LEARNING MATERIAL

SEMESTER & BRANCH: 6^{TH} SEMESTER CIVIL ENGINEERING

THEORY SUBJECT: LAND SURVEYING- II (TH-1)

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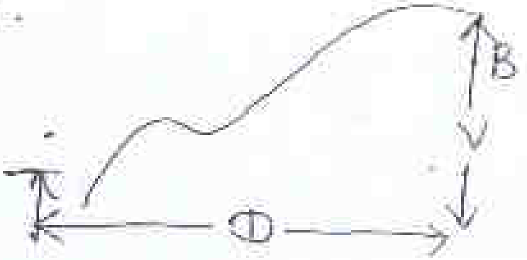
Tacheometric Surveying :-

> Tacheometry is a branch of surveying in which horizontal and vertical distances are determined by taking angular observations with an instrument is known as tacheometer.



> The chaining operation is completely eliminated in such survey.
> Tacheometric surveying is adopted in rough and difficult places where direct levelling and chaining are either not posible or very tedious.
> It is also used in the location survey for railway, road etc.

Advantages :-

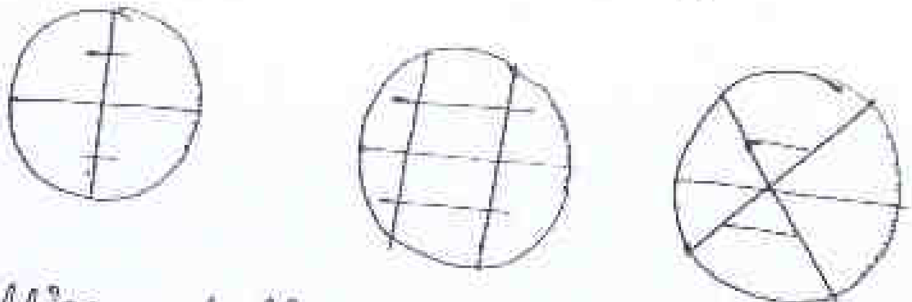
1. This method are useful for the preparation of topographical maps in which both horizont and vertical distance are required.
2. The method are quiet conient for reconnaissance surveys of read roads railways.
> The methods are useful for hydrographic survey

Instruments used in tacheomatry :-

a) The tacheometry.
b) Levelling staff and stadia rod.

a) The tacheometer:-

→ It is nothing but a transit theodolite fitted with a stadia diaphragm and analytical lens. The different form of stadia diaphragm commonly used as given below.



b) Levelling staff and stadia rod:-

→ For short distances, ordinary levelling staff are used. The levelling staff is normally 4m long and can be folded into three parts

→ The graduations are so marked that a minimum reading of 0.005 m can be taken..

→ For long sights a specially designed graduated rod is used which is known as a stadia rod.

→ It is also 4 m long and may be folded on telescopic.

→ The graduations are bold and clear and the minimum reading that can be taken is 0.001 m.

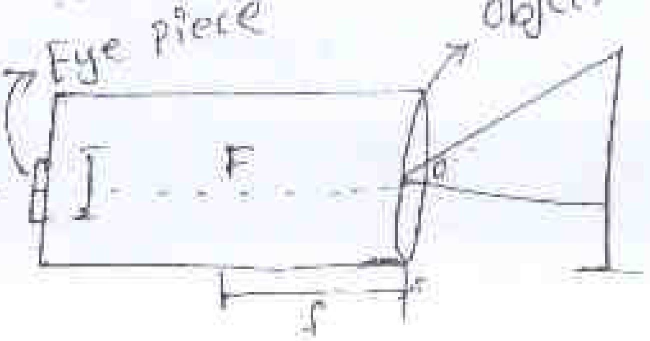
Characteristics of tacheometer:-

1. The value of the multiplying constant $\frac{f}{i}$ should be 100

O → optical centre

F → Focus

f → focal length



b) The telescope should be powerful having a mangi-fication of 20 to 30 diameter.

c) The telescope should be fitted with an analytic lens to make the additative constant (f+d) exactly equal to zero.

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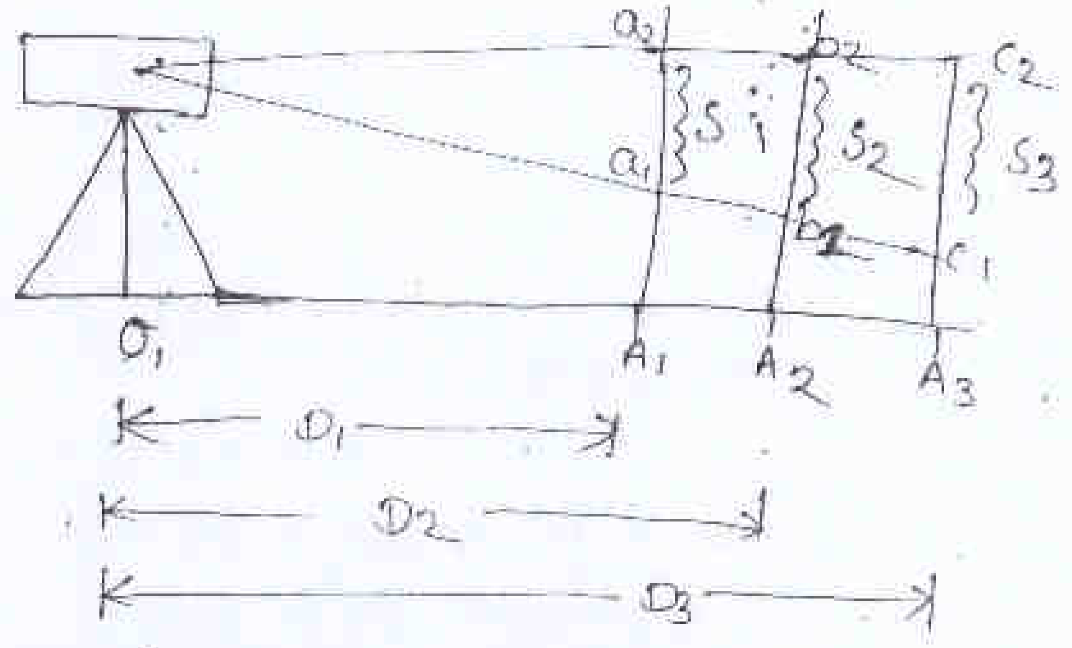
Principle of tacheometry:—

The principle of tacheometry is based on the property of isosceles tringles where the ratio of the distance of the base from the apex and the length of the base is always constant



In this figure $O_1a_1a_2$ and $O_1b_1b_2$, $O_1c_1c_2$ are all isosceles tringles where D_1, D_2 and D_3 are the distances of ases from the apices and S_1 S_2 and S_3 are the lengths of the bases

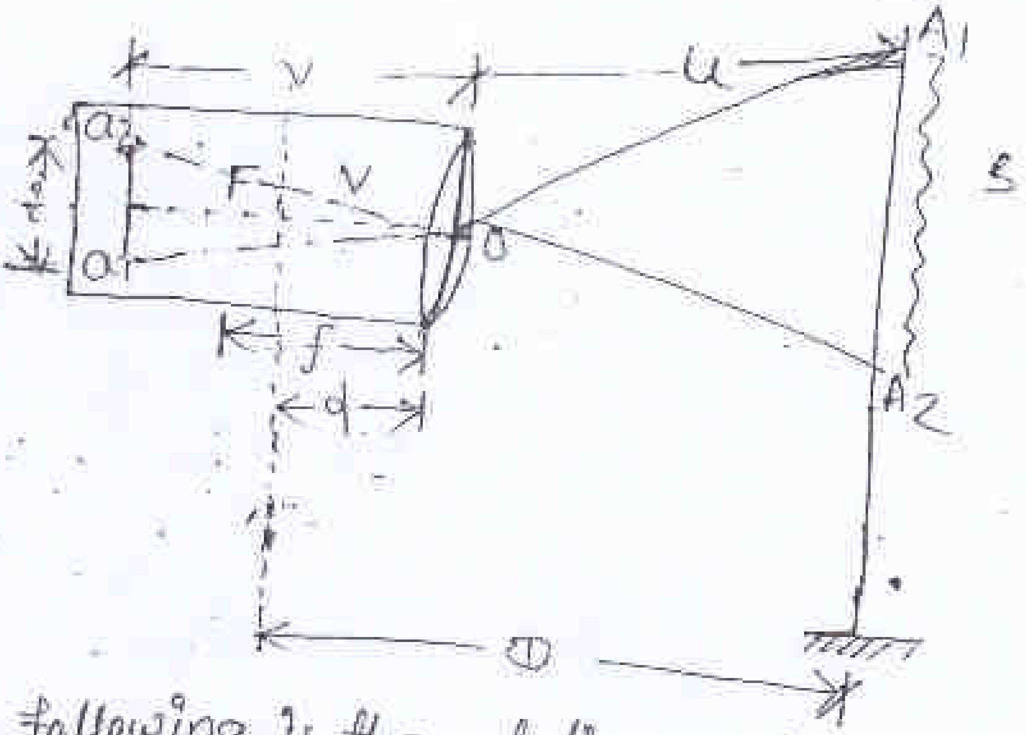
So According to stated principle.

$$\frac{D_1}{S_1} = \frac{D_2}{S_2} = \frac{D_3}{S_3} = \text{Constant} \left(\frac{f}{i}\right)$$

The constant $\frac{f}{i}$ is known as the multiplying

where $f \rightarrow$ focal length of objective
$i \rightarrow$ stadia intercept.

Theory of stadia tacheometry:-



The following is the notation used in stadia tacheometry

$O \rightarrow$ optical centre of object glass.
$s \rightarrow$ staff intercept.
$F \rightarrow$ Focus
$V \rightarrow$ Vertical axis of the instrument
$f \rightarrow$ Focal length of object glass
$d \rightarrow$ Distance betn optical centre and vertical axis of the instrument.
$u \rightarrow$ distance betn optical centre and staff.
$v \rightarrow$ Distance betn optical centre and image.
$i \rightarrow$ length or height of image.

from similar tringles

$$\frac{i}{s} = \frac{v}{u}$$

$$\Rightarrow v = \frac{iu}{s} \quad \text{.... (i) eq}^n$$

From propoties of lens

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v} \quad \text{...... (ii) eq}^n$$

Putting the value of 'v' in eqⁿ ①

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

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

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

$$\Rightarrow u = f\left(1 + \frac{s}{i}\right) \quad \text{.... (iii) eq}^n$$

from figure

$$D = u + d$$

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

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

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

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

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

$$\frac{f}{i} = K, \quad f + d = C$$

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

$D = KS + C$

$D \rightarrow$ Distance betn vertical axis of the instrument and object.

Imp $\rightarrow K \rightarrow$ Multiplying constant $(\frac{f}{i})$

$C \rightarrow$ additive constant $(f+d)$

$S \rightarrow$ staff intercept.

Determination of tachometric or stadia constant (K, C)

The constants may be determine by.

(i) Laboratory measurement.

(ii) Field Measurement

Laboratory Measurement:-

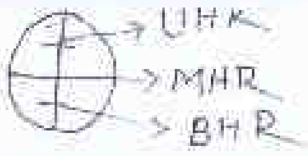
The focal length 'f' of the lens can be determined by means of an optical bench, according to the equations.

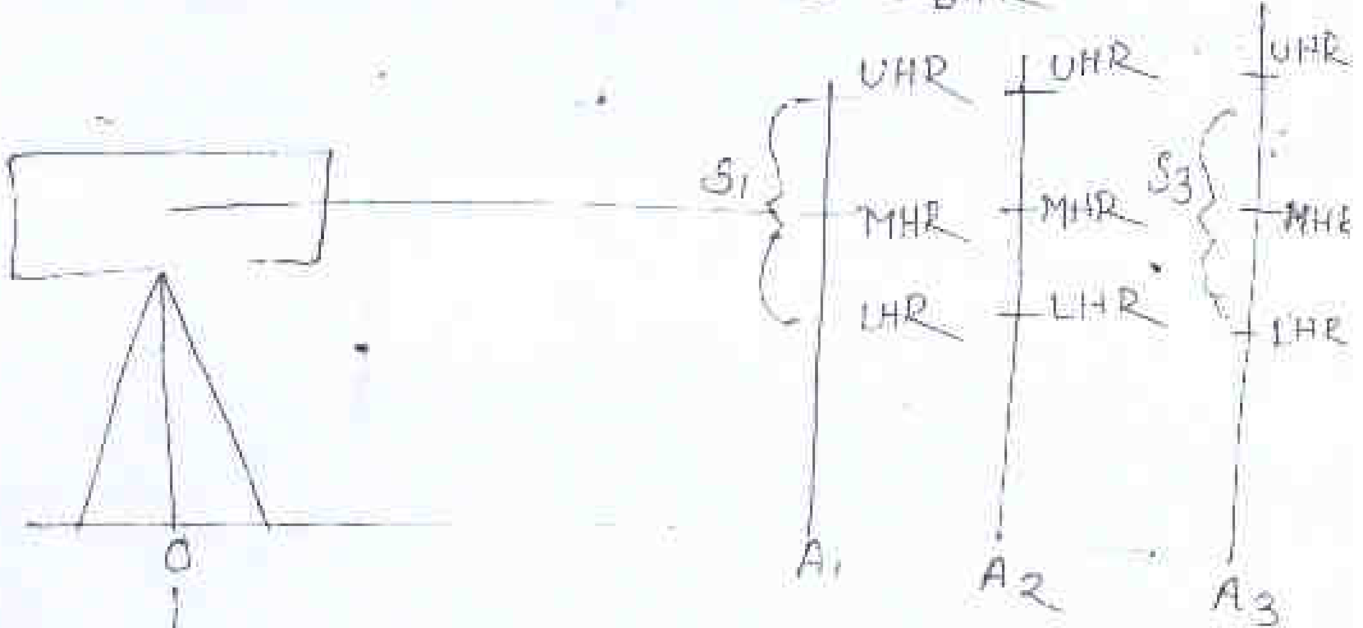
$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$

The stadia intercept 'i' can be measured from the diaphragm with the help of a vernier scale.

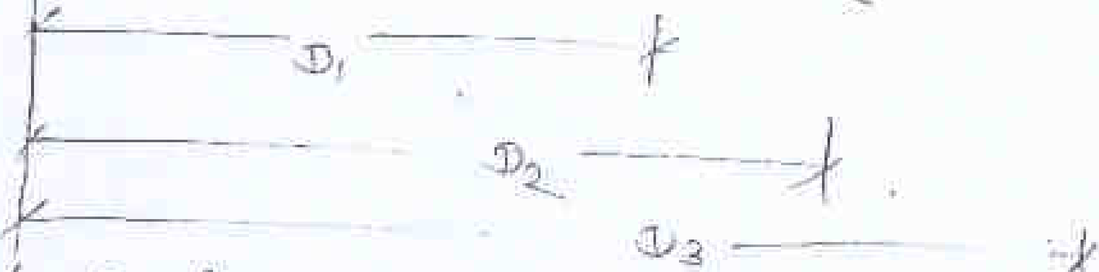
The distance 'd' between the optical centre and vertical axis of the instrument can also be measured. In this manner, The multiplying constant $(\frac{f}{i})$ and additive $(f+d)(C)$ constants can be calculated.

2. Field Measurement:—





stadia intercept : UHR - LHR



A fairly level ground is ~~selected~~ selected Then tachoometer is set up at 'O' and pegs are fixed at A_1, A_2 and A_3

→ The staff intercepts (stadi hair readings are noted at each of the pegs. Let these intercepts are be S_1, S_2 and S_3 respectively.

→ The horizontal distances of the pegs from 'O' are accurately Measured. Let these distances be D_1, D_2 and D_3

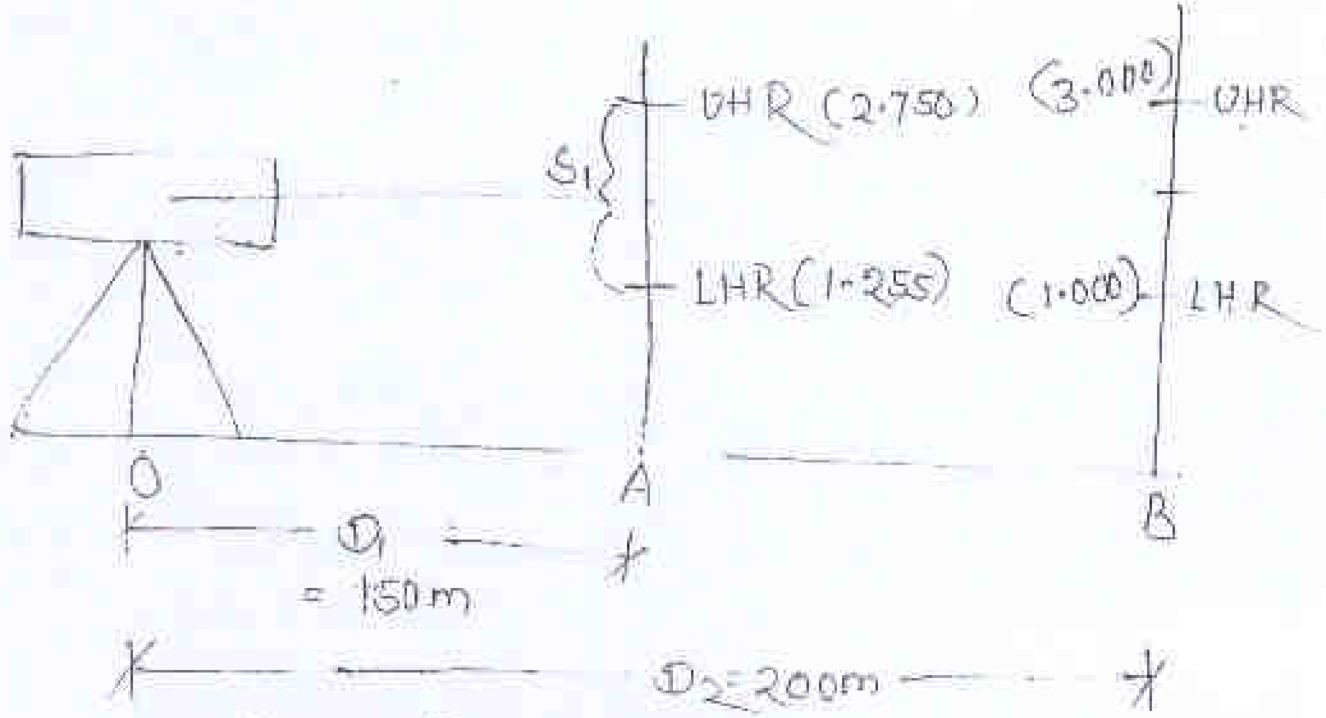
→ By putting the values of D_1, D_2, D_3 ...... and S_1, S_2, S_3 ... in the general equation.

$$D = KS + C$$

$$D_1 = KS_1 + C, \quad D_2 = KS_2 + C, \quad D_3 = KS_3 + C$$

Q:- Determine the values of stadia constants from the following observations.

Instrument statio	Staff reading on	Distance	Stadia reading	
			Lower	upper
O	A	150	1.255.	2.750
	B	200	1.000	3.000



→ General eqn.

$$D = KS + C$$

For first staff position

$$D_1 = KS_1 + C$$

$$\Rightarrow D_1 = K(UHR - LHR) + C$$

$$\Rightarrow 150 = K(2.750 - 1.255) + C$$

$$\Rightarrow 150 = K(1.495) + C$$

$$\Rightarrow 150 = 1.495K + C \quad \text{——} \quad (1) \text{ eq}^n$$

For 2nd staff position

$$D_2 = KS_2 + C$$

$$\Rightarrow D_2 = K(UHR - LHR) + C$$

$$\Rightarrow 200 = K(3.000 - 1.000) + C$$

$$\Rightarrow 200 = 2K + C \text{ ——— (ii) eq}^n$$

$$150 = 1.495K + C \text{ ------ (i) eq}^n$$

$$(-) \quad 200 = 2K + C \text{ ------ (ii) eq}^n$$

$$(-) \quad (-) \quad (-)$$

$$-50 = -0.505K$$

$$K = \frac{-50}{-0.505} = 99$$

Put the value K in eq^n (i)

$$150 = 1.495K + C$$

$$\Rightarrow 150 = 1.495 \times 99 + C$$

$$\Rightarrow C = 150 - (1.495 \times 99)$$

$$\Rightarrow C = 1.995$$

$$\boxed{\begin{array}{l} K = 99 \\ C = 1.995 \end{array}} \begin{array}{l} < K = 100 \\ > 0 \end{array}$$

Q-2 Determine the values of stadia constants from the following observations.

Instrument statio	staff reading on	Distance (m)	Stadia readings Lower	Stadia readings upper
O	A	150	1.255	2.750
	B	200	1.000	3.000
	C	250	0.750	3.255

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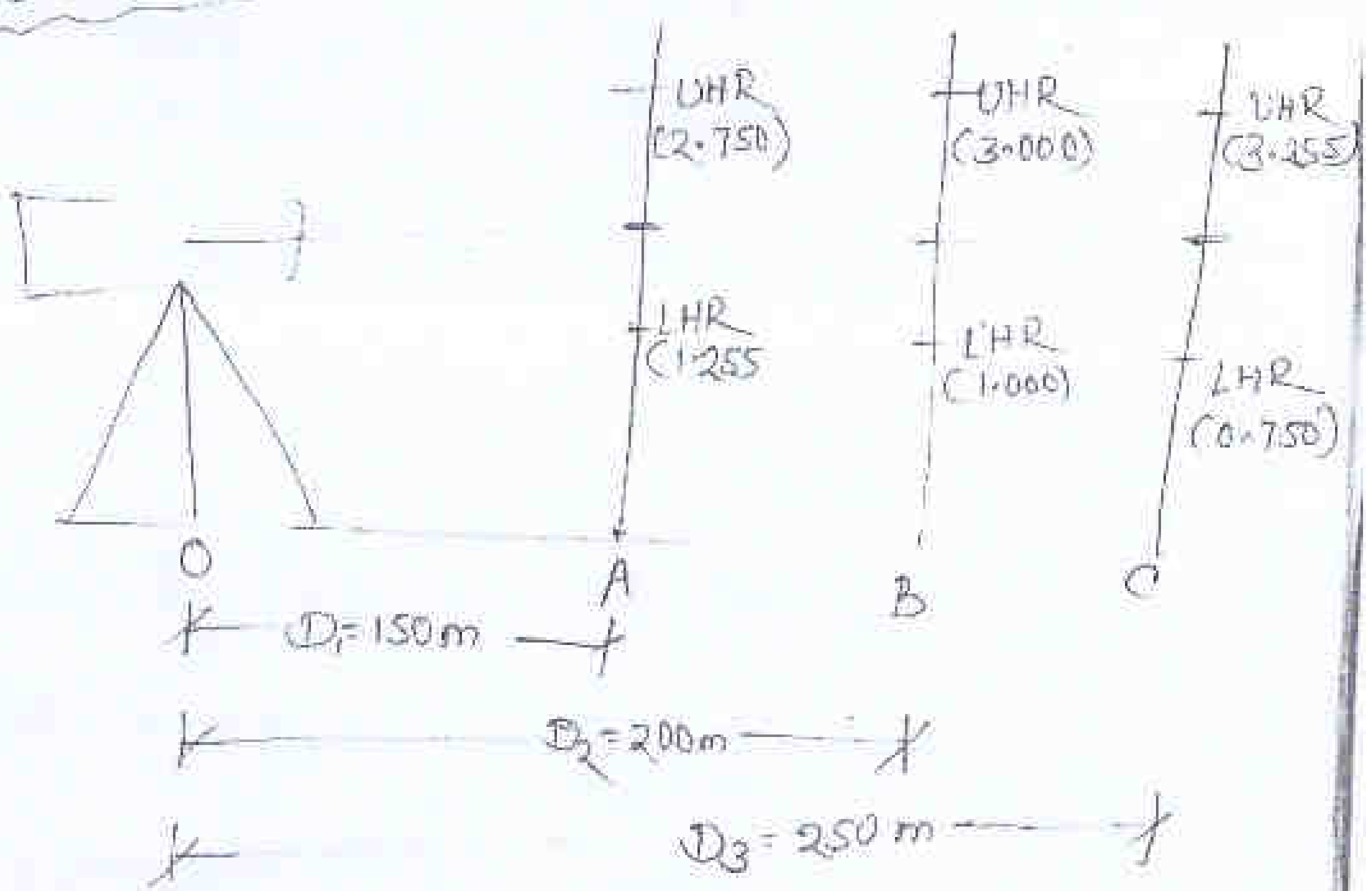


The general eqⁿ of theory of tacheometry

$$D = KS + C$$

Where $K = \left(\frac{f}{i}\right)$ = Multiplying constant.

C = additive constant $(f+d)$

D = Distance between instrument station and position of staff.

S = Stadia intercept $(UHR - LHR)$

For first position of staff.

$$D_1 = KS_1 + C$$

$\Rightarrow 150 = K(UHR - LHR) + C$

for 1st position of staff.

