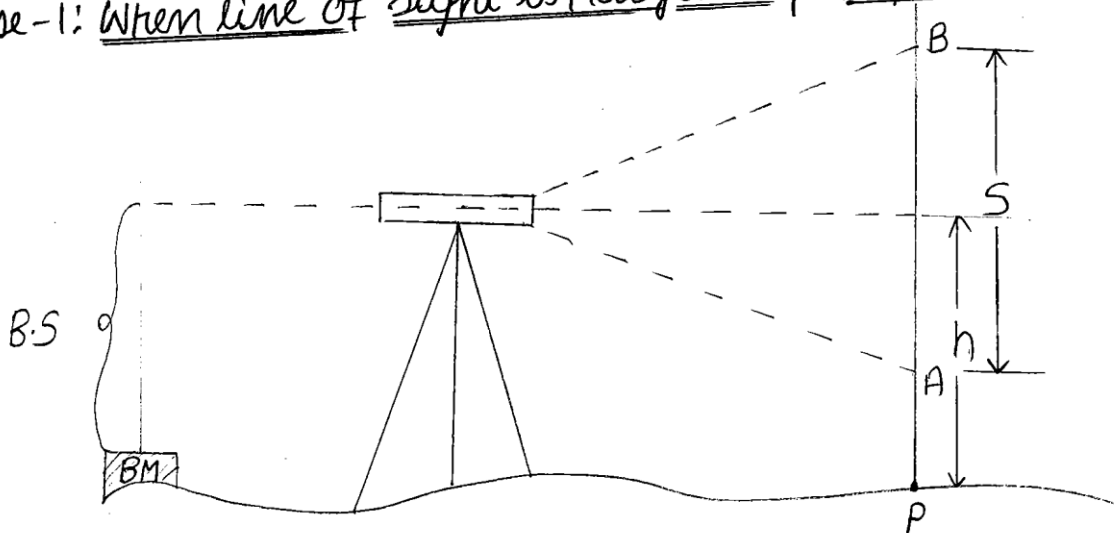
Equation (4) is General tacheometric equation.

The,  $\left[ \frac{f}{i} \right]$  is Multiplying constant &  $[f+d]$  = Additive constant

$\left[ \frac{f}{i} \right]$  &  $[f+d]$  are tacheometric constants

Fixed Hair Method:-

Case-1: When line of sight is Horizontal & staff held vertical:



