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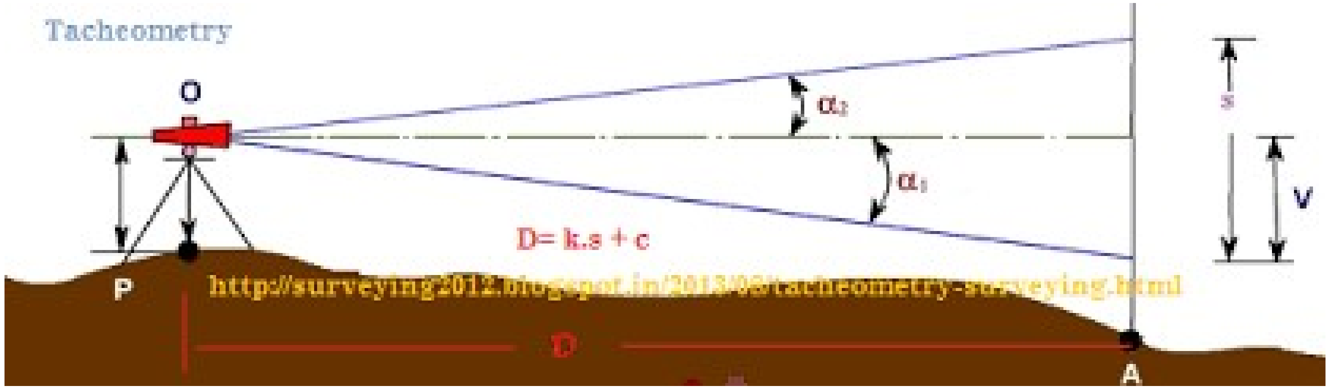
Module - 6
Tacheometric Surveying



Subject:- Surveying Code:-3140601	Prepared by: Asst.Prof. Janki Patel (Civil Department, ACET)	AMIRAJ COLLEGE OF ENGINEERING & TECHNOLOGY

Introduction

- Tacheomertic is the branch of the surveying in which the horizontal distance between the instrument station to the staff station and also the vertical distance of a point are determine.
- Chaining operation is completely eliminated in this method.
- Less accurate as compare to chaining.

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Use of Tacheometry

- When obstacle (Step, broken ground, stretches of water)
- In rough country both horizontal and vertical measurement are tedious and chaining is inaccurate, difficult and slow.
- This method is used for find out the contour.

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Purposes of Tachometry

- Prepare contour map.
- Used in hydrographic survey.
- Location survey for road, railway, reservoir etc.
- Checking of the distance which measured with the help of the tap.
- To measure the horizontal distance at which the distance measured by the tap or chain is difficult.

Principle of Tacheometry

- The principle of techeometry is based on the property of isosceles triangle.

- Statement :-
- In isosceles triangle the ratio of the perpendiculars from the vertex on their bases

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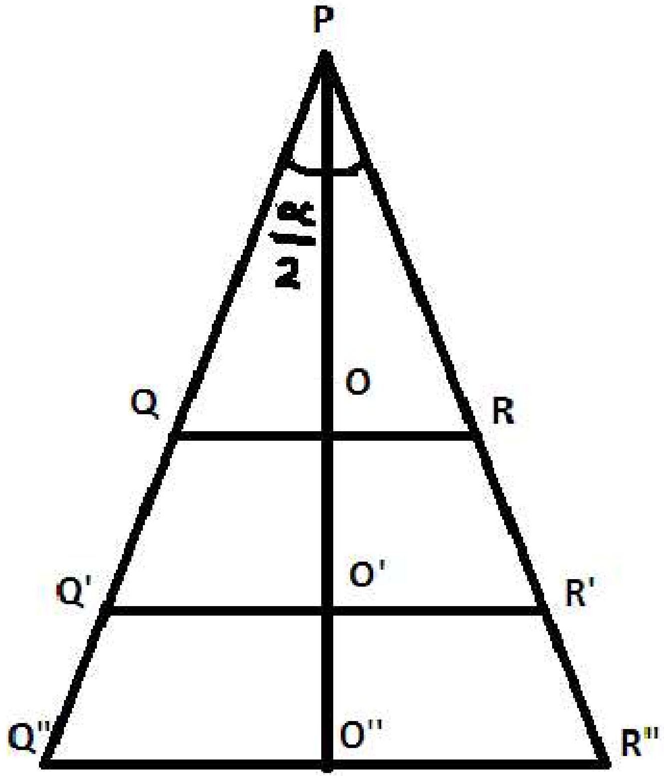
- Here; PQR, PQ’R’, PQ”R” are all isosceles triangle whose base are QR, Q’R’ and Q”R” and their vertex is at P. and here PO, PO’ and PO” are the perpendicular to their respective bases.



$$\frac{PO}{QR} = \frac{PO'}{Q'R'} = \frac{PO''}{Q''R''} = \text{constant K} = 2\cot\frac{\alpha}{2}$$

here constant K = $\frac{f}{i}$

Instrument used

Instrument

- A TECHEOMETER
- A LEVELLING STAFF

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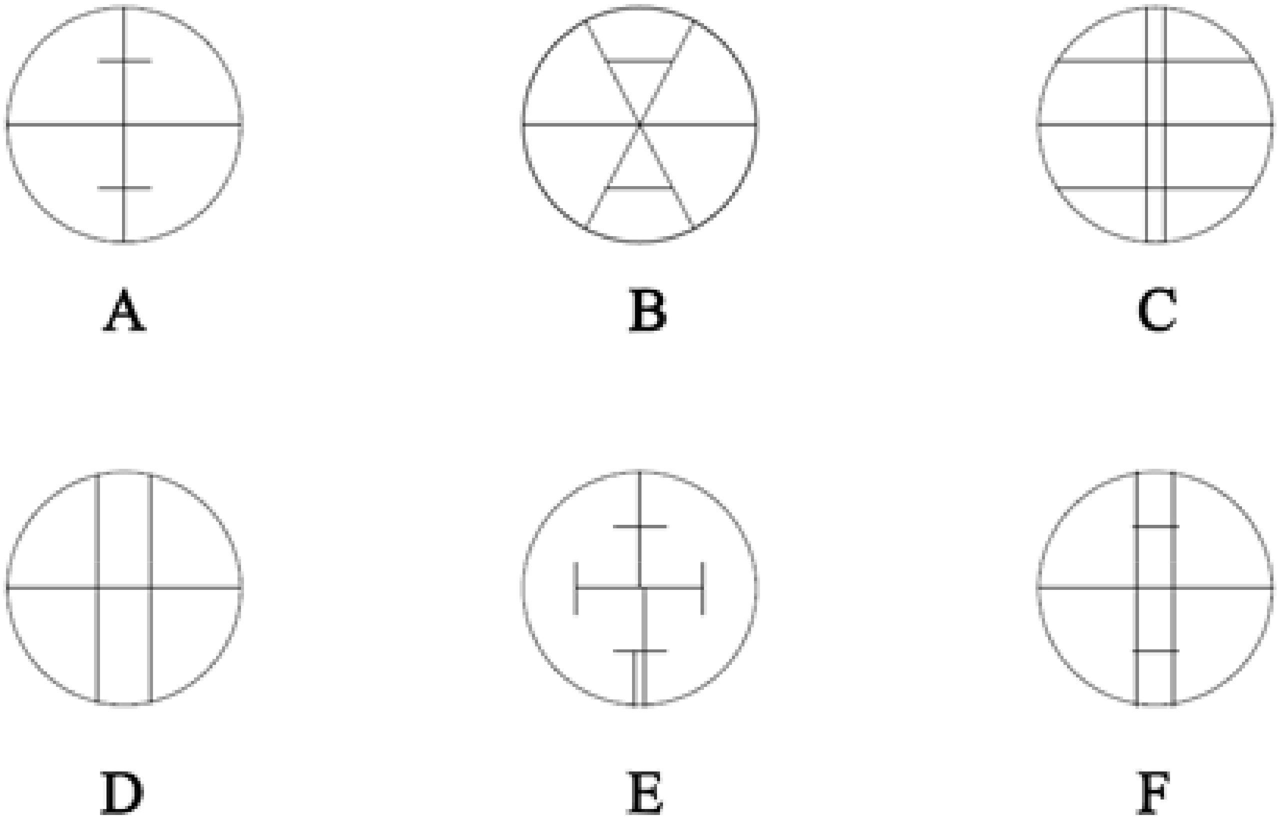
A Tacheometer

- A tacheomtry is usually transit theodolite having a stadia diaphragm.
- The diaphragm is equipped with two horizontal hairs called stadia hair in addition to regular cross hair.
- The additional hairs are equidistance from the central.
- The diaphragm commonly used in second slide.



STADIA DIAPHRAGMS

Levelling Staff or Stadia Rod

- The stadia rod or staff used with tacheometry may be usual type of levelling staff having least count of 0.005m.
- Stadia rod is usually in one piece but for easy transport it may be folding.
- Width of the staff is 5cm to 15cm.
- Height may be 3m to 5m.
- It is graduated in meter, Centimeter.
- The graduation must be simple and clear.

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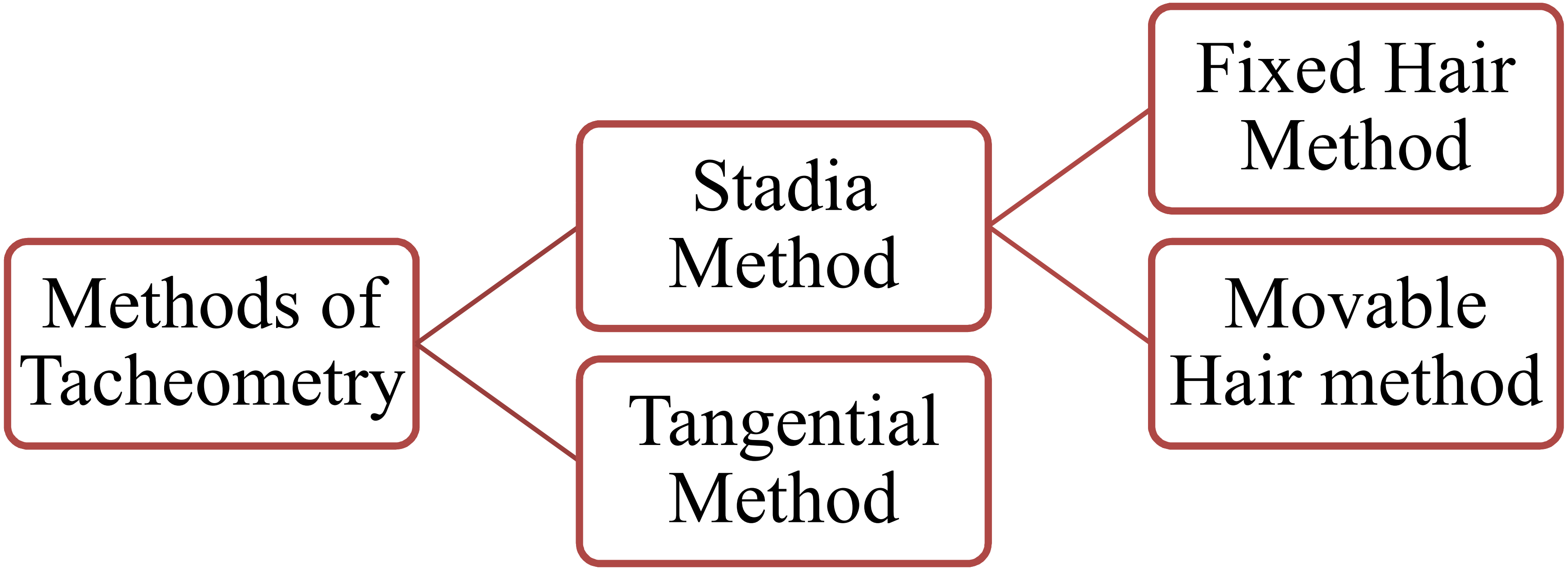
Methods of Tacheometry



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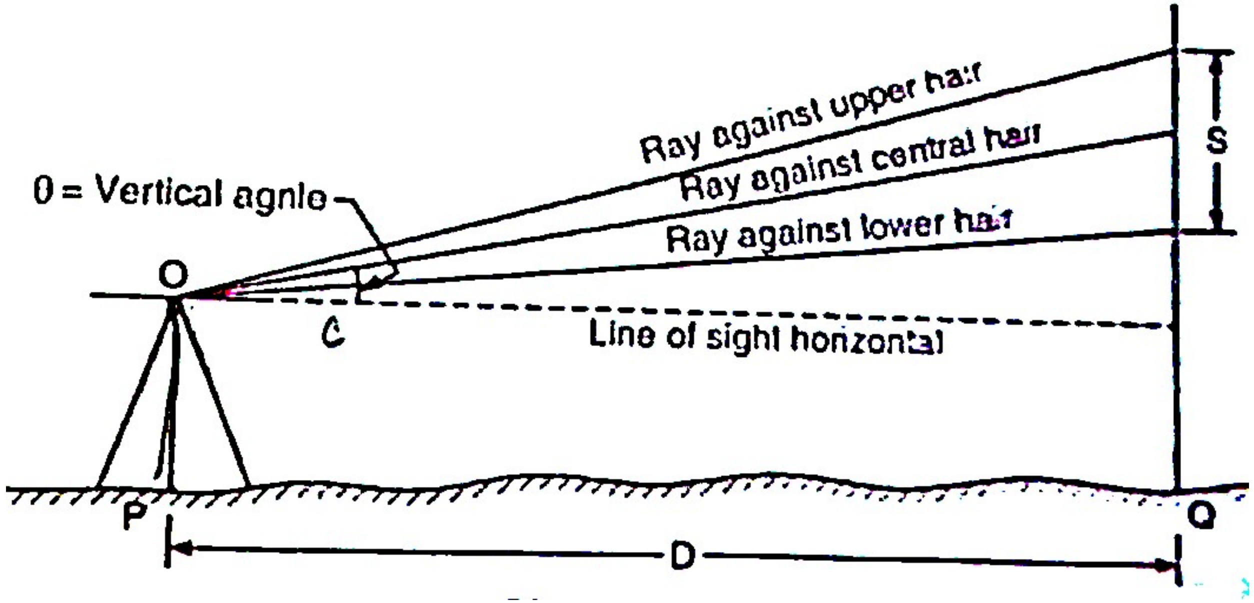
Stadia Method

- In the stadia method, a tacheometry is setup at a station P and a staff is held at another station Q.



- The staff intercept (S) between the upper stadia hair and the lower stadia hair is measured.
- The vertical angle (**θ**) is also measured.
- The horizontal distance D between P and Q, and the difference of elevation of P and Q is calculated from the staff intercept (S) and the vertical angle (**θ**) by using formula.

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Fixed hair method

- The upper and lower stadia hair is fixed. (stadia interval is fixed)
- The distance between the upper stadia hair and lower stadia hair, called stadia interval (i) is fixed.
- The value of the staff interval (S) varies with the distance.
- Generally stadia method means fixed hair method.

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Movable hair method

- In this method the stadia hairs (i) is not fixed.
- Stadia hairs can be moved or adjusted by the micrometer screws.
- In this method the staff intercept (S) is fixed.
- The stadia interval measured corresponding to the staff intercept.

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Difference

Fixed hair method

- Stadia interval (i) is fixed.
- Staff intercept (S) is not fixed.
- Fixed hair method is most commonly used to take staff reading speedy.
- Tacheometry and staff are used.

Movable hair method

- Stadia interval (i) is not fixed.
- Staff intercept (S) is fixed.
- This method is not generally used because unconvenient to measure the stadia interval accurately.
- Substance theodolite and staff are used.

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Tangential Method

- In this method diaphragm of the tacheometer is not provided with the stadia hair.
- Reading are taken by the central horizontal hair.
- Staff with two targets at a fixed distance (S) is used for taking reading.
- The vertical angles θ_1 & θ_2 are measured.
- The vertical angle and the fixed distance (S) are used to determine the horizontal distance (D).

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Difference

Stadia hair method

- Diaphragm of the tacheometer is provided with three stadia hair.
- Looking through the telescope the three stadia hair readings taken.
- One vertical angle is observed.
- This method is most commonly used in practice.

Tangential method

- Diaphragm of the tacheometer is not provided with stadia hair.
- The readings are taken by the single horizontal hair adjust upper and lower target respectively.
- Two vertical angle is observed.
- This method is not commonly used in practice

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Fixed hair method

- There are main three cases for finding the distance and Elevation.
- Case : 1 When the line of sight is horizontal and staff is held Vertical.
- Case : 2 When the line of sight is inclined and staff is held Vertical. ((a) considering angle of elevation $+\theta$ (b) considering angle of depression $-\theta$)
- Case : 3 When the line of sight is inclined but staff is held normal to the line of sight.

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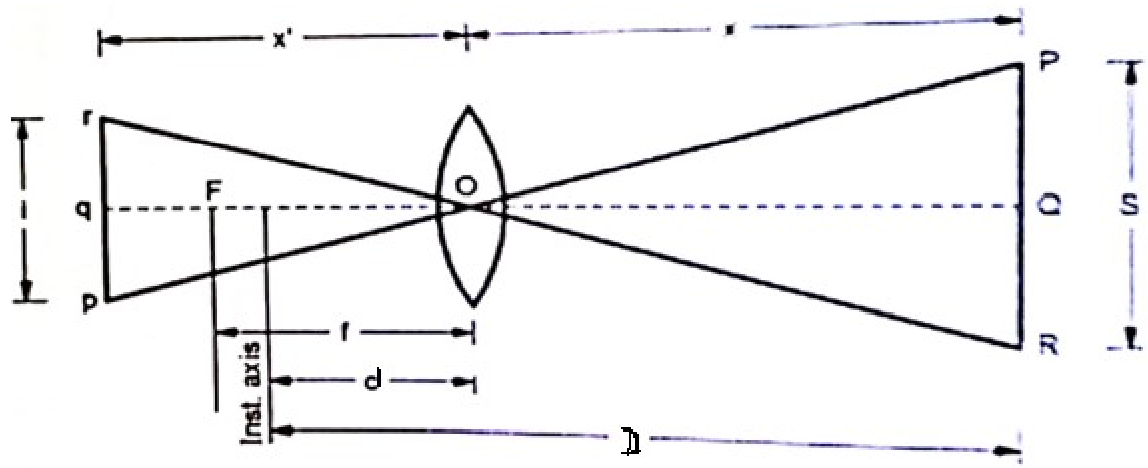
Case : 1 When the line of sight is horizontal and staff is held Vertical.

Horizontal Distance Formula



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- O = The optical center of the object glass.
- p,q,r = the top, axial, and bottom hair reading.
- pr = i = Length of the image.
- f = Focal length of the image glass.
- S = Staff in intercept on PQ.
- x = Horizontal distance from O to the staff.
- x' = Horizontal distance from O to the plane of the hairs.
- d = Horizontal distance from O to the vertical axis of the instrument.
- D = Horizontal distance from axis to the staff.

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- The rays Pop and Qoq passing through O are the straight lines.
- Triangle POQ and poq are similar hence $\frac{x}{x'} = \frac{s}{i}$

But x and x′ are conjugate focal length (distance)

$$\frac{1}{f} = \frac{1}{x'} + \frac{1}{x}$$

Multiplying both by fx

$$x = \frac{x}{x'}f + f$$

Substituting $\frac{x}{x'} = \frac{s}{i}$

$$x = \frac{s}{i}f + f$$

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Add c on both the side

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

But x + d = D

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

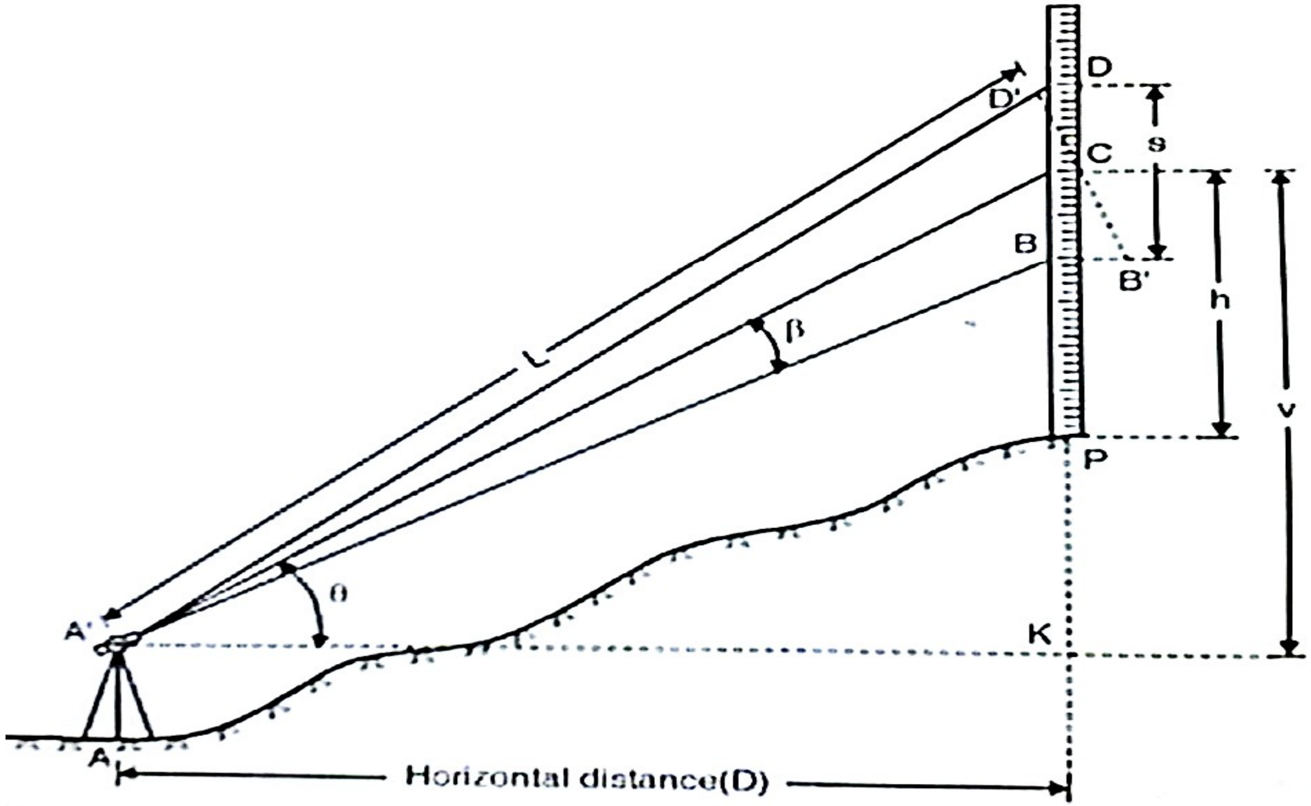
The constant $K = \frac{f}{i}$ is known as the multiplying constant or stadia interval factor and the constant $C = f + d$ is known as the additive stadia of the instrument.

Vertical Distance formula

- When the line of sight is horizontal V = 0

Case : 2 When the line of sight is inclined and staff is held Vertical.

- Considering angle of elevation +θ



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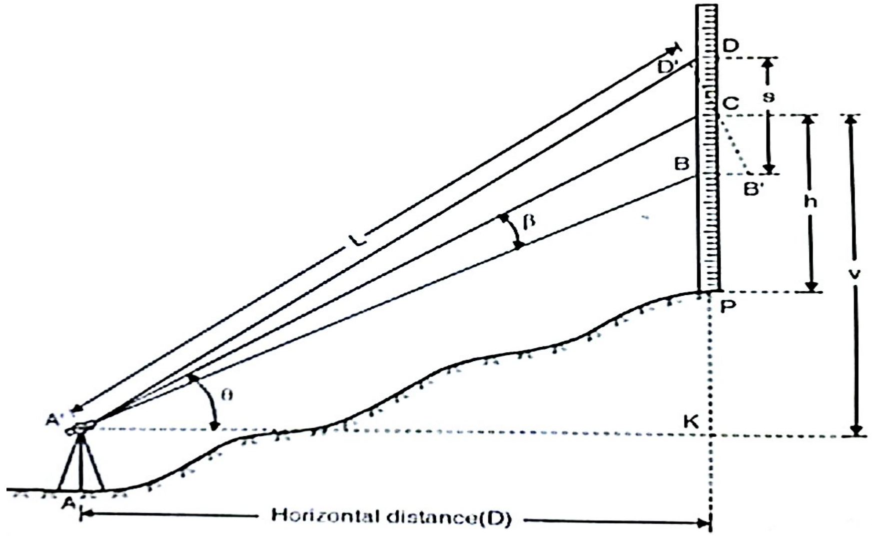

- Let A is the instrument station
- A’ is the position of the instrument axis
- P is the staff station
- DBC are the points on the staff cut by the hair of the diaphragm.
- ∠CA’K = is an inclined of the line of sight A’C to the horizontal
- BD = S is the staff intercept (difference between the top and bottom hair reading)

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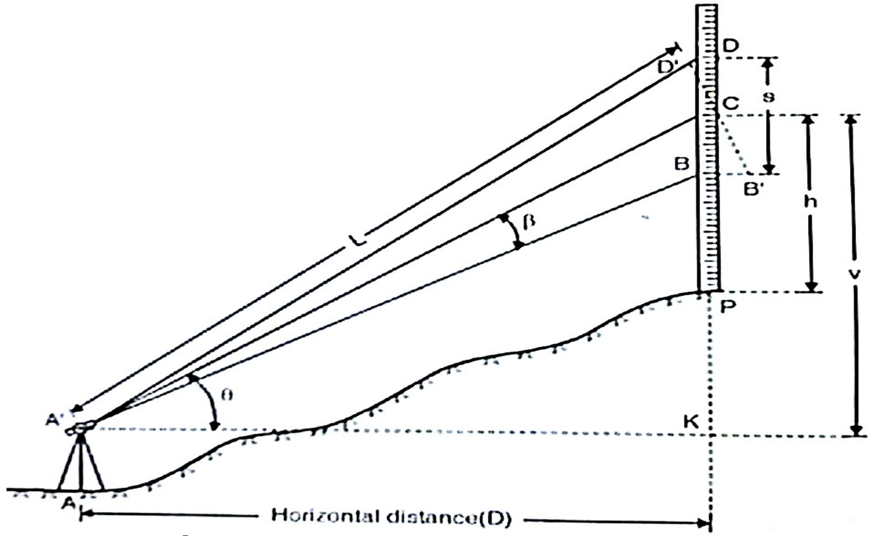

- CP = h is the central hair or axial hair reading.
- A'C = L is the distance along the line of collimation from A' to C
- A'K = D is the horizontal distance from the instrumental to the staff station P
- CK = V is the vertical distance from the instrument axis to point C (Central hair reading)
- Draw a perpendicular line through C to the line of sight A'C so that it cuts A'D in D' and A'B in B' is the projection of DB perpendicular to A'C as shown in figure
- Line BD is perpendicular to the line A'K and B'D' is perpendicular to A'C

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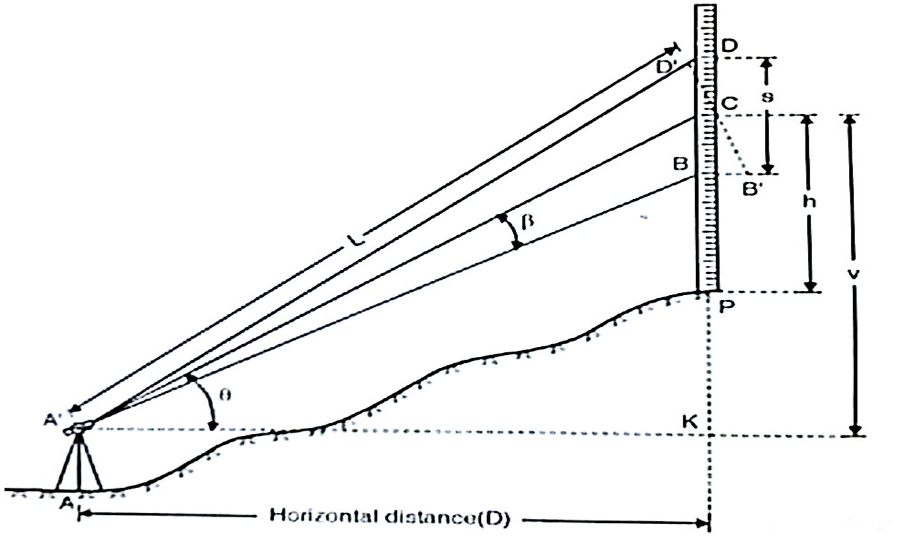
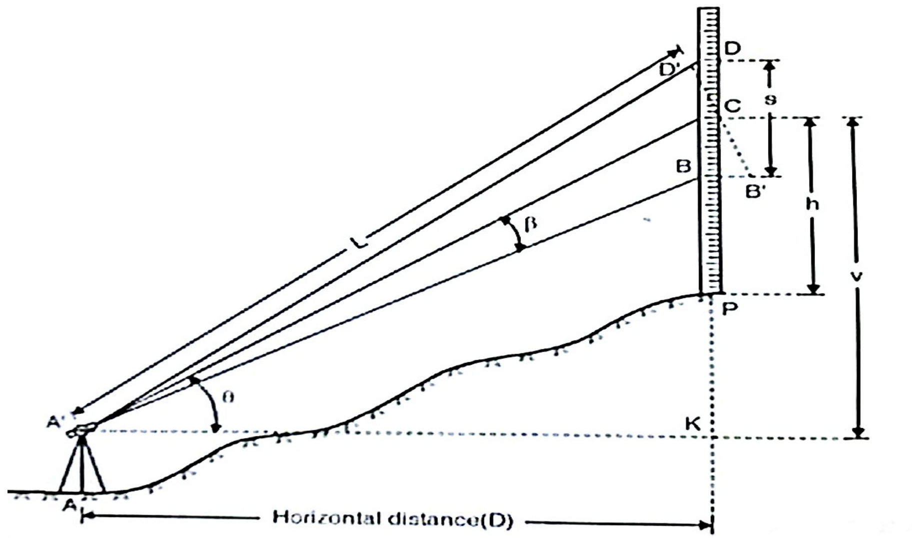


- ∠DCD' = ∠BCB' = and ∠DA'C = ∠BA'C = β
- ∠A'D'C = $90^0 - β$
- Angle ∠DD'C = $180^0 – (90^0 – β)$
- $= 90^0 + β$
- Angle ∠BB'C = $90^0 – β$

- From ΔS DD'C and BB'C
- D'C = DC Cosθ
- B'C = BC Cosθ
- D'C + B'C = DC Cosθ + BC Cosθ
- D'B' = (DC + BC) Cosθ
- D'B' = DB Cosθ
- D'B' = S Cosθ



Horizontal Distance D

Horizontal Distance D,When the line of sight is horizontal, then:

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

Here DB = S

So,

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

Now inclined distance A'C = $\mathbf{L = \frac{f}{i}(D'B') + (f + d)}$

But here D'B' = S Cosθ

$$\mathbf{L = \frac{f}{i}(S\ Cos\theta) + (f + d)}$$

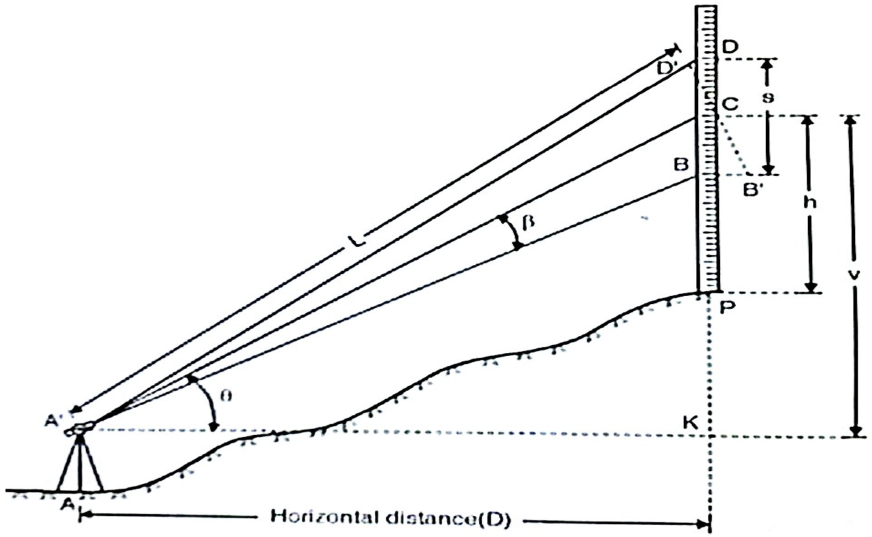
Horizontal distance $D = L\ Cos\theta$

$$D = L = \frac{f}{i}(S\ Cos\theta)(Cos\theta) + (f + d)(Cos\theta)$$

$$D = \frac{f}{i} S\ Cos^2\theta + (f + d) Cos\ \theta$$

Here $\frac{f}{i} = K$ and $(f + d) = C$

$$\mathbf{D = \frac{f}{i} S\ Cos^2\theta + (f + d) Cos\ \theta}$$



Vertical distance

From $\Delta A'CK$, $CK = V = L\ Sin\theta$

Put the value of $L = \frac{f}{i}(S\ Cos\theta) + (f + d)$

$$V = \frac{f}{i}(S\ Cos\theta)(Sin\theta) + (f + d)(Sin\theta)$$

$$V = \frac{f}{i}\frac{S\ Sin\ 2\theta}{2} + (f + d)\ Sin\theta$$

Here $\frac{f}{i} = K$ and $(f + d) = C$

So, $V = \frac{KS\ Sin2\theta}{2} + (C)\ Sin\theta$

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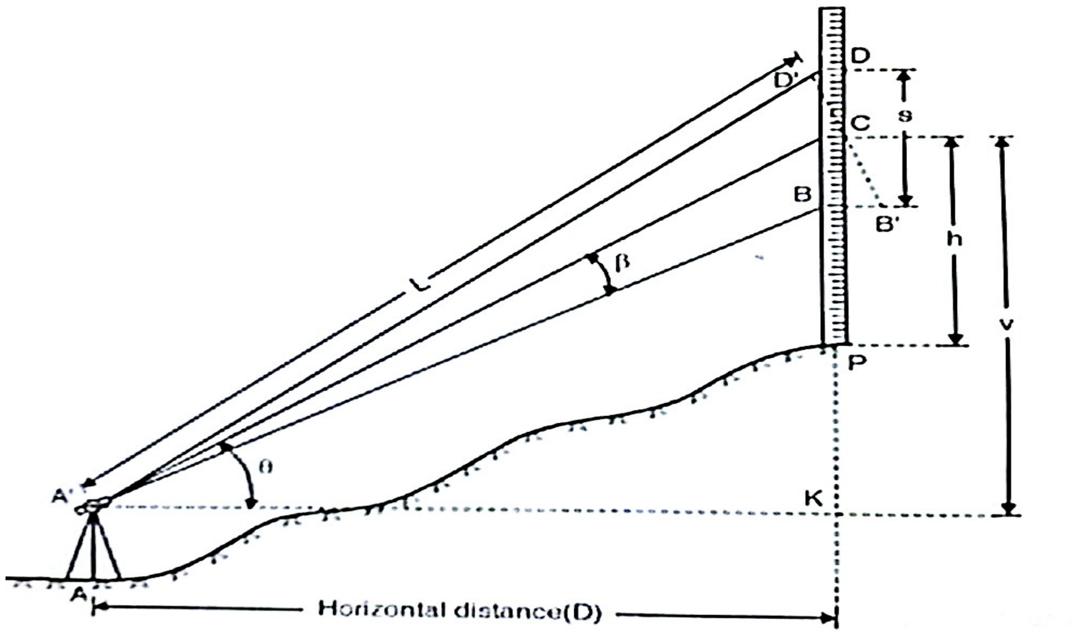
* Elevation of the staff station for angle of elevation

- Elevation of staff station= Elevation of instrument + R.L. of B.M. + V- h



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*** Elevation of the staff station for the angle of depression.**

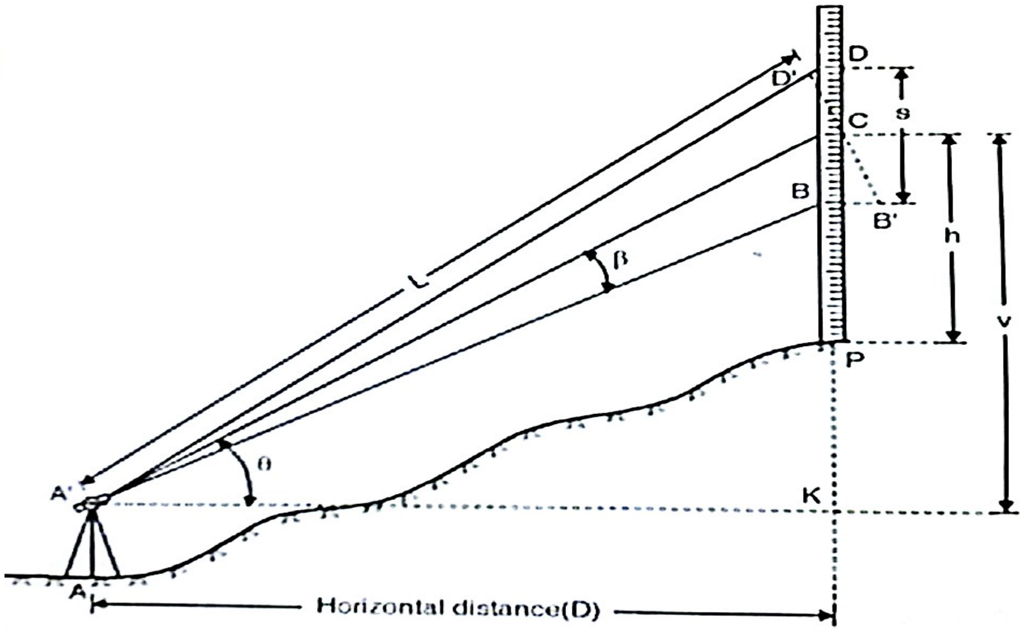
- Elevation of staff station= Elevation of instrument + R.L. of B.M. - V- h

- Horizontal Distance D:

$$D = \frac{f}{i} S \cos^2\theta + (f + d)\cos\theta$$

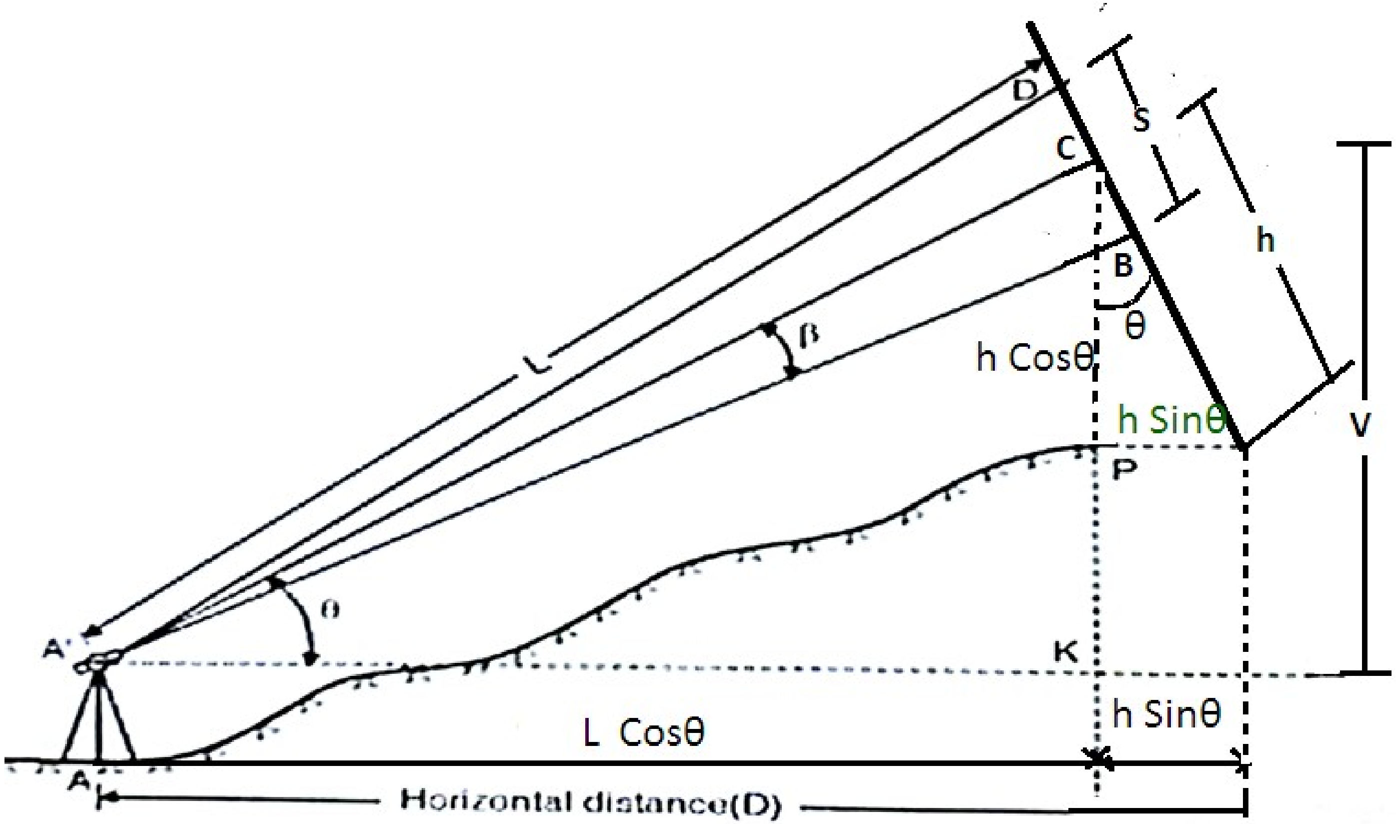
- Vertical Distance V

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



Case : 3 When the line of sight is inclined and staff is held normal to the line of sight.

Considering angle of Elevation +θ



- Horizontal distance formula :-

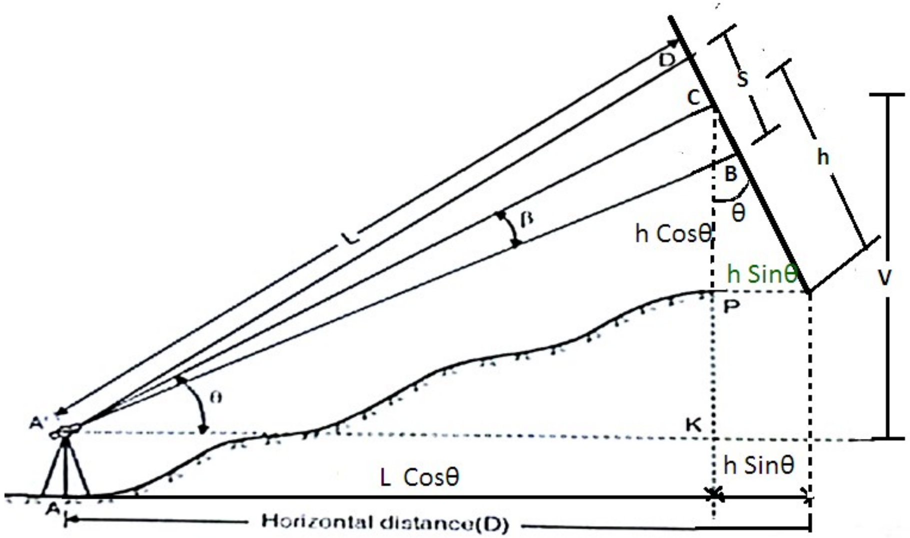
$$D = \frac{f}{i}(S) + (f + d)$$

From the figure the Horizontal distance D :-

$$D = L\,Cos\theta + h\,Sin\theta$$

$$= (KS + C)\,Cos\theta + h\,Sin\theta$$

$$= KS\,Cos\theta + C\,Cos\theta + h\,Sin\theta$$



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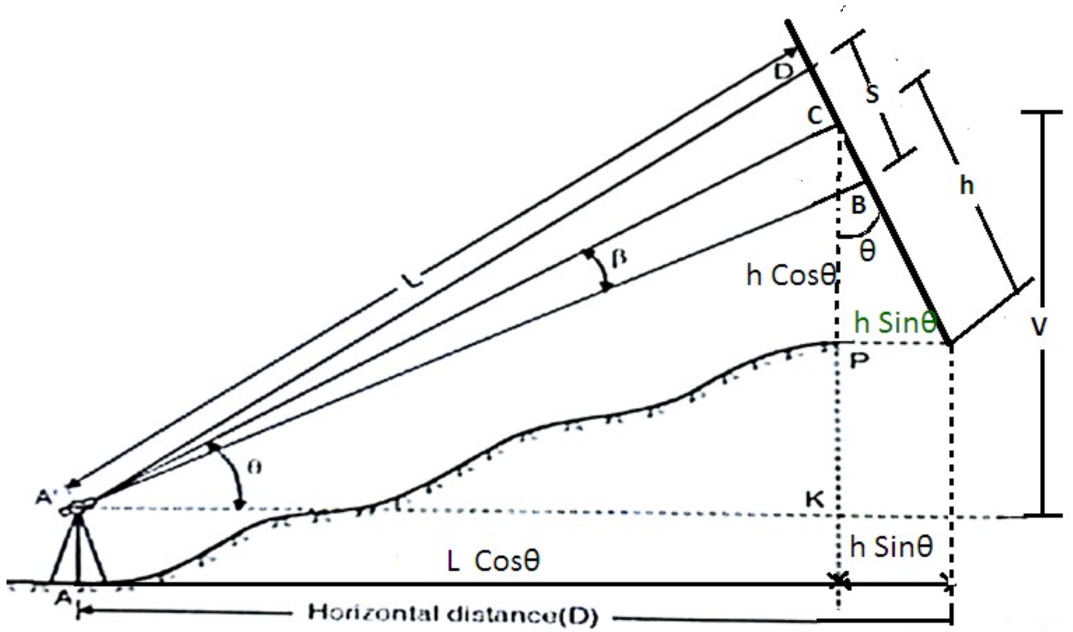
- Vertical distance formula :-
- Vertical distance $V = L\ Sin\theta$

$$= (KS + C)\ Sin\theta$$

$$= KS\ Sin\theta + C\ Sin\theta$$



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- Elevation of the staff station :-
- Elevation of staff station= Elevation of instrument + R.L. of B.M. + V- h Cosθ

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- Considering angle of depression – θ
- Horizontal distance formula:-
- Horizontal

  distance $D = L \cos\theta - h \sin\theta$

  $= (KS + C) \cos\theta - h \sin\theta$

  $= KS \cos\theta + C \cos\theta - h \sin\theta$

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- Vertical distance formula :-

  Vertical distance $V = L \sin\theta$

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

  $= KS \sin\theta + C \sin\theta$

- Elevation of the staff station :-

Elevation of staff station = Elevation of instrument + R.L. of B.M. - V- h $\cos\theta$

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Tangential method

- This method is used only when the theodolite is simple and transit type.
- This method is also used when the staff is far away from the instrument.
- In this method the staff consist of two vanes or target (S) 2m to 3 m apart.
- The vertical angle θ_1 and θ_2 are measured in theodolite

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- There are main three cases for finding the Distance and Elevation.
- Case : 1 Both the angle are angles of elevation in this case, staff is held vertically.
- Case : 2 Both the angle are angles of depression in this case, staff is held vertically.
- Case : 3 When the one angle is the angle of elevation and the another angle is the angle of depression and the staff held vertical.

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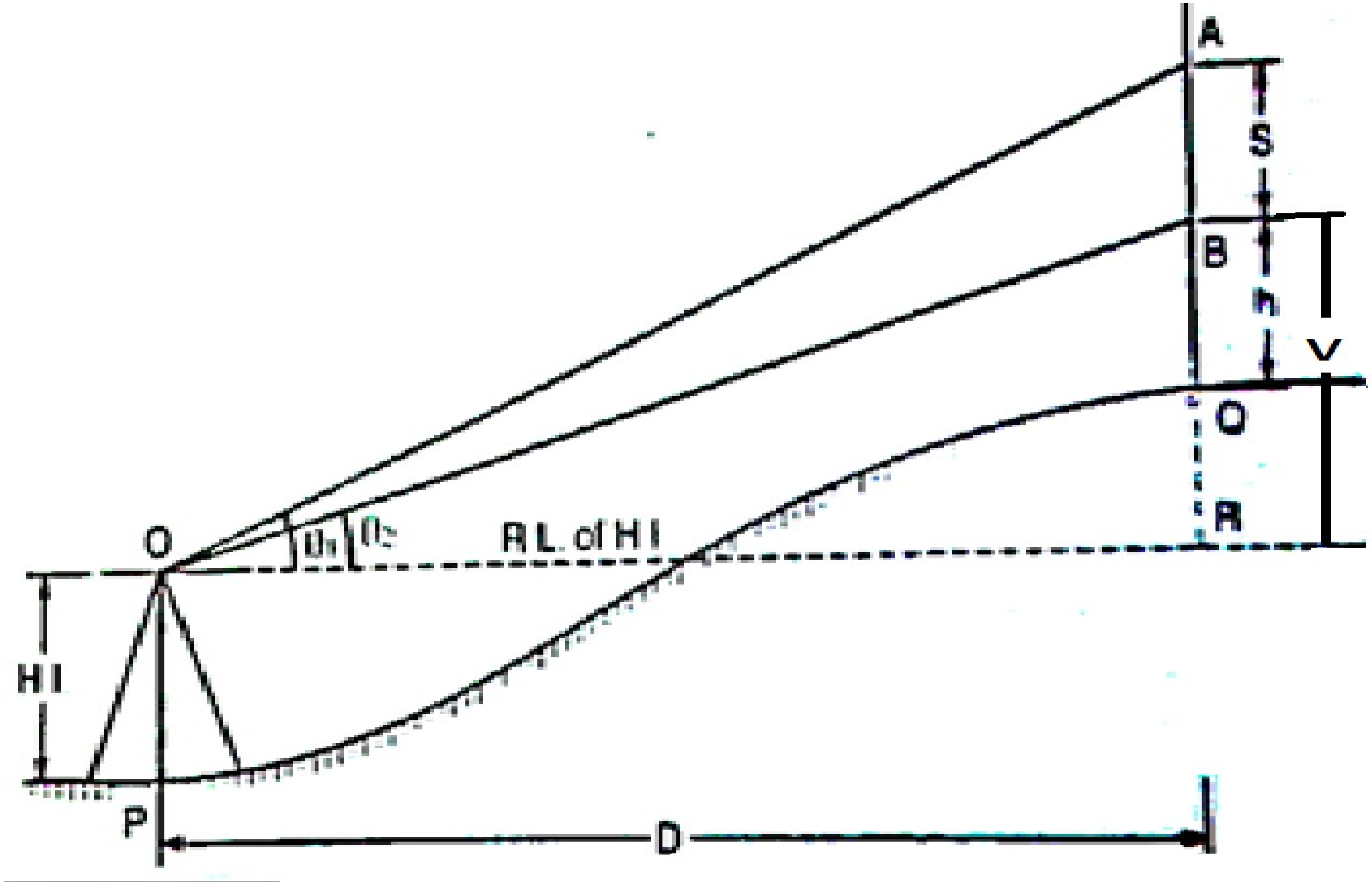
Case : 1 Both the angle are angles of elevation in this case, staff is held vertically.



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- From the fig.

$V + S = D \tan\theta_1$

$V = D \tan\theta_2$

$S = D \tan\theta_1 - V$

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

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

$$D = \frac{S}{(\tan\theta_1 - \tan\theta_2)}$$

$$V = \frac{S \tan\theta_2}{(\tan\theta_1 - \tan\theta_2)}$$

R.L of Q = R.L of H.I + V - h

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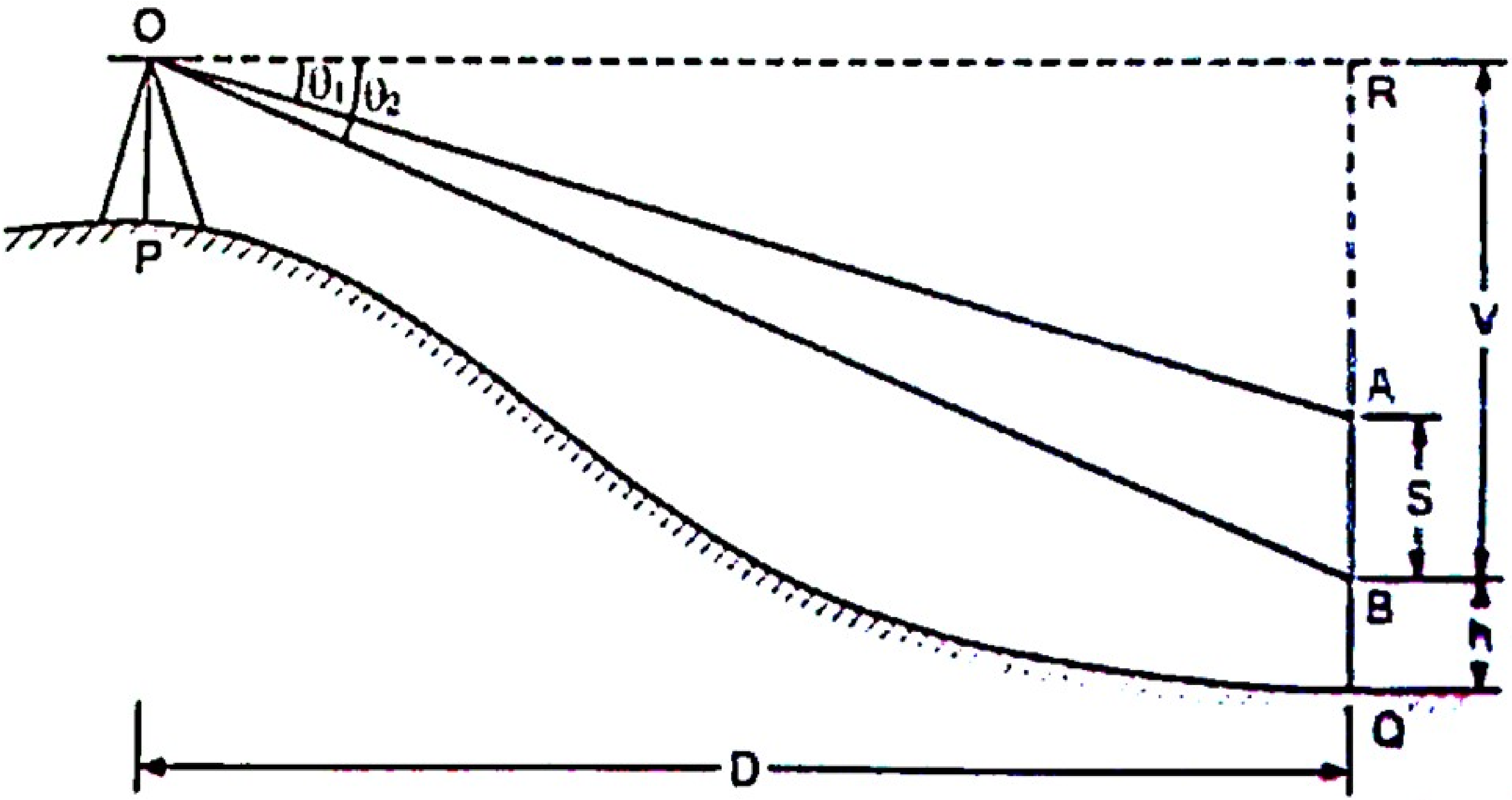
Case : 2 Both the angle are angles of depression in this case, staff is held vertically.



- From the fig.

$V - S = D \tan\theta_1$

$V = D \tan\theta_2$

$S = V - D \tan\theta_1$

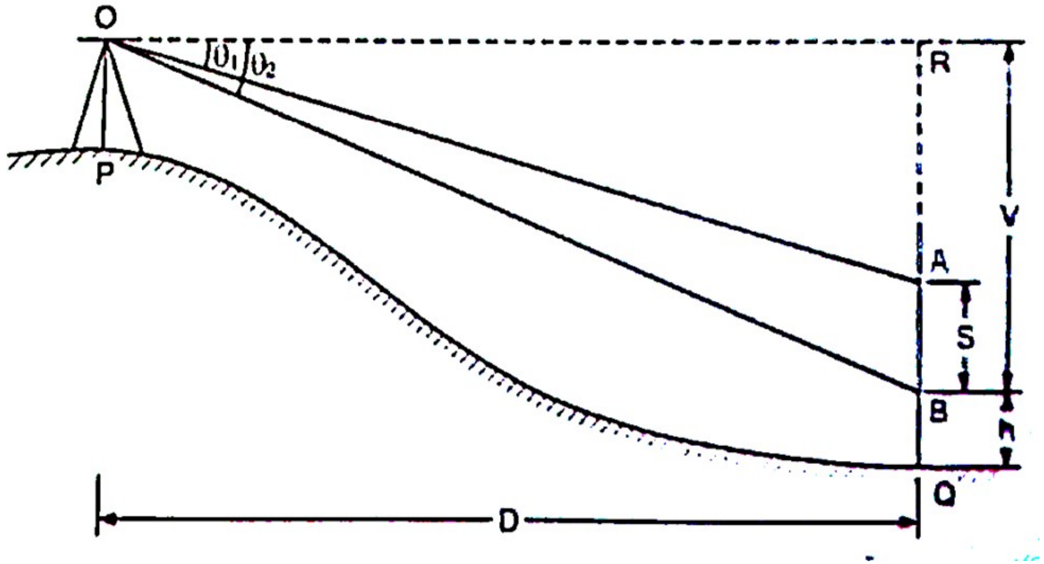
$S = D \tan \theta_2 - D \tan \theta_1$

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

$$D = \frac{S}{(\tan\theta_2 - \tan\theta_1)}$$

$$V = \frac{S \tan\theta_2}{(\tan\theta_2 - \tan\theta_1)}$$

R.L of Q = R.L of H.I - V - h



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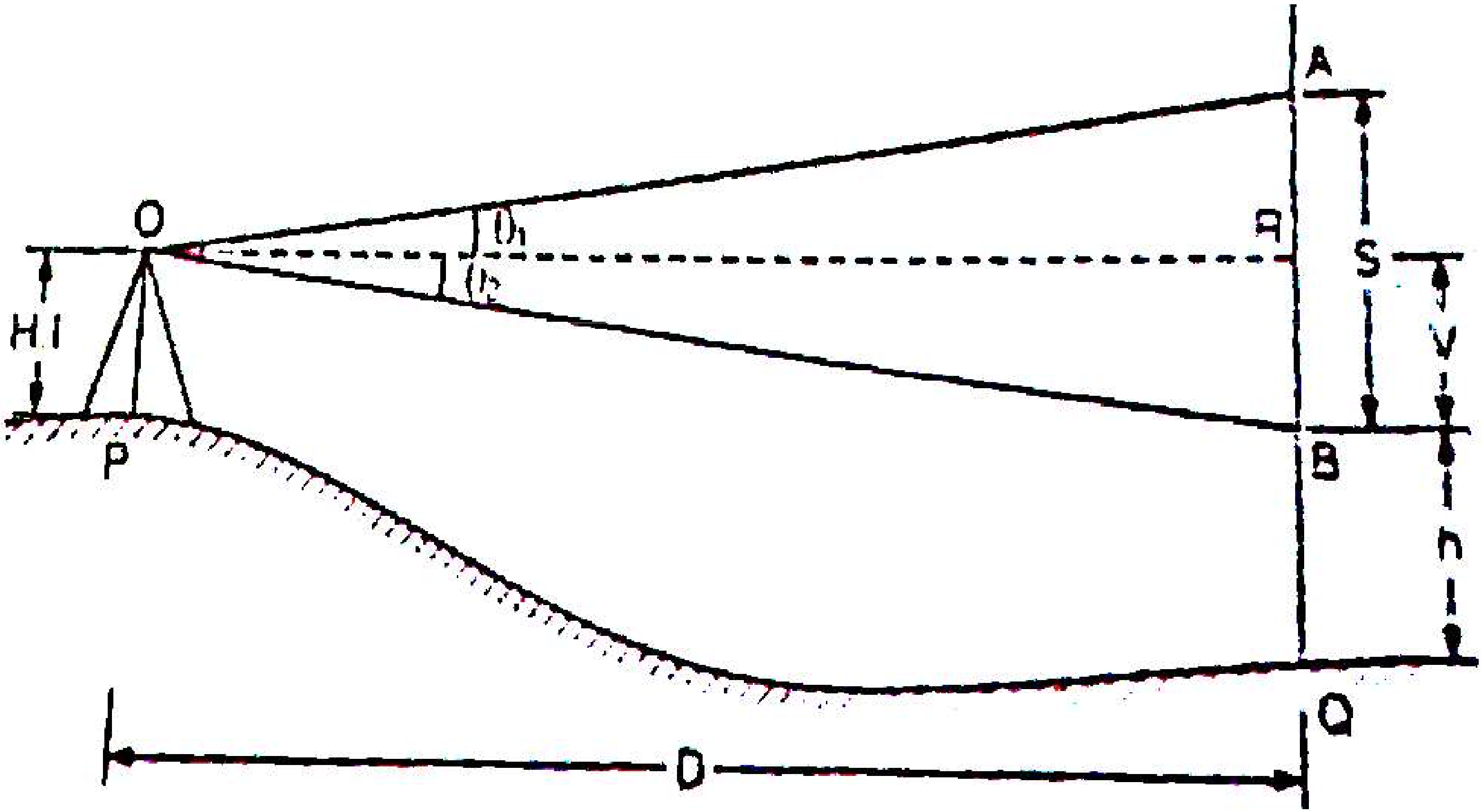
Case : 3 When the one angle is the angle of elevation and the another angle is the angle of depression and the staff held vertical.



- From the fig.

$S - V = D \tan\theta_1$

$V = D \tan\theta_2$

$S = V + D \tan\theta_1$

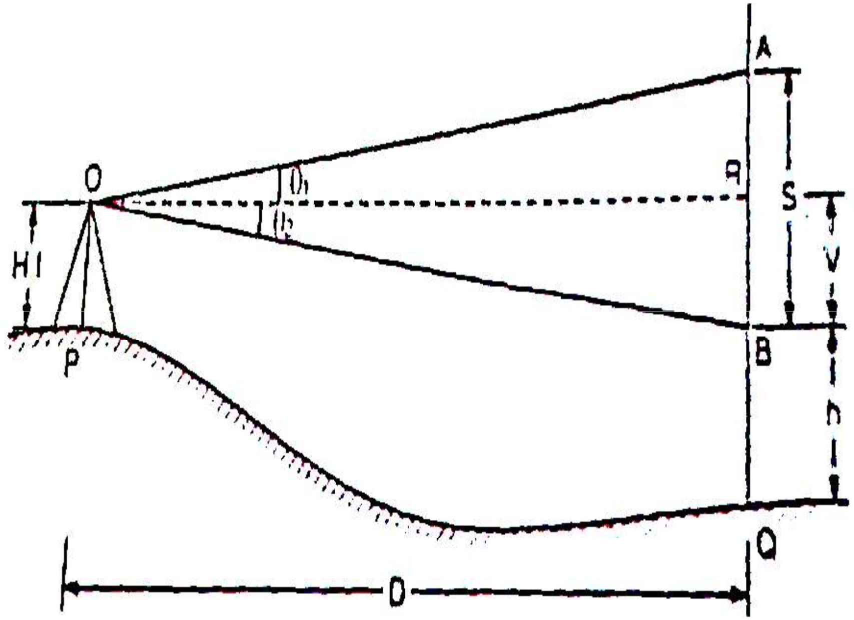
$S = D \tan \theta_2 + D \tan \theta_1$

$S = D (\tan\theta_2 + \tan\theta_1)$

$$D = \frac{S}{(\tan\theta_2 + \tan\theta_1)}$$

$$V = \frac{S \tan\theta_2}{(\tan\theta_2 + \tan\theta_1)}$$

R.L of Q = R.L of H.I - V - h



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Disadvantages of the tangential method

- Two vertical angles are measured.
- It require comparatively more time.
- This method is very tedious.