TACHEOMETRY

It is the branch of surveying which deals with various measurements like vertical distance and horizontal distance that is measured indirectly from taking only instrumental observation.

→ This method is rapid and convenient.

→ The survey is conduct for preparing contour map of site.

→ It may be used for knowing elevation of highway or railway.

→ The instrument employed for tacheometric purpose, is tacheometer which is similar to theodolite having diaphragm fitted with two additional horizontal wires, called stadia hairs.

Situation where it can be used:-

→ When obstacles like river, broken ground, stretches of water, it gives speed & accuracy to work.

→ In rough country where measurement of horizontal and vertical distances are difficult, inaccurate

and slow.

→ In locating contours & filling details in a topographic survey, this method is fast and best.

Difference betn

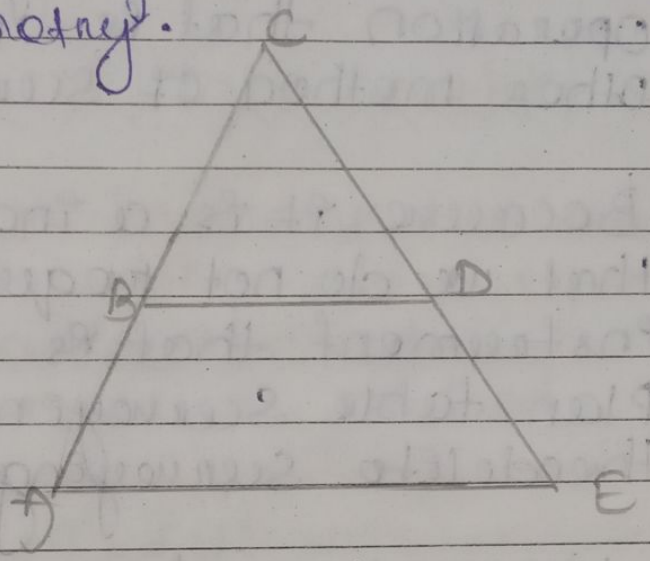
Theodolite	Tacheometer
→ It is used for measurement of horizontal and vertical angle.	→ It is used for measurement of horizontal and vertical distances.
→ In theodolite survey distances are measured by chain or tape.	→ In Tacheometer survey direct measurement of distances are possible.
→ Suitable for plane & hilly area with less obstacles.	→ Suitable in case obstacles like rivers, broken ground.
→ More stations are required in theodolite survey.	→ Less stations are required in Tacheometer survey.

Principle of Tacheometry

The main principle of tacheometry is based on the basic principle of

isosceles triangle.

→ In any two side equal triangle means isosceles triangle, there is one property which is used in the Tacheometry.



It state that, Ratio of the perpendicular to vertex on their base and their base is always constant in isosceles triangle.

Advantages of Tacheometric surveying

Following are the advantages of tacheometric surveying:-

→ It require low amount of time compare to other ways of surveying.

→ We can do survey in area like hill & mountain where it is very difficult to do survey by other method

→ If we not need very high standards

and accuracy then this is right method.

→ It is not necessary to do chain operation that is required in other method of surveying.

→ Because it is a indirect method that we do not require some instrument that is necessary in plan table surveying or in theodolite surveying.

Uses of Tacheometry

→ It is used for the preparation of contour map in case when both horizontal & vertical distances needed.

→ It is also very useful for triangulation surveying.

→ Sometimes work of surveying is in difficult areas when it is not possible to use some direct method like theodolite traversing or plane table surveying.

→ Tacheometry is reconnaissance survey for highways, roadways

and railways.

→ It can be used as establishment of secondary control points.

Methods of Tacheometric surveying

There is basically two methods of tacheometric measurements such as:-

1. Stadia method
2. Tangential Method

Stadia Method

The stadia method is further divided into two types :-

(a) Fixed hair method
(b) Movable hair method

(a) **Fixed hair Method** :- In this method, stadia hairs are kept at fixed interval and the intercept on the levelling staff varies, depending upon the horizontal distance between the instrument station and the staff.

→ By using this methods we can calculate RL, elevation and horizontal distance.

→ usually, this method is preferred because it consume less time compare

to movable method.

→ In this method, hair is kept fixed and we take reading on staff.

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

Where, H = horizontal distance
K = Multiplying constant
S = upper reading − lower reading
C = Addictive constant.

∴ (It is only apply if V = 0)

formula for horizontal distance when V is not equal to zero.

$$\boxed{H = KS\cos^2\theta + C.\cos\theta}$$

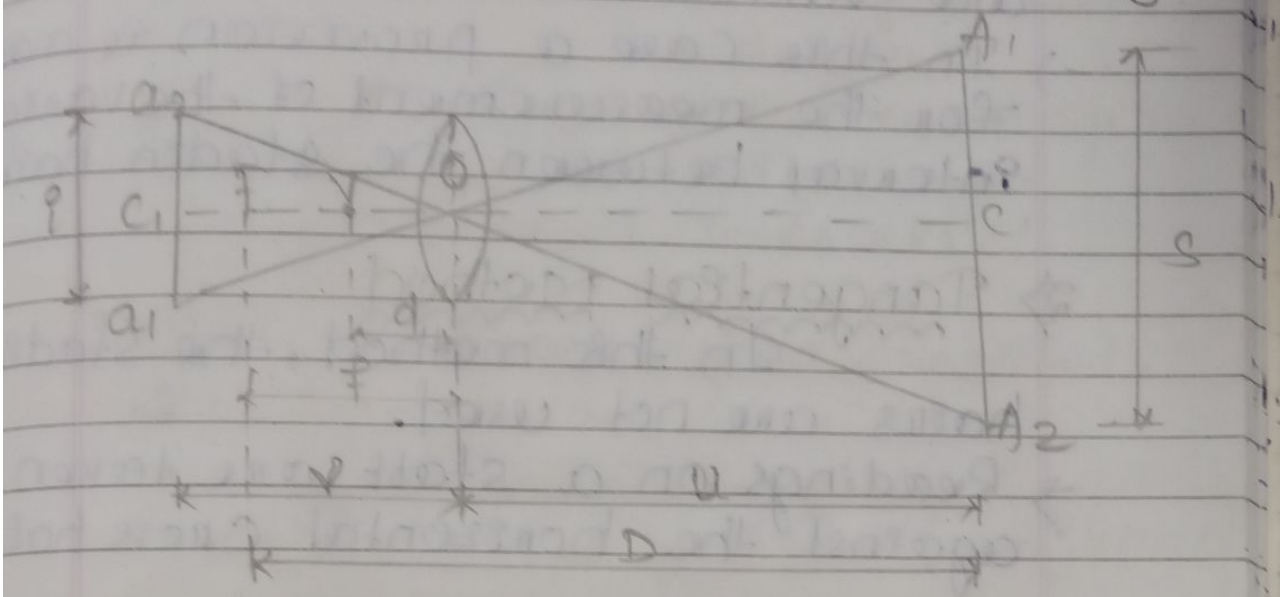
Where, θ = angle, $K = \frac{f}{i}$ & C = (f+d)

* Almost all survey is based on stadia method because it is easy and convenient.

