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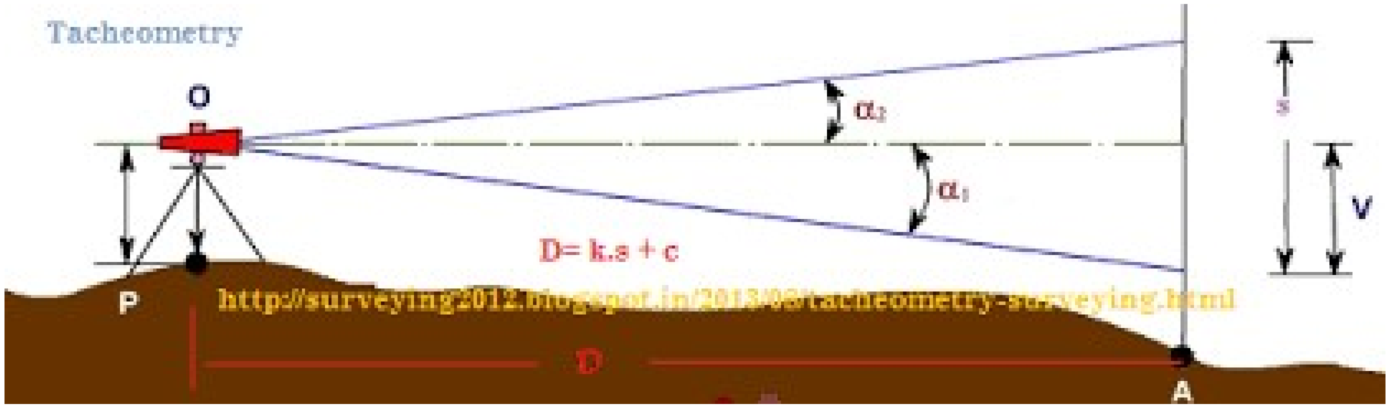
Module - 6
Tacheometric Surveying (Example)



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

Formulas to Solve Examples

- Fixed Hair Method
- Case : 1 (When the line of sight is horizontal and staff is held Vertical)
- **Horizontal distance D = KS + C**

Here D = Horizontal Distance
S = Staff intercept
K = Multiplying Constant
C = Additive constant

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Example : 1

- The Following Reading were taken with a tacheometer on to a vertical staff, Calculate tacheometric constant

Horizontal Distance	Stadia Reading (m)		
45	0.885	1.110	1.335
60	1.860	2.160	2.460

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

$D_1 = KS_1 + C$

$45 = K\ (1.335 – 0.885) + C$

$45 = K\ (0.45) + C$ ....(3)

$D_2 = KS_2 + C$

$60 = K\ (2.460 – 1.860) + C$

$60 = K\ (0.6) + C$

$C = 60 - K\ (0.6)$ ....(4)

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Now put the value of eq 4 in eq 3

45 = K (0.45) + C ....(3)

45 = K (0.45) + 60 - K (0.60)

45 – 60 = - 0.15 K

- 15 = - 0.15 K

K = 100

Put the value of K in Eq no 3

45 = K (0.45) + C

45 = 100 (0.45) + C

C = 0

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Example 2

The stadia reading with horizontal sight at a vertical staff held 50 m away from the tacheometer were 1.385 and 2.380. the focal length of the object glass was 25cm. The distance between the object glass and trunion axis of a tacheometer was 15 cm. Calculate the stadia interval.

$D = KS + C$

$D = (f/i)\ S + (f + d)$ .... (1)

Here $D = 50m$

$S = 2.380 – 1.385 = 0.995$

$f = 25cm = 0.25m$

$d = 15cm = 0.15m$

Put the all value in equation no 1

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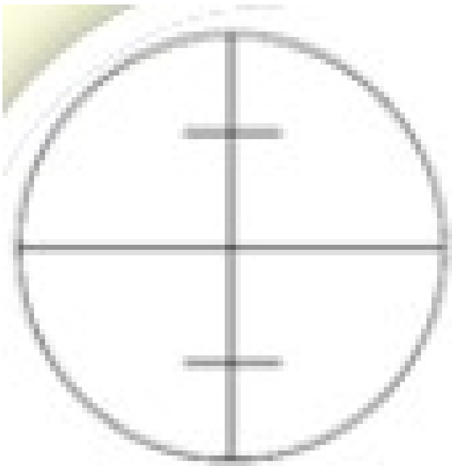
$$50 = ((0.25 \times 0.995) / i) + (0.25 + 0.15)$$

$$i = 0.005 \text{ m}$$

$$i = 5 \text{ mm}$$



Example 3

- A staff held vertically at a distance of 50 m and 100m from the centre of the theodolite with a stadia hair, the staff intercept with the telescope is 0.500 and 1.000 respectively. The instrument was then setup over a station P of RL 1850.95 m and the total height of instrument was 1.475m. The hair reading on a staff held vertically at station Q were 1.050, 1.900 and 2.750 with the line of sigth horizontal. Calculate the horizontal distance of PQ and RL of Q ppint.