$\Rightarrow 150 = K(2.750 - 1.255) + C$

$\Rightarrow 150 = K(1.495) + C$

$\Rightarrow 150 = 1.495K + C$ .... (i) eqⁿ

For 2nd position of staff:-

$$D_2 = KS_2 + C$$

$$\Rightarrow 200 = K(3.000 - 1.000) + C$$

$$\Rightarrow 200 = 2K + C \text{ ...... (ii) eq}^n$$

For third position of staff

$$D_3 = KS_3 + C$$

$$\Rightarrow 250 = K(3.255 - 0.750) + C$$

$$\Rightarrow 250 = 2.505\,K + C \text{ ...... (iii) eq}^n$$

$$150 = 1.495K + C \text{ .... (i) eq}^n$$

$$200 = 2K + C \text{ .... (ii) eq}^n$$

$$250 = 2.505K + C \text{ .... (iii) eq}^n$$

Solving eq^n (i) & eq^n (ii)

$$150 = 1.495K + \cancel{C} \text{ ..... (i)}$$

$$- \underset{(-)}{200} = \underset{(-)}{2K} \underset{(-)}{+} C \text{ ..... (ii)}$$

$$\overline{-50 = -0.505K}$$

$$\Rightarrow K = \frac{50}{0.505}$$

$$\Rightarrow K = 99$$

Put the value of 'K' in eq^n (ii)

$$200 = 2K + C$$

$$\Rightarrow 200 = (2 \times 99) + C$$

$$\Rightarrow C = 200 - (2 \times 99)$$

$$\Rightarrow C = 2$$

$K = 99$

$C = 2$

Solving eqⁿ (ii) & (iii)

$200 = 2K + C$ ...... (ii) eqⁿ

$- \quad 250 = 2.505K + C$ ...... (iii) eqⁿ

$\quad (-) \quad (-) \quad (-)$

$-50 = -0.505K$

$\Rightarrow 50 = 0.505K$

$\Rightarrow K = \dfrac{50}{0.505} = 99$

$K = 99$

$C = 2$

Put the value 'K' in eqⁿ (iii)

$250 = 2.505 \times 99 + C$

$\Rightarrow C = 250 - (2.505 \times 99)$

$\Rightarrow C = 2$

Solving eqⁿ (iii) & eqⁿ (i)

$250 = 2.505K + C$ ——— (iii) eqⁿ

$- \quad 150 = 1.495K + C$ ...... (i) eqⁿ

$\quad (-) \quad (-) \quad (-)$

$K = 99$

$C = 1.995$

$100 = 1.01K$

$\Rightarrow K = \dfrac{100}{1.01}$

$\Rightarrow K = 99$

Put the value 'K' in eqⁿ (i)

$150 = (1.495 \times 99) + C$

$\Rightarrow C = 150 - (1.495 \times 99)$

$\Rightarrow C = 1.995$

$$\text{Avg of } K = \frac{99+99+99}{3} = 99$$

$$\text{Avg of } C = \frac{2+2+1.995}{3} = 1.992$$

Tacheometry surveying method:-

Tacheometry involves mainly two methods.

1. Stadia method
2. Tangential method.

1. Stadia method :-

In this method, the diphagm of the tacheometer is provided with two stadia hair (Upper and lower)

→ Looking though the telescope the stadia hair readings are taken.

→ The difference in these readings gives the stadia intercepts.

→ To determine the distance between the station and staff, The staff intercept is multiplied by stadia constant.

→ The stadia method may be two kinds

(i) Fixed hair method.

(ii) Moveable hair method.

Fixed hair method:-

→ The distance betⁿ the stadia hairs is fixed in this method.

→ The vertical distance betⁿ top and bottom stadia hair is called as stadia interval.

→ When the staff is sighted through the telescope telescope, AC is intercepted by the upper and lower stadia.

→ The staff intercept made by the stadia hair varies directly with the distance from the instrument station and staff station.

→ Hence in fixed hair method the staff intercept (s) and vertical angle (α) are measured to calculate the horizontal distance and difference in elevation.

Moveable hair method:-

→ The stadia hairs are not fixed in this method. The stadia hairs are moveable.

→ The stadia interval is varied by moving the stadia hairs vertically by means of micrometer screws.

→ The staff is provided with two targets or vanes a known distance apart.

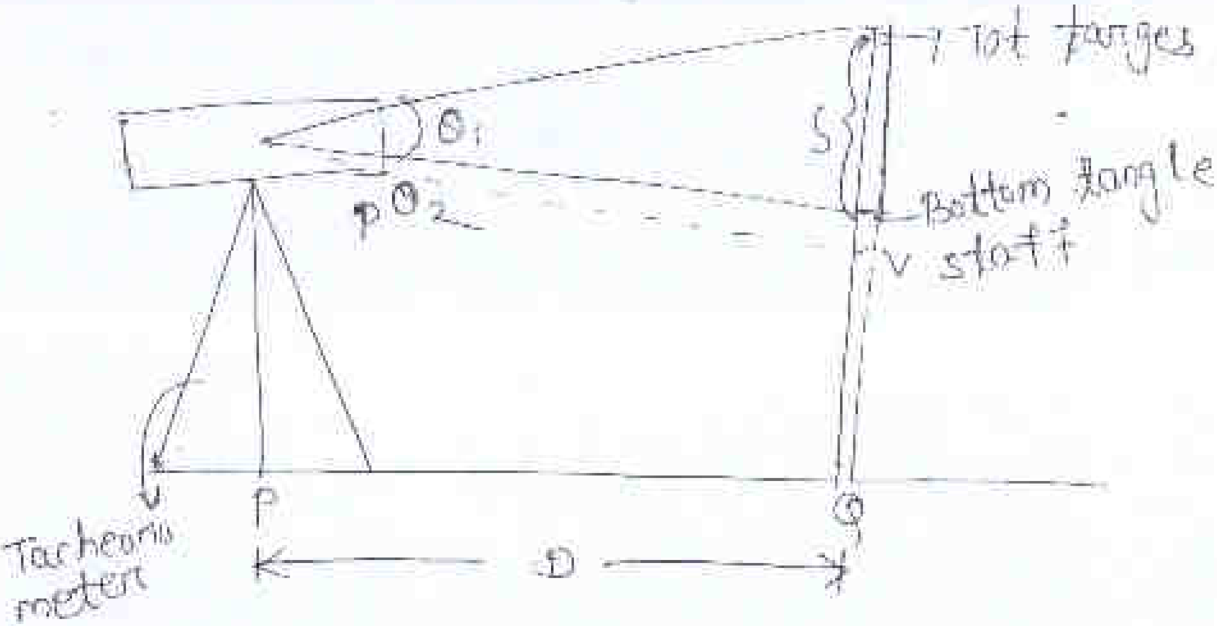
→ During observation the distance between stadia hairs is so adjusted the upper hair bisects the upper target and the lower hairs bisects the lower target.

→ The stadia interval (i) and vertical angles (α) are measured then the horizontal distance and different in elevation are calculated.

The tangential method:-

→ In this method the diaphragm of the tacheometer is not provided.

→ The ~~read~~ readings are taken by the single horizontal hair.



→ A staff with two target at fixed distance (s) is use for taking the measurment.

→ The vertical angle θ_1 and θ_2 to the two target are measured.

→ These vertical angle and the fixed distance are used to determine the horizontal distance 'D' and the difference of elevation.

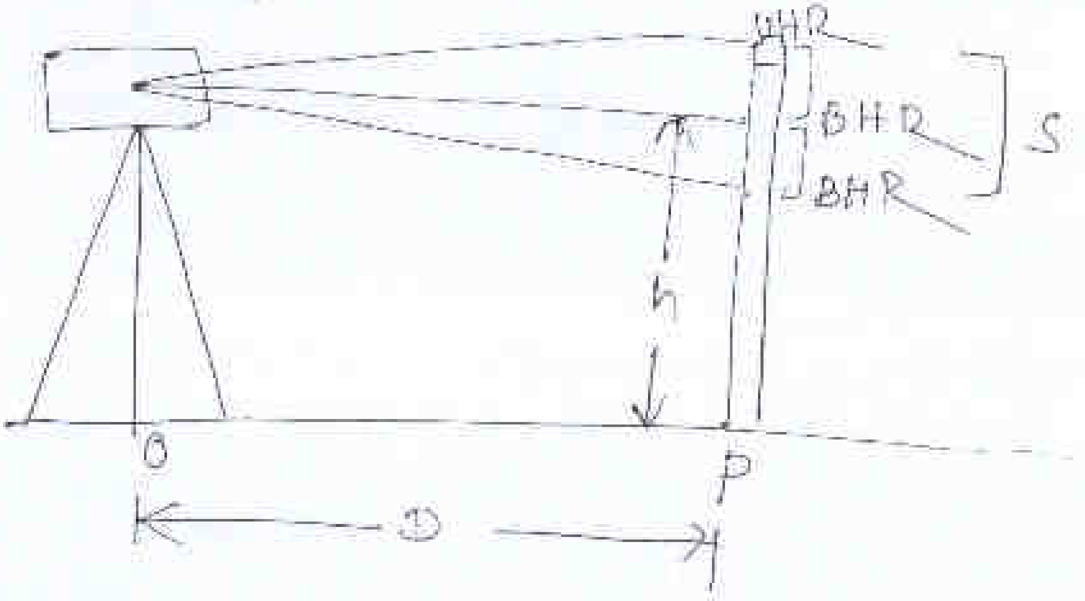
Determination of distance and elevation-stadia system

Fixed hair method:-

while taking observation the telescope of the tameter may be horizontal or inclined according to the position of staff. The difference case are explained below.

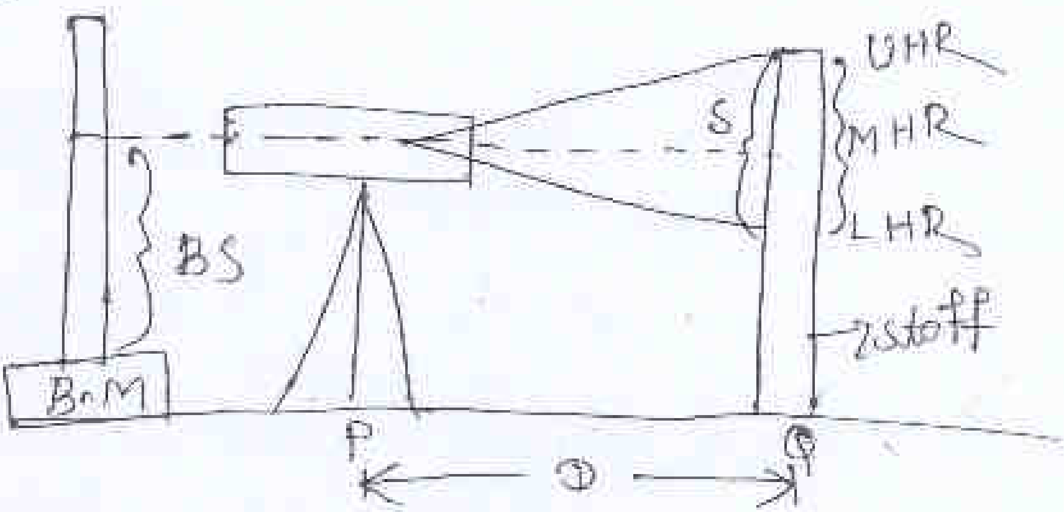
Case-I

When the line of sight is horizontal but held vertical.



When the line of sight is horizontal the general tacheometry eqn is given by

Dt-03.05.21 $D = KS + C$



$D = KS + C$

$S = UHR - LHR$

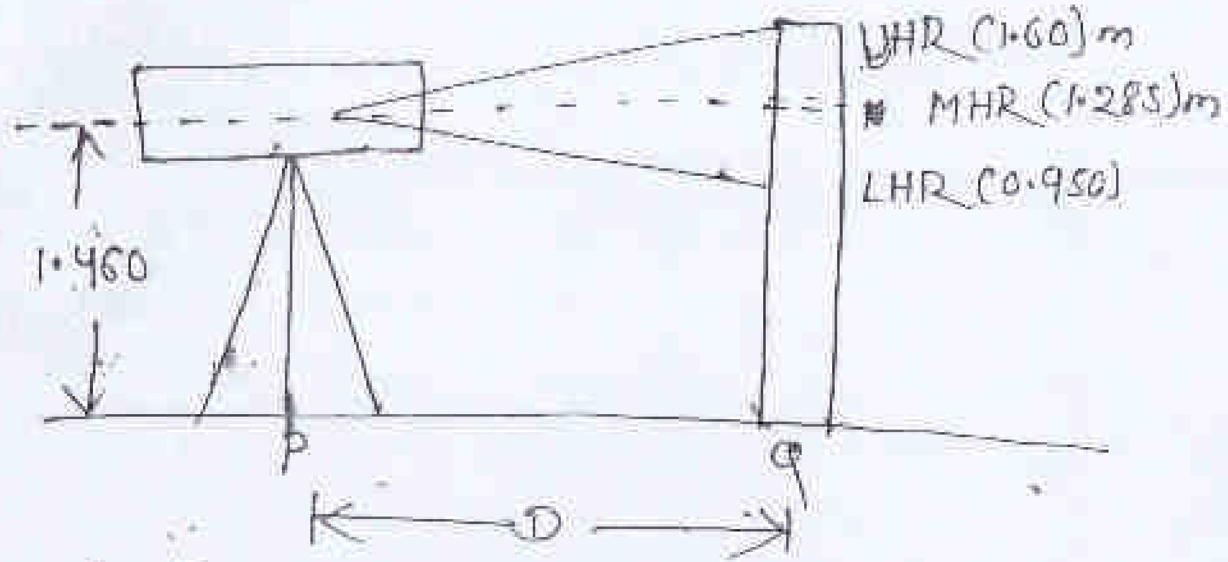
Height of instrument (HI) = BM + BS

RL of Q = (HI − MHR)

Q-3. The following readings where taken with a techometer with the line of sight is horizontal and a staff held vertical.

0.950	1.285	1.620 m
Lower	Middle	Upper

Determine the horizontal distance from the instrument station to the staff station if a multipying constant 100 additive constant 0.15m. Also determine the R.L of staff station if the R.L of instrument is 101.580m and height of instrument axis is 1.460mt.



Data given:—

Multiplying constant (K) = 100

Additive constant (C) = 1.15 m

Horizontal distance (D) = KS + C

$D = 100 \times (1.620 - 0.950) + 0.15$

$= 67.150$ mt.

R.L of axis of instrument.

= R.L of 'P' + Height of instrument axis

$= 101.580 + 1.460$

$= 103.040$ mt

R.L of staff station = R.L of axis of instrument − MHR

or (R.L of Q)

$= 103.040 - 1.285$

Case- II

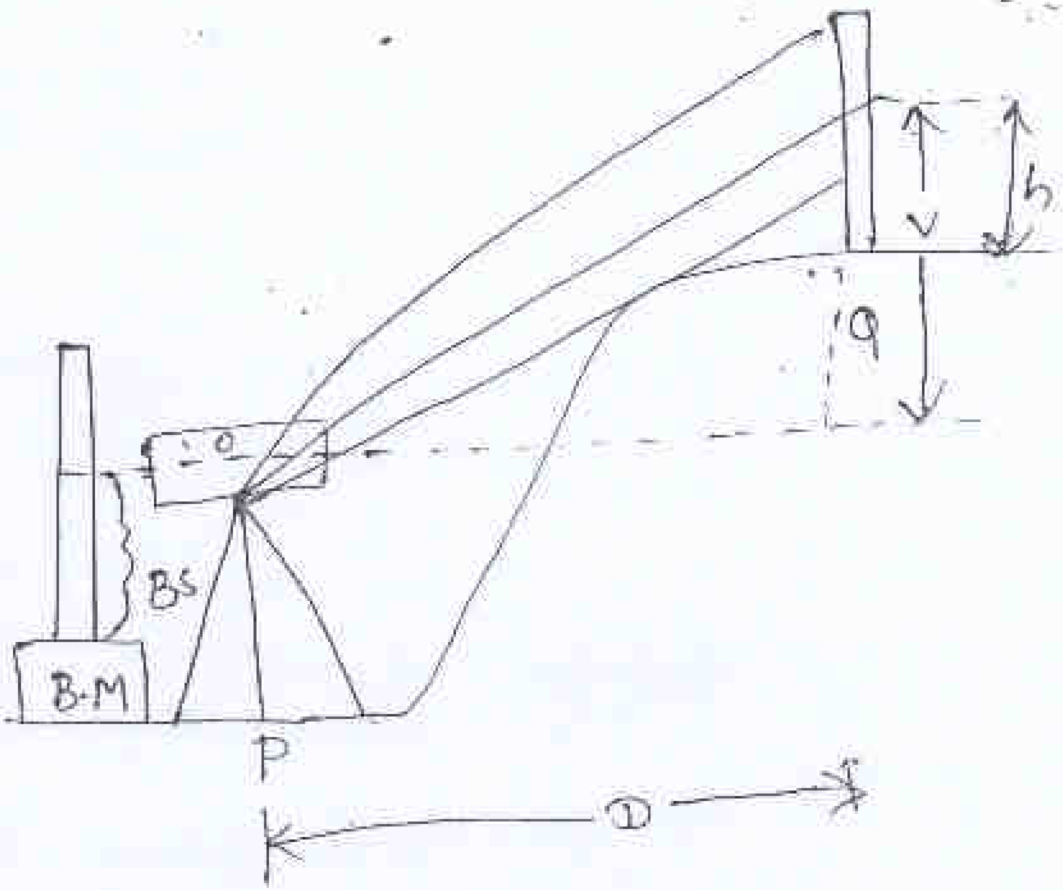
When the line of sight is inclined staff is kept vertically

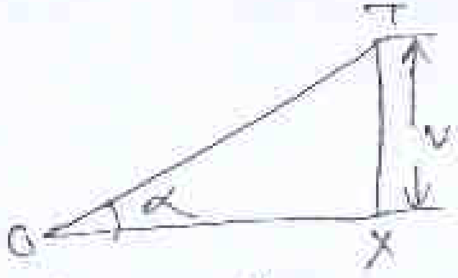
*** Angle of elevation:-**

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

$V = D\tan\alpha$

R.L of Q = (B.M + B.S) + V - h

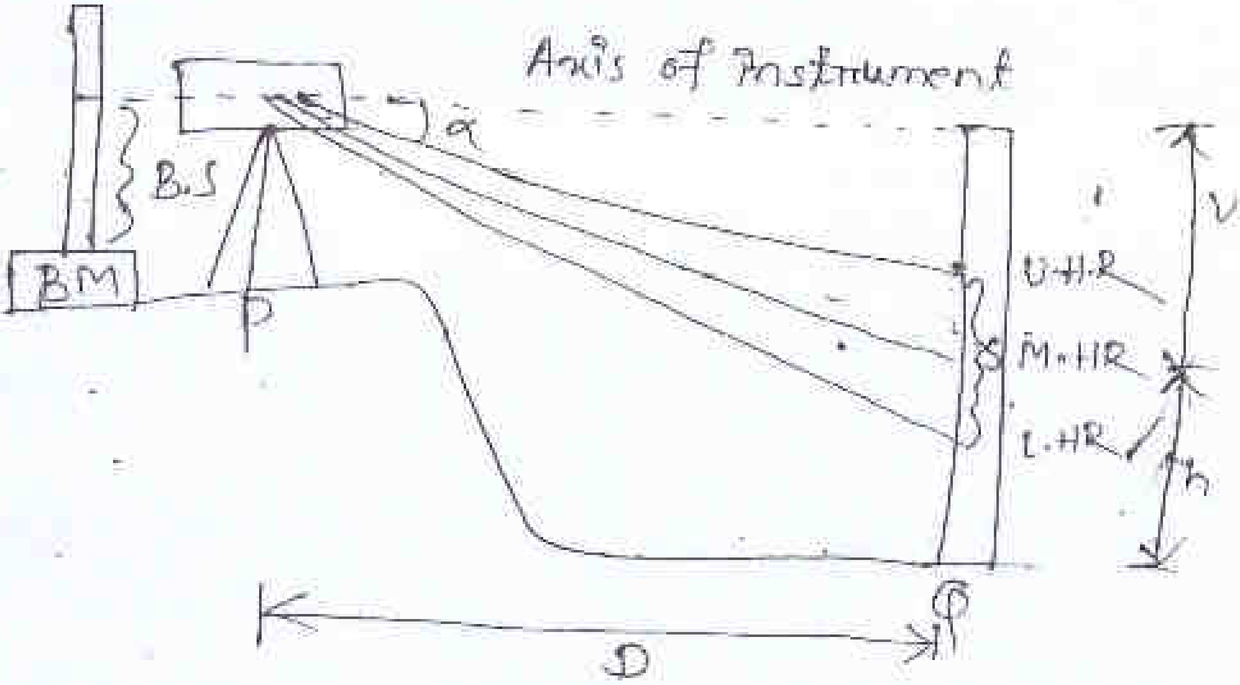




$\tan\alpha = \frac{V}{D}$

$\Rightarrow V = \tan\alpha$

Angle of depression:-



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

$$V = D\tan\alpha$$

$$R.L\ of\ Q = (B.M + B.S) - V - h$$

Case-II

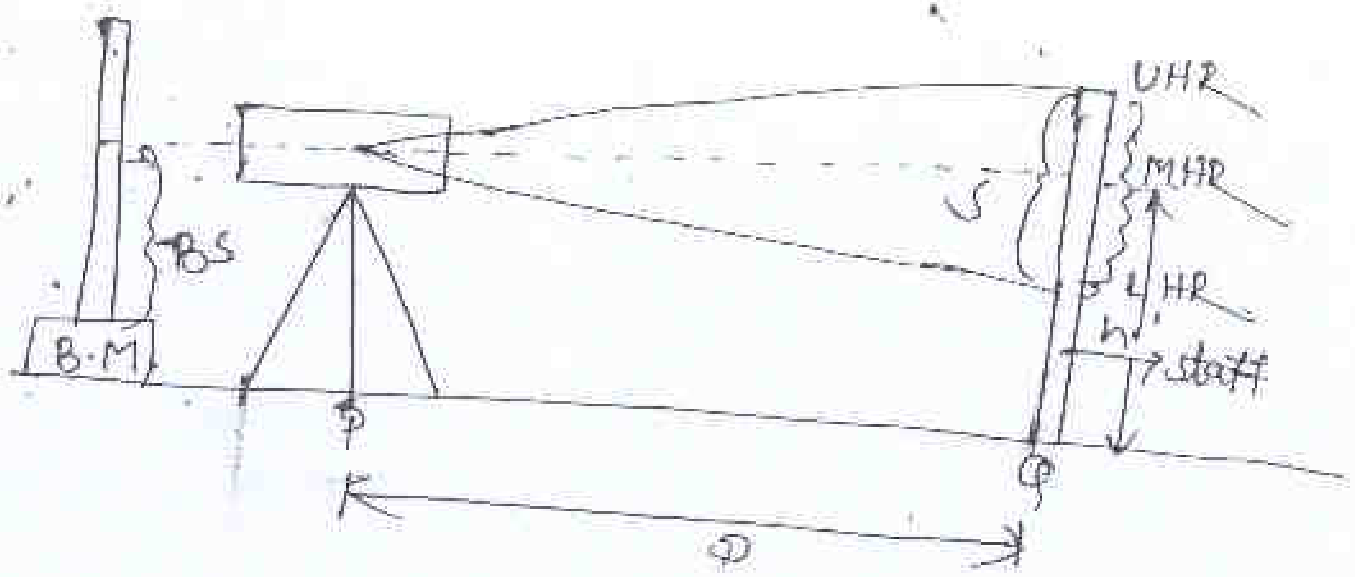
When line of sight is inclined but staff is held vertically.