→ In this method we use theodolite that has 3 hair on it.

→ It is usually done by stadia rod.

Theory of Stadia Tacheometry



A_1, A_2, C = Readings on staff cut by three hairs

a_1, a_2, C_1 = bottom, top & central hairs of diaphragm

$a_1, a_2 = i$ = length of image

$A_1, A_2 = S$ = staff intercept

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 and staff.

v = distance betn optical centre and image

(b) Movable Hair Method :- In this method, the intercept on the levelling staff is kept constant and the

distance between the stadia hairs are variable.

→ In this case a provision is made for the measurement of the variable interval between the stadia hairs.

2) Tangential Method

In this method, the stadia hairs are not used.

→ Readings on a staff are taken against the horizontal cross hair.

→ To measure the staff intercept, two pointing of the telescope are necessary.

→ Full metre value readings are taken to avoid the decimal point and also for simplification of computations.

→ This method is not adopted as two vertical angles are required to be measured for one single observation.

When the line of sight is horizontal, the distance is given by

$$D = \frac{C \times S}{n} + (f + d)$$

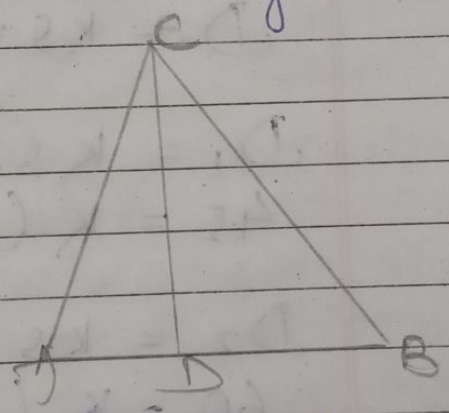
where, D = horizontal distance
C = constant varying from 600 to 1000
n = Sum of the readings in the micrometer
S = Staff intercept

When the line sight is inclined, the formula is,

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

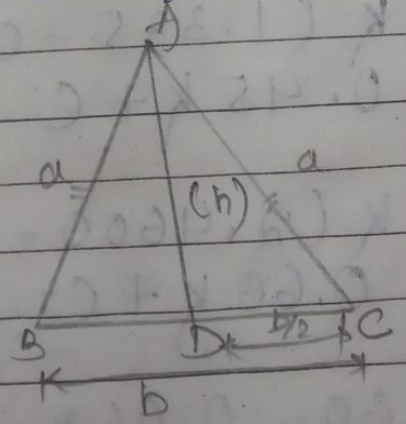
Area of Isosceles triangle

formula:-



AC = CB
∠A = ∠B

Area of Isosceles triangle = 1/2 x base x height



$AD^2 = AB^2 - BD^2$

$$AD^2 = a^2 - \left(\frac{b}{2}\right)^2$$

$$= a^2 - \frac{b^2}{4}$$

$$AD = \sqrt{a^2 - \frac{b^2}{4}}$$

$$\text{Area of } \Delta = \frac{1}{2} \times b \times \sqrt{a^2 - \frac{b^2}{4}}$$

Que

Horizontal Distance	Stadia Reading	
45	0.885	1.335
60	1.800	2.4600

$$D = KS + C$$

$$D_1 = KS_1 + C$$

$$45 = K(1.335 - 0.885) + C \quad \text{--- (i)}$$

$$D_2 = KS_2 + C$$

$$60 = K(2.4600 - 1.800) + C \quad \text{--- (ii)}$$

$$45 = K(1.335 - 0.885) + C$$

$$45 = 0.45K + C \quad \text{--- (iii)}$$

$$60 = K(2.4600 - 1.800) + C$$

$$60 = 0.66K + C$$

$$C = 60 - 0.66K \quad \text{--- (iv)}$$

Put the value of equ^n (iv) in equ^n (iii)

$$45 = 0.45K + C$$
$$\Rightarrow 45 = 0.45K + 60 - 0.66K$$
$$\Rightarrow 45 = 60 - 0.21K$$
$$\Rightarrow 0.21K = 60 - 45 = 15$$

$$\Rightarrow K = 71.42$$
$$\boxed{K \simeq 100}$$

Put the value of K in equ^n (3)

$$45 = 0.45K + C$$
$$45 = 100 \times 0.45 + C$$
$$45 = 45 + C$$
$$\Rightarrow C = 45 - 45 = 0 \quad \text{(Ans)}$$

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

Sol^n Given,

$D = 50\,m$

$S = 2.380 - 1.385 = 0.995$

$f = 25\,cm = 0.25\,m$

$d = 15\,cm = 0.15\,m$

$$D = KS + C$$

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

$$50 = \frac{0.25}{i} \times 0.995 + (0.25 + 0.15)$$

$$50 = \frac{0.249}{i} + 0.4$$

$$\Rightarrow i = \frac{0.649}{50} = 0.0129 \text{ m}$$

$$\therefore \boxed{i = 1.3 \text{ mm}}$$

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

Sol Calculation of tacheometric constant:-

$$D = KS + C$$

$$50 = K \times (0.500) + C \quad \ldots (i)$$

$100 = K \times (1.000) + C$ - - - - (ii)

$50 = 0.500K + C$

$\Rightarrow C = 50 - 0.500K$ - - - - (iii)

put the equ^n (iii) in equ^n (2)

$100 = K \times 1.000 + C$

$100 = 1.000K + 50 - 0.500K$

$100 = 50 - 0.5K$

$\Rightarrow 0.5K = 50 - 100$

$\Rightarrow 0.5K = -50$

$\Rightarrow K = -100$

$\therefore \boxed{K = -100}$

Now put the value of K in eq^n (3)

$C = 50 - 0.500K$

$= 50 - 0.500 \times (-100)$

$= 50 + 100.5$

$\therefore \boxed{C = 150.5}$

$\therefore$ If $K = +100$ & $C = 150.5$ then ~~constt~~ instrument is perfect.