$h$  = Central hair Reading

When the line of sight is horizontal & staff held vertical,

The General tacheometric equation is for Distance,

$$D = \frac{f}{i}(s) + [f+d]$$

RL of instrument  $\neq$

RL of Height of Instrument = RL of B.M + B.S

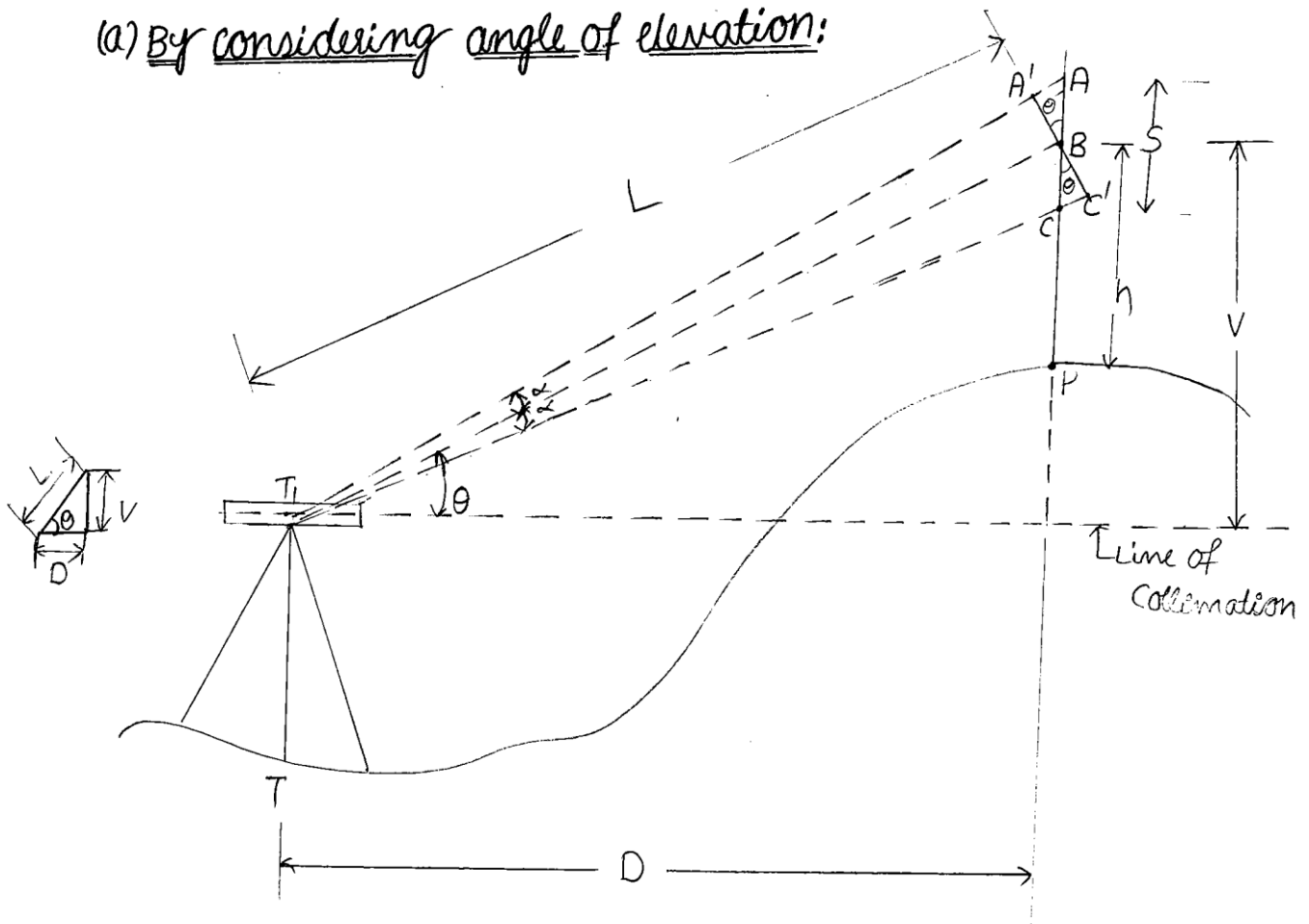
RL of staff station A = RL of Height of Instrument -  $h$

(8)

RL of staff station A = RL of BM + B.S -  $h$

Case - 2: When line of sight is inclined & staff held vertical:

(a) By considering angle of elevation:



In the above figure,

T = instrument station

P = staff station

AC = S = staff intercept [Upper Hair Reading -  
Lower Hair Reading]

h = central hair reading

(5)

$V$  = vertical distance of central hair ~~reading~~ above line of collimation.

$D$  = Horizontal distance b/w Instrument & staff.

$T_1B = L$  = inclined distance

$\theta$  = Angle of elevation [It is an angle between central hair & line of collimation]

$\alpha$  = Angle made by upper & lower stadia rays with central rays.

$A, B, C$  = staff readings cut by stadia hairs

Let,  $A'C'$  is drawn perpendicular to  $T_1B$ .

Now inclined distance  $T_1B [L]$

$$= \left[ \frac{f}{i} \right] A'C' + [f+d] \rightarrow (1)$$

Horizontal distance,  $D = L \cos \theta$

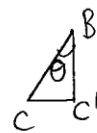
By substituting the value of 'L' from eq (1)

$$D = \left[ \frac{f}{i} \right] A'C' \cos \theta + [f+d] \cos \theta \rightarrow (2)$$

$$A'C' = A'B + BC'$$



$$\cos \theta = \frac{A'B}{AB} \Rightarrow ABC \cos \theta = A'B$$



$$\cos \theta = \frac{C'B}{BC} \Rightarrow BC \cos \theta = C'B$$

$$A'C' \Rightarrow A'B + BC' \Rightarrow ABC \cos \theta + BC \cos \theta. \quad [\because AB + BC = S]$$

$$\Rightarrow \cos \theta [AB + BC]$$

$$\Rightarrow \cos \theta (S) \Rightarrow S \cos \theta.$$

(6)

By substitute A'C' value in eq(2), then

Horizontal distance,  $D = \left[\frac{f}{i}\right] s \cos \theta (\cos \theta) + [f+d] \cos \theta$

$$D = \left[\frac{f}{i}\right] s \cos^2 \theta + [f+d] \cos \theta \rightarrow (3)$$

from the figure

Vertical distance,  $V = L \sin \theta$

$$V = \left[\frac{f}{i}\right] A'C' + [f+d] \sin \theta$$

$$V = \left(\frac{f}{i}\right) s \cos \theta \sin \theta + [f+d] \sin \theta$$

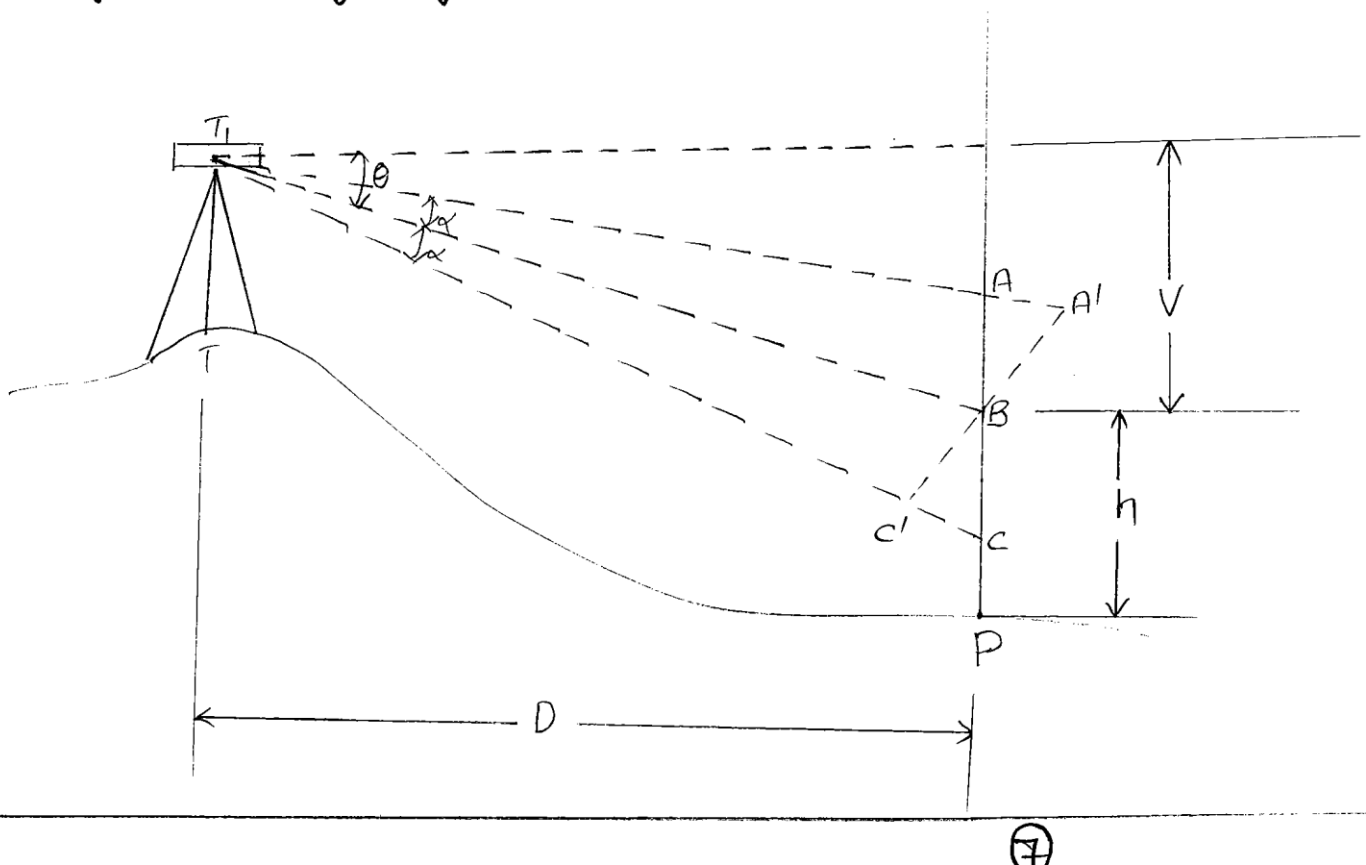
[∵  $\sin 2\theta = 2 \sin \theta \cos \theta$ ]

$$\frac{\sin 2\theta}{2} = \sin \theta \cos \theta$$

$$V = \left[\frac{f}{i}\right] s \frac{\sin 2\theta}{2} + [f+d] \sin \theta \rightarrow (4)$$

RL of P = RL of line of collimation + V - h

(b) By considering angle of depression



Horizontal distance,

$$D = \left[ \frac{f}{i} \right] (s) \cos^2 \theta + [f+d] \cos \theta \rightarrow (1)$$

Vertical distance,

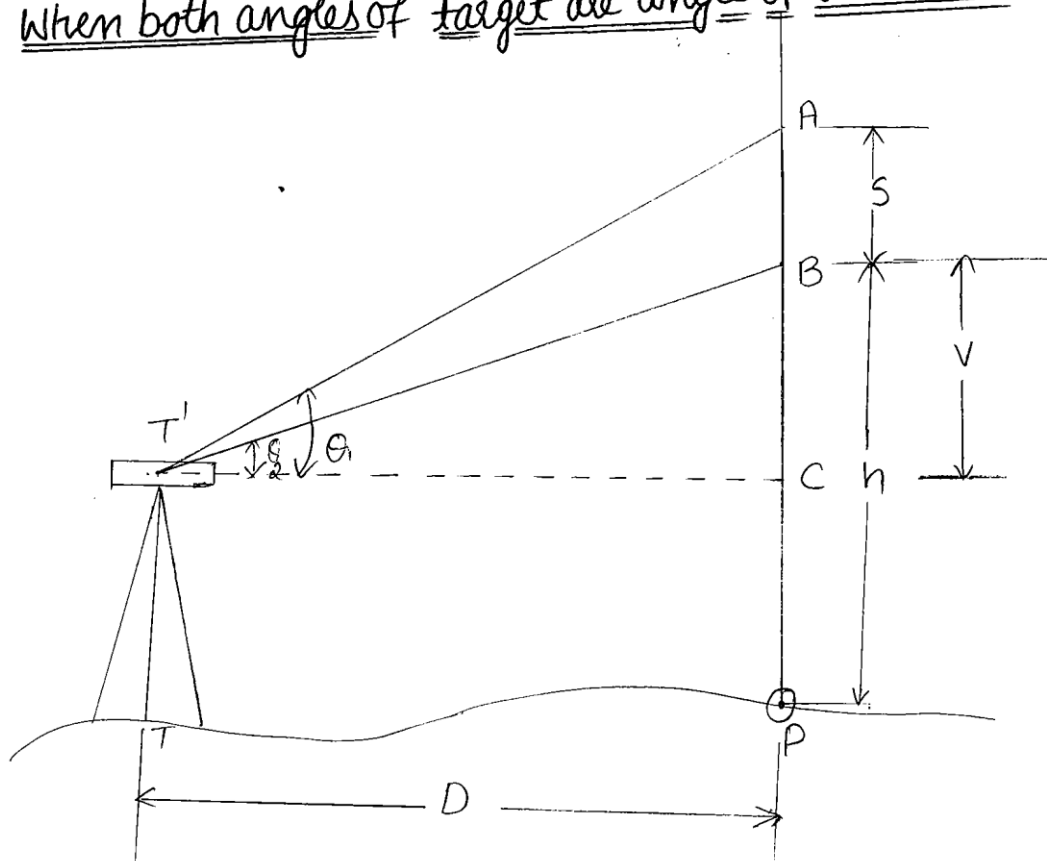
$$V = \left[ \frac{f}{i} \right] (s) \frac{\sin 2\theta}{2} + [f+d] \sin \theta \rightarrow (2)$$

$$RL \text{ of } P = RL \text{ of line of collimation} - V - h.$$

2) Tangential Tacheometry: This method is generally adopted when the theodolite is not provided with stadia diaphragm. In this method, the horizontal & vertical distances are calculated from the observed ~~at~~ vertical angles to two names fixed at a known distance apart on the staff. This method is not preferred because atleast two vertical angles are required to be taken. But in case of tacheometry only one vertical angle is sufficient.

Depending upon the vertical angles ~~are~~ three cases are adopted

Case-1: When both angles of target are angle of elevation:





In the above figure,

T = Instrument station

P = staff station

S = Distance between targets

V = Vertical distance b/w lower target & line of collimation.

h = Height of lower name above the staff station.

$\theta_1$  = Vertical angle made by upper target

$\theta_2$  = Vertical angle made by lower target

From  $\Delta^{\text{le}} AT'C$ ,

$$\tan \theta_1 = \frac{V+S}{D} \Rightarrow V+S = D \tan \theta_1 \rightarrow (1)$$

from  $\Delta^{\text{le}} BT'C$ ,

$$\tan \theta_2 = \frac{V}{D} \Rightarrow D \tan \theta_2 = V \rightarrow (2)$$

Substitute eq (2) in eq (1), we get

$$D \tan \theta_2 + S = D \tan \theta_1,$$

$$S = D \tan \theta_1 - D \tan \theta_2$$

$$S = D [\tan \theta_1 - \tan \theta_2]$$

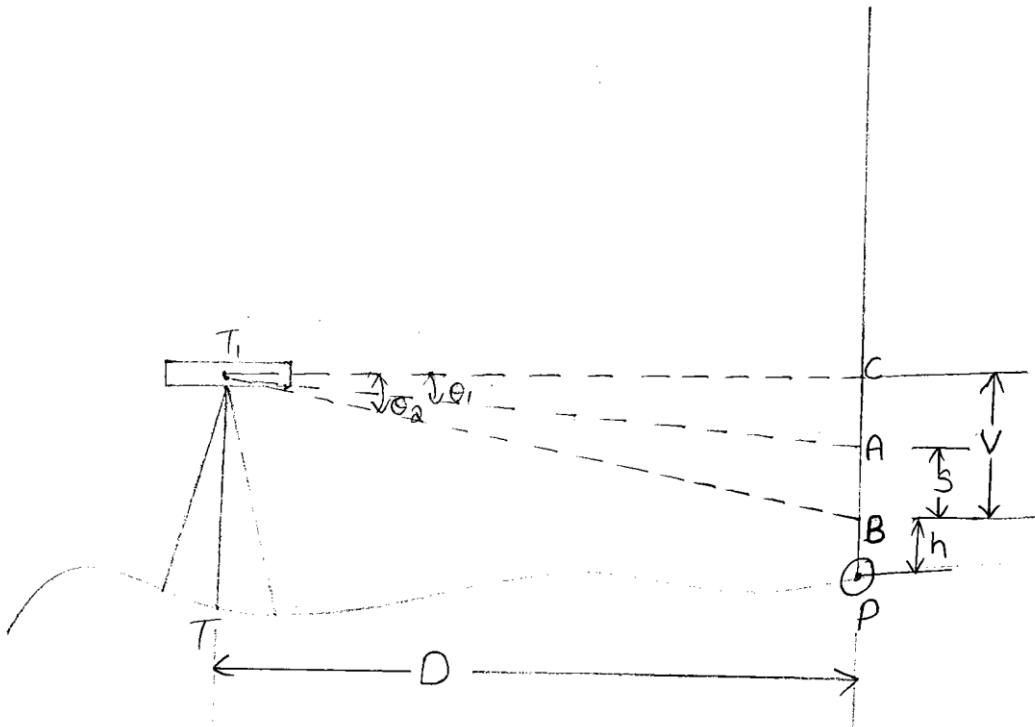
$$D = \frac{S}{[\tan \theta_1 - \tan \theta_2]} \rightarrow (3)$$

from eq (2),

$$V = D \tan \theta_2 \Rightarrow V = \frac{S \tan \theta_2}{[\tan \theta_1 - \tan \theta_2]} \rightarrow (4)$$

RL of P = RL of line collimation + V-h

Case-2: When both angles of targets are angle of depression:



In the above figure,

$$\text{From } \Delta^{ie} CT, A, \tan \theta_1 = \frac{V-S}{D} \Rightarrow V-S = D \tan \theta_1 \rightarrow (1)$$

$$\text{From } \Delta^{ie} CT, B, \tan \theta_2 = \frac{V}{D} \Rightarrow V = D \tan \theta_2 \rightarrow (2)$$

Substitute eq (2) in eq (1), then

$$D \tan \theta_2 - S = D \tan \theta_1,$$

$$D \tan \theta_2 - D \tan \theta_1 = S$$

$$D [\tan \theta_2 - \tan \theta_1] = S$$

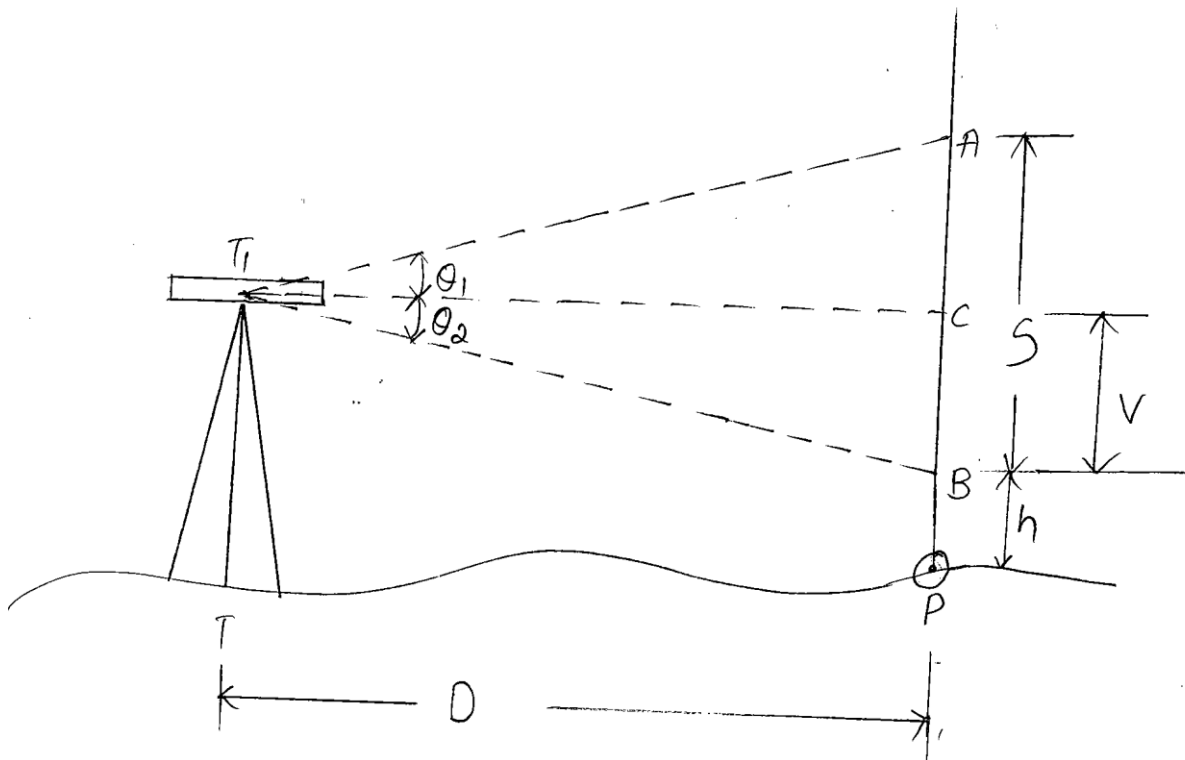
$$D = \frac{S}{[\tan \theta_2 - \tan \theta_1]} \rightarrow (3)$$

From eq (2),  $V = D \tan \theta_2$

$$V = \frac{S \tan \theta_2}{[\tan \theta_2 - \tan \theta_1]} \rightarrow (4)$$

RL of P = RL of line of collimation - V-h.

Case-3: When one angle is angle of elevation & other angle is angle of depression:



In the above figure,

From  $\Delta^{ie} AT_1C$ ,

$$\tan \theta_1 = \frac{S-V}{D} \Rightarrow S-V = D \tan \theta_1$$

$$D \tan \theta_1 = S-V \rightarrow (1)$$

From  $\Delta^{ie} CT_1B$ ,

$$\tan \theta_2 = \frac{V}{D}$$

$$D \tan \theta_2 = V \rightarrow (2)$$

By substituting the value of 'v' from (2) in (1), we get

$$S - D \tan \theta_2 = D \tan \theta_1$$

$$S = [D \tan \theta_1 + D \tan \theta_2]$$

$$S = D [\tan \theta_1 + \tan \theta_2]$$

$$D = \frac{S}{[\tan \theta_1 + \tan \theta_2]} \rightarrow (3)$$

from eq (2),

$$V = D \tan \theta_2$$

$$V = \frac{S \tan \theta_2}{[\tan \theta_1 + \tan \theta_2]} \rightarrow (4)$$

$\therefore$  RL of P = RL of line of collimation - V-h.