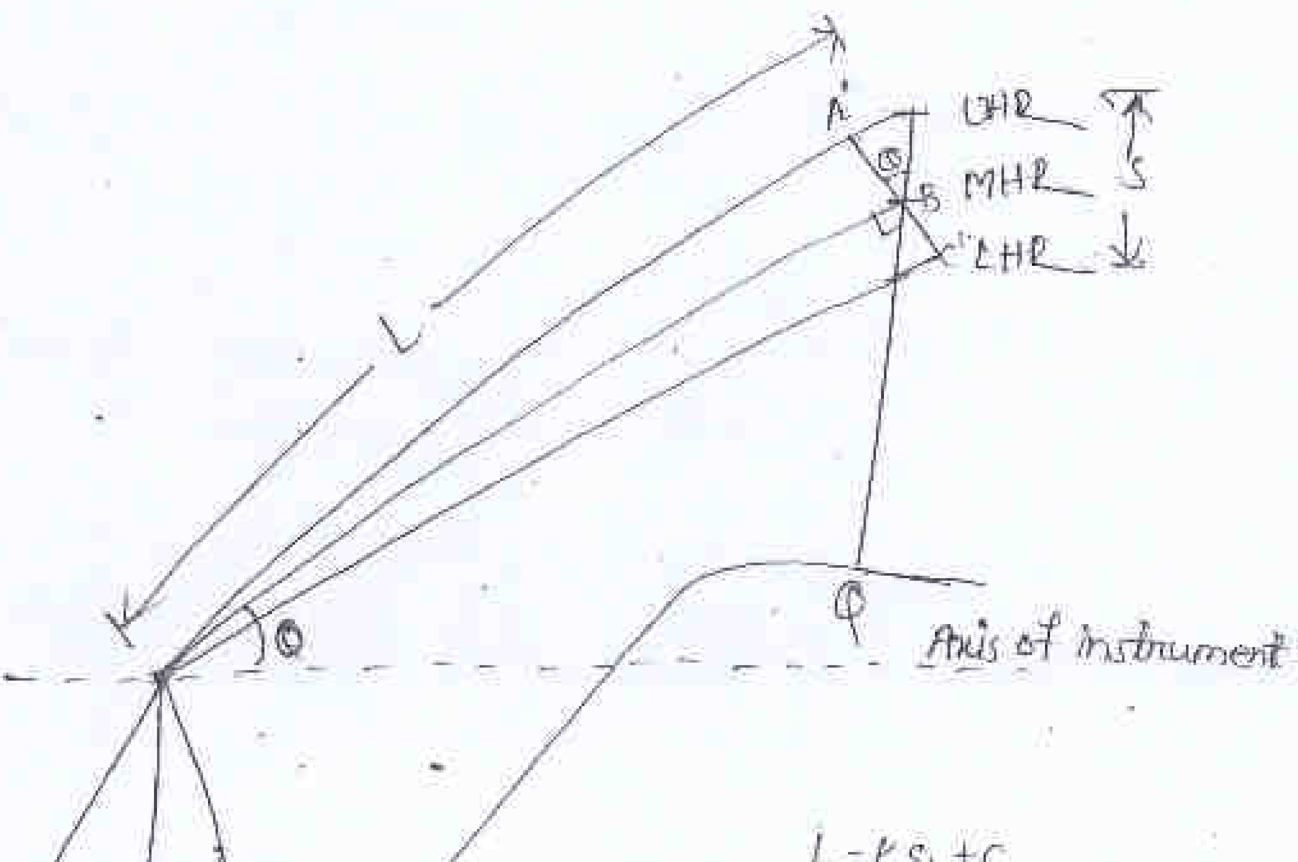
Here the measured angle may be the angle of elevation or that of depression

→ Considering angle of elevation:- (Positive)

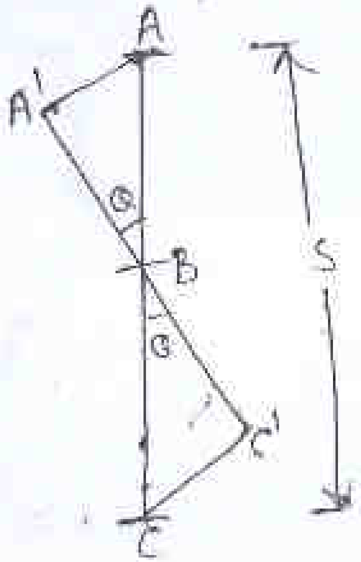
Case-I

When the line of sight is horizontal and staff held vertical.


UHR
MHR
LHR
S
h
BS
B·M
staff
P
Q
D


L
A
UHR
MHR
LHR
S
θ
Q
Axis of Instrument
P
D

$L = KS_1 + C$



$A'BC' = S_1$

$L = KS_1 + C$

$S_1 = A'B + BC'$

$A'B = \frac{S}{2} \cos\theta$

$B'C = \frac{S}{2} \cos\theta$

$S_1 = A'B + B'C$

$= \frac{S}{2}\cos\theta + \frac{S}{2}\cos\theta$

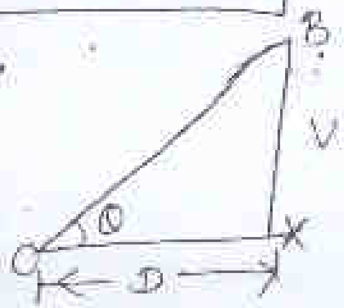
$= S\cos\theta$

$L = KS\cos\theta + C$

$\therefore D = L\cos\theta$

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

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

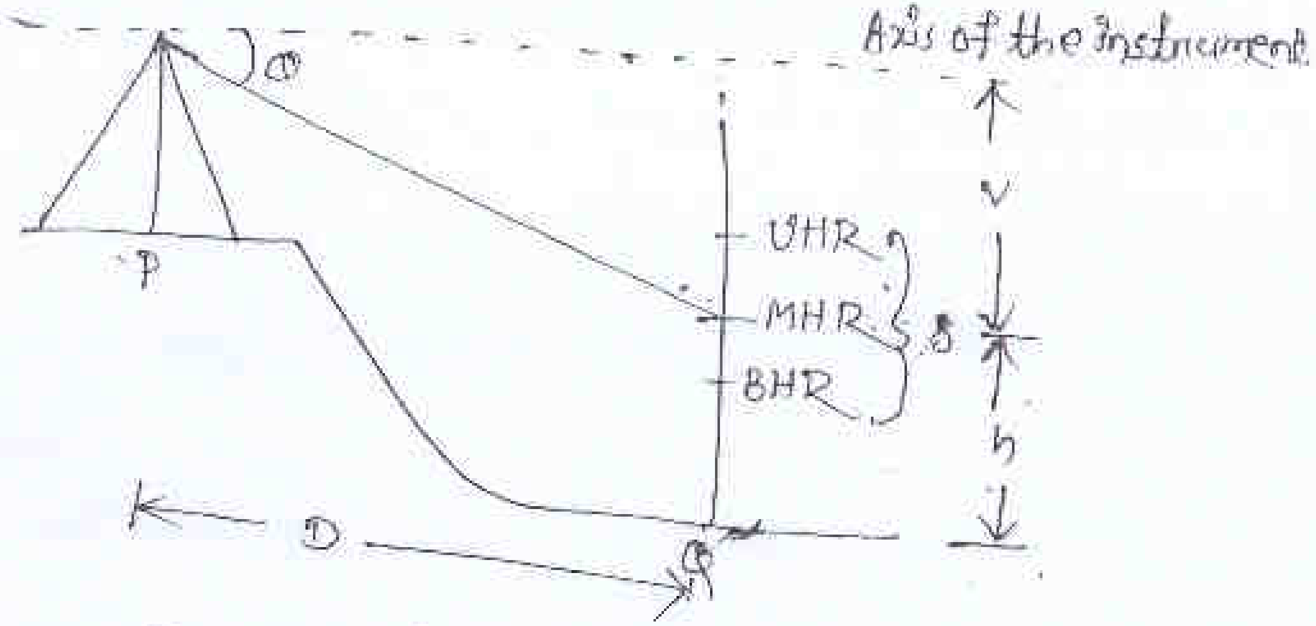


$\therefore \tan\theta = \frac{V}{D}$

$\Rightarrow \boxed{V = D\tan\theta}$

RL of Q = Axis of the instrument + V - h

Considering angle of depression:- (negative)



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

$V = D\tan\theta$

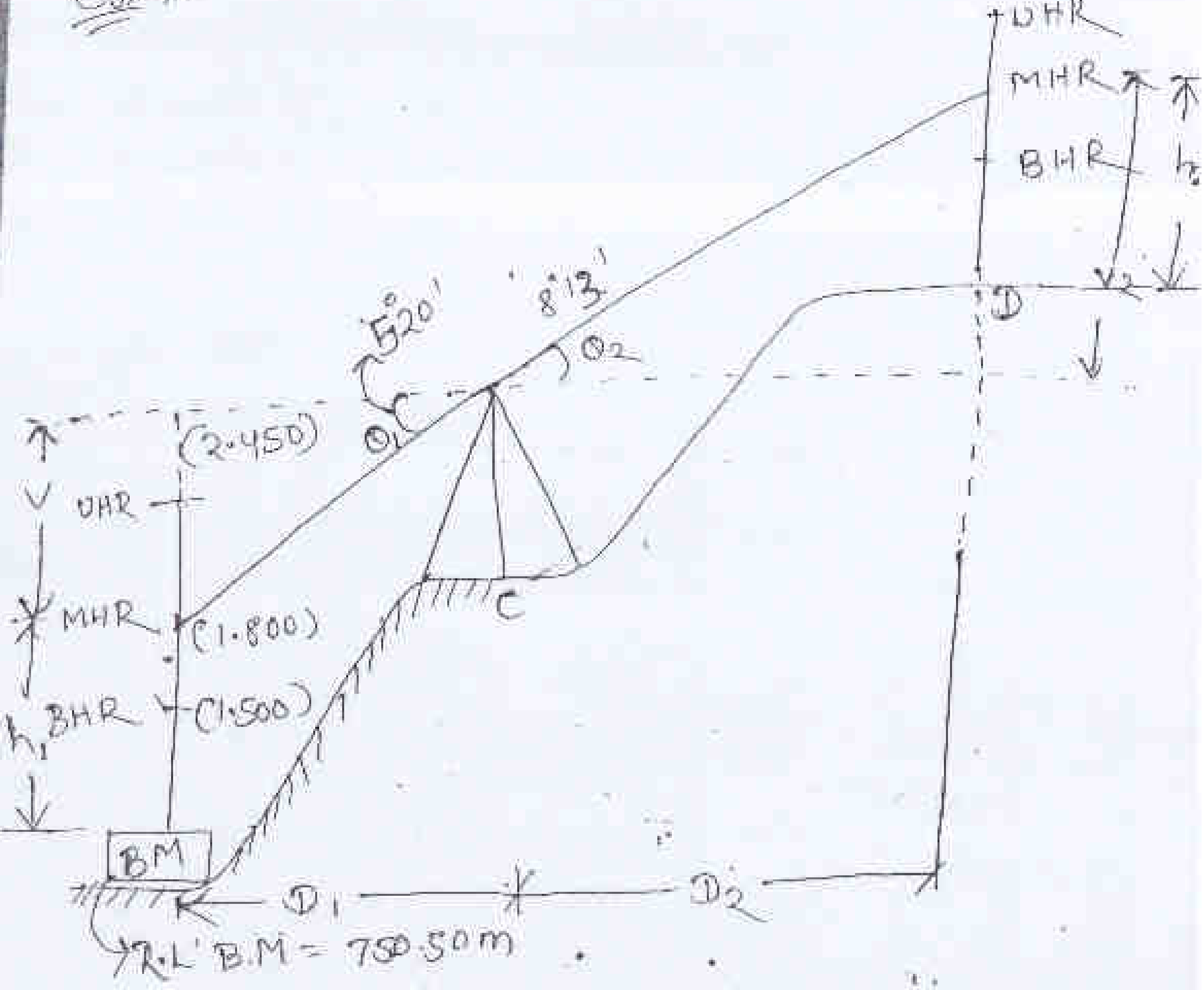
RL of 'Q' = Axis of the instrument − V − h

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

Instrument station	staff station	vertical angle	Hair readings (m)	Remarks
C	B.M	$-5°20'$	1.500, 1.800, 2.450	RL of B.M
C	D	$+8°12'$	0.750, 1.500, 2.750	= 750.50 m

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

Soln:-



For 1st case

$D_1 = KS_1 \cos^2\theta + C\cos\theta$

$D_1 = 100(2.450 - 1.500)\cos^2(5°20') + 0.15\cos(5°20')$

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$= 94.32$ mt

$V_1 = D_1 \tan\theta_1$

$= 94.32 \times \tan(5°20')$

$= 8.80$ mt.

For 2nd case

$D_2 = KS_2 \cos^2\theta_2 + c\cos\theta_2$

$= 196.06$ mt

The horizontal distance $CD = 196.06$ mt.

$$V_2 = D_2 \tan\theta_2 = 196.06 \times \tan(8^\circ 13')$$

$$= 28.210 \text{ mt}$$

$h_1 = 1.800$ m

$h_2 = 1.500$ m

$$R_L \text{ of } 'D' = R_L \text{ of } B.M + h_1 + V_1 + V_2 - h$$

$$= 750.50 + 1.800 + 8.80 + 28.310 - 1.500$$

$$= 787.910 \text{ mt}$$

Q-3

The following observations were taken with a tacheometer fitted with analytical lens. the staff is being vertically. the constant of tacheometer is 100.

Instrument station	Height of instrument	Staff station	Vertical angle	Staff Reading in (m)	Remarks
P	1.255	B.M	$-4^\circ 20'$	1.325, 1.825, 2.350	RL of BM = 255.7
P	1.255	A	$+6^\circ 30'$	0.850, 1.600, 2.350	
B	1.450	A	$-7^\circ, 24'$	1.715, 2.315, 2.915	

Find the horizontal distance PA and AB, also calculate the RL of 'B'.

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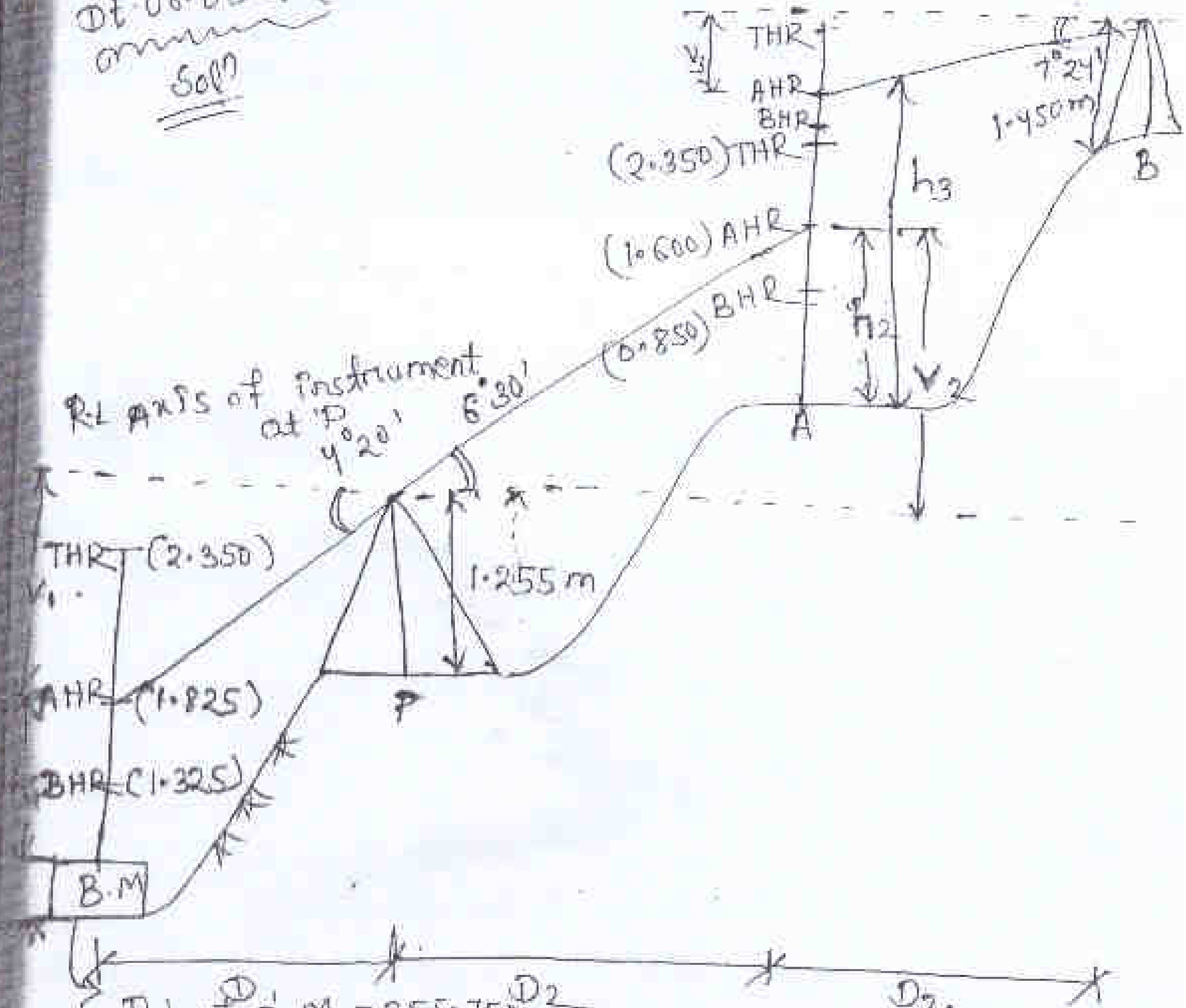
Soln



R.L of B.M = 255.750

Here $K = 100$, $C = 0$

For 1st observation :-

$$D_1 = KS_1 \cos^2\theta_1 + \cancel{C}^{\,0} \cos\theta_1$$

$$D_1 = KS_1 \cos^2\theta_1$$

$$= 100(2.350 - 1.325)\cos^2(4°20')$$

$$= 101.91 \text{ m}$$

$$V_1 = D_1 \tan\theta_1$$

$$= 101.91 \times \tan(4°20')$$

$$= 7.72 \text{ m}$$

For 2nd observation :-

$$D_2 = KS_2\cos^2\theta_2 + \cancel{C\cos\theta_2}^{0}$$

$$D_2 = KS_2\cos^2\theta_2$$

$$= 100(2.350 - 0.850)\cos^2(6°30')$$

$$= 148.07m$$

$$V_2 = D_2\tan\theta_2$$

$$= 148.07 \times \tan(6°30')$$

$$= 16.87m$$

For 3rd observation.

$$D_3 = KS_3\cos^2\theta_3 + \cancel{C\cos\theta_3}^{0}$$

$$D_3 = KS_3\cos^2\theta_3$$

$$= 100(2.915 - 1.715)\cos^2(7°24')$$

$$= 118.009\,m$$

$$V_3 = D_3\tan\theta_3$$

$$= 118.009\tan(7°24')$$

$$= 15.326m$$

The horizontal distance PA = 148.07m

The horizontal distance AB = 118.009m

RL of axis of instrument at 'P'

$$= B.M + h_1 + V_1$$

$$= 255.750 + 1.825 + 7.72$$

$$= 265.295\,m.$$

R.L of 'A' = RL of axis of instrument of $P + V_2 - h_2$

$= 265.295 + 16.87 - 1.600$

$= 280.565$ m.

RL of axis when instrument 'B'

$=$ R.L of 'A' $+ h_3 + V_3$

$= 280.565 + 2.315 + 15.326$

$= 298.206$ m

R.L of B = 298.206 m − HI
(R.L of axis when instrument at 'B')

$= 298.206 - 1.450$

$= 295.756$ m

Q:-

The following observations where made using a tacheometer with an anallatic lengs. The multiplying constant being 100.

Instrument station	Height of the instrument	Staff station	W.C.B	Vertical angle	Hair Reading in mt	Remark
O	1.550	A	30°30'	4°30'	1.55, 1.755, 2.355	RL of O = 150.000 m
		B	75°30'	10°15'	1.250, 2.000, 2.750	

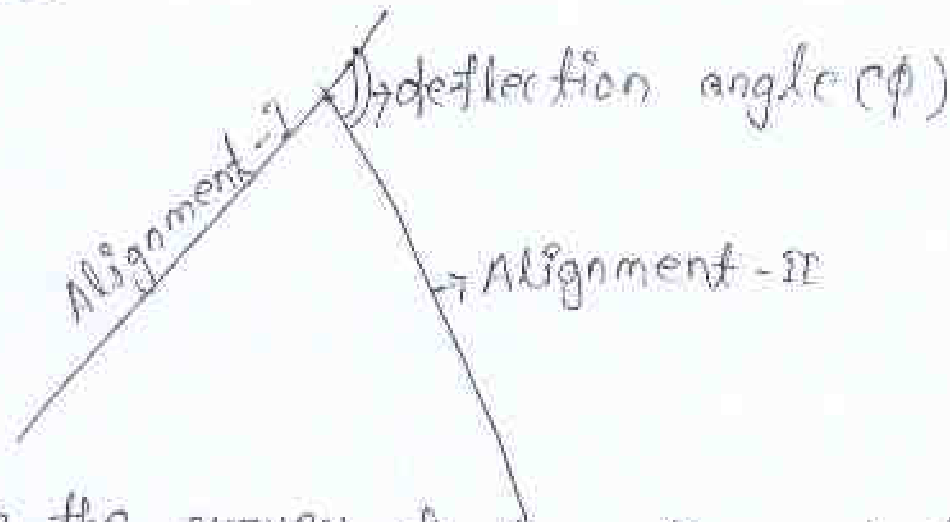
Calculate the distance AB and R.L of 'A' and 'B'

find the gradient of the line 'AB'

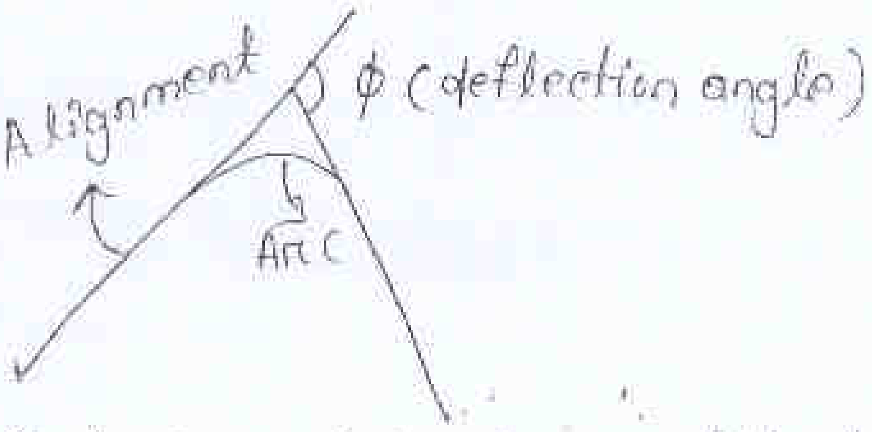
~~→ During the survey of the aligment of a project involving roads and railways. The direction of line may change due to~~

UNIT- II

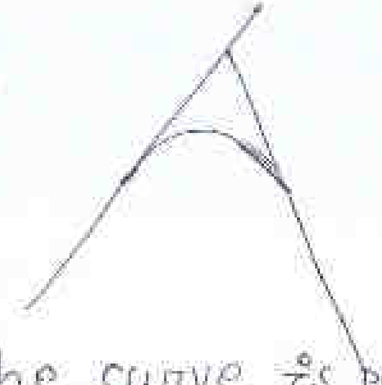
Curves:-



→ During the survey of the alignment of a project involving roads and railways. The direction of line may change due to unavoidable ~~cho~~ circumstances. The angle of the change in direction is known as deflection



→ From it to be possible for a vehicle to run easily along the road or railway track. The two straight lines are connected by an arc which is know as the curve of the road or track.



→ when the curve is provided in the horizontal plane. it is known as horizontal curve.

→ The alignment of any project. The nature of may not be uniform and may consist of different gradients (rising gradient is followed by falling gradient and vice-versa)

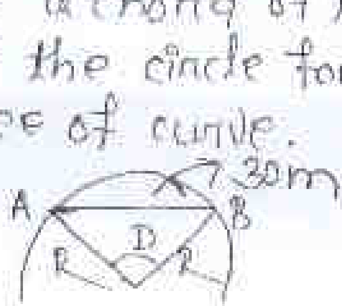
→ In such case. A parabolic curved path is provided in the vertical plane in order to connect the gradients for easy movement of the vehicles. The curve is known as vertical curve.

Curve
- Horizontal curve
  - simple curve
  - compound curve
  - Reverse curve
  - Transition curve
  - Lamined curve.
- Vertical curve

Terms related to curve:-

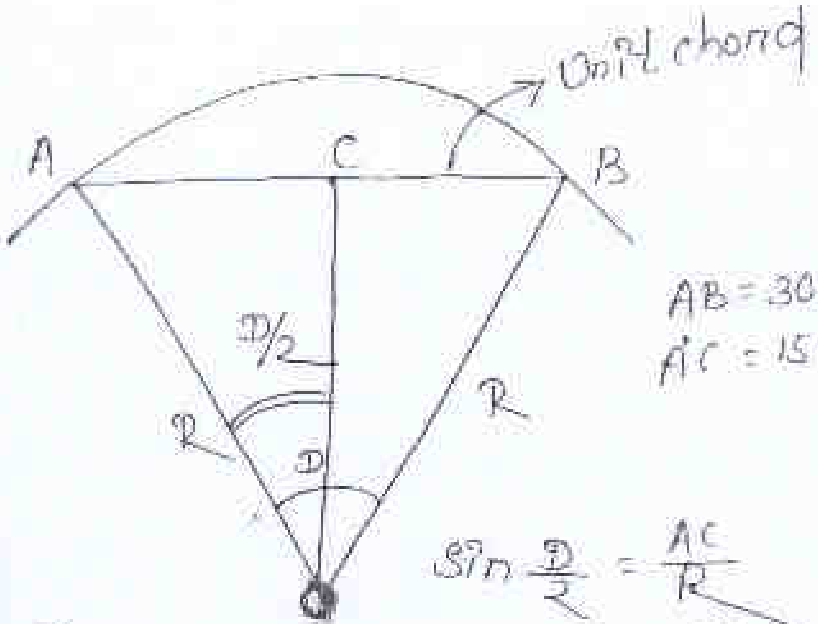
1. Degree of curve:- The angle a chord of length 30 m subtends at the centre of the circle formed by the curve is known as degree of curve.

→ It is denoted by 'D'.



... designed according to either the radius ... of curve.