Que The micrometer readings of a Subtense theodolite are 3.455 & 3.405. The distance between the targets is 3 m. The constants of the instrument are 600 & 0.5 m. Calculate the distance between

the instrument & the staff.

Sol^n Given

$n = 3.455 + 3.405 = 6.860$
$C = 600$
$(f+d) = 0.5$
$S = 3m$

$$\text{Distance} = \frac{C \times S}{n} + (f+d)$$

$$= \frac{600 \times 3}{6.860} + 0.5$$

$$= 262.89 \text{ m}. \text{ (ans)}$$

Que The same distance was measured by a tacheometer and a subtense theodolite.

Records of the tacheometer reading are as follows:-
Staff intercept = 1.285 m
Angle of elevation = 5° 0'
$\frac{f}{q} = 100$ & $(f+d) = 0.2$

Subtense theodolite readings:-
Staff intercept = 2 m
Angle of elevation = 5° 30'
Constants = 1000 & 0.3
Find the total number of turns in micrometer.

Sol^n Given

Case-I Tacheometer readings :-

$S = 1.255$ m

$\theta = 5°0'$

$\frac{f}{i} = 100$

$(f+d) = 0.2$

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

$$= 100 \times 1.255 \times \cos^2 5° + 0.2 \times \cos 5°$$

$$= 125.5 \times 0.996 + 0.199$$

$$= 125.19 \text{ m} \quad \text{------} (1)$$

Case-II

Theodolite readings :-

$S = 2$ m

$\theta = 5°30'$

$C = 1000$

$(f+d) = 0.3$

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

$$= \frac{1000 \times 2 \times \cos^2 5°30'}{n} + 0.3 \times \cos 5°30'$$

$$= \frac{1980}{n} + 0.298 \quad \text{------} (2)$$

from equ^n (1) & (2)

$$\frac{1980}{n} + 0.298 = 125.19$$

$$\Rightarrow \frac{1980}{n} = 125.19 - 0.298$$

$$\Rightarrow \frac{1980}{n} = 124.89$$

$$\Rightarrow n = \frac{1980}{124.89} = 15.85$$

$$\boxed{\therefore n = 15.85}$$

Land surveying

It is the technique, profession, and science of determining the three-dimensional position of points and the distances and angles between them.

Derivation of theory of stadia Tacheometry:-

$$\frac{I}{V} = \frac{S}{u}$$

$$\frac{1}{V} = \frac{S}{Iu} \quad \text{------ (i)}$$

We know that,

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

$$\frac{1}{f} = \frac{S}{Iu} + \frac{1}{u} \Rightarrow \frac{1}{f} = \frac{1}{u}\left(\frac{S}{I} + 1\right)$$

$$\Rightarrow \boxed{u = f\left(1 + \frac{S}{I}\right)} \quad \text{--- (iii)}$$

$$D = u + d = f\left(1 + \frac{S}{I}\right) + d$$

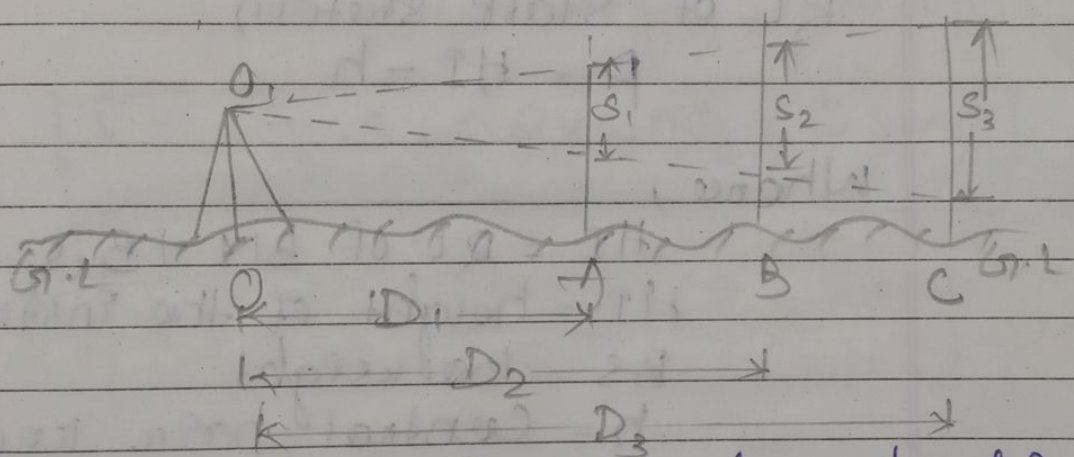
$$D = f + f \times \frac{S}{I} + d$$

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

$$\left(\because K = \frac{f}{I} \;\&\; C = (f + d)\right)$$

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

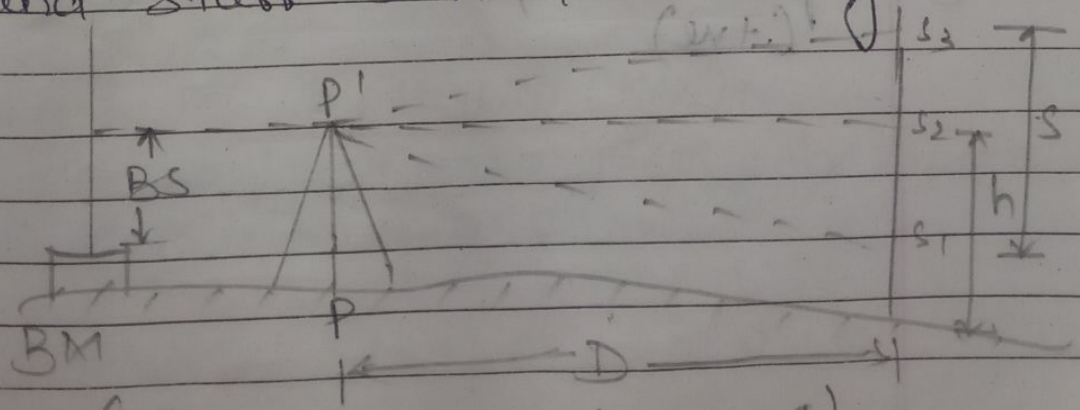
Principle



$$\frac{D_1}{S_1} = \frac{D_2}{S_2} = \frac{D_3}{S_3} = \frac{f}{I} \text{ (constant)}$$

Case - I

When Line of sight is Horizontal and staff is held vertically.



(fixed-hair method - case 1)

When the line of sight is horizontal, the general tacheometric equation for distance is,

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

$\frac{f}{i} = K = 100$, is the multiplying constant

$f+d = C = 0$, is the additive constant

RL of staff station

$$P = HI - h$$

Whence,

HI = RL of BM + B.S

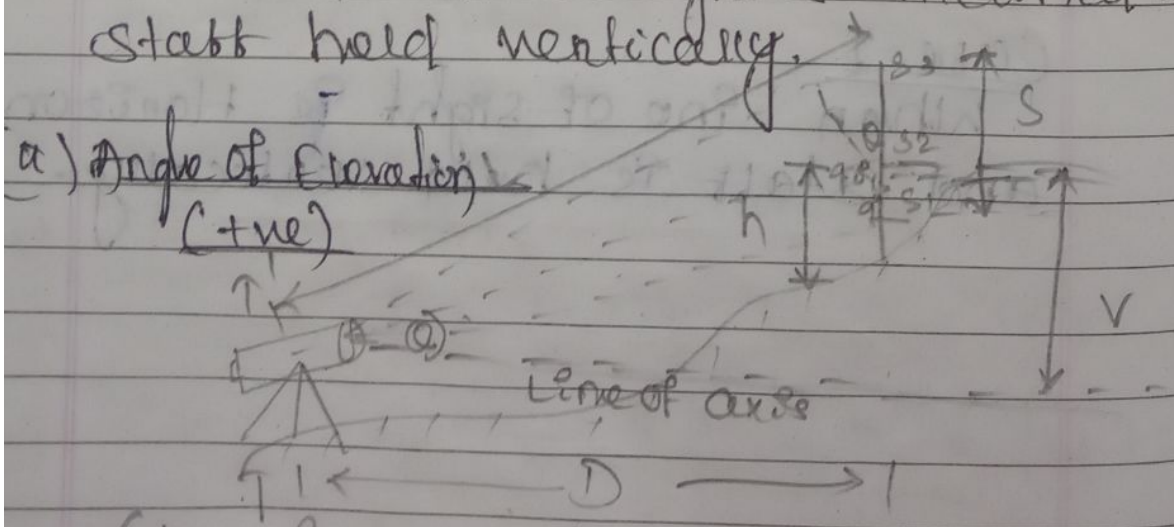
HI = height of the instrument

BS = Backsight

h = Central hair reading.

<u>Case-II</u>

When Line of sight is inclined & staff held vertically.



(L = Inclined distance betn instrument & staff)

$$L = \frac{f}{i} \times S + C$$

$$\boxed{L = \frac{f}{i} S \cos\theta + C}$$

$$D = L \cos\theta$$
$$= \left(\frac{f}{i} S \cos\theta + C\right) \times \cos\theta$$

$$\therefore \boxed{D = \frac{f}{i} S \cos^2\theta + C \cos\theta}$$

$$V = L \sin\theta$$
$$= \left(\frac{f}{i} S \cos\theta + C\right) \sin\theta$$

$$\boxed{V = \frac{f}{i} S \cos\theta \times \sin\theta + C \sin\theta}$$

OR

$$\boxed{V = \frac{f}{i} S \frac{\sin 2\theta}{2} + C \sin\theta}$$

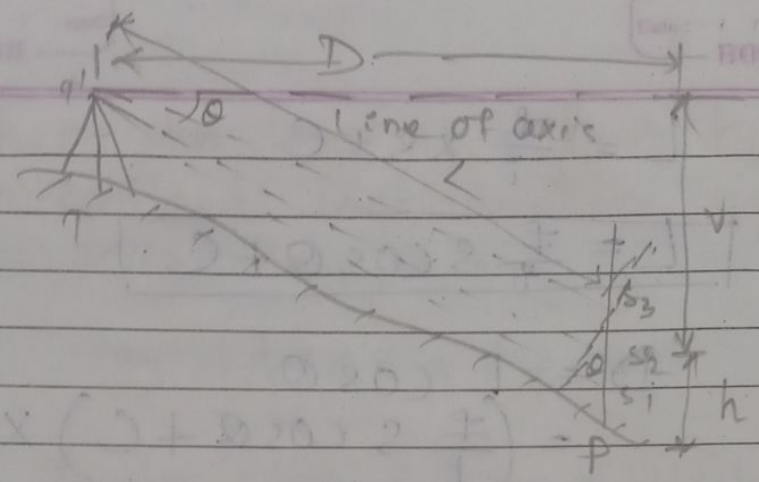
$$\left(\because \sin 2\theta = 2 \sin\theta . \cos\theta \Rightarrow \frac{\sin 2\theta}{2} = \sin\theta \times \cos\theta\right)$$

RL of station P = RL of axis of instrument + V − h.

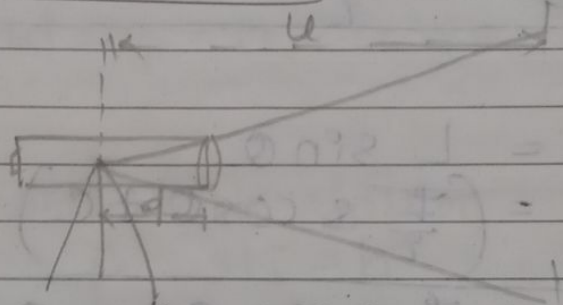
(b) Angle of depression (−ve)

In this case also, the expression for D & V are same

RL of staff = RL of axis − V − h



Anallactic lens



Here, $k = 100$ & $c = 0$

$$\boxed{D = ks}$$

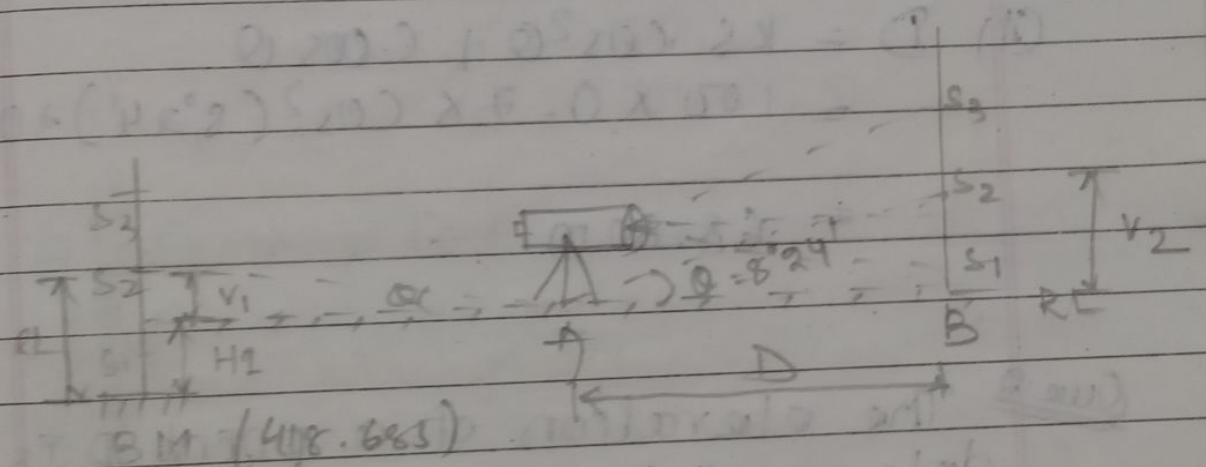
Problems

Que-1 A tacheometer was set up at a station A & the readings on a vertically held staff at B have 2.255, 2.605 & 2.955, the line of sight being at an inclination of +8°24'. Another observation on the vertically held staff at B. M gave the readings 1.640, 1.920 & 2.200, the inclination of the line of sight being +16'. Calculate the horizontal distance betn A & B and the elevation of B if the

RL of B.M is 418.685 metres. The constants of the instruments were 100 & 0.3.

Soln Given

B.M	B	RL of BM
$S_1 = 1.64$	$S_1 = 2.255$	418.685 m
$S_2 = 1.92$	$S_2 = 2.605$	$K = 100$ &
$S_3 = 2.20$	$S_3 = 2.955$	$C = 0.3$



(i) $V_1 = KS \dfrac{\sin 2\theta}{2} + C \cdot \sin\theta$

$= 100 \times 0.56 \dfrac{\sin 2 \times 1°6'}{2} + 0.3 \times \sin 1°6'$

$= 1.081$ m

RL of Line of sight

$= BM + S_2 - V_1$

$= 418.685 + 1.92 - 1.081$

$= 419.524$ m

$$V_2 = KS\frac{\sin 2\theta}{2} + C\sin\theta$$

$$= 100 \times 0.7 \times \frac{\sin 2 \times 8°24'}{2} + 0.3 \times \sin 8°24'$$

$$= 10.3\ m$$

RL of B = RL of (LOS) + V_2 − S_2

= 419.524 + 10.3 − 2.605

= 427.219 m

(ii) $D = KS\cos^2\theta + C\cos\theta$

$= 100 \times 0.7 \times \cos^2(8°24') + 0.3\cos 8°24'$

$= 68.80\ m$

Que 2 The elevation of a point P is to be determined by observations from two adjacent stations of a tacheometric survey. The staff was held vertically upon the point and the instrument fitted with an anallactic lens, the constant of the instrument being 100. Compute the elevation of the point P from the following data, taking both the observations as reliable. Also calculate the distance of A & B from P.

Inst. station	Height of axis	staff point	Vertical Angle	staff reading
A	1.42	P	+2°24'	1.230, 2.085, 2.880
B	1.40	P	−3°36'	0.785, 1.800, 2.815

Elevation of station

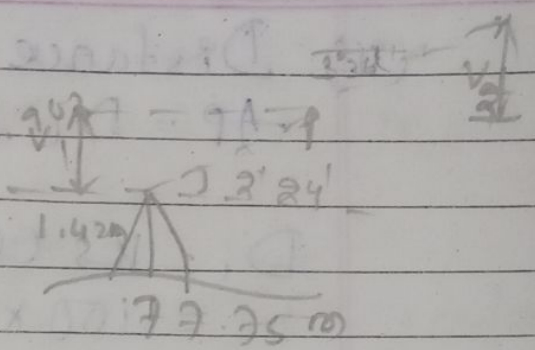
77.750 m

97.135 m

Soln

(i) RL of P

(a) from p to A



$$V_1 = KS \frac{\sin 2\theta}{2}$$

$$= 100 \times 1.65 \times \frac{\sin(2 \times 2°24')}{2}$$

$$= 6.91 \text{ m}$$

RL of p (from A) = 77.75 + 1.42 + 6.91

= 86.05 m

(b) from p to B

$$V_2 = KS \frac{\sin 2\theta}{2}$$

$$= 100 \times 2.03 \times \frac{\sin(2 \times 3°36')}{2}$$

$$= 12.752 \text{ m}$$

RL of P (from B) = RL + Height − V_2

= 97.135 + 1.4 − 12.752

= 85.78 m

$$\text{Avg} = \frac{86.05 + 85.78}{2} = 85.93 \text{ m}$$

(ii) Distance of A & B

$AP = D_1$ & $PB = D_2$

$D_1 = KS\cos^2\theta$

$= 100 \times 1.65 \times \cos^2(2°24')$

$= 164.7\ m$

$D_2 = KS\cos^2\theta$

$= 100 \times 2.03 \times \cos^2(3°36')$

$= 202.2\ m$

$D = D_1 + D_2 = 164.7 + 202.2$

$\therefore \boxed{D = 366.9\ m}$

Que To determine the multiplying constant of a tacheometer, the following observations were taken on a staff held vertically at distance, measured from the instrument:-

Observation	Horizontal Distance in (m)	vertical angle	Staff Intercept
1	50	$+3°48'$	0.500 m
2	100	$+1°06'$	1.000 m
3	150	$+0°36'$	1.500 m

The focal length of the object glass is 20 cm & the distance from the object to trunion axis is 10 m. The staff is held vertically at all these points. Find the multiplying constant.

Sol^n Case-1

$D_1 = 50\,m$, $\theta = 3^\circ 48'$; $S = 0.5\,m$, $C = 0.3\,m$

$D = KS\cos^2\theta + C\cos\theta$

$50 = K \times 0.5 \times \cos^2(3^\circ 48') + 0.3 \times \cos(3^\circ 48')$

$K_1 = 99.80$

Case-2

$D_2 = 100\,m$, $\theta_2 = 1^\circ 6'$; $S = 1\,m$

$D = KS\cos^2\theta + C\cos\theta$

$100 = K \times 1 \times \cos^2(1^\circ 6') + 0.3 \times \cos(1^\circ 6')$

$K_2 = 99.79$

Case-3

$D_3 = 150\,m$, $\theta_3 = 0^\circ 36'$, $S = 1.5\,m$

$D = KS\cos^2\theta + C\cos\theta$

$150 = K_3 \times 1.5 \times \cos^2(0^\circ 36') + 0.3 \times \cos(0^\circ 36')$

$K_3 = 99.87$

$$K = \frac{K_1 + K_2 + K_3}{3}$$

$$= \frac{99.8 + 99.79 + 99.87}{3}$$

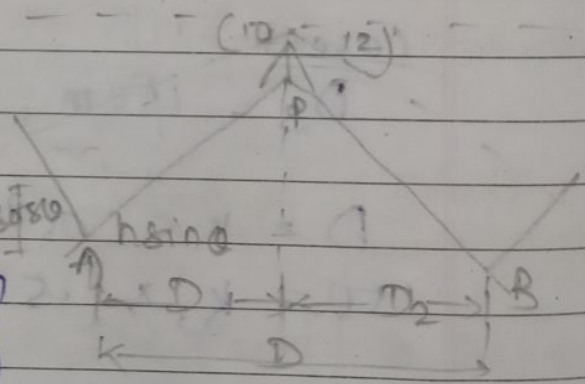
$\therefore \boxed{K = 99.82}$

Que Two points A & B are on opposite sides of a summit. The tacheometer was set up at P on top of the summit, and the following readings were taken.

Inst. station	Height of Inst.	Staff station	Vertical Angle	Their Readings	Remarks
P	1.500	A	$-10°0'$	1.150, 2.050, 2.950	RL of P = 450.500 m
P	1.500	B	$-12°0'$	0.855, 1.605, 2.355	

The tacheometer is fitted with an anallatic lens, the multiplying constant being 100. The staff was held normal to the line of sight. Find distance between A & B.

$D_1 = AP$



$D_1 = L\cos\theta - h\sin\theta$

$= KS_1\cos\theta_1 - h\sin\theta$

$= (100 \times 1.8 \times \cos 10)$

$- 2.05 \times \sin 10$

$= 176.91\ m$

$PB = D_2 = KS_2\cos\theta_2 - h_2\sin\theta_2$

$= 100 \times 1.5 \times \cos 12 - 1.605 \times \sin 12$

$= 146.388\ m$

$AB = AP + PB = 176.91 + 146.388 = 323.298\ m$

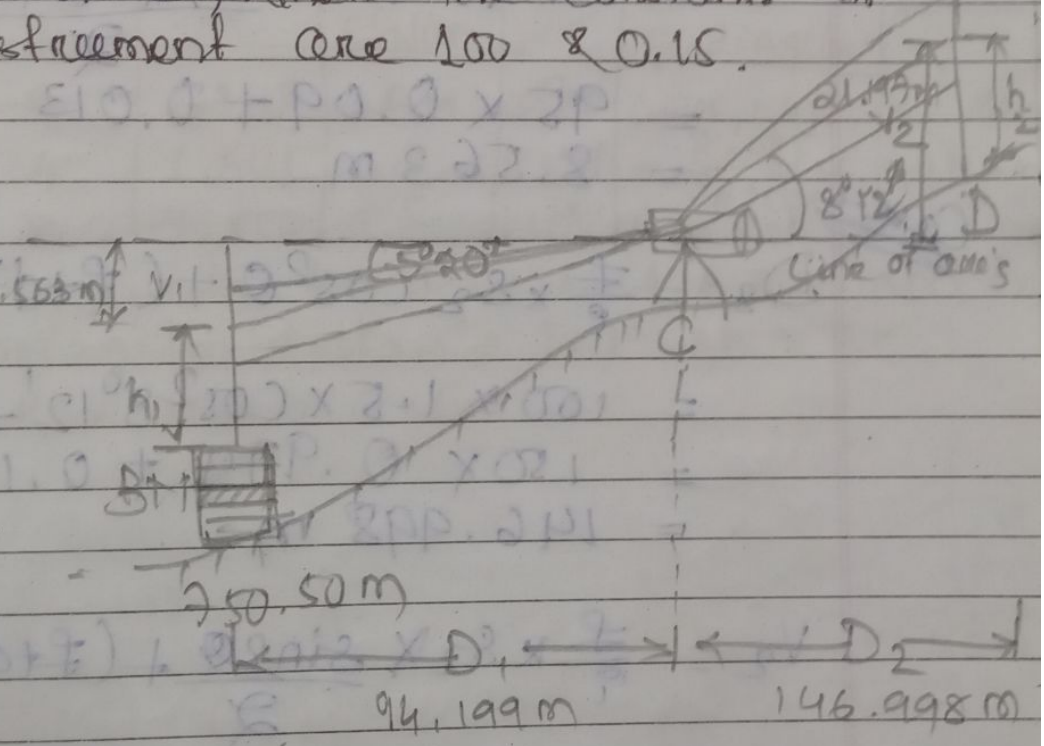
Problems

① A tacheometer was set up at a station C and the following readings were obtained on a staff vertically held.

Inst. station	Staff station	Vertical Angle	Main Readings (m)	Remarks
C	BM	$-5^\circ 20'$	1.50, 1.80, 2.450	RL of BM = 750.50m
C	D	$+8^\circ 12'$	0.75, 1.50, 2.250	

Calculate the horizontal distance CD and RL of D, when the constants of instrument are 100 & 0.15.

Sol^n



Given

$f/K = 100$

$(f+d)C = 0.15$

$\theta_1 = -5^\circ 20'$

$\theta_2 = +8^\circ 12'$

$S_1 = 2.450 - 1.50$
$= 0.95$ m

$S_2 = 2.250 - 0.75$
$= 1.5$ m

When the staff held vertically, the horizontal distance are given by

Case-1

$$D_1 = \frac{f}{i} \times S_1 \cos^2\theta + (f+d) \times \cos\theta$$

$$= 100 \times 0.95 \times \cos^2 5^\circ 20' + 0.15 \times \cos 5^\circ 20'$$

$$= 95 \times 0.99 + 0.149$$

$$= 94.199 \text{ m}$$

$$V_1 = \frac{f}{i} \times S_1 \times \frac{\sin 2\theta}{2} + (f+d) \sin\theta$$

$$= 100 \times 0.95 \times \frac{\sin 2 \times (5^\circ 20')}{2} + 0.15 \times \sin 5^\circ 20'$$

$$= 95 \times 0.09 + 0.013$$

$$= 8.563 \text{ m}$$

Case-2

$$D_2 = \frac{f}{i} \times S_2 \cos^2\theta + (f+d) \times \cos\theta$$

$$= 100 \times 1.5 \times \cos^2 8^\circ 12' + 0.15 \times \cos 8^\circ 12'$$

$$= 150 \times 0.979 + 0.148$$

$$= 146.998 \text{ m}$$

$$V_2 = \frac{f}{i} \times S_2 \times \frac{\sin 2\theta}{2} + (f+d) \times \sin\theta$$

$$= 100 \times 1.5 \times \frac{\sin 2 \times (8^\circ 12')}{2} + 0.15 \times \sin 8^\circ 12'$$

$$= 21.197 \text{ m}$$

RL of ~~Distance~~ BM $+ h_1 + V_1$

ans. $= 250.50 + 1.80 + 8.563$ m

$= 260.863$ m

RL of D = RL of Inst. axis + $V_2 - h_2$

= 760.863 + 21.193 − 1.80

= 780.56 m

∴ CD distance is 146.998 m and RL of D is 780.56 m.

2) The following observations were made in a tacheometric survey.

Inst Station	HI of Inst	Staff Station	θ	Hair Readings	Remarks
A	1.345	BM	−5°30'	0.905, 1.415, 2.005	RL of BM = 450.00 m
A	1.345	B	+8°0'	0.765, 1.655, 2.525	
B	1.550	C	+10°0'	1.500, 2.25, 3.000	

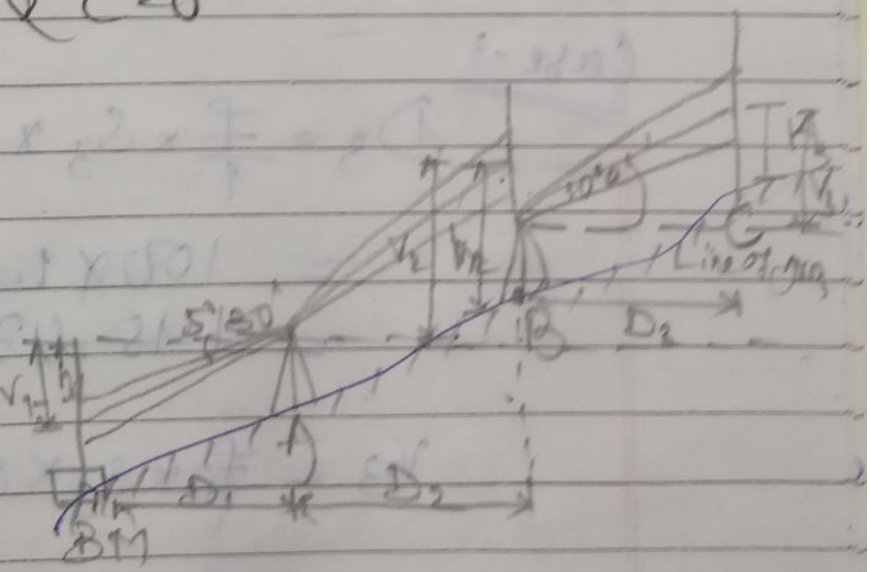
Calculate the RLs of A, B & C and the horizontal distance betn AB & BC.

K = 100 & C = 0

Sol^n Given

$\frac{f}{i} = 100$

$(f+d) = 0$



Case-1

$D_1 = \frac{f}{i} \times S_1 \times \cos^2\theta$

$= 100 \times (2.005 - 0.905) \times \cos^2 5°30'$

$= 108.989$ m

$$V_1 = \frac{f}{q} \times S_1 \times \frac{\sin 2\theta}{2}$$

$$= 100 \times 1.1 \times \frac{\sin 2(5°30')}{2}$$

$$= 10.494 \text{ m}$$

Case-2

$$D_2 = \frac{f}{q} \times S_2 \times \cos^2\theta$$

$$= 100 \times 1.8 \times \cos^2 8°0'$$

$$= 176.514 \text{ m}$$

$$V_2 = \frac{f}{q} \times S_2 \times \frac{\sin 2 \times (8°0')}{2}$$

$$= 100 \times 1.8 \times \frac{\sin 16°}{2}$$

$$= 24.807 \text{ m}$$

Case-3

$$D_3 = \frac{f}{q} \times S_3 \times \cos^2\theta$$

$$= 100 \times 1.5 \times \cos^2 10°0'$$

$$= 145.477 \text{ m}$$

$$V_3 = \frac{f}{q} \times S_3 \times \frac{\sin 2\theta}{2}$$

$$= 100 \times 1.5 \times \frac{\sin 20°}{2}$$

$$= 25.658 \text{ m}$$

RL of axis when inst. at A

$= RL \text{ of } BM + V_1 + h_1$

$= 450.50 + 10.494 + 1.455$

$= 462.449 m$

RL of axis when inst at B.

$= RL \text{ of axis at } A + V_2 - h_2$

$= 462.449 + 24.807 - 1.656$

$= 485.6 m$

RL of A = RL of axis at A - HI

$= 462.449 - 1.345$

$= 461.104 m$

RL of B = RL of axis at B + HI

$= 485.6 + 1.550$

$= 487.15 m$

RL of C = RL of B + $V_3 - h_3$

$= 487.15 + 25.652 - 2.25$

$= 510.552 m$

∴ Distance bet^n AB = 176.514 m &

BC = 145.277 m

RL of A = 461.104 m

RL of B = 487.15 m

RL of C = 510.552 m.

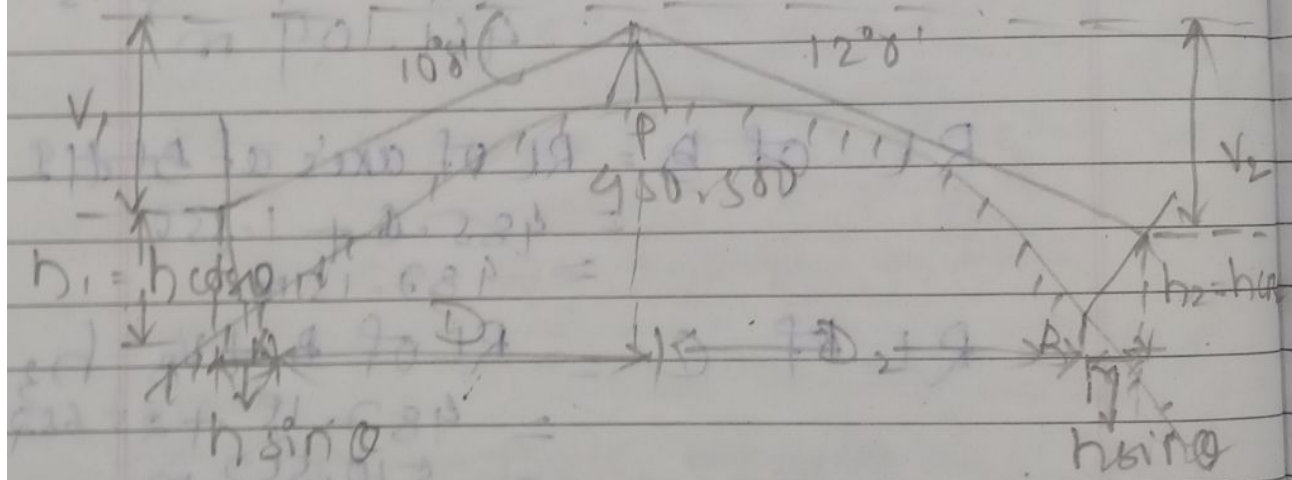
3) Two point A & B are on opposite sides of a summit. The tacheometer was set up at P on top of the summit and the following readings were taken

Inst. Station	H.I	Staff Angle	Mean Readings	Remark
P	1.500	$-10°0'$	1.150, 2.050, 2.950	RL of P = 450.500m
P	1.500	$-12°0'$	0.855, 1.605, 2.355	

The tacheometer is fitted with an anallactic lens, the multiplying constant being 100. The staff was held normal to the line of sight.

Find:- (a) The distance betn A & B, &

(b) The gradients of PA & PB lines



When the staff is held normal to the line of sight, horizontal distance:

(a) $D = \frac{f}{i} \times s \times \cos\theta + (f+d)\cos\theta - h\sin\theta$

$D_1 = 100 \times 1.8 \times \cos 10° + 0 - 2.050 \times \sin 10°$

$= 176.91\,m$

$D_2 = 100 \times 1.5 \times \cos 12° + 0 - 1.605 \times \sin 12°$

$= 146.388\,m$

Distance betn A & B = $D_1 + D_2$

$= 176.91 + 146.388$

$= 323.298\ m$

(b) Vertical distance,

$V = \frac{f}{q} \times S \times \sin\theta$

$V_1 = 100 \times 1.8 \times \sin 10^\circ$

$= 31.257\ m$

$V_2 = 100 \times 1.5 \times \sin 12^\circ$

$= 31.186\ m$

$h_1 = h\cos\theta = 2.050 \times \cos 10^\circ$

$= 2.018\ m$

$h_2 = h\cos\theta = 1.605 \times \cos 12^\circ$

$= 1.569\ m$

RL of axis inst. at P = $450.500 + 1.500$

$= 452.000\ m$

RL of A = RL of inst. axis $- V_1 - h_1$

$= 452.000 - 31.257 - 2.018$

$= 416.725\ m$

RL of B = $452.000 - 31.186 - 1.569$

$= 419.245\ m$

Gradient PA (falling) = $\frac{452.000 - 416.725}{176.91}$

$= \frac{1}{5.56}$

(1 in 5.56)

Gradient of PB (falling)

$$= \frac{450.500 - 419.245}{146.389}$$

$$= \frac{1}{4.68} \quad (1 \text{ in } 4.68)$$

* What is tacheometry?

Ans It is the branch of surveying in which horizontal & vertical distances are measured by taking angular observations with a tacheometer.

* What is the principle of tacheometry?

Ans The principle of tacheometry is based on the property of iso scales triangles where the distances of the bases from the apices and the lengths of the bases always a constant ratio.

* What is the diff^n bet^n a theodolite & tacheometer?

Ans When a theodolite is fitted with an anallactic lens, it is known as a tacheometer. Without the anallactic lens, the instrument called a simple transit theodolite.

* Why is an anallactic lens provided in

a tacheometer?

Ans The anallactic lens is provided in a tacheometer to make the additive constant zero.

* What is tangential tacheometry?

Ans In this system of tacheometry, the angles of elevation or depression are measured and the distances are calculated from the values of tangents of the angles.

* A transit theodolite fitted with a stadia diaphragm & anallactic lens is known as a Tacheometer.

* The stadia diaphragm is provided for measuring :- Horizontal Distance.

* An anallactic lens is provided to make the additive constant equal to :- 0.

* The multiplying constant is denoted by $\left(\frac{f}{i}\right)$ & additive constant is $(f+d)$.

* In tangential tacheometry the staff is held vertically.

* The subtense bar is used to measure Horizontal Distance.