- Calculation of tacheometric constant

D = KS + C

50 = K(0.005) + C ....(1)

100 = K(1.000) + C ....(2)

50 = K(0.005) + C ....(1)

C = 50 – 0.005 K ....(3)

Put the value of C in Eq 2

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$100 = K(1.000) + C$ ....(2)

$100 = 1.000\ K + 50 – 0.005\ K$

$K = 100$

Now put the value of K in eq 3

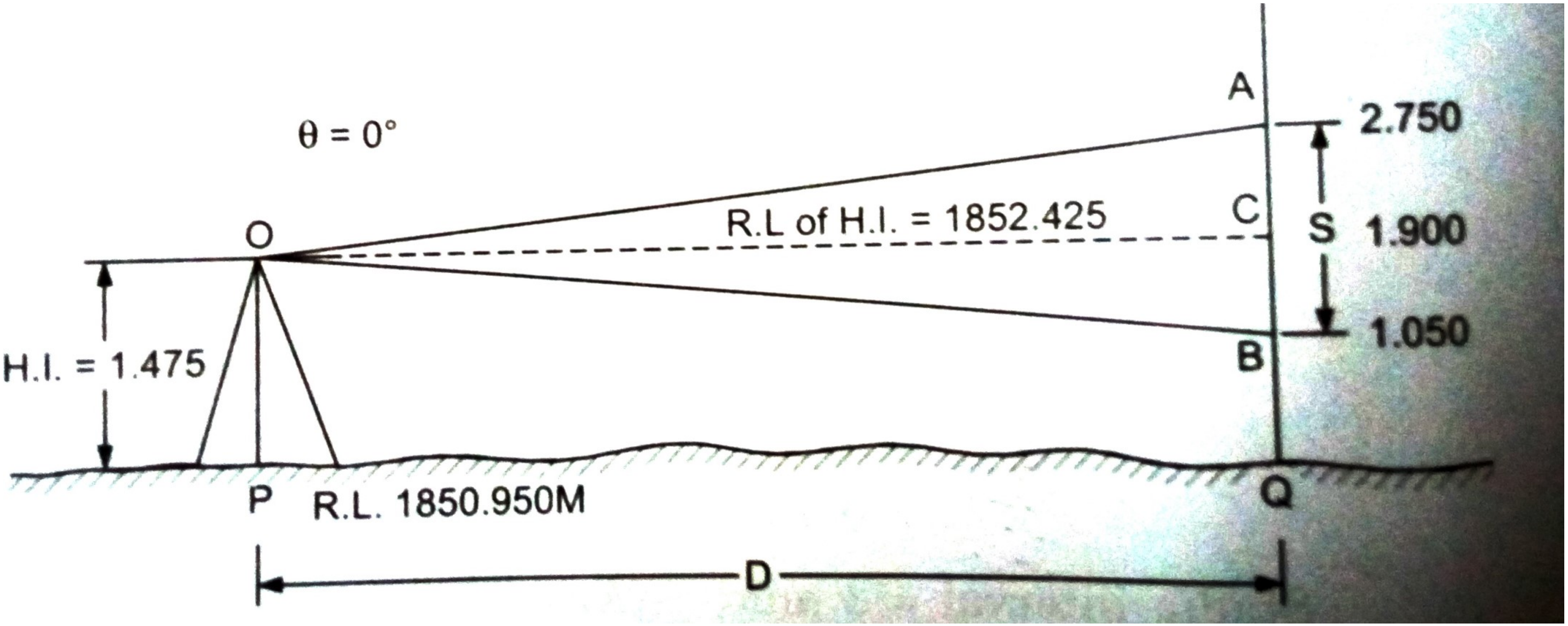
$C = 50 – 0.005\ K$ ....(3)

$C = 50 – 0.005\ (100)$

$C = 0$

Note: if K = 100 and C = 0 means your instrument is perfect

- Calculation of horizontal distance between PQ



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D = KS + C ....(1)

Now

S = 2.750 – 1.050 = 1.700m

K = 100

C = 0

Put all the value in equation no 1

D = 100 (1.700) + 0

D = 170m

- Calculation of RL of Q point

- RL of Q = 1850.95 + 1.475 – 1.900

  = 1850.525m

Formulas to Solve Examples

- Fixed Hair Method
- Case : 2 (When the line of sight is inclined and staff is held Vertical)

- **Horizontal distance D = KS $Cos^2\theta$ + C $Sin\theta$**
- **Vertical Desistance V = KS $Sin2\theta/2$ + C $Sin\theta$**

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Example 4

- A tachometer was setup at a station A and the following readings were obtain on a staff held vertically, calculate the horizontal distance AB and RL of B, when the constant of instrument are 100 and 0.15

Inst. Station	Staff Station	Vertical angle	Hair Reading (m)			Remark
A	BM	$-6^0 40'$	1.200	1.900	2.600	RL of BM = 850.50m
	B	$+8^0 20'$	0.800	1.600	2.400	

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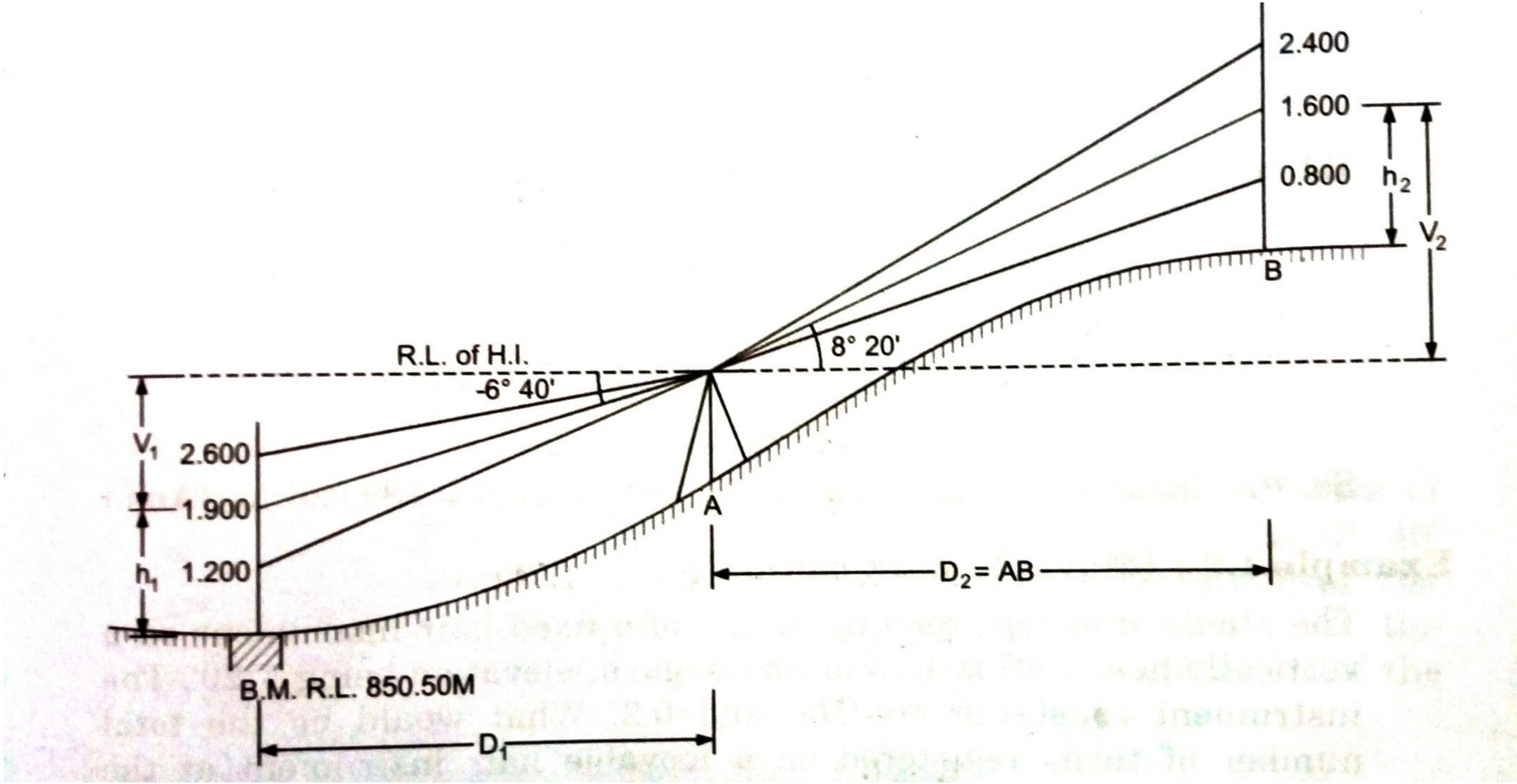
2.400
1.600
0.800
h_2
V_2
B
8° 20'
R.L. of H.I.
-6° 40'
V_1
2.600
1.900
h_1
1.200
A
D_2 = AB
B.M. R.L. 850.50M
D_1

- In the first observation

$S_1 = 2.600 – 1.200 = 1.400m$

$\Theta_1 = - 6^0 40'$ (Depression)

K = 100 and C = 0.15

Vertical Desistance $V_1 = KS \sin 2\theta/2 + C \sin\theta$

$= 100(1.400) \sin(2 \times 6^0 40')/2 + 0.15 \sin 6^0 40'$

$= 16.143 + 0.0174$

$= 16.160m$

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- In the second observation

$S2 = 2.400 – 0.800 = 1.600$

$\Theta_2 = + 8^{0}20'$ (Elevation)

Vertical Desistance $V_2 = KS \text{ Sin}2\theta/2 + C \text{ Sin}\theta$

$= 100(1.600) \sin(2 \times 8^{0}20')/2 \quad + \quad 0.15 \text{ Sin } 8^{0}20'$

$= 22.944 + 0.022$

$= 22.966m$

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- Horizontal distance $D_2 = KS\ Cos^2\theta + C\ Sin\theta$

$= 100\ (1.600)\ Cos^2\ 8^0 20' \quad + \quad 0.15\ Sin 8^0 20'$

$= 156.639 + 0.148$

$= 156.787m$

RL of Instrument Axis = RL of BM + h1 + V1

= 850.500 + 1.900 + 16.160

= 868.560m

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RL of B = RL of Inst. axis + V2 – h2

= 868.560 + 22.966 – 1.600

RL of B = 889.926m

Example 5

- To determine the gradient between two point P and Q a tacheometer was set up at a R station and the following observation where taken keeping the staff held vertical, if the horizontal angle PRQ is $36^0 20'$ determine the avg. Gradient between P and Q Point take K = 100 and C = 0 and RL of HI = 100m

Staff station	Vertical angle	Staff Reading
P	$+ 4^0 40'$	1.210, 1.510, 1.810
Q	$- 0^0 40'$	1.000, 1.310, 1.620

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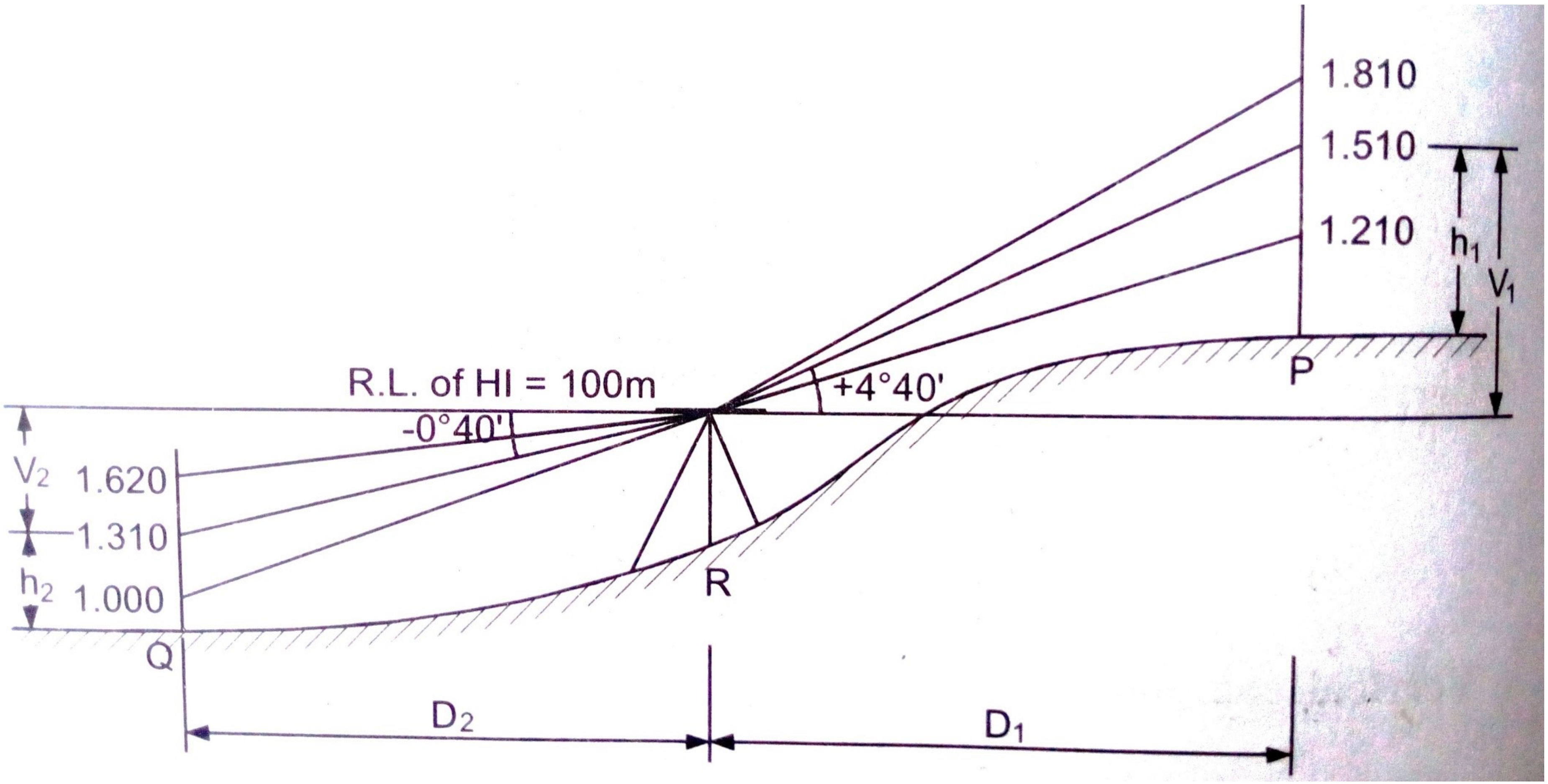

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- In the first observation (From R to P)

$S_1 = 1.810 - 1.210 = 0.6m$

$\Theta_1 = + 4^0 40'$

Horizontal distance D = KS $Cos^2\theta$ + C $Sin\theta$

$= 100 \times 0.6 \times Cos^2 4^0 40' + 0$

$= 59.60m$

Vertical Desistance V = KS $Sin2\theta/2$ + C $Sin\theta$

$= 100 \times 0.6 \times Sin(2 \times 4^0 40') / 2 + 0$

$= 4.865m$

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- In the Second observation (From R to Q)

$S_2 = 1.620 – 1.000 = 0.62m$

$\Theta_2 = - 0^0 40'$

Horizontal distance $D = KS\ Cos^2\theta + C\ Sin\theta$

$= 100 \times 0.62 \times Cos^2\ 0^0 40' + 0$

$= 61.99m$

Vertical Desistance $V = KS\ Sin2\theta/2 + C\ Sin\theta$

$= 100 \times 0.62 \times Sin(2 \times 0^0 40') / 2 + 0$

$= 0.721m$

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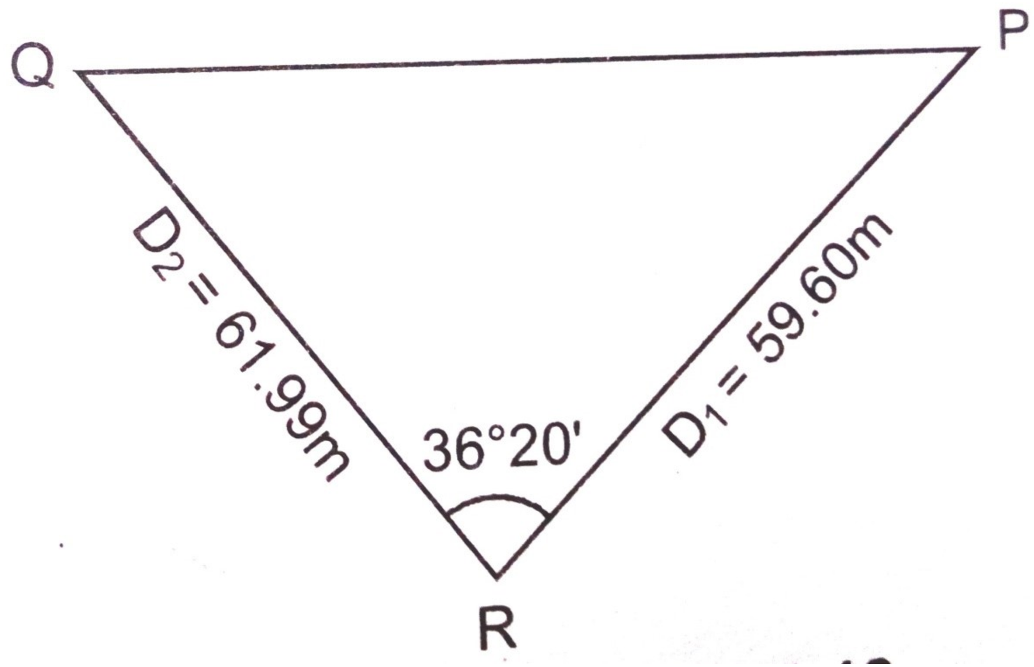
- Avg. Gradient Between P and Q point



- Distance D1 = PR = 59.60m,

  Distance D2 = QR = 61.99m

  $\angle$ PRQ = $36^0 20'$

$PQ^2 = PR^2 + QR^2 - 2 \times PR \times QR \times \cos 36^0 20'$

$PQ^2 = (59.60)^2 + (61.99)^2 - 2 \times 59.60 \times 61.99 \times \cos 36^0 20'$

PQ = 37.978m

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- Difference of Elevation between P and Q
- RL of P = RL of HI + $V_1 - h_1$

  = 100 + 4.865 – 1.510

  = 103.355m

- RL of Q = RL of HI – $V_2 - h_2$

  = 100 – 0.721 – 1.310

  = 97.969m

- Difference of RL of P & Q = 103.355 – 97.969

  = 5.386

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- Average gradient between P and Q

  = Difference in RL between P & Q / Distance of P & Q

= 5.386 / 37.978

= 1 / 7.051

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Formulas to Solve Examples

- Fixed Hair Method
- **Case : 3** (When the line of sight is inclined and staff is held Normal to the line of signt)

- If angle is + ve
- **Horizontal distance**

  D = KS Cosθ + C Cosθ + h Sinθ
- **Vertical Desistance**

  V = KS Sinθ + C Sinθ

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- If angle is - ve
- **Horizontal distance**

$$D = KS\ Cos\theta + C\ Cos\theta - h\ Sin\theta$$

- **Vertical Desistance**

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

Example 6

- Find out the distance between P and Q by using the bellow data given in table, the staff held normal to the line of sight in both the cases value of the tacheometer constant is 100 and 0.3

Instrument	Staff at	Line	Bearing	Vertical angle	Hair Reading
A	P	AP	$84^0 36'$	$3^0 30'$	1.35, 2.10, 2.85
A	Q	AQ	$142^0 24'$	$2^0 45'$	1.955, 2.875, 3.765

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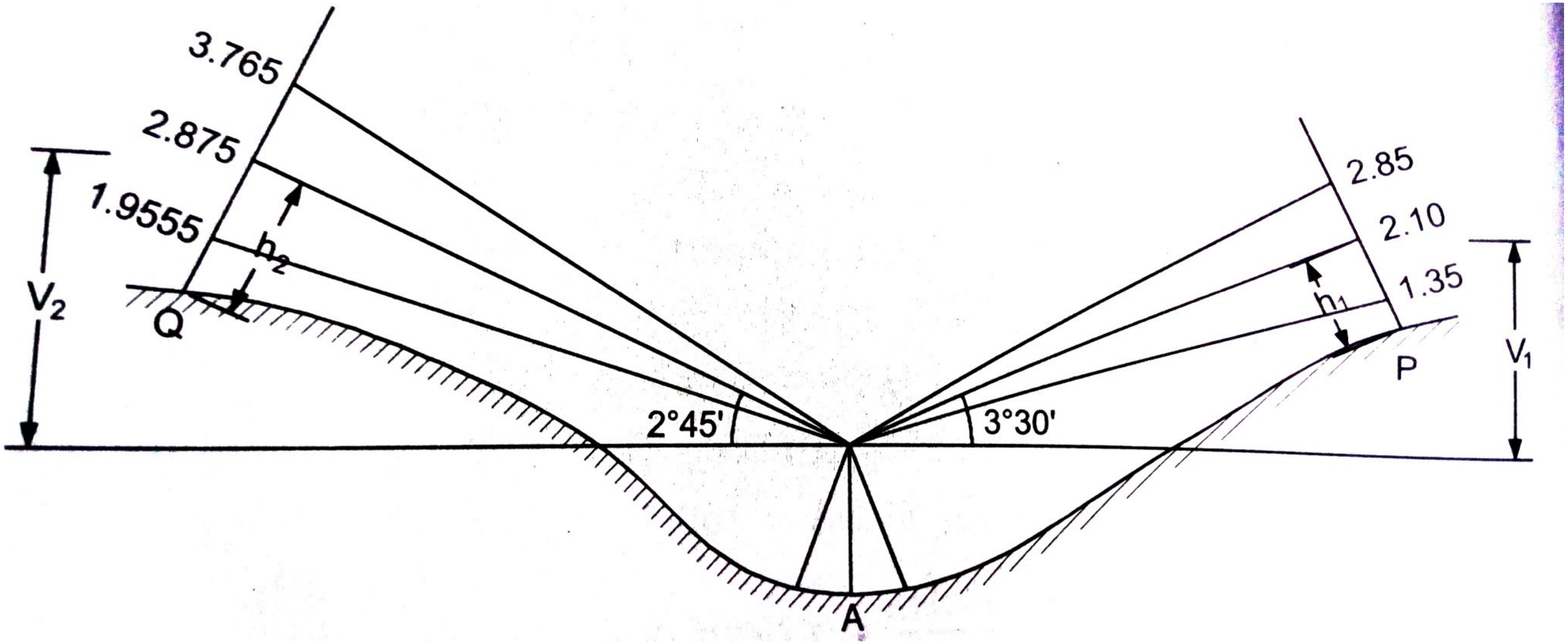
3.765
2.875
1.9555
h_2
V_2
Q
2°45'
2.85
2.10
1.35
h_1
V_1
P
3°30'
A

$S_1 = 2.85 – 1.35 = 1.5m$
$S_2 = 3.765 – 1.955 = 1.809m$

Horizontal Distance

AP = D = $KS_1 \cos\theta_1 + C \cos\theta_1 + h_1 \sin\theta_1$

$= 100 \times 1.5 \times \cos 3^0 30' + 0.3 \times \cos 3^0 30'$
$+ 2.10 \times \sin 3^0 30'$
$= 149.72 + 0.299 + 0.128$
$= 150.147m$

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AQ = D = $KS_2 \, Cos\theta_2 + C \, Cos\theta_2 + h_2 \, Sin\theta_2$

$= 100 \times 1.809 \times Cos\ 2^0 45' + 0.3 \times Cos\ 2^0 45' + 2.875 \times Sin\ 2^0 45'$

$= 180.742 + 0.299 + 0.138$

$= 181.179m$

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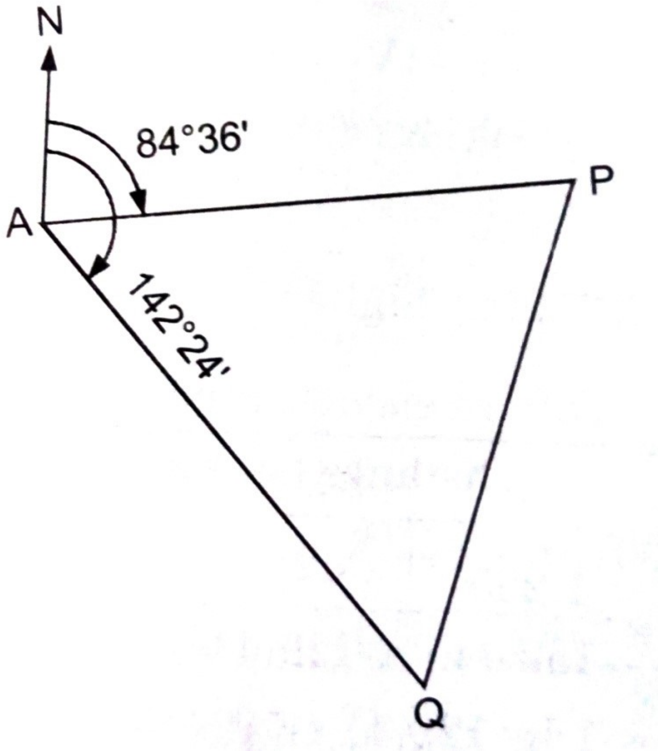
- Angle PAQ = Bearing of AP – Bearing of AQ

$= 142^0 24' - 84^0 36'$

$= 57^0 48'$



- Using Cosine rule

$PQ^2 = AP^2 + AQ^2 - 2 \times AP \times AQ \times \cos 57^0 48'$

$PQ^2 = (150.147)^2 + (181.179)^2 - 2 \times 150.147 \times 181.179 \times \cos 57^0 48'$

$PQ = 162.41m$

Formulas to Solve Examples

- Tnagential Hair Method
- **Case : 1 (**Both the angle are angles of elevation in this case, staff is held vertically.)
- **Ho**

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

- **Ve** **e**

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

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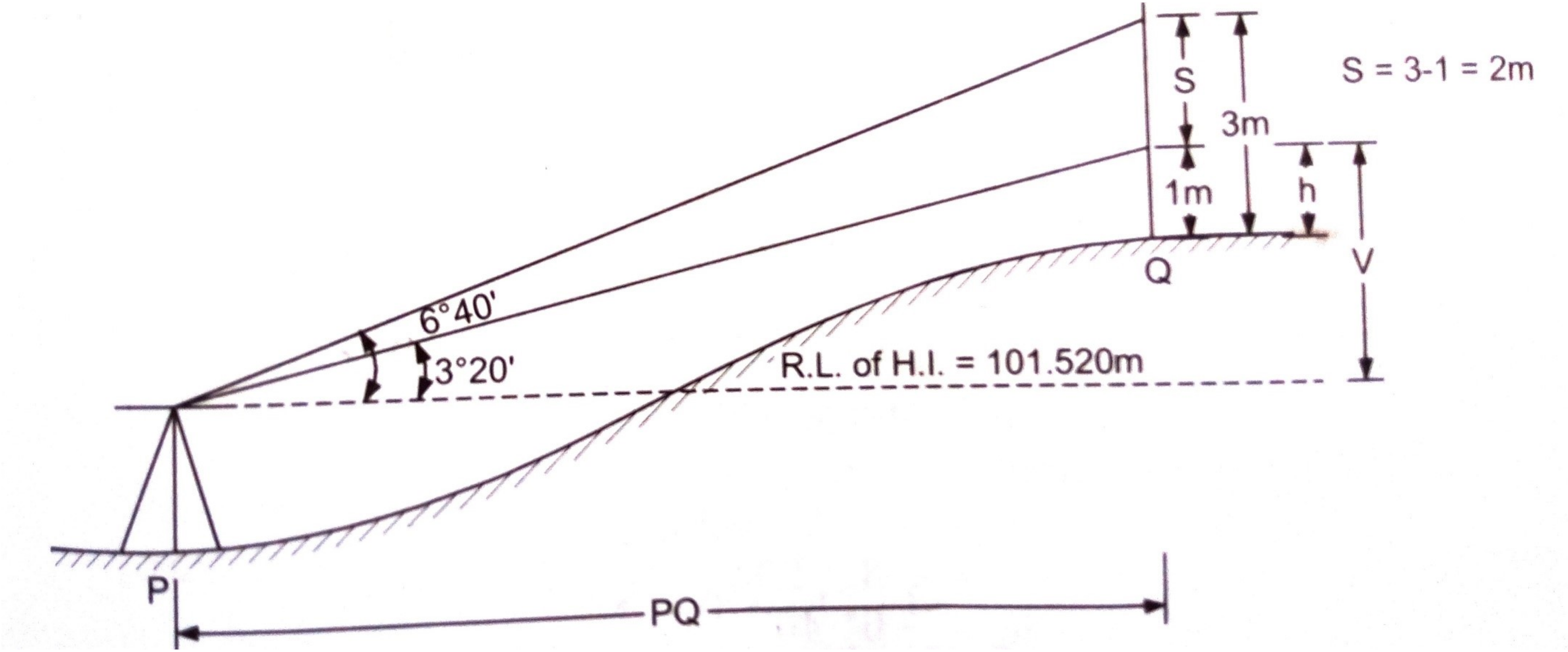
Example 7

- The vertical angles to vanes fixed at 1m and 3m above the foot of the staff held vertically at station Q were + $3^0 20'$ and $6^0 40'$ respectively from instrument station P. if the elevation of the instrument axis at station P is 101.520m calculate

(1) the Horizontal distance between P & Q and
(2) the elevation of the staff station Q)


S = 3-1 = 2m
S
3m
1m
h
V
Q
6°40'
3°20'
R.L. of H.I. = 101.520m
P
PQ

$S = 3 - 2 = 1$

$\theta_1 = 6^0 40'$

$\theta_2 = 3^0 20'$

$h = 1$

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

$$= \frac{2}{\tan 6^0 40' - \tan 3^0 20'}$$

$= 34.13m$

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

$$= \frac{2 \times \tan 3^0 20'}{\tan 6^0 40' - \tan 3^0 20'}$$

$$= 1.99m$$

Elevation of Staff station Q = RL of HI + V – h

= 101.520 + 1.99 – 1.0

= 102.510m

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Formulas to Solve Examples

- Tnagential Hair Method

- **Case : 2 (**Both the angle are angles of Depression in this case, staff is held vertically.)

- **Horizontal distance**

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

- **Vertical Desistance**

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

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Example 8

- The vertical angles to vanes fixed at 1m and 3m above the foot of the staff held vertically at station Q were - $3^0 20'$ and - $6^0 40'$ respectively from instrument station P. if the elevation of the instrument axis at station P is 101.520m calculate

(1) the Horizontal distance between P & Q and
(2) the elevation of the staff station Q)

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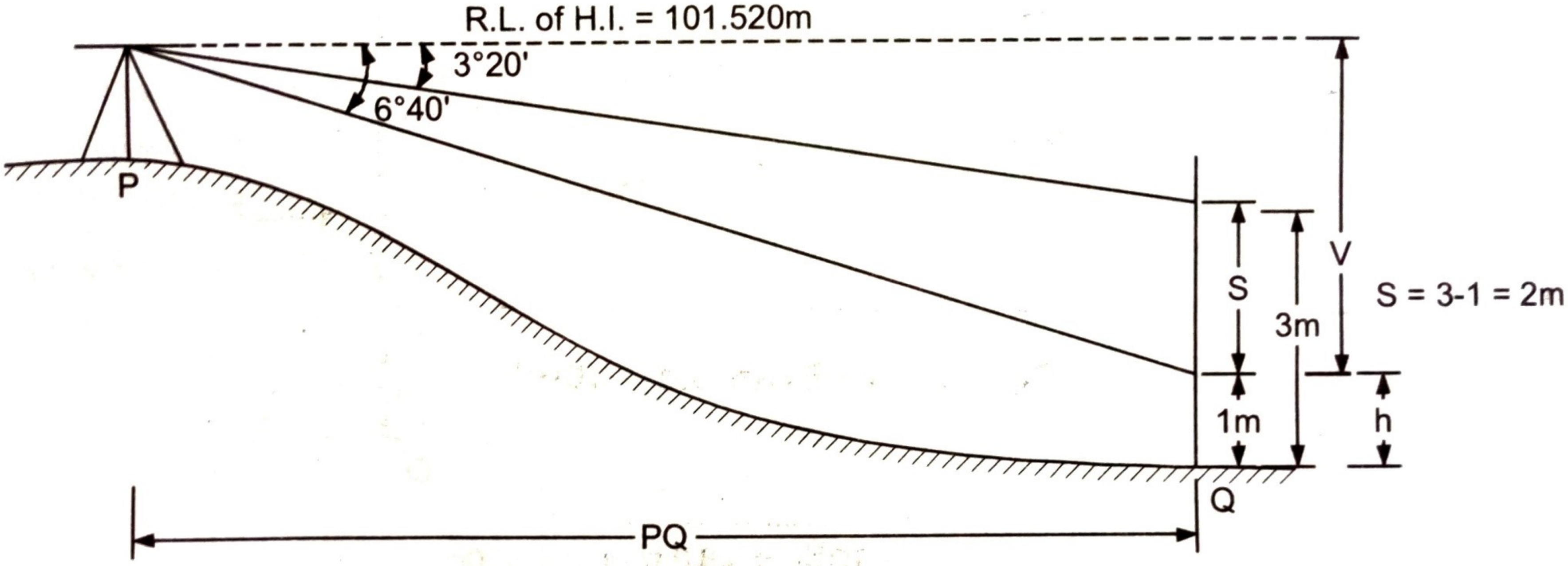
R.L. of H.I. = 101.520m
3°20'
6°40'
P
V
S
3m
S = 3-1 = 2m
1m
h
Q
PQ

$S = 3 - 2 = 1$

$\theta_1 = -3^0 20'$

$\theta_2 = -6^0 40'$

$h = 1$

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

$$= \frac{2}{\tan 6^0 40' - \tan 3^0 20'}$$

$= 34.13m$

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

$$= \frac{2 \times \tan 6^0 40'}{\tan 6^0 40' - \tan 3^0 20'}$$

$$= 3.99\text{m}$$

Elevation of Staff station Q = RL of HI + V – h

= 101.520 – 3.99 – 1.0

= 96.530m

Example 9

- The vertical angles to vanes fixed at 1m and 3m above the foot of the staff held vertically at station Q were + $3^0 20'$ and - $6^0 40'$ respectively from instrument station P. if the elevation of the instrument axis at station P is 101.520m calculate

(1) the Horizontal distance between P & Q and
(2) the elevation of the staff station Q)

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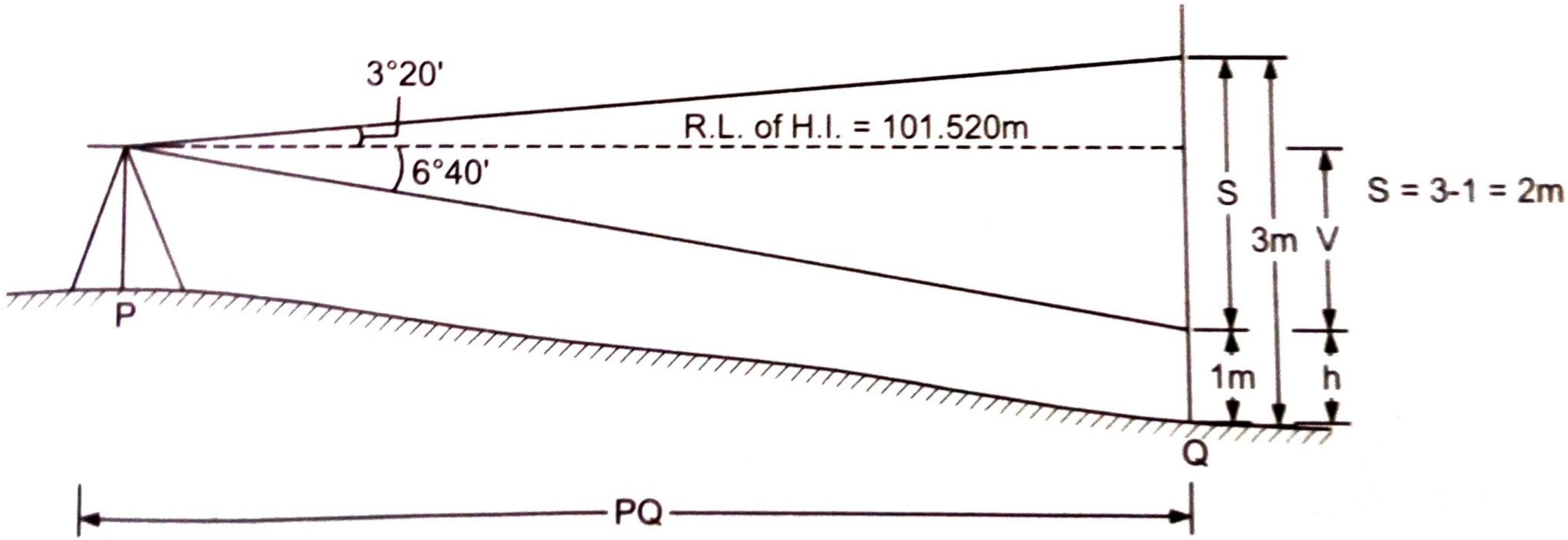
3°20'
R.L. of H.I. = 101.520m
6°40'
S
3m
V
S = 3-1 = 2m
P
1m
h
Q
PQ

$S = 3 - 2 = 1$

$\theta_1 = + 3^0 20'$

$\theta_2 = - 6^0 40'$

$h = 1$

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

$$= \frac{2}{\tan 3^0 20' + \tan 6^0 40'}$$

$= 11.43m$

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

$$= \frac{2 \times \tan 6^0 40'}{\tan 6^0 40' + \tan 3^0 20'}$$

$$= 1.34m$$

Elevation of Staff station Q = RL of HI - V – h

= 101.520 – 1.34 – 1.0

= 99.180m

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