Relation bet^n radius and degree of curve:—



AB = 30 m
AC = 15 m

$\sin\frac{D}{2} = \frac{AC}{R}$

$\sin\frac{D}{2} = \frac{15}{R}$

$\sin\frac{D}{2} = \frac{D}{2}$

$R = \frac{15}{\frac{D}{2}}$

$180^\circ = \pi^c$

$1^\circ = \frac{\pi}{180}$

$\frac{D^\circ}{2} = \frac{\pi}{180} \times \frac{D}{2}$

$R = \frac{15}{\frac{\pi}{180} \times \frac{D}{2}}$

$R = \frac{15 \times 360}{\pi D}$

$R = \frac{15 \times 360}{3.141 \times D}$

$R = \frac{1718.9}{D} \simeq \frac{1719}{D}$.

A

.05.21

Let AB be the unit chord of 30m.

O → Centre
R → Radius of the curve.
D → Degree of the curve.

Here, OA = R
AB = 30 m
AC = 15 M

$m\angle AOC = \frac{D}{2}$

From triangle OAC

$$\sin\frac{D}{2} = \frac{AC}{OA} = \frac{15}{R}$$

So 'D' is very very small. $\sin\frac{D}{2} = \frac{D}{2}$

$$R = \frac{15}{D/2}$$

$$R = \frac{15 \times 360}{\pi D} = \frac{15 \times 360}{3.141 \times D} = \frac{1718.9}{D}$$

$$\simeq \frac{1719}{D}$$

Super elevation :-

When a vechicle moves under a circular path. A force acts on the vechicle is called as centrifugal force $\left(\frac{MV^2}{R}\right)$

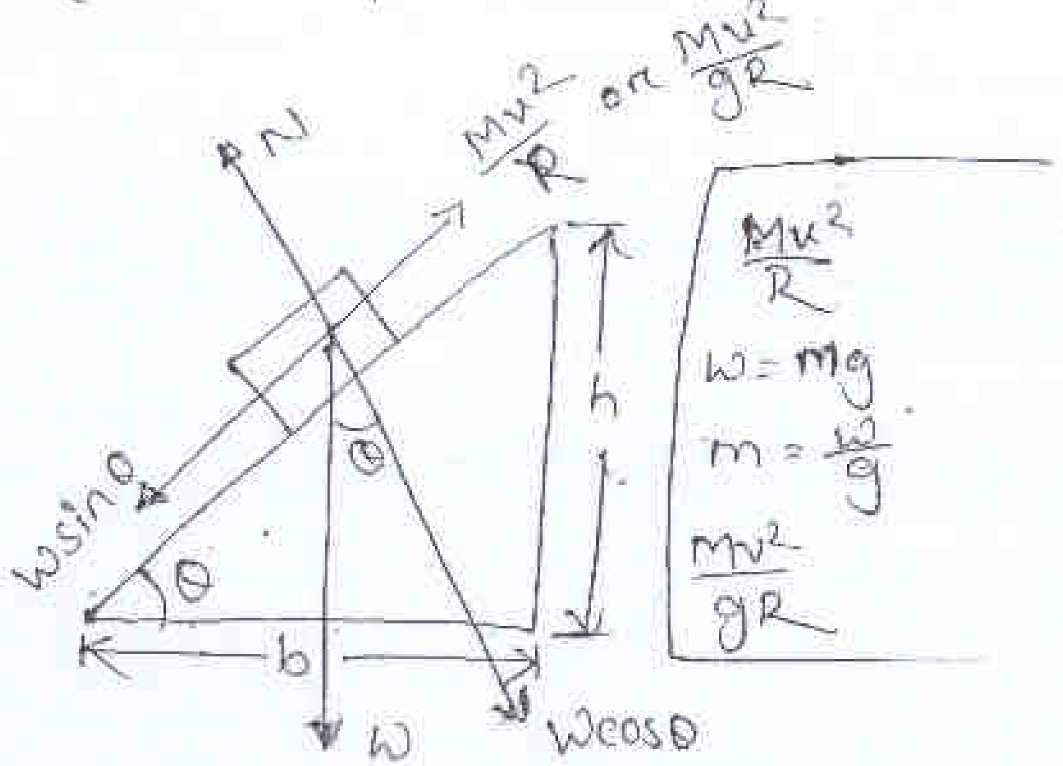
This centrifugal force tends to push the vechicle away from the road or track.

This is because. There is no component to counterbalance this centrifugal force.

To counter balance this centrifugal force the outer edge of the road is ~~kept~~

the inner edge.

⇒ The height through which the outer edge of the road or rail is raised is known as superelevation or cant.



$$W\sin\theta = \frac{Wv^2}{gR}$$

When 'θ' is very small

$$\sin\theta = \tan\theta = \frac{h}{b}$$

$$\Rightarrow \cancel{W}\frac{h}{b} = \frac{\cancel{W}v^2}{gR}$$

$$\Rightarrow h = \frac{bv^2}{gR} \text{ for road}$$

$$\therefore h = \frac{Gv^2}{gR} \text{ for railway}$$

$G \to$ gauge.

where $b \to$ width of road in mt.

$G \to$ Distance between rails

$R \to$ Radius of curve.

$g \rightarrow$ Acceleration due to gravity. $9.81\ m/sec^2$

$v \rightarrow$ speed of the vehicle in m/sec

$h \rightarrow$ super elevation in mt.

Centrifugal ratio:-

The ratio between the centrifugal force and the weight of the vechicle is known as centrifugal ratio.

$$C.R = \frac{P}{W} = \frac{\frac{Wv^2}{gR}}{W} = \frac{v^2}{gR}$$

Allowable value for centrifugal ratio in roads $= \frac{1}{4}$

Allowable value for C.R in railways $= \frac{1}{8}$

Types of Horizontal curve:-

(i) Simple curve.

(ii) Compound curve.

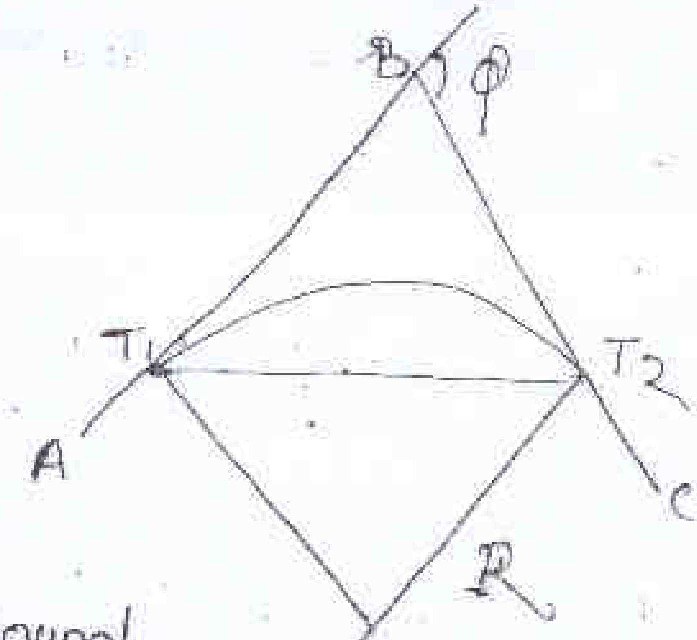
(iii) Reverse curve.

(iv) Transition curve.

(v) Leminsed curve

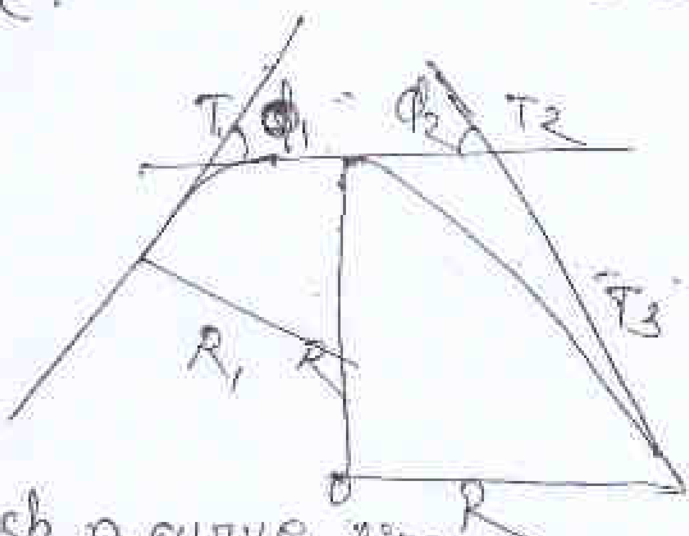
(i) simple curve:-

When a curve consists of a single arc with constant radius connecting two tangent it is said to be a circular curve.



(ii) Compound curve :-

→ When a curve consist of two or more arc with different radii is called as compound curve.



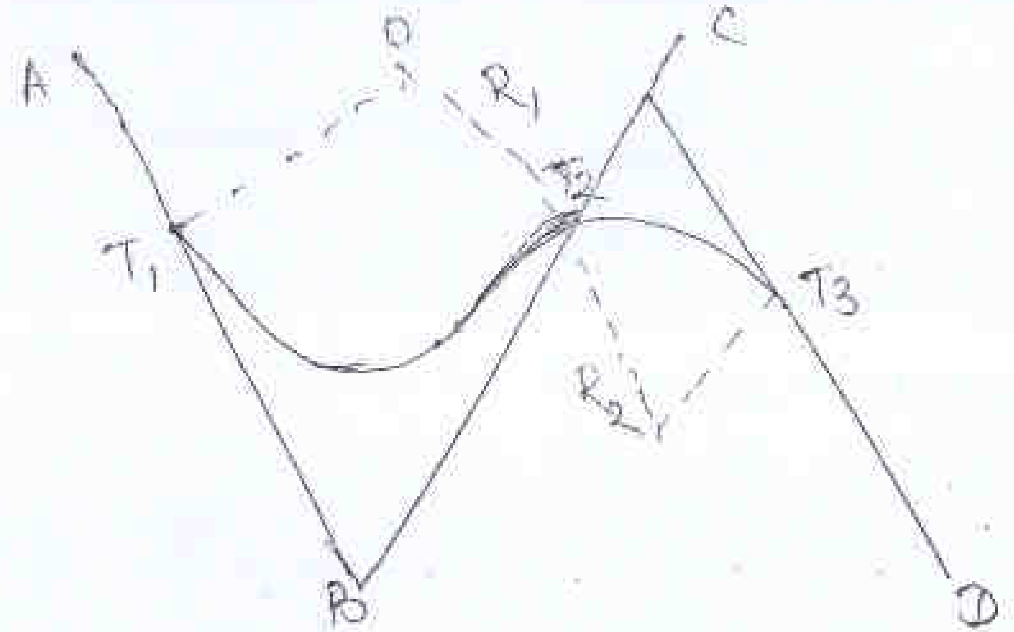
→ Such a curve lies on the same side of a common tangent and the centers of different arcs lie on the same side of their tangents.

(iii) Reverse curve :-

→ A Reverse curve consists of two arc bending in opposit directions.

→ Their centres lies on opposite sides of the curve.

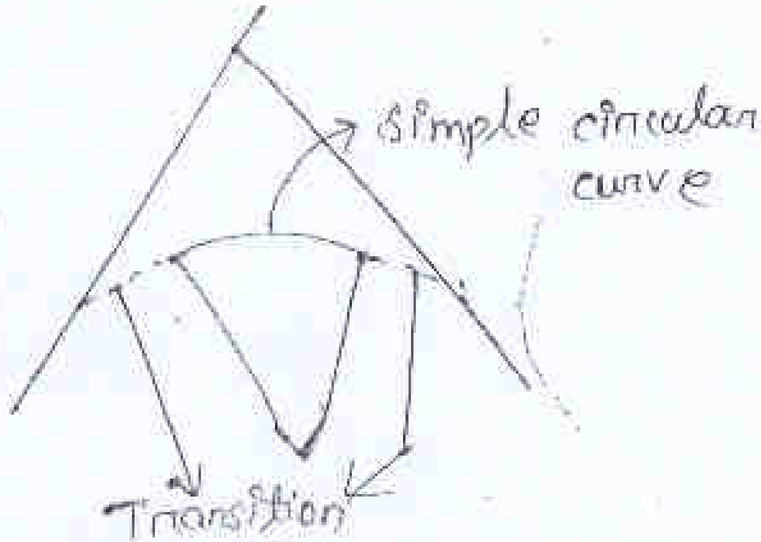
→ Their radii may be either equal or different.



(iv) Transition curve :-

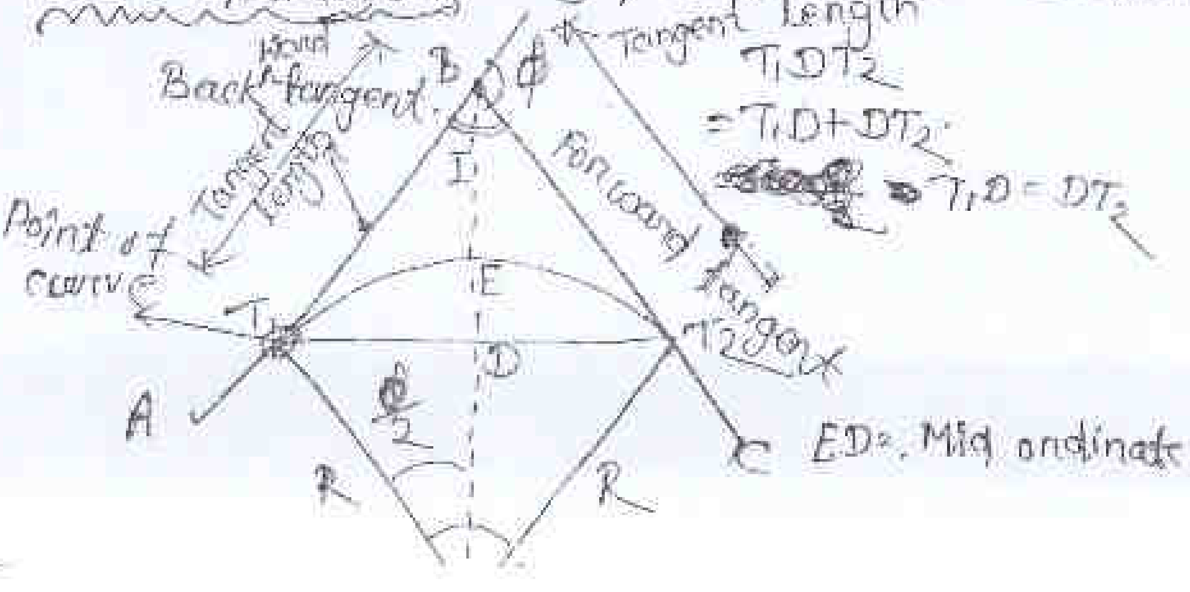
→ A curve of variable radious is known as transition curve.

→ It is also called as spiral curve.



Basic definations

B → Point of Inter-section.



$\sin\frac{\phi}{2} = \frac{T_1D}{R}$

$\Rightarrow T_1D = R\sin\frac{\phi}{2}$

$T_1DT_2 = 2 \times T_1D = 2R\sin\frac{\phi}{2}$

length of long-chord.

1. Back tangent :-

→ The tangent line at the begining of the curve is calle back tangent.

→ The straight 'AB' is the back tangent.

2 Forward tangent:-

→ The tangent line at the end of the curve is called as forward tangent.

→ The straight BC is the forward tangent.

Point of curve:-

→ It is the begining of the curve where the curve touches the back tangent.

→ It is also called as tangent curve.

Point of Intersection (I)

→ It is the intersection point of back tangent and forward tangent :-

Deflection angle (ϕ):-

The angle B'BC between the tangent AB produced and the tangent BC is called the deflection angle ϕ

Tangent length:-

It is the distance between the point of curve (T_1) to the point of intersection. (OR)

It is equal to the distance between the point of intersection (I) to the point of tangency (T_2) i.e.

Apex distance or external distance

→ It is the distance between the point of intersection (B) and the mid point of the curve (E)

→ The midpoint of the curve (E) is called apex or summit.

Length of the curve :- (L)

→ It is the length of the curve between the point of curve (T_1) and the point of tangency (T_2).

→ The arc length $\widehat{T_1ET_2}$ is the length of curve.

Long chord :- (L)

→ It is the chord joining point of curve (T_1) and the point of tangency (T_2)

i.e The length $T_1T_2 = L$

Mid ordinate:

It is the distance betn mid point of the curve (E) and the mid point of the long chord (D')

→ It is also called as versince of the curve.

Normal chord :-

→ It is also called as unit chord.

→ It is the chord between two stations or pegs at regular interval on a churve.

Sub chord :-

→ It is a chord which is shorter than the normal chord or unit chord.

→ The first chord and last chord are usually sub chord.

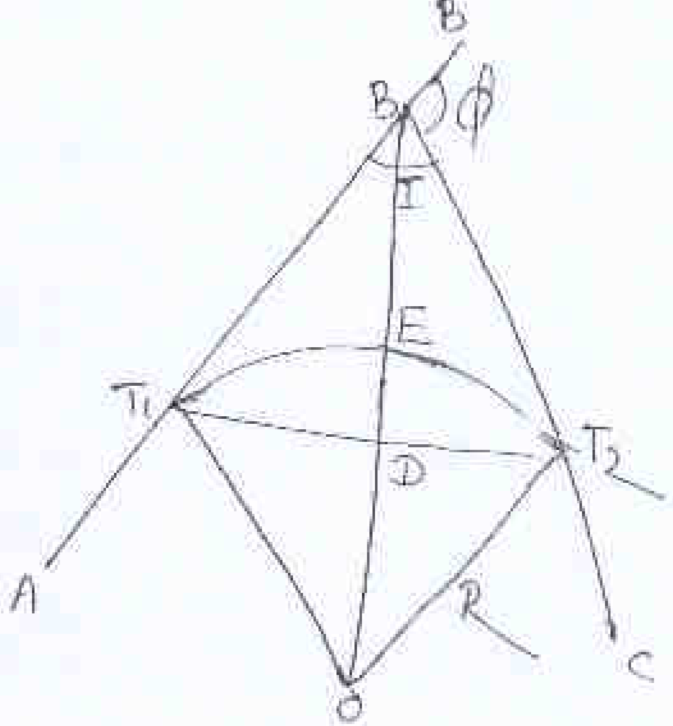
Right handed curve :-

→ It is a curve deflects to the right side of the direction of progress of survey.

Left handed curve :-

→ It is a curve which deflects to the left side of the direction of progress of survey.

Relationship between elements of a simple circular curve :-



AT_1B & BT_2C → Tangent

T_1B & BT_2 → Tangent length

T_1 → Point of curve.

$m\angle ABC$ = Intersection angle (I)

$m\angle B'BC$ = deflection angle (ϕ)

$\overset{\frown}{T_1ET_2}$ = Curve length (L)

T_1DT_2 = Length of long chord (L)

DE = Mid ordinary

EB = Apex distance / Versine of curve.

1- Length of curve (l)

$l = R\phi \rightarrow$ degree

$\rightarrow \boxed{l = \frac{\pi R\phi}{180^\circ}}$

$180^\circ = \pi$
$1^\circ = \frac{\pi}{180^\circ}$
$\phi = \frac{\pi\phi}{180^\circ}$

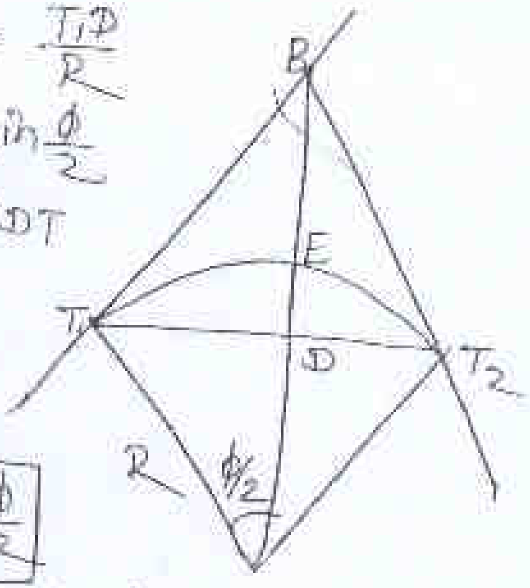
2- length of long chord:-- (L)

$\sin\frac{\phi}{2} = \frac{T_1D}{R}$

$DT = T_1D = R\sin\frac{\phi}{2}$

$T_1DT_2 = 2\times DT$

$= 2R\sin\frac{\phi}{2}$



T_1DT_2
$= T_1D + DT_2$
$= 2\times TD$
$(T_1D = DT_2 = DT)$

$\boxed{L = 2R\sin\frac{\phi}{2}}$

3- Tangent length (t):-

ΔBT_1D

$T_1D = R\sin\frac{\phi}{2}$

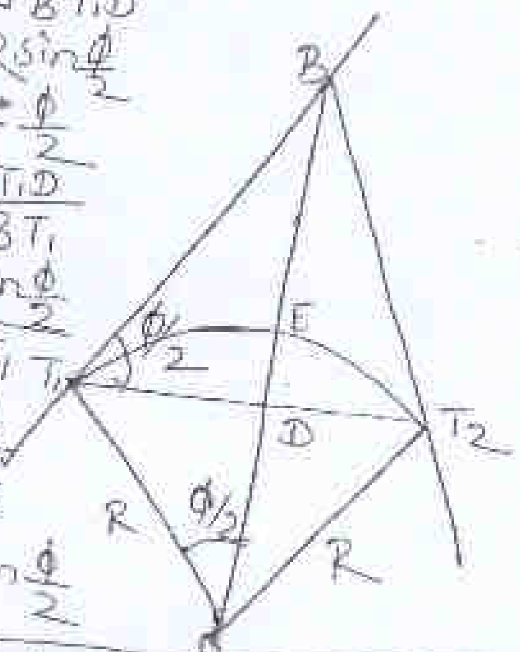
$m\angle BT_1D = \frac{\phi}{2}$

$\Rightarrow \cos\frac{\phi}{2} = \frac{T_1D}{BT_1}$

$\Rightarrow \cos\frac{\phi}{2} = \frac{R\sin\frac{\phi}{2}}{BT_1}$

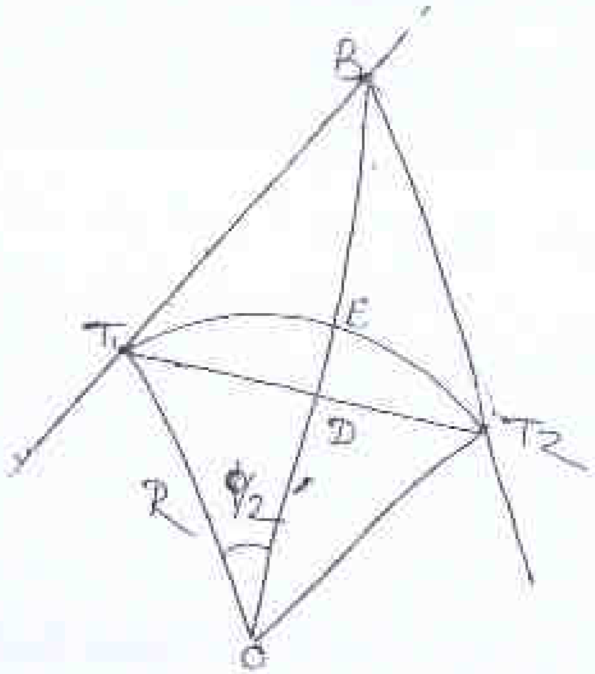
$\Rightarrow BT_1 = \frac{R\sin\frac{\phi}{2}}{\cos\frac{\phi}{2}}$

$\Rightarrow BT_1 = R\tan\frac{\phi}{2}$



$\boxed{\text{Tangent Length } (t) = R\tan\frac{\phi}{2}}$

4- Mid ordinate (DE):-



$OE = R$

ΔT_1DO

$T_1O = R$

$m\angle T_1OD = \frac{\phi}{2}$

$OD = R\cos\frac{\phi}{2}$

$ED = OE - OD$

$= R - R\cos\frac{\phi}{2}$

$= R(1-\cos\frac{\phi}{2})$

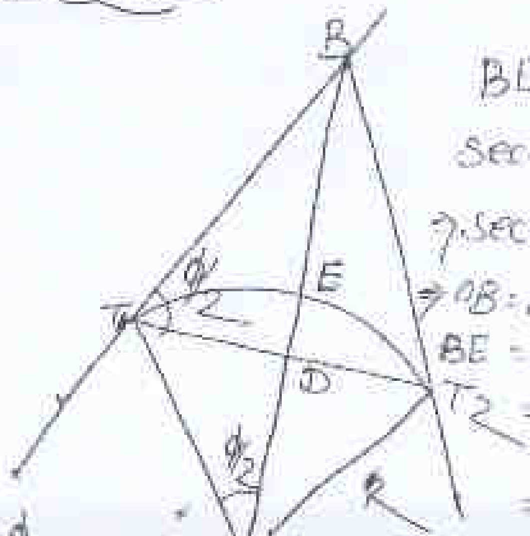
$$\boxed{DE = R(1-\cos\frac{\phi}{2})}$$

5- Apex distance-(BE)

~~$ED = R(1-\cos\frac{\phi}{2})$~~

$BT_1 = R\tan\frac{\phi}{2}$

ΔBDT_1



$BE = OB - OE$

$\sec\frac{\phi}{2} = \frac{OB}{OT_1}$

$\Rightarrow \sec\frac{\phi}{2} = \frac{OB}{R}$

$\Rightarrow OB = R\sec\frac{\phi}{2}$

$BE = OB - OE$

$= R\sec\frac{\phi}{2} - R$

$= R(\sec\frac{\phi}{2} - 1)$

$m\angle T_1 = \frac{\phi}{2}$

$\sin\frac{\phi}{2} = \frac{BD}{BT_1}$

$BD = R\tan\frac{\phi}{2}\cdot\sin\frac{\phi}{2}$

$BE = BD - DE$

$= R\tan\frac{\phi}{2}\cdot\sin\frac{\phi}{2} - R(1-\cos\frac{\phi}{2})$

Apex distance =

$BE = R(\sec\frac{\phi}{2} - 1)$

Chainge of tangent point :- (T_1 & T_2)

Chainage of 'T_1' = Chainage of 'B' - tangent length

chainage of 'T_2' = Chainage of T_1 + curve length

* Two straight intersed at chainage 2050.45mt and the angle of intersection is 120°. if the radius of simple circular curve to be introduced is 5000m. calculate the followings.

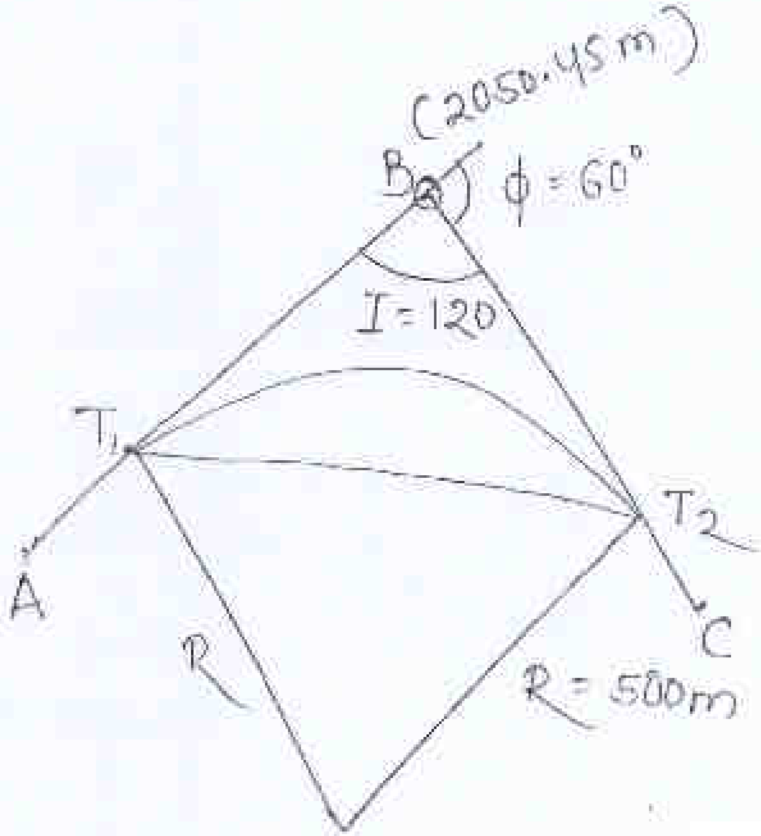
(i) Tangent distance.

(ii) Chainage of the point of commencent

(iii) Chainage of the point of tangency

(iv) Length of long chord.

Soln



Data Given :

Radius of curve (R) = 500m

Intersection angle (I) = 120°

Deflection angle $\phi = 180° - 120° = 60°$

point = 2050.45m

→ Tangent length (BT_1 & BT_2)

$= R \tan \frac{\phi}{2}$

$= 500 \times \tan \frac{60^\circ}{2}$

$= 288.675$ mt

→ Chainage of ~~point of~~ the point of comment (T_1)

= Chainage of 'B' - Tangent length

$= 2050.45 - 288.675$

$= 1761.775$ m

→ Curve length (L)

$= \frac{\pi R \phi}{180^\circ}$

$= \frac{\pi \times 500 \times 60^\circ}{180^\circ}$

$= 523.598$ m

→ Chainage point of tangency

(T_2) = Chainage of T_1 + Curve length

$= 1761.75 + 523.59$

$= 2285.34$ m

Length of long chord (l)

$= 2R \sin \frac{\phi}{2}$

$= 2 \times 500 \times \sin\left(\frac{60^\circ}{2}\right)$

$= 2 \times 500 \times \sin 30^\circ$

$= 500\ m$

Setting out of simple curve

Linear method — Angular method.

Linear method :-

These methods are used where high degree accuracy is not reqd and the curve is short.

→ In this method only tape or chain is used no angular measurement is reqd.

Angular method :-

→ These methods are more accurate than the linear method and are commonly used in practics.

→ In this method the curve is set out by making both linear and angular measurement

Linear method :-

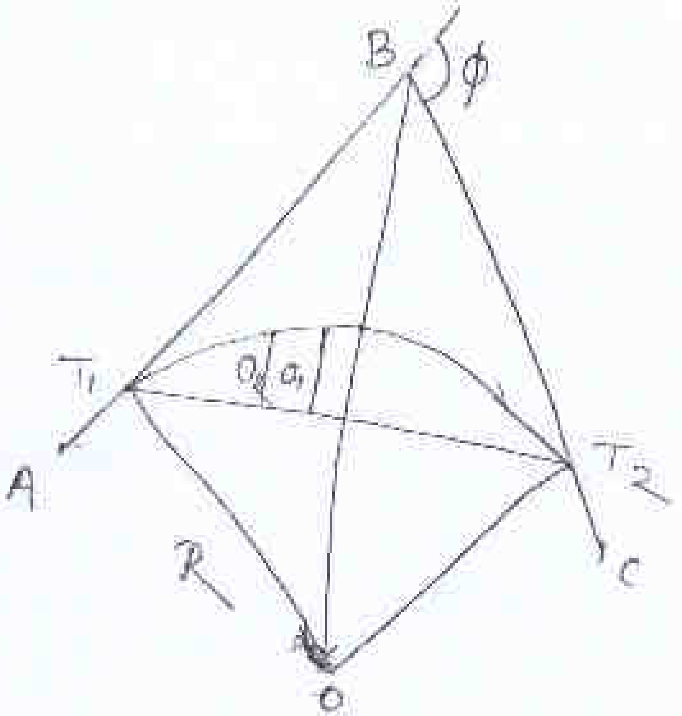
The following are the general method employed for setting out curves by chain and tape.

(i) Taking offsets from longer chord.

(ii) Taking offsets from chord produced.

(iii) Successively bisecting of the arc.
(iv) Taking offsets from tangents.

Taking offsets from long chord:-



Let AB and BC be two tangents metting at point 'B' with deflection angle 'ϕ'.

The following data are calculated for setting out of curve.

1. The tangent length is calculated according to the formula (TL) $= 2R \tan\frac{\phi}{2}$
2. Tangent point T_1 and T_2 are marked.
3. The length of the curve is calculated according to the formula (CL) $= \frac{\pi R \phi}{180^\circ}$
4. The chainage of T_1 and T_2 are found out
5. The length of long chord is calculated from $L = 2R \sin\frac{\phi}{2}$.

6. The long chord is divided into two equal halves (The left half and the right half).

Here the curve is ~~symmetri~~ symmetrical in both the ~~halfes~~. halves.

7. Considering the left half of the long chord. The ordinates $O_1, O_2, O_3, \ldots$ are calculated at a distance $x_1, x_2, x_3 \ldots$ taken from 'D' towards the tangent point 'T_1'

$$R^2 = (OD + O_x)^2 + x^2$$

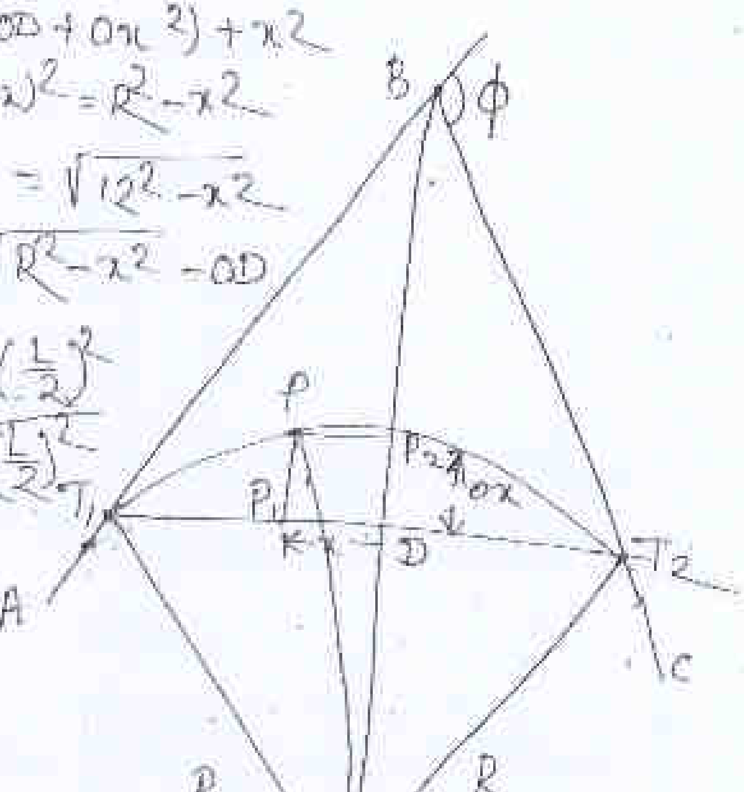
$$(OD + O_x)^2 = R^2 - x^2$$

$$OD + O_x = \sqrt{R^2 - x^2}$$

$$O_x = \sqrt{R^2 - x^2} - OD$$

$$R^2 = OD^2 + \left(\frac{L}{2}\right)^2$$

$$OD = \sqrt{R^2 - \left(\frac{L}{2}\right)^2}$$



$$O_x = \sqrt{R^2 - x^2} - OD$$

$$O_x = \sqrt{R^2 - x^2} - \sqrt{R^2 - \left(\frac{L}{2}\right)^2}$$

Let 'P' be point at a distance 'x' from 'D', The PP_1 (Ox) is required ordinate.

A line P_1P_2 is drawn parallel to T_1T_2

$R^2 = (OD + Ox)^2 + x^2$

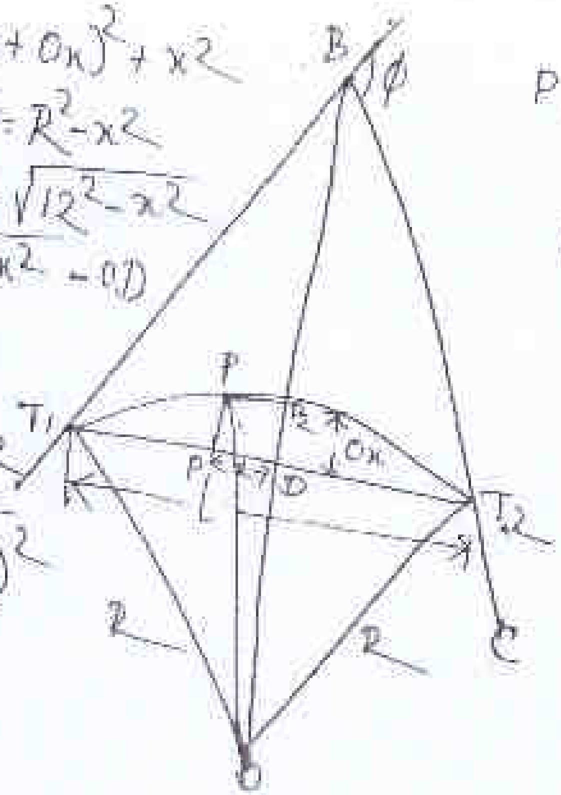
$(OD + Ox)^2 = R^2 - x^2$

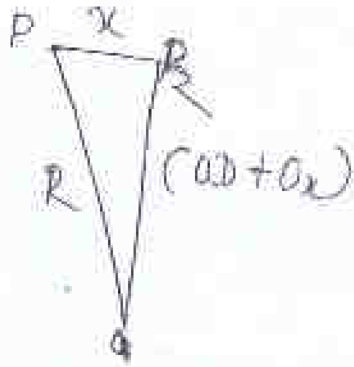
$OD + Ox = \sqrt{R^2 - x^2}$

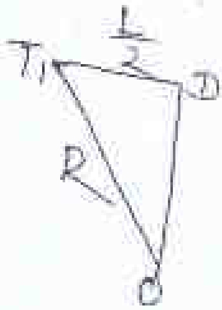
$Ox = \sqrt{R^2 - x^2} - OD$

$R^2 = OD^2 + \left(\frac{L}{2}\right)^2$

$OD = \sqrt{R^2 - \left(\frac{L}{2}\right)^2}$

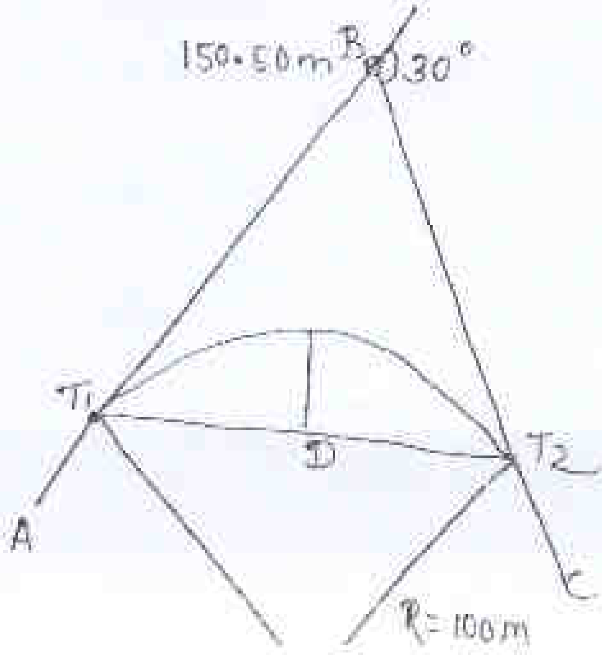






Q-1

Two tangents 'AB' and 'BC' intersect at a point 'B' chainage 150.50 m. Calculate all the necessary data for setting out a circular curve of radious 100m and deflection angle 30° by the method of offsets from long chord.



Solⁿ :-

Data given :-

Radius of curve (R) = 100m

Deflection angle (ϕ) = 30°

Chainage of intersection point = 150.50 m

(i) Tangent length = $R \tan\frac{\phi}{2}$

$= 100 \times \tan\left(\frac{30^\circ}{2}\right)$

$= 26.79 m$

(ii) Chainage of T_1 = 150.50 − tangent length

$= 150.50 - 26.79$

$= 123.71 m$

(iii) Curve length = $\frac{\pi R \phi}{180^\circ}$

$= \frac{\pi \times 100 \times 30^\circ}{180^\circ}$

$= 52.36 m$

(iv) Chainage of T_2 = Chainage of T_1 + Curve length

$= 123.71 + 52.36$

$= 176.07 m$.

(v) Length of long chord = $2R \sin\frac{\phi}{2}$

$= 2 \times 100 \times \sin\frac{30^\circ}{2}$

$= 51.76 m$

(vi) Mid ordinate = $R\left(1 - \cos\frac{\phi}{2}\right)$

$= 100\left(1 - \cos\frac{30^\circ}{2}\right)$

(vii) The long chord is divided into two equal halves

Each half $= \frac{1}{2} \times$ long chord.

$$= \frac{1}{2} \times 51.76$$

$$= 25.88\ m$$

Assum unit chord = 5m

$$O_x = \sqrt{R^2 - x^2} - \sqrt{R^2 - \left(\frac{L}{2}\right)^2}$$

$$O_5 = \sqrt{R^2 - 5^2} - \sqrt{R^2 - \left(\frac{L}{2}\right)^2}$$

$$= \sqrt{100^2 - 5^2} - \sqrt{100^2 - \left(\frac{51.76}{2}\right)^2}$$

$$= 3.28\ m$$

$$O_{10} = \sqrt{100^2 - 10^2} - \sqrt{100^2 - \left(\frac{51.76}{2}\right)^2}$$

$$= 2.90\ m$$

$$O_{15} = \sqrt{100^2 - 15^2} - \sqrt{100^2 - \left(\frac{51.76}{2}\right)^2}$$

$$= 2.27\ m$$

$$O_{20} = \sqrt{100^2 - 20^2} - \sqrt{100^2 - \left(\frac{51.76}{2}\right)^2}$$

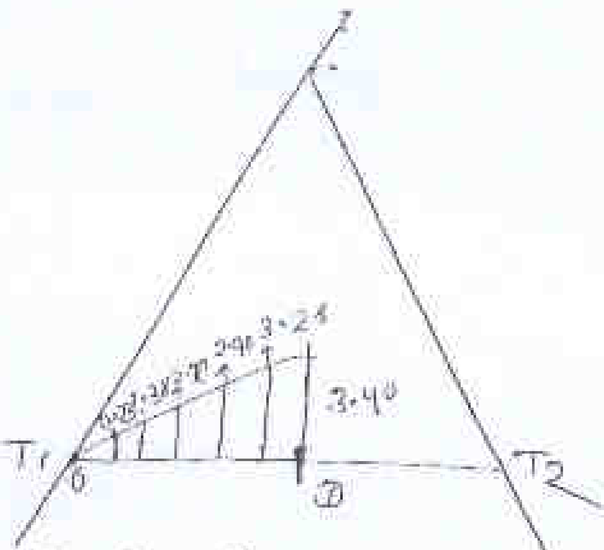
$$= 1.38$$

$$O_{25} = \sqrt{100^2 - 25^2} - \sqrt{100^2 - \left(\frac{51.76}{2}\right)^2}$$

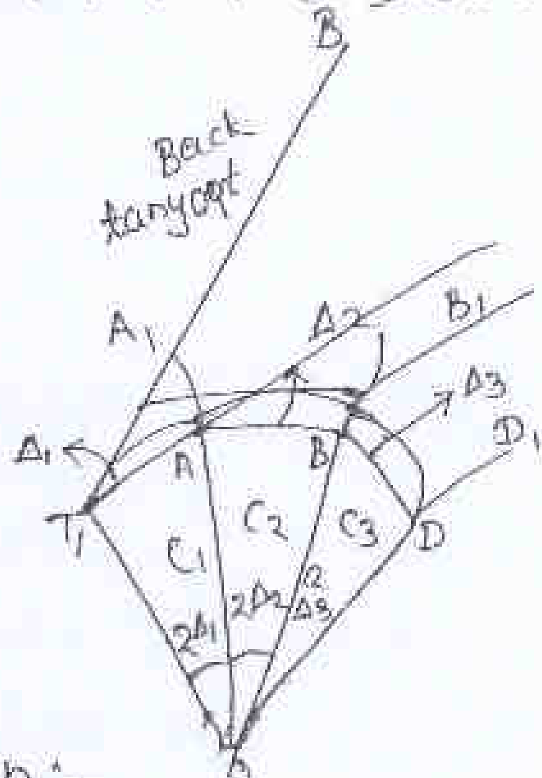
$$= 0.23$$

$$O_{25.88} = \sqrt{100^2 - 25.88^2} - \sqrt{100^2 - \left(\frac{51.76}{2}\right)^2}$$

= 0 Checked.

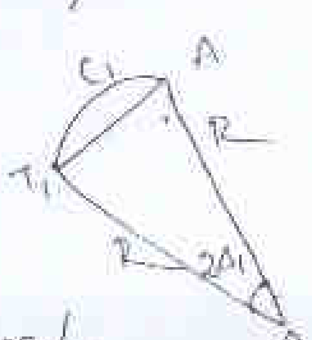


Taking offsets from the chord produced:-



Assumption:-

:- Length of arc/curve = length of its chord.

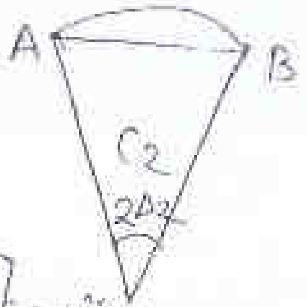


In triangle

OT_1A

$C_1 = R\,2\Delta_1$ ---(i)

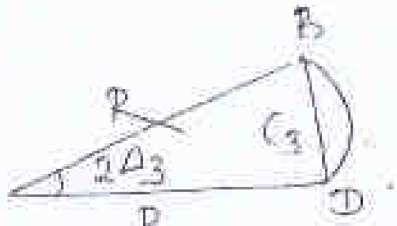
Consider Δ AB0



$C_2 = R\,2\Delta_2$

$\boxed{\Delta_2 = \frac{C_2}{2R}}$ ...(ii) eqn

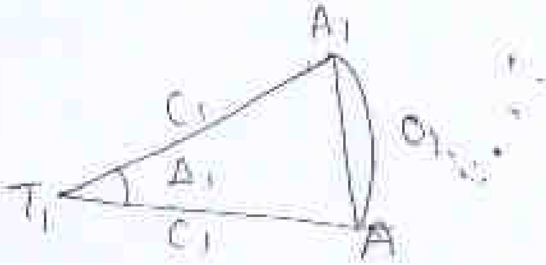
Consider BD0 Δ



$C_3 = R \times 2\Delta_3$

$\boxed{\Delta_3 = \frac{C_3}{2R}}$ ..... eqn (iii)

Consider arc TAA' :-



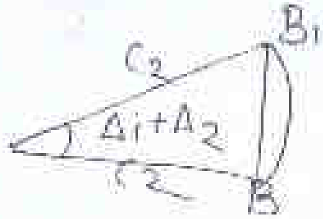
$AA' = C_1\Delta_1$

$O_1 = C_1 \frac{C_1}{2R}$

$= \frac{C_1^2}{2R}$

$= \frac{C_1}{2R}(C_0 + C_1)$

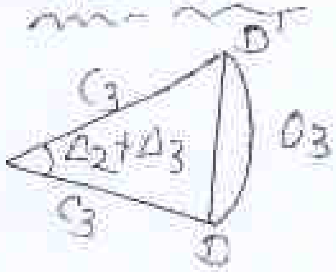
Consider Arc $AB'B$.



$$BB' = C_2 \times (\Delta_1+\Delta_2)$$
$$= C_2 \times \left(\frac{C_1}{2R} + \frac{C_2}{2R}\right)$$
$$BB' = \frac{C_2}{2R}(C_1+C_2)$$

$$O_2 = \frac{C_2}{2R}(C_1+C_2)$$

Consider Arc BDD'



$$DD' = C_3(\Delta_2+\Delta_3)$$
$$\Rightarrow O_3 = C_3\left(\frac{C_2}{2R} + \frac{C_3}{2R}\right)$$
$$\Rightarrow O_3 = \frac{C_3}{2R}(C_2+C_3)$$

for 'n' offsets

$$O_n = \frac{C_n}{2R}(C_{n-1}+C_n)$$

Check :-

$O_1 + O_2 + O_3 \ldots\ldots O_n$

= Length of curve.

Q Two tangents AB and BC intersect at a point 'B' at chainage 150.50m calculate all the necessary data for setting out a circular curve of radius 100mt and deflection angle 30° by the method of offset from chord produced.

Soln

Chainage of point of intersection = 150.50 m

Radius of curve (R) = 100 m

deflection angle (ϕ) = 30°

(1) Tangent length $= R \tan\frac{\phi}{2}$

$= 100 \times \tan\left(\frac{30^\circ}{2}\right)$

$= 26.79$ m

(2) Chainage of T_1 = chainage of intersection point − tangent length.

$= 150.50 - 26.79$

$= 123.71$ m

(3) Curve length $= \frac{\pi R \phi}{180^\circ}$

$= \frac{\pi \times 100 \times 30^\circ}{180^\circ}$

$= 52.36$ m

(4) chainage of T_2 = chainage of T_1 + curve length

$= 123.71 + 52.36$

$= 176.07$ m

(5) length of long chord $= 2R \sin\frac{\phi}{2}$

$= 2 \times 100 \times \sin\frac{30^\circ}{2}$

$= 51.76$ mm

Q-1

Dt-21.05.2021

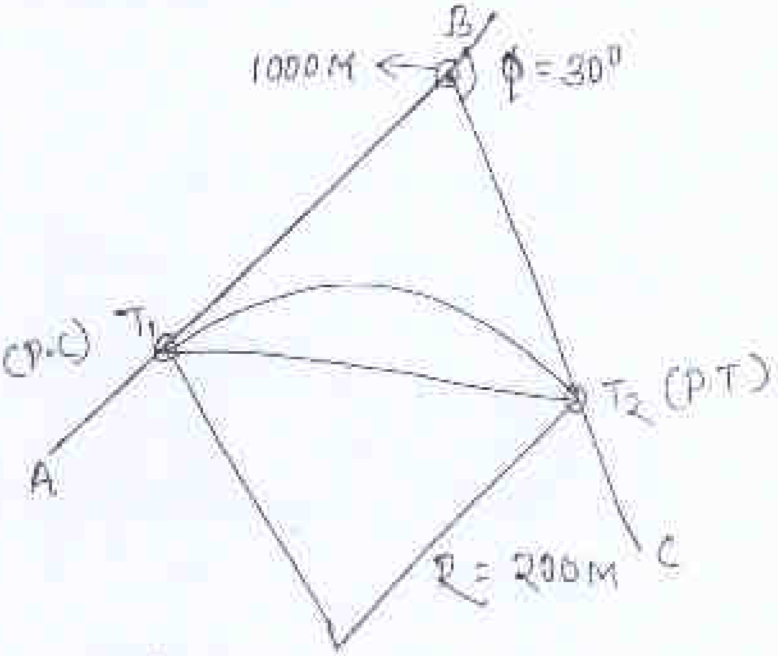
1. Two tangents intersect at a chainage of 1000 m. The deflection angle being 30°. Calculate all the necessary data for setting out a circular curve of radius 200 m. by the method of offsets from the chord produced. Taking a peg interval of 20 m.

Soln:-

Radius of curve (R) = 200m

Deflection angle (ϕ) = 30°

Chainage of intersection = 1000 M



1. Tangent length (TL) = $R \tan\frac{\phi}{2}$

$= 200 \times \tan\left(\frac{30°}{2}\right)$

$= 200 \times \tan 15°$

$= 53.58$ m

2. Chainage of 1st tangent point = chainage of intersection − tangent length

$= 1000 - 53.58$

$= 946.42$ m

3- Curve length (CL) = $\frac{\pi R \phi}{180^\circ}$

$= \frac{\pi \times 200 \times 30^\circ}{180^\circ}$

$= 104.72 m$

4- Chainage of 2nd tangent point = chainage of T_1 + curve length

$= 946.42 + 104.72$

$= 1051.14 m$

5- Length of long chord = $2R \sin \frac{\phi}{2}$

$= 2 \times 200 \times \sin \frac{30^\circ}{2}$

$= 103.52 m$

initial sub chord = $950 - 946.42$

$= 3.58 m$

No of full chord of length 20m = 5 Nos

final sub chord = $1051.14 - 1050$

$= 1.14 m$

$O_n = \frac{C_n}{2R}(C_n + C_n)$

$O_1 = \frac{C_1}{2R}(C_0 + C_1) = \frac{C_1^2}{2R} = \frac{3.58^2}{2 \times 200} = 0.03 m$

$O_2 = \frac{C_2}{2R}(C_1 + C_2)$

$= \frac{20}{2 \times 200}(3.58 + 20) = 1.179 m$

$O_3 = \frac{C_3}{2R}(C_2 + C_3)$ $\quad C_3 = C_2$

$O_3 = \frac{C_3}{2R}(C_3 + C_3)$

$= \frac{C_3}{2R}(2C_3)$

$= \frac{2C_3^2}{2R}$

$= \frac{C_3^2}{R}$

$= \frac{20^2}{200} = 2.0m$

$O_4 = \frac{C_4^2}{R} = \frac{20^2}{200} = 2.0M$

$O_5 = \frac{C_5^2}{R} = \frac{20^2}{200} = 2.0M$

$O_6 = \frac{C_6^2}{R} = \frac{20^2}{200} = 2.0M$

$O_7 = \frac{C_7}{2R}(C_6 + C_7)$

$= \frac{1.4}{2 \times 200}(20 + 1.14) = 0.0CM$

Necessary check:-

$C_1 + C_2 + C_3 \ldots\ldots\ldots C_n =$ Curve length

$\Rightarrow 3.58 + 20 + 20 + 20 + 20 + 20 + 1.14$

$= 104.72$ (OK)

Offsets from tangents:-

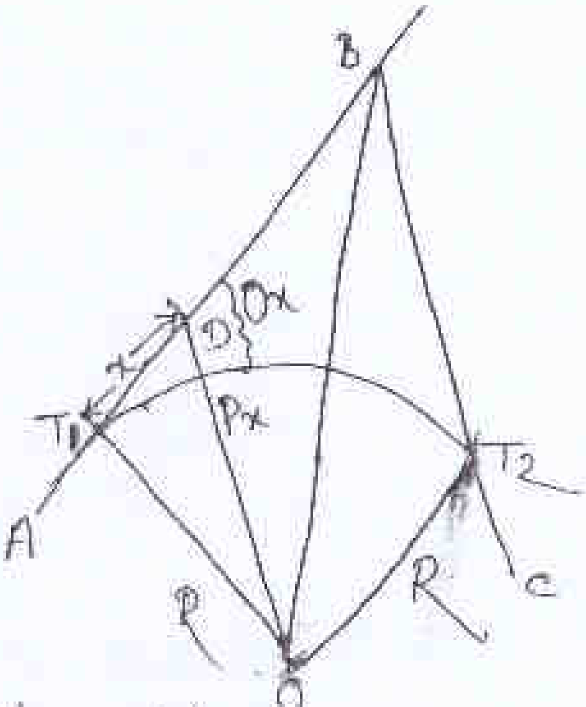
→ Offsets from tangents may be

(i) Radial offset

(ii) Perpend

(i) Radial offsets:-

→ Let AB and BC are two tangents intersecting and the tangent points are;



$OD = R + O_x$

$T_1D = x$

$OT_1 = R$

→ Let us take point 'D' on the rear tangent AB such that $T_1D = x$

Let us O_x be the radial offset at 'D' the 'D' is joined with centre 'O' so OD is the radial ~~line~~ line

No from triangle T_1OD

$$OT_1^2 + T_1D^2 = OD^2$$

$OT_1 = R$, $T_1D = x$, $OD = R + O_x$

$$\Rightarrow R^2 + x^2 = (R + O_x)^2$$

$$\Rightarrow \boxed{O_x = \sqrt{R^2 - x^2} - R}$$

→ The calculated distance O_x is cutoff from the radial line ⑧ to get the first point of the curve P_x.

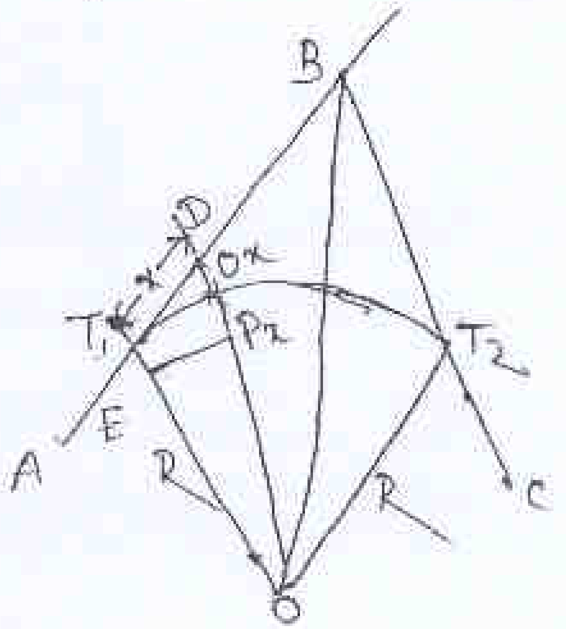
→ By increasing the value of 'x' by regular amount of offsets are obtained. These are set off along the respective radial line.

→ The other half of the curve can be set out from the second tangent point 'T_2'. Let a point D be taken at a distance 'y' from T_2. The tangent 'O_y' is calculated as

$$\boxed{O_y = \sqrt{R^2 + x^2} - R}$$

(ii) By perpendicular offset :-

→ Let AB and BC are two tangents meeting at a point 'B'. Then tangent length is calculated and the tangent points T_1 and T_2 are marked.



$\triangle OEP_x$

$OE = R - O_x$

$OP_x = R$

$EP_x = x$

→ A point 'D' is taken along the rear tangent AB at a distance x from T_1 that is $T_1D = x$.

→ Let O_x be the perpendicular offset 'D'. The line EP_x is drawn parallel to T_1D.

→ In triangle OEP_x

$OE = R - O_x$

$OP_x = R$

$EP_x = x$

$OP_x^2 = EP_x^2 + OE^2$

$\Rightarrow R^2 = x^2 + (R - O_x)^2$

$\Rightarrow (R - O_x)^2 = R^2 - x^2$

$\Rightarrow (R - O_x) = \sqrt{R^2 - x^2}$

$\Rightarrow \boxed{O_x = R - \sqrt{R^2 - x^2}}$

→ The calculated distance O_x is cut off from the tangent to get the first point of the curve P_1.

→ By increasing the value of 'x' by regular amount A number of offsets are obtained.

→ The other half of the curve can be set out from second tangent point 'T_2'. Let D_1 be taken at a distance 'y' from 'T_2'. The offset O_y is calculated as

$$\boxed{O_y = R - \sqrt{R^2 - y^2}}$$

Q. Two tangents meet at an angle 130° Calculate the length of offsets from the tangents for setting out a curve of 200m radius if

a) The offsets are radial.

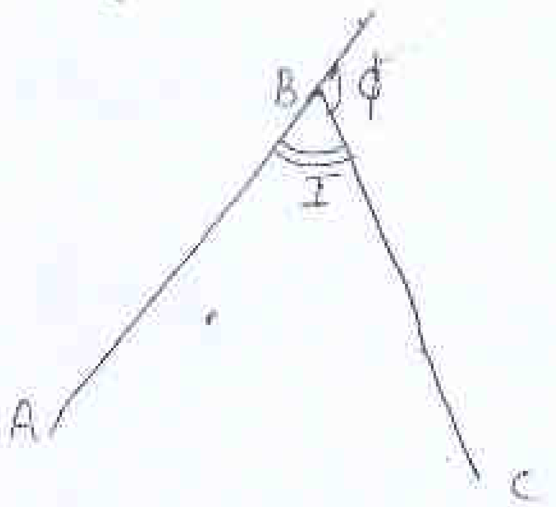
b) The offsets are perpendicular to the tangent.

Sol^{n}

Data given:-

Intersection angle $(I) = 130°$

Radius$(R) = 200$ mt



(i) Deflection angle 'ϕ' $= 180° - I$

$= 180° - 130°$

$= 50°$

(ii) Tangent length $= R \tan\frac{\phi}{2}$

$= 200 \times \tan\left(\frac{50°}{2}\right)$

$= 93.26$ mt

Step - III

Radial offsets

offset 'x' distance T_1

$O_x = \sqrt{R^2 + x^2} - R$

Assume per interval $= 20$m

$O_{20} = \sqrt{200^2 + 20^2} - 200$

$= 0.998\ mt$

$O_{40} = \sqrt{200^2 + 40^2} - 200$

$= 3.96\ mt$

$O_{60} = \sqrt{200^2 + 60^2} - 200$

$= 8.806\ mt$

$O_{80} = \sqrt{200^2 + 80^2} - 200$

$= 15.406\ mt$

$O_{93.26} = \sqrt{200^2 + 93.26^2} - 200$

$= 20.67\ mt$

Perpendicular offset :-

$O_x = R - \sqrt{R^2 - x^2}$

Peg interval 20mt

$O_{20} = 200 - \sqrt{200^2 - 20^2}$

$= 1.00\ mt$

$O_{40} = 200 - \sqrt{200^2 - 40^2}$

$= 4.04\ mt$

$O_{60} = 200 - \sqrt{200^2 - 60^2}$

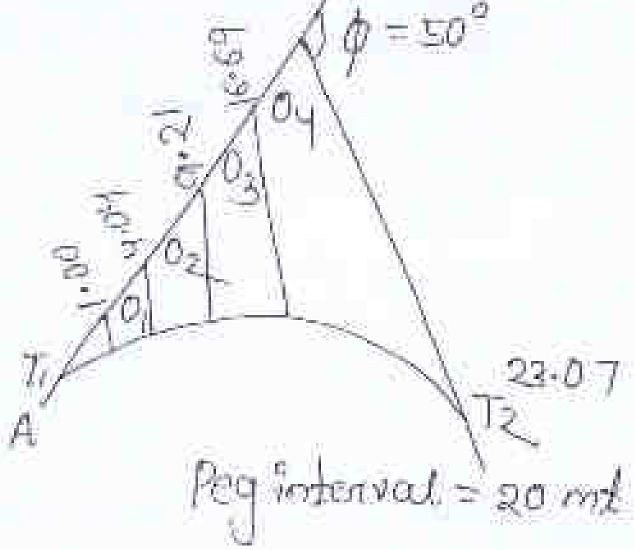
$= 9.21\ mt$

$O_{80} = 200 - \sqrt{200^2 - 80^2}$

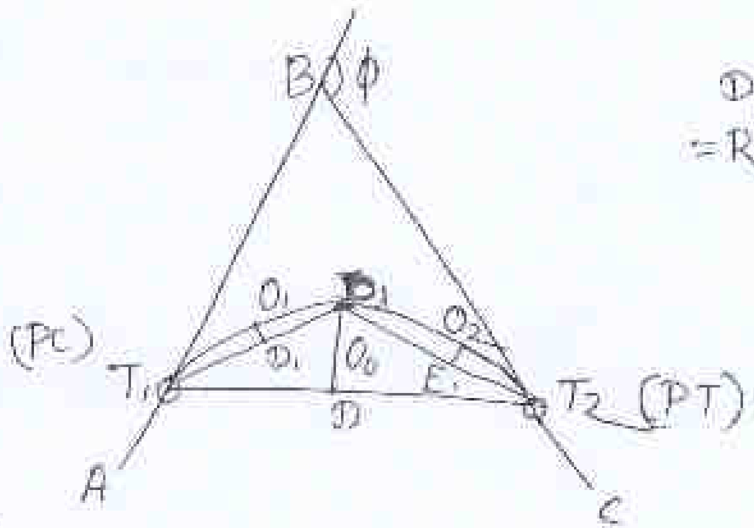
$= 16.69\ mt$

$O_{93.26} = R \sec\left(\frac{\phi}{2} - 1\right)$

$= 200 \sec\left(\frac{50^0}{2} - 1\right)$



Successive bisection of Arcs :-



D_1F & $EG = R(1-\cos\frac{\phi}{4})$

$DE = R(1-\cos\frac{\phi}{2})$

1) Let AB and BC are two tangents intersecting at 'B'. The deflection angle being 'ϕ'. The tangent length is calculated and tangent points T_1 and T_2 are marked on the ground with pegs.

2) T_1T_2 is the length of long chord which is bisected at 'D'. A perpendicular is setout at this point and a distance DD_1 is cut off which is equal versed sine of the curve. DD_1 = versed sine of curve

$= R(1-\cos\frac{\phi}{2})$

3. Again the length T_1D_1 and T_2D_2 will serve as long-

4. The distance T_1D_1 and T_2D_2 are measured and bisected D_1 and E_1. Now the distance D_1F and E_1G_1 will be equal to the versed sine of curve which is given by

$$D_1F = E_1G_1 = R\left(1 - \cos\frac{\phi}{4}\right)$$

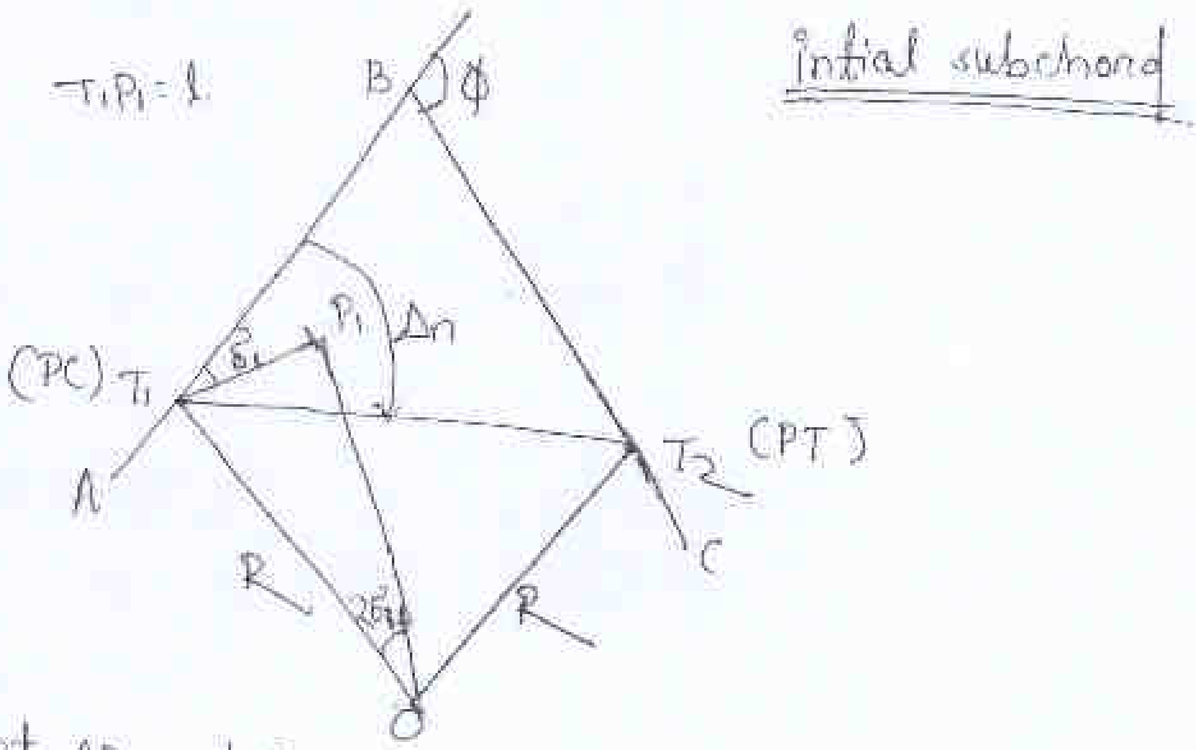
The calculated distances D_1F and E_1G_1 are cut off along the perpendicular drawn at G_1 and E_1

5. This process is continued until the bisecting chord is not practically possible.

Then the points on the curve are joined by free hand.

Angular method / Instrumental method :-

Horizontal curve setting by deflection angle method or rankine's method :-



1. Let AB and BC are two tangents intersecting at point 'B'. The deflection angle being 'ϕ'. The tangent length is calculated and tangent point T_1 and T_2 are marked.

Let $P_1 \rightarrow$ First point of the curves.

$T_1P_1 \rightarrow l_1$ length of initial subchord.

$\delta_1 \rightarrow$ Deflection angle for first sub chord.

$\Delta n \rightarrow$ Total deflection angle for the chords.

~~[illegible]~~ $m\angle T_1OP_1 = 2m\angle BT_1P_1$

chord T_1P_1 = arc T_1P_1

$C_1 = R 2\delta_1$ degree

$180^\circ = \pi^R$

$1^\circ = \frac{\pi}{180}$

$2\delta_1 = \frac{\pi}{180} \times 2\delta_1$

$C_1 = \frac{\pi}{180} R 2\delta_1$

~~[illegible]~~

$C_1 = \frac{\pi R\, m\angle T_1OP_1}{180}$

$\Rightarrow C_1 = \frac{\pi R(2\delta_1)}{180^\circ}$

$\Rightarrow \frac{1}{2\delta_1} = \frac{\pi R}{180 \times C_1}$

$\Rightarrow 2\delta_1 = \frac{C_1 \times 180}{\pi R}$

$\Rightarrow \delta_1 = \frac{180^\circ \times C_1}{2\pi R}$

$= \frac{90 C_1}{\pi R}$ degree

$\Rightarrow \delta_1 = \frac{90 \times 60 \times C_1}{\pi R}$

$= \frac{90 \times 60 \times C_1}{3.141 \times R}$

$\Rightarrow \delta_1 = \frac{1719.19 C_1}{R} \simeq \frac{1718.9 C_1}{R}$

$$\delta_1 = \frac{1718 \cdot 9 C_1}{R} \text{ min.}$$

$$\delta_2 = \frac{1718 \cdot 9 C_2}{R}$$

$$\vdots$$

$$\delta_n = \frac{1718 \cdot 9 C_n}{R}$$

$$\delta_1 + \delta_2 + \cdots \cdots \delta_n = \Delta_n$$

$$= \frac{\phi}{2}$$

when the degree of curve 'D' is given.

$$\boxed{\delta_1 = \frac{DG}{60}} \text{ degree}$$

Q Two tangents intersect at chainage 1250.0m. The angle of intersection is 150°. Calculate all data necessary. For setting out a curve of radius 25.0m by the defluction angle method. The peg interval may be taken as 20m. prepare a setting out table when least count of the vernier is 20". calculate data for field checking.

Soln

Step-1

Data given:-

Radius (R) = 250m

Intersection angle (I) = 180° - I

= 180° - 15° = 30°

Chainage of intersection = 1250.00 m

Peg interval = 20m LC of vernier = 20"

Step-II

Calculate tangent length (T.L) = $R \tan\frac{\phi}{2}$

$= 250° \tan\left(\frac{30°}{2}\right)$

= 67.0m

Curve length C.L

$= \frac{\pi R \phi}{180°}$

$= \frac{\pi \times 250 \times 30°}{180°}$

= 130.89 mt.

Step-III

Chainage of 1st tangent point

= Chainage of intersection − Tangent length

= 1250.00m − 67m

= 1183.00m

Chainage of 2nd tangent point

= chainage of 1st tangent point + curve length

= 1183.00 + 130.89m

= 1313.89m

Step-IV

Length of initial subchord

= 1190 − 1183

= 7.0m

No of full chord = 6 Nos

Chainage corrected = 1190 + (20X6)

= 1310 mt

Length of final subchord = 1313.89 − 1810

= 3.89

Step-V

Deflection angle for initial subchord

$$\delta_1 = \frac{1718.9 \times C_1}{R}$$

$$= \frac{1718.9 \times 7.0}{250}$$

= 0° [illegible]

Deflection angle for full chord

$$\delta_2 = \frac{1718.9 \times C_2}{R}$$

$$= \frac{1718.9 \times 20}{250}$$

$$= 2^\circ 17' 31''$$

Deflection angle for final subchord

$$\delta_n = \frac{1718.9 \times C_n}{R}$$

$$= \frac{1718.9 \times 3.89}{250}$$

$$= 0^\circ 26' 45''$$

Step-vi

Arithmetic check.

Total deflection angle.

$$\Delta n = \delta_1 + 6 \times \delta_0 \times \delta_n$$

$$= 0^\circ 48' 8'' + (6 \times 2^\circ 17' 31'') + 2^\circ 26' 45''$$

$$= 14^\circ 59' 59'' \simeq \frac{30^\circ}{2} = 15^\circ$$

Hence it is Ok

Problems faced in curve setting:-

→ The followings are the differ problems that occures:-

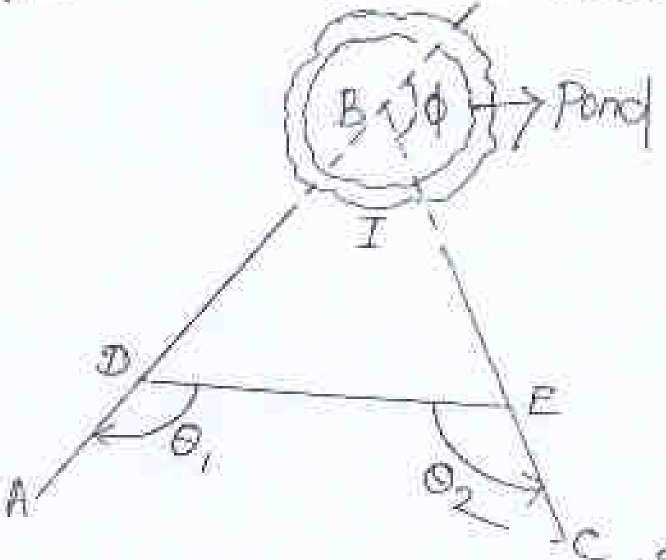
(1) The point of intersection may be in a cessible.

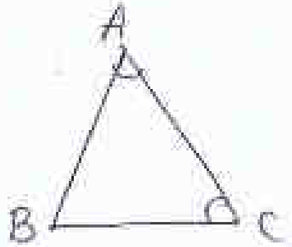
(2) Both tangent points may be in a cessible

(3) It may not be possible to set out the full curve from one point.

(4) There may be a an obstacle across the curve

Inaccessible point of intersection:-





$$\frac{BC}{\sin m\angle A} = \frac{AB}{\sin m\angle C} = \frac{AC}{\sin m\angle B}$$

→ Let two straight lines AB and BC intersect at 'B' which is inaccessible so the deflection angle 'ϕ' can't be measured.

→ Let us select two points 'D' and 'E' along AB and BC respectively. Then the distance DE is measured and the angle θ_1 and θ_2 are measured by theodolite.

$m\angle BDE = 180° - \theta_1$

$m\angle BED = 180° - \theta_2$

→ Angle of intersection (I) $= 180° - (180° - \theta_1 + 180° - \theta_2)$

$= 180° - 180° + \theta_1 - 180° + \theta_2$

$= (\theta_1 - \theta_2 - 180°)$

→ So deflection angle $(\phi) = 180^\circ - I$

$$= 180^\circ - (\theta_1 + \theta_2 - 180^\circ)$$

$$= 180^\circ - \theta_1 - \theta_2 + 180^\circ$$

$$= 360^\circ - (\theta_1 + \theta_2)$$

→ Applying the sine rule in ΔBDE

$$\frac{BD}{\sin(180^\circ - \theta_2)} = \frac{BE}{\sin(180^\circ - \theta_1)} = \frac{DE}{\sin(\theta_1 + \theta_2 - 180^\circ)}$$

$$BD = DE \frac{\sin(180^\circ - \theta_2)}{\sin(\theta_1 + \theta_2 - 180^\circ)}$$

$$BE = DE \frac{\sin(180^\circ - \theta_2)}{\sin(\theta_1 + \theta_2 - 180^\circ)}$$

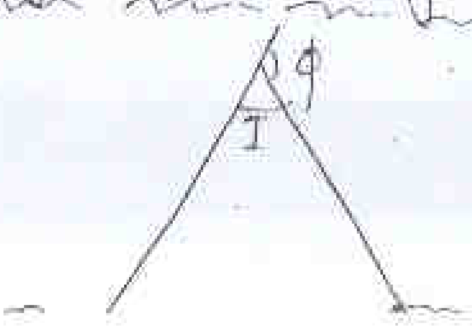
$$BT_1 = R \tan\frac{\phi}{2}$$

$$= R \tan \frac{[360^\circ - (\theta_1 + \theta_2)]}{2}$$

$DT_1 = BT_1 - BD$, $ET_2 = BT_2 - BE$

→ Now tangent points are fixed by measuring distances DT_1 and ET_2 when T_1 and T_2 are marked / fixed. Then curve can be set out by any method.

(2) Both tangent point being inaccessible :-



→ In this case The tangent points 'T_1' and 'T_2' are inaccessible But intersection point 'B' is accessible. calculate the deflection 'ϕ' by using formula.

$$\phi = 180^\circ - I$$

(a) Tangent length $BT_1 = BT_2 = R\tan\frac{\phi}{2}$

(b) Curve length $= \frac{\pi R \phi}{180^\circ}$

(c) Length of long chord $= 2R\sin\frac{\phi}{2}$

(d) Apex distance 'BF' $= R\left(\sec\frac{\phi}{2} - 1\right)$

(e) Versedsine of curve $(EF)^2 = R\left(1-\cos\frac{\phi}{2}\right)$

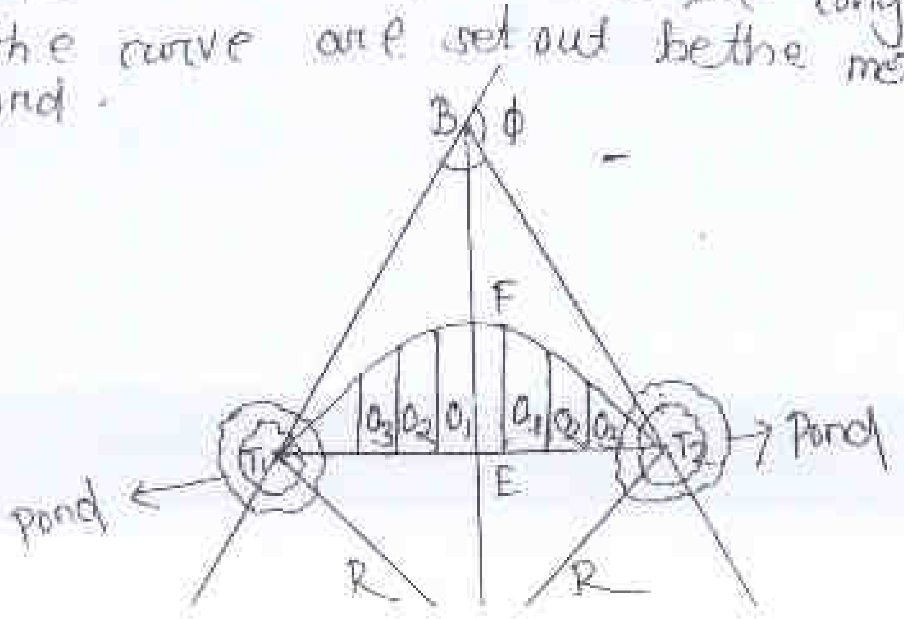
(f) chainage of point T_1

= chainage of 'B' $- BT_1$

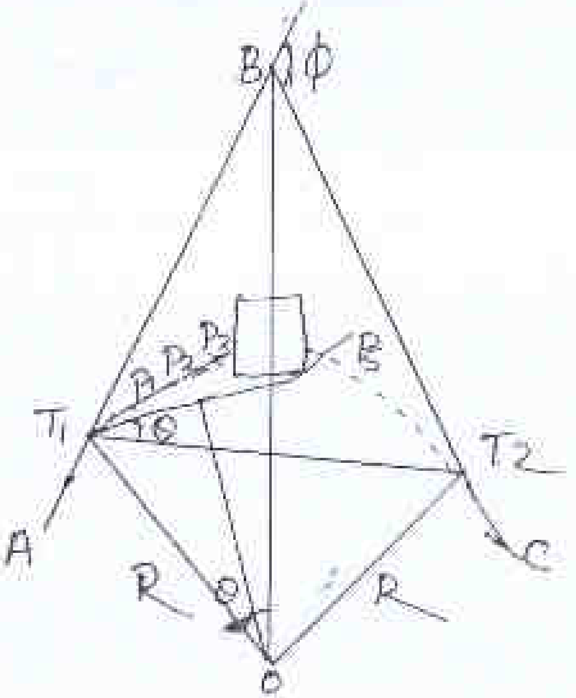
chainage of T_2

= chainage of T_1 + curve length.

→ The angle of intersection is bisected and along his line the apex distance and versed sine are setout to get the point 'E' and 'F' At 'E' perpendicular to EF is drawn which represents the long chord. The points on the curve are set out be the method of long chord.



Obstacles occuring across the Curve :-



(1) Suppose a building comes across the curve from T_1 points $P_1 P_2 \ldots P_4$ and marked them. Then the total deflection angle for P_4 is setout. Let this angle be 'θ'.

(2) Then the length of long chord T_1P_5 is calculated as follows

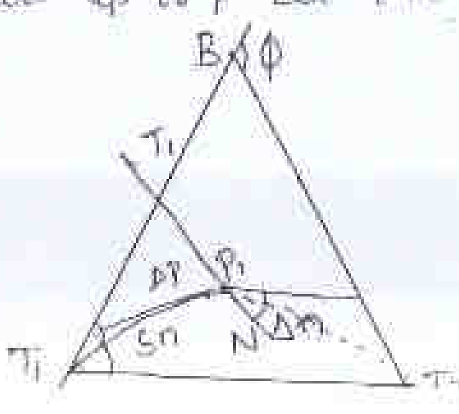
$$T_1P_5 = 2R\sin\theta$$

(3) This calculated length is measured along the line T_1P_5 to locate the point P_5 on the curve.

4) Then normal procedure is followed in order to locate the remaining points on the curve.

When full curve can't be setout from a one point:-

(1) The tangent points T_1 and T_2 are marked on the in usual way. The theodolite is setup at 'T_1' and the points on the curve are setout as usual up to 'p' Let the total deflection angle be Δp.



→ Then theodolite is shifted and setup at 'P' vernier 'A' is setout at z and the ranging road at T_1 is bisected.

→ Then the angle Δ_P is set on vernier 'A' and a point T_1 is marked.

→ The line T_1P_1 is the tangent to the curve at P.

→ The deflection angle for the next point 'N' is set and marked on the ground.

→ The process is repeated untils all the points are located. The calcula of deflection angle and mode of setting out are same as in rankin method.

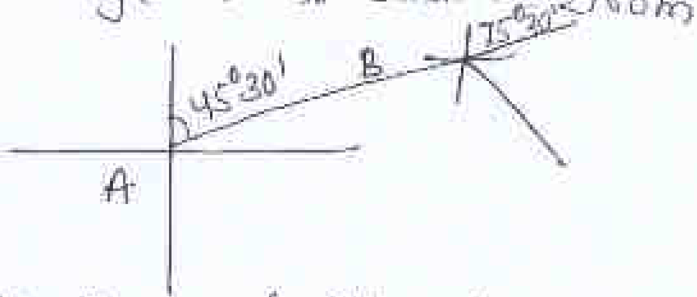
Q Two lines AB and BC to be connected by a 3° curve intersect at a chainage of 2760m the WCB of AC and BC are 45°30' and 75°30' respectively. Calculate all necessary data for setting out the curve by the method of offset from long chord.

Sol^n

Data given :-

degree of curve = 3°

(1) Chainage of intersection = 2760m



Deflection angle (ϕ) = 75°30' − 45°30'
= 30°

2) Radius of curve (R) = $\frac{1719}{D}$

$= \frac{1719}{3} = 573\,m$

(3) Tangent length = $R \tan\frac{\phi}{2}$

$= 573 \tan\left(\frac{30°}{2}\right)$

$= 153.53\,m$

(4) Curve length = $\frac{\pi R \phi}{180°} = \frac{\pi \times 573 \times 30}{180°}$

$= 300.022\,m$.

UNIT-3

Basics on scale and Basics on map:-

Maps are the cartographer's representation of an area and a graphical representation of selected natural and man made features of the whole or a part of the earth surface on a flat sheet of paper on a definite scale.

-> There are many different types of maps. all the maps are broadly classified on the basis of two criteria. namely scale and contents and purpose

-> On the basis of scale. The map may be classified as either a small scale map or a large scale map.

-> Some of large scale maps are cadastral maps utility maps, urban plan maps transportation or Network maps.

-> On the basis of the content maps are classified either as physical maps considered as small scale map or cultural maps.

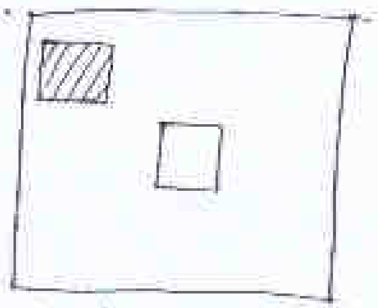
Map scale:-

-> The process of representing geographic features on a sheet of paper involves the reduction of these features

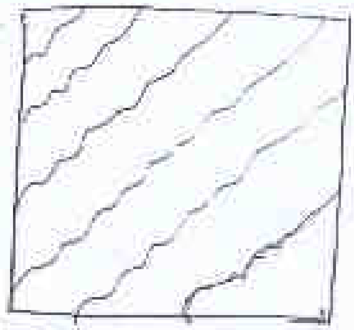
-> The ratio betn the reduction depiction on the map and the geographical features in the real world is known as map scale.

-> That is the ratio of the distance between two points on the map and the corresponding distance on the ground.

→ The scale may be expressed in three ways and pictorial representation of these three types

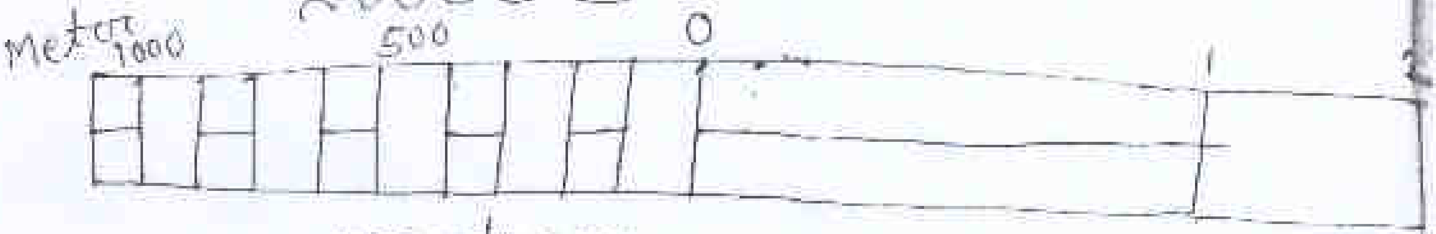


1 inch = 1 mile
Verbal scale



1:50.000
Fraction scale

Graphic scale



250m to 1cm.

Fraction scale:-

→ If two points are 1 km apart in the field.
They may be presented on the map as separated by some fraction of that distance. The scale is 1cm to 1 km.

1 Km = 100,000 cm

$\boxed{1:100.000}$

So there are 100,000cm in 1km. So this scale can be expressed as the fraction 1:100,000.
The method of representing this type of scale is called as representing fraction (RF) method.

Graphic scale :-

This scale is a line printed on the map and divided into units that are equivalent to some distance such as 1km or 1mile.

→ The measured ground distance appears directly on the map in graphical representation.

Verbal scale :-

This is an expression in common speach such as four centimeters to the kilometer "an inch to mile"

→ This common method of expressing a scale has the advantage of being easily understood by Most map users.

Map projection :-

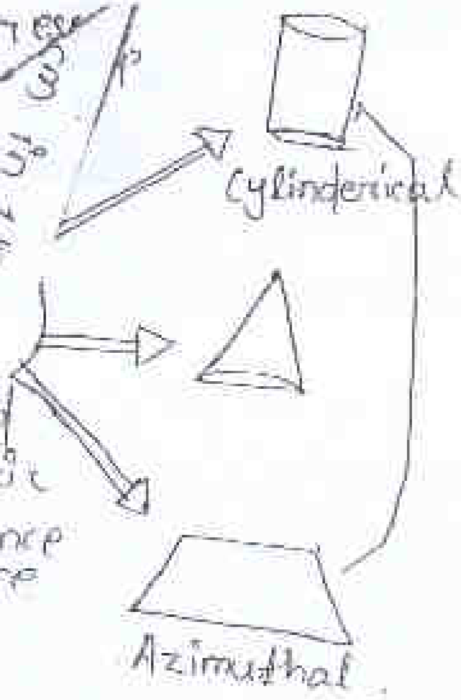
→ A transformation of the sperical or ellipsoidal earth onto a flat map is called as map projection.

→ Map projection can be onto a flat surface or a surface that can be made flat by cutting such a cylinder or a cone.

→ If the globe after scaling cuts the surface. The projection is called secant.

→ Lines where cuts take place or where the surface touches the globes have no projection distortion.

→ The ~~scale~~ may be expresse
pictorial representation



Advantages of Projection

→ Globes are hard to store and use for practical demonstration purpose.

→ Globes cann't show the whole world at once at equal visual range.

→ Projection can be optimized to minimize distortion specific to region.

→ Computer screens are flat projection can be useful in visualizing entire earth on screen.

→ Projected map can be used for thematic mapping.

Types of map projection:-

Projection based on earth surface can be used for mapping particular parts of the world!

1. Cylinder

* wrapped around the earth. so that it touches the equator

* Accurate in the equatorial zone

*

2. Cone

* placed over the earth so it touches midway bet" the equator and the pole.
* Accurate in the mid latitude zone.

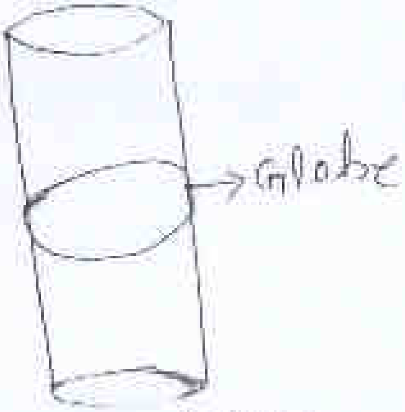
plane/Azimuth

→ Touches the earth at pole.
→ ~~Accurat~~
→ Accurate in the polar region.

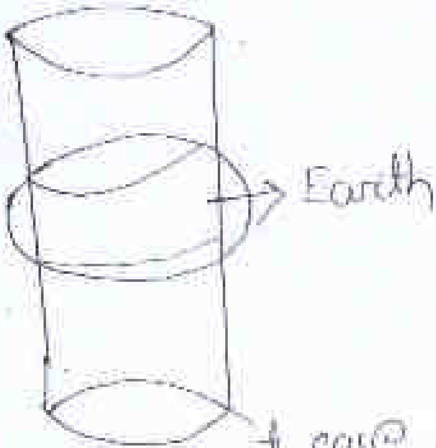
Cylinderical projection:-

If we wrap a sheet of paper round the globe in the form of cylinder, and tranfer the geographical features of the globe onto it and then unroll the sheet and lay of on a flat surface. The projection is called as cylinderical projection.

→ Earth intersects cylinder on one circle - tangent case
→ Earth intersects the cylinder on two small circles - secent case.
→ Points where cylinder touches earth have no distortion.



Tangent case

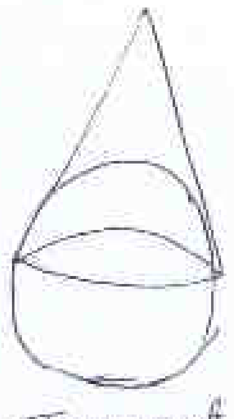


secent case.

Conical projection:-

→ Earth intersect the cone on one circle that is tangent case.

→



Tangent case

→ Earth intersects the cone on two small circle → secant case.

→ points where cone touches earth has no distortion.

Azumuthal projection:-

→ Earth intersects the plane on a small circles

→ All points on circle intersection have no scale distortion.

commonly used map projection and their comparison.

(i) Mercators:-

→ This is used for navigation ~~or~~ for maps of equatorial regions.

→ Any straight line on map is a thum line.

→ Direction along a thumb line are true between any two points on a map, but thumb line is not the shortest distance between points.

→ Distances are true only along equator and are correcta

→ Special scale can be used to measure distances along other parallels.

→ Two particular parallels can be made correct in scale instead of the equator.

→ Area and shapes of large areas on distorted. Distortion increases as distance increases from the equator, and is extreme is polar regions.

Oblique mercator:—

→ This is used to show regions along a great circle other than the equator on a meridian.

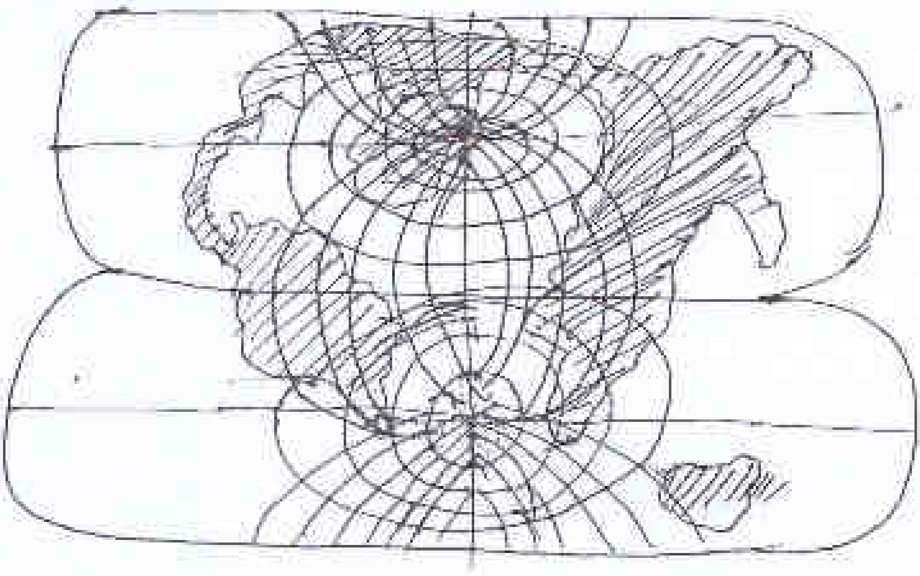
→ These region have their general extent oblique to the equator

→ This kind of map can be made to show as a straight line. The shortest distance between any two pre selected points along the selected great circle.

→ Distances are true only along the great circle

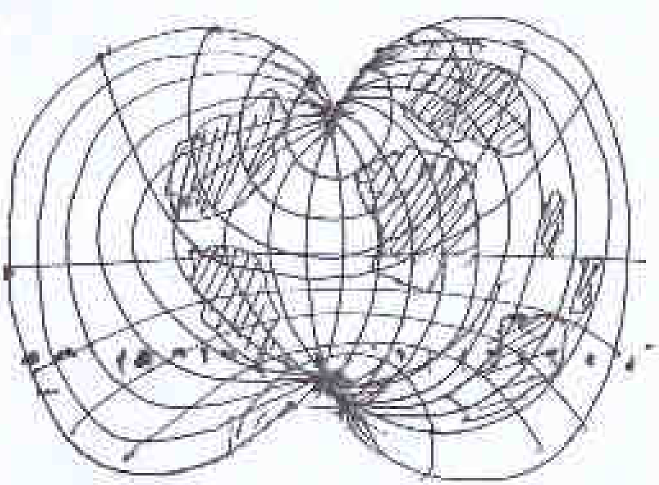
→ Distances directions, areas shapes are accurate within 15° of the great circle.

Transverse ... projection



- This type mercator is alsoused for mapping large area that are mainly north to south in exten.
- Distances are true only along the central meridian selected by the map maker.
- All distances, directions shapes and area are reasonable accurate.
- Distrtion of distances, direction shapes area increases rapidly outside the defined distance.
- The cental meridian and each meridian 90° ~~from the~~ it are straight.
- other meridians are complex curves concave towards central meridians.
- This projection is a transverse cylindrical case. in which the scale will be kept exact along the untral meridians and the equators.
- This projection is also orthomorphic projection with small shapes and angles maintained accurately

Polyconic projection :-



→ This projection is generally used for a small regular shaped area

→ survey of india uses this projection for making topographical maps of scale 1: 250,000 and more.

this projection is not conformal.

→ Although this projection is not uniform. shapes and areas not being retained exactly. It comes closer to complyance with the most of these projections

The scale is not.

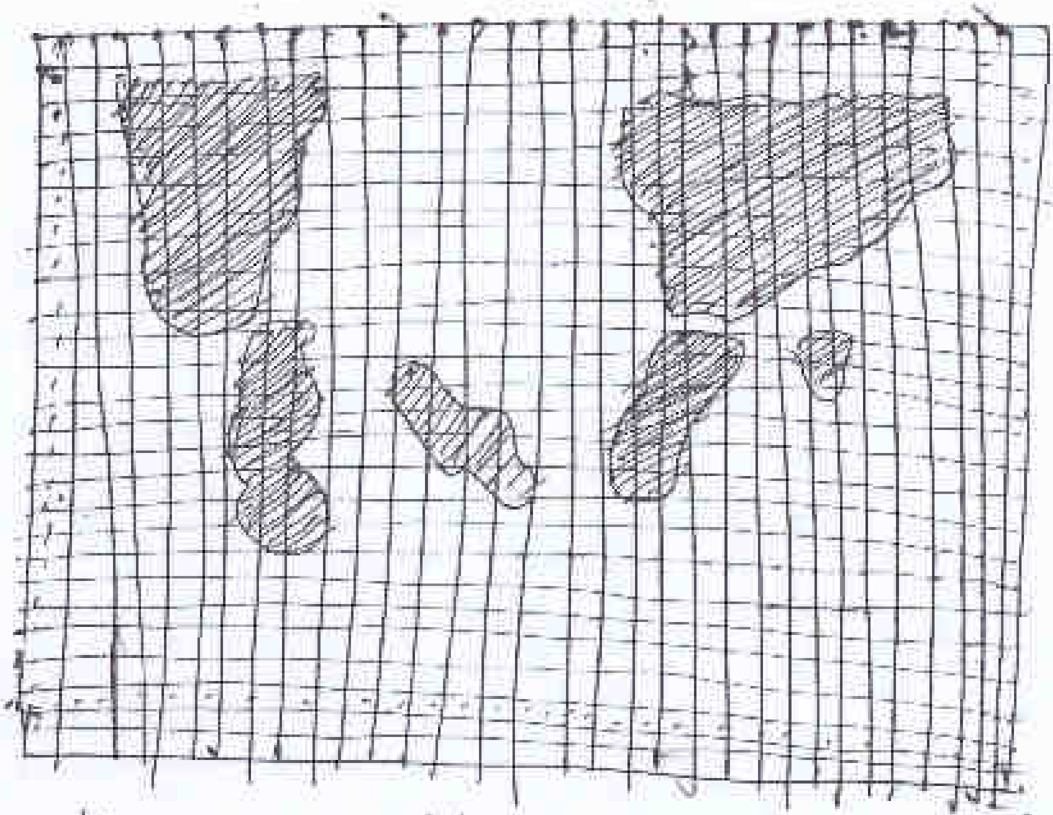
→ It can't be used on a large area without notable distortion.

Lambert conical orthomorphic projection :-

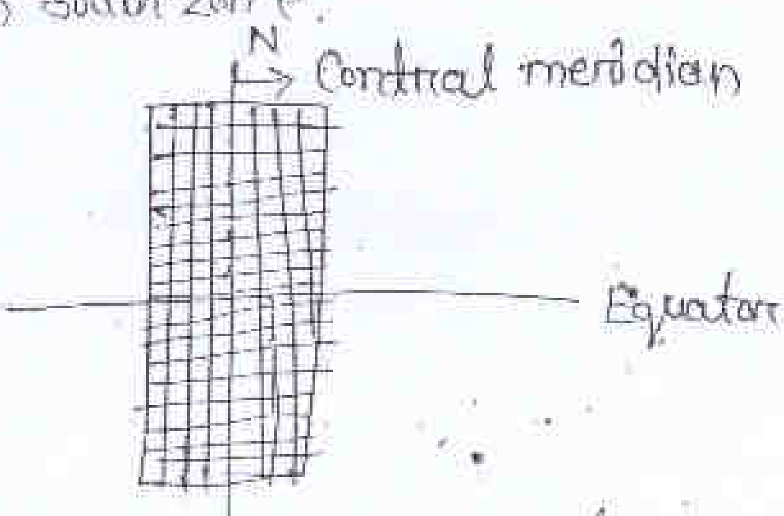
→ This projection portrays a portion of earth surface on the developed surface of a secant cone.

→ It is used along the parallel of latitude ad orth-orphic projection with two standard parallels countries having predominant east-west direction for topographical mapping.

Universal Transverse mercator Grid :- (UTM)



→ For the UTM grid The world is divided into 60° north south zone.



→ Each zone covers a 6°-wide strip of longitude.

→ The maximum extent of the zone was chosen to minimise distortion.

→ The zones are numbered consecutively beginning at zone 1 between 180° and 174° west to zone 60° between 174° and 180° east longitude.

→ Each zone is then divided into 19 segments with an 8° difference in latitude plus an additional segments at the extreme north with a 12° difference in latitude.

→ The rows of these segments are lettered from south to north by the letter C though X.

→ By specifying letter in a number each element in the UTM system is uniquely identified.

Classification of map :-

physical map :-

→ These are designed to show the natural land scape features of earth.

→ They are best know for showing topography either by colors or as shaded relief.

→ Physical maps often have a green to brown to gray colour scheme for showing the elevati of the map.

→ Darker geens are used for near sea level ele-vation with colour grading into tansand brows as elevations increase.

→ The colour gradient often terminate in shades of gray to highest elevation.

shown in blue colour often with a light colour for the most shallow areas and da[rker] in a gradient or by intervals for are[as] of deeper water.

→ Glaciers and ice caps are shown in white colours.

→ Physical maps usually shows the most impor-tant political boundaries such as state an[d] country boundaries

→ Major cities and major roads are often shown.

→ The cultural information is not the focus of a physical map but it is ~~of~~ ten included for geographic reference and to increase the utility of the map for many users.

Topographic map:-

→ Topographic maps are reference that show the shape of earth's surface.

→ They usually do this with lines of equal elevation known as contour lines.

→ But elevation can also be shown using colour, colour gradients etc.

→ Topographical maps are frequently used by hunters hikers etc.

→ They are also essential tools of the for geologi-sts surveyors, engineers, architechs, biologists and may other professsionals especially people in the military.

→ Topographic maps also show of other important natural features such as lakes, rivers and streams. Therera locations are determined by topography making them important natural elements of topographic maps.

→ Important cultural features are also shown on topographic maps.

→ These include roads buildings placenames Bench marks churches. A standard set of special symbols has been developed for the use.

Road maps :-

→ A road map is a map that primerily display roads and transport links naether than natur geological information.

→ It is a type of navigational map that commonly incl political Bounderies and level marking it also political map

Political maps:-

→ Political maps are among the most widely used reference maps.

→ They are mounted on walls of classroom through -out the world.

→ They show the geographic boundaries b/w govern-mental units such as countries, states etc.

→ They also show roads, cities, water features such as oceans rivers, and lakes.

→ Political maps help people understand the geogra-phy of the world.

→ The political maps are also called as "reference map" because people refer to them.

Economic and resource maps

→ An economic and resources maps shows the specific type of economic activity and availbility of resourc in an area of country.

→ on the map of brazil letters mean industries and symbols mean- agriculture land marks.

→ It could also use colors as well to represent symbo

Climate maps :-

→ A climate map shows the geographic distribution of the monthly or annual avarage values of climat variables - i.e temperature. relative himudity pere pitation. percentage of possible sunshine. Inselation. wind speed and dirertion over regions..

Thematic maps

→ A thematic map shows the spatial distrsbution of one or more specific data themes for selected geographic areas.

UNIT - I

Basics on GPS & DGPS and ETS

Global positioning system :- (GPS)

- The Global positioning system is defined as a radio navigation system involving satellites and computers that can determine the latitude and longitude of a reciver on the earth by computing the time difference for signals reaching from different satellites to the reciver.
- GPS is used to support a range of military commercial and consumer applications.
- There are almost 30 GPS satellite out of which 27 satellites are active and rest are spare. situated 6 orbits at a hight of 10600 miles above the earth surface.
- The positions of satellites are such that from any point on the earth.
- Every four satellites will be above the horizon
- The GPS satellite contain a computer an atomic clock and a radio
- Each satellite continuously broadcast its changing position with time to the reciver on the earth.
- The reciver contains a computer which triangulates its own position by getting bearing from three of four satellites.
- So the exact location of the recls at a specific time instant can be determined in terms of latitude and longitude.

Functioning of GPS :-

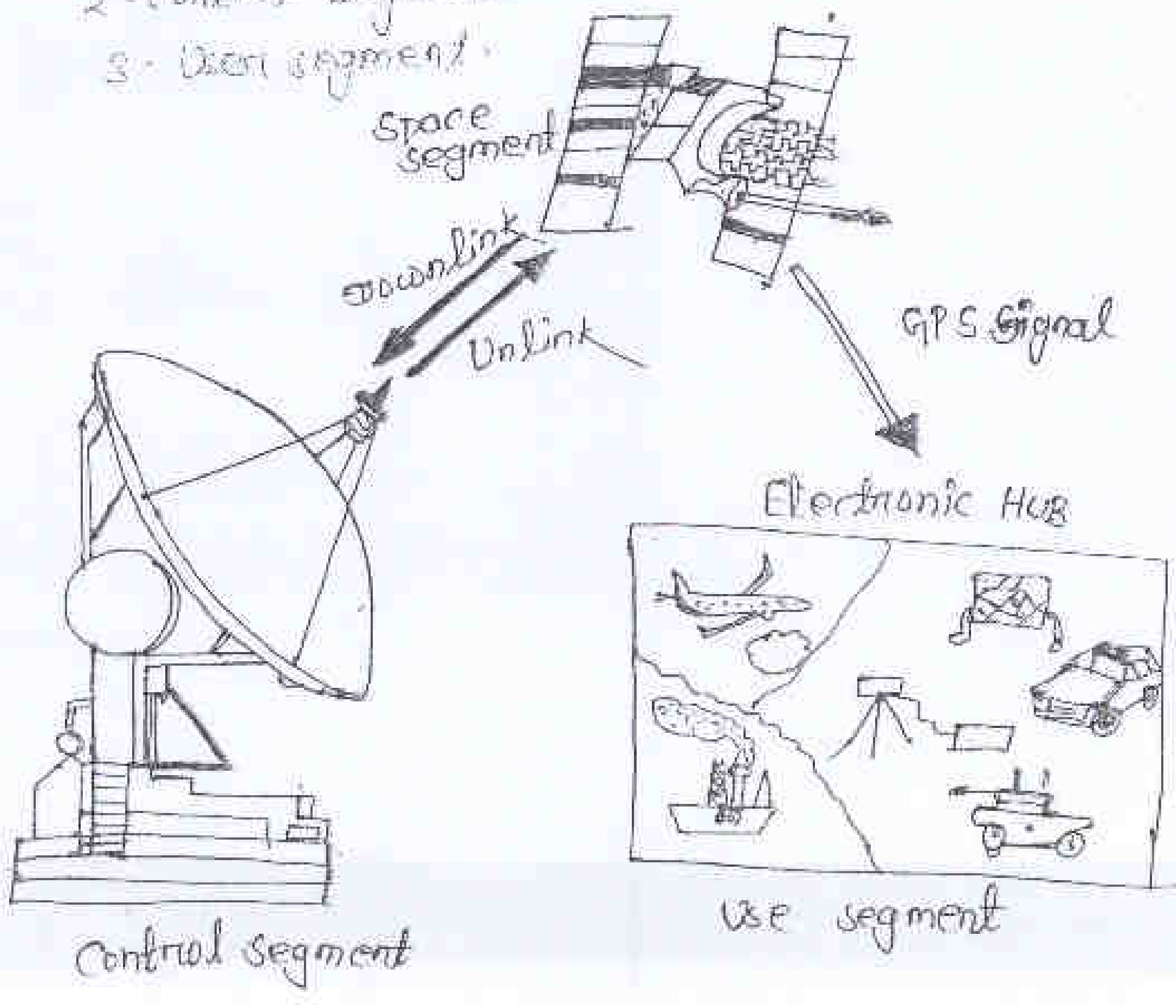
Dt ·05·07·21

→ The GPS satellites are orbiting the earth continuously. The radio signals from the satellites are controlled and corrected by control stations.

→ Signals are received by the GPS receiver on the earth. The GPS receivers needs only three satellites to plot 2D map. By using four satellites, it can correctly draw a 3D map to locate the geographical position of the object over the earth surface.

→ The entire fuctioning is carried out by three main components. They are as follows.

1. Space segment
2. Control segment
3. User segment



Space segment :-

- The space segment consist of 30 GPS satellites inclined at 55° and orbiting around in every 12 hours from a height of 10660 miles above the earth's surface
- Due to earth's rotation on its own axis. A satellite will take 24 hours for a complete rotation around the earth.
- The higher altitude covers a large area over the earth's surface. The position of GPS satellites are such that every four satellites covers a speci point (receiver) on the earth surface.
- Satellite singnals can be received any where within a satellites effective range singnals emitted continuously from the satellites has a definite frequency for allowing the receiver to identify the signals.
- The signal moves at speed of equal to that of light. The elapsed for reaching the signal from the satellite to the receiver can determine. The distance of receiver from the corresponding. GPS satellite.

Control segment :-

- The control segment consists of five unmanned monitor stations and one master station.
- The monitor stations continuously received radio singnals emitted by the GPS satellites and transmitted to the master station for it necessary correction on time and orbital location
- The corrected information is then sent back to the GPS satellites through ground antennas

User segments:-

→ The user segment consists of the user and their GPS receivers and it's number is numerous.

→ The signal transmitted by the satellite take approximately 67 milli seconds to reach a receiver.

→ Four different signals are generated in the receiver having the same structure as those received from the four satellite.

→ By synchronising the signals generated, the four signals time shift 'Δt' are measured as a ~~timing segment~~ by the satellite is used by CDMA processing for the purpose

→ The time shift for all four satellite signals are used to determine the signal transit time.

→ The signal transit time is used for determine the distance of the respective ~~[illegible]~~ satellites.

→ The receiver calculates the latitude, longitude height and time of the user from the known range of the four satellites

→ The signal transmitted with different C/A codes processing

GPS signal transmission:-

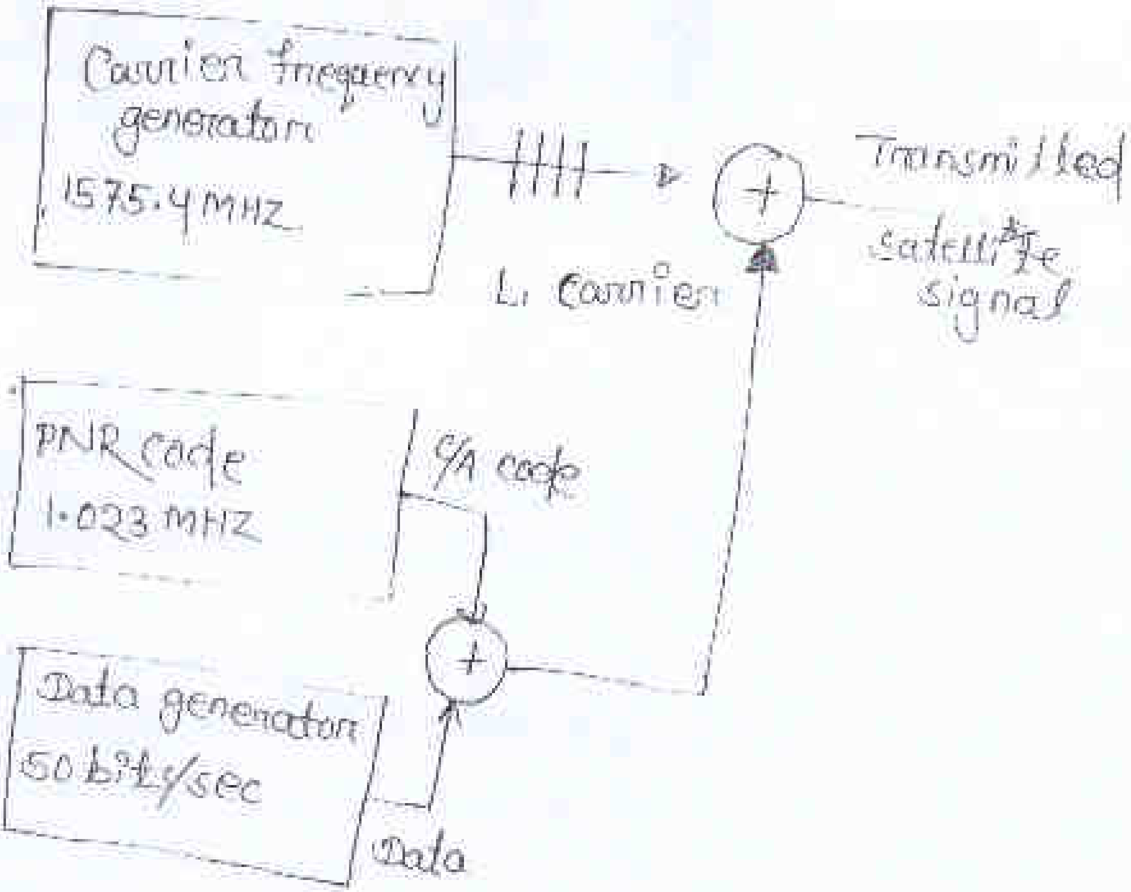
1. The GPS satellite transmits the time signal and data synchronized on board atomic clock at a frequency of 1575.4 MHz.

2. The signal strength is received by the earth ranging from -158 dBW to -160 dBW.

3. The satellite transmits signal at a rate of 50 bits/sec.

4. By using navigation SMS the receiver determine the travel time for each of these four satellites to locate

are ... in ... .



→ The generation of satellite signal comprises of coarse/Acquisition(C/A) code.

PNR code and carrier frequency code

→ The data is modulated and transmitted as satellite signal.

→ The frequency of 1575.4 MHZ as carrier frequency is processed through CDMA and data is transmitted by (DSSSM)

DSSSM → Direct sequence spread spectrum modulation.

Total station:-

Total station is the most popular and mordenised instrument for measuring horizontal and vertical angles along with slope distance of an object in surveying operation in a single setup.

→ The instrument is an electronic theodolite combined with EDM device.

EDM - Electronic Distance Measurement.
and was first introduced in 1971. ~~Before~~
→ Before this in 1960 ~~and~~ ~~the~~ Carl Zeiss discovered the electronic theodolite which is popularly known as electronic tacheometer.

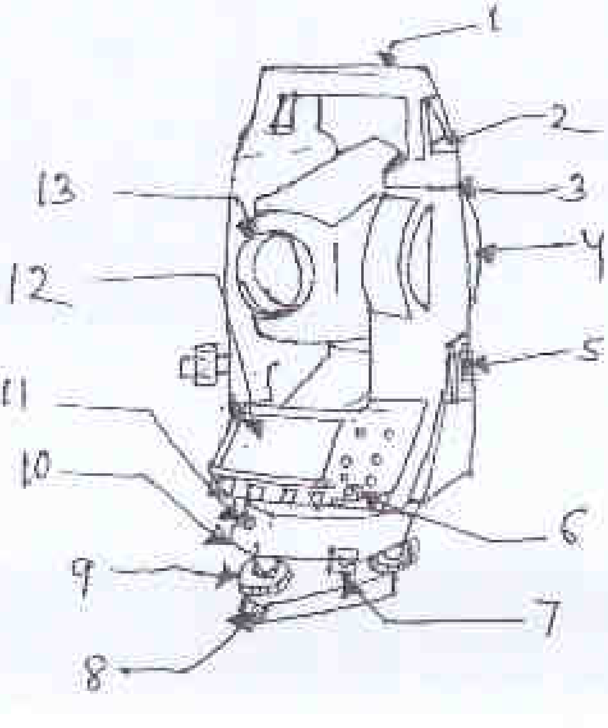
→ ~~This~~ This electronic tacheometer is the pillar of this modern total station instrument.

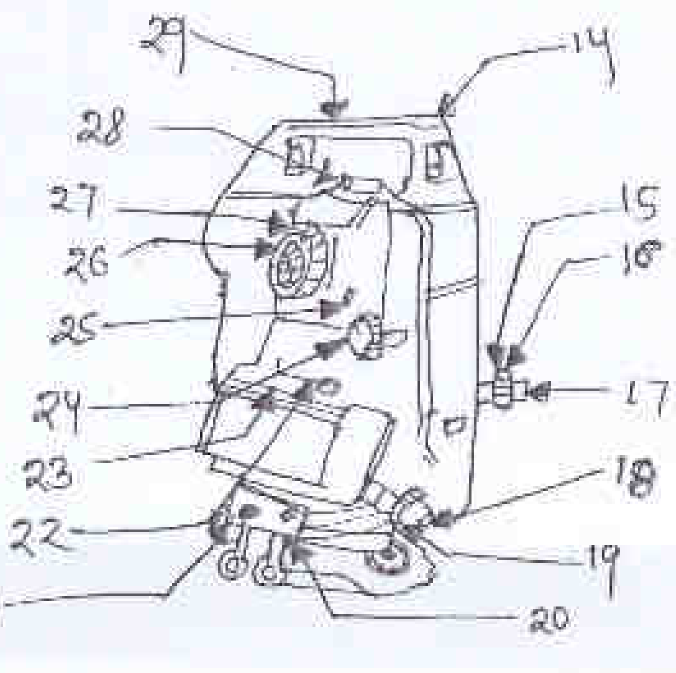
→ The surveyor can receive the field data in terms of coordinates (Northing, easting, Height) and process it for recording.

→ The recent advancement of this instrument is done by introducing in-built microprocessor.

→ By using this microprocessor, long distances can be easily measured with the help of remote control and necessary calculations are made simultaneously. This type of total station is known as Robotic total station.

→ The storage data is transferred to the computer for making 2D or 3D base maps using Autocad software.





1- Handle
2- Handel securing screw
3- Data input/output terminal (Remove handle to view)
4- Instrument height mark
5- Battery cover
6- operation panel
7- Tribrach clamp (SET 300S/500S/600S : shifting clamp)
8- Base plate
9- levelling foot screw.
10- Circular level adjusting screws
11- Circular level.
12- Display
13- Objective lens
14- Tubular compass slot.
15- Optical plummet focussing ring
16- optical plummet reticle cover
17- optical plummet eyepiece.
18- Horizontal clamp.
19- Horizontal fine motion screw
20- Data input/output connector (Besides the operation panel on SET 600/600S)
21- External power source connector (Not included on SET 600/600S)
22- Plate level
23- Plate level adjusting screw
24- Vertical clamp.
25- vertical fine motion screw
26- Telescope eyepiece
27- Telescope focussing ring

28- peep sight
29 - Instrument center mark.

Instrument :-

The total station instrument consists of three major components:-

1. An electronic measuring device
2. An electronic distance measuring device (EDM)
3. A microprocessor.

→ These three components work together to measure horizontal vertical angles and the distance in a single set up.

→ The recorded data is computed by these parameter for displaying on the LCD read out in built in the instrument.

→ The axis of the instrument rotates about the horizontal axis of read the horizontal angle of the object with reference to 0° at North.

→ similarly. The telescope can be rotated about the vertical axis to measure the vertical angle.

→ The EDM device attached to the total station instrument can read the horizontal distance upto 4km accurately.

→ There are two types of circles attached to the total station instrument.

→ one is the horizontal circle at the upper part of the tribrach rotating along the horizontal plane.

→ The 2nd type is the vertical circle at the upp part of the instrument to read the vertical angle by rotating along vertical plane.

→ The distance measurement is carried out by an infra-ared carrier signal emitted from a solid state in built emitter through its optical path.

→ The infaared light is reflected either by the prism or the object in the field.

→ The distance can be measured by summing of full or partial number of wavelength recorded in the memory of the instrument by phase shift method.

→ The reflector is a corner cube prism for the EDM signal.

→ The alignment of the mirror in the prism is very important as the waves or pulses transmitted are either in the visible or infrared region.

→ The important features of the total station is its control panel consist of key board and multi-line LCD

→ Most total stations have such panels at both faces of the instrument.

Operation of total station in surveying :-

The total station is basically a special type of theodolite. The principal operation of total station is almost similar to that of a theodolite. operated in surveying. The different steps are given below.

1. Orientation:-

→ The orientation of the total station instrument is very vital as the features of the instrument vary from one to another. The general procedure for the orientation of the instrument to take field records is

→ Leveling the instrument with the help of an optical plumment.

→ Use of horizontal clamp and tangent screw for horizontal angle measurement.

→ Use of vertical clamp and tangent screw for vertical angle measurement.

→ Initialization of the instrument before commencement of work.

→ Set the angular measurements format as horizontal and vertical angles.

→ Set the distance measurement mode as horizontal, vertical, height and slope distance.

Setting up:-

→ The setting of the instrument over tripod by clamping the lower base (Tribrach) is as follows.

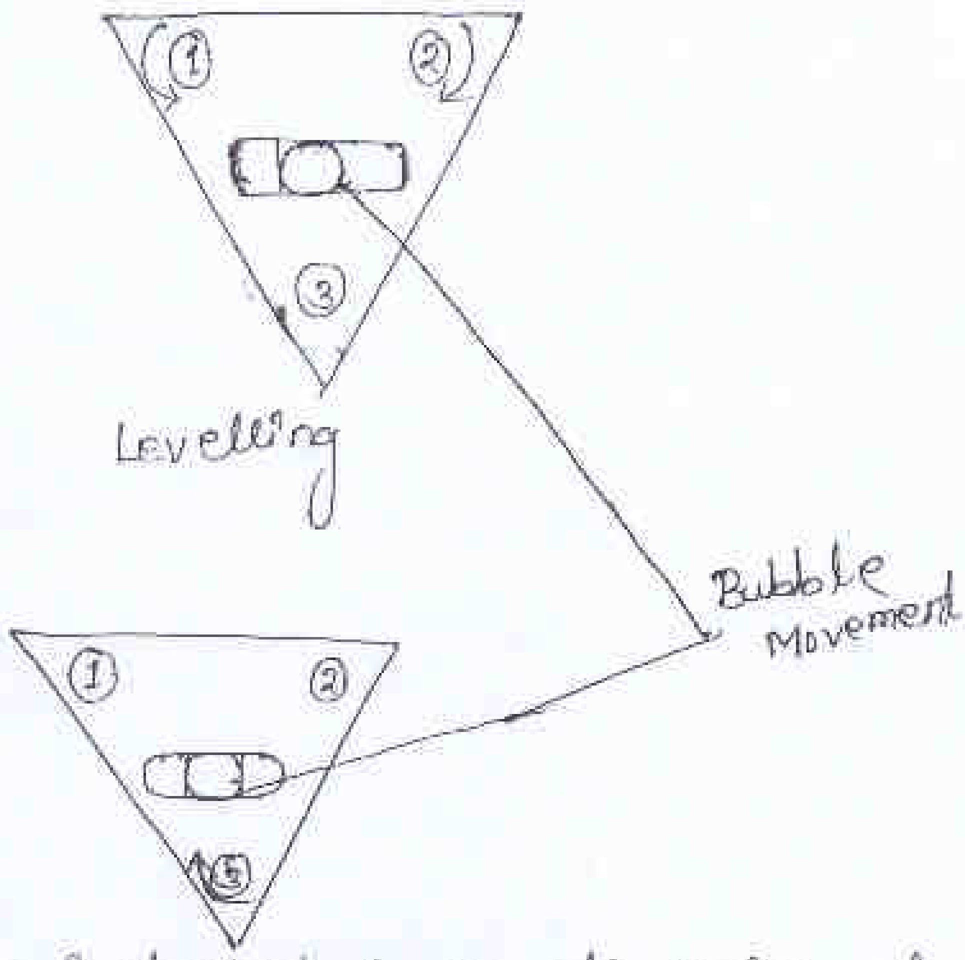
(a) Spread and set the tripod legs in such a manner that the instrument will come to a height nearly equal to the height of the eye of the surveyer.

b) The tripod should be approximately over the point by using plumb bob or eye estimation.

→ Firmly fix the tripod legs on the ground.

→ Mount the total station over the tripod and centr

→ Level the instrument by using a three foot screw as we do increase of a normal levelling operation.



(f) centering is checked by an optical plummet and centre of the cross hairs. if the centre is out repeat the procedure to make it centre once again.
→ Loosen the tripod base plate screw and use three levelling screw for time adjustment.
→ For making centering and levelling of the instrument the translation of the instrument over the lower plate and movement of the foot screw is done simultaneously.

Measurement of angles and distances:-

These operations are done as follows:

1. Switch on the instrument immediatly after the setup is completed and give some time for its initialisation
2. Put the temperature and atmospheric pressure value from its manual to the instrument as input data.

3. Put PPM and prism constant as input.
4. Check all these incorporated data again before starting the recording operation

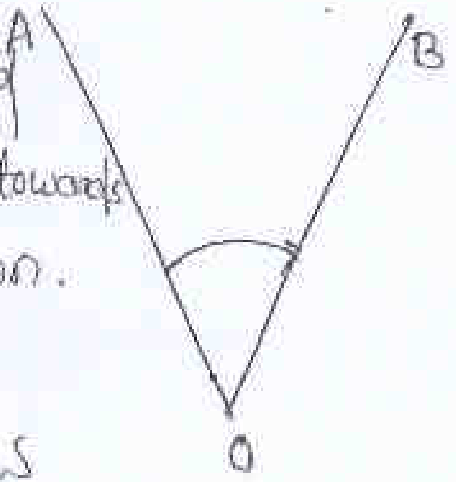
5) Measure horizontal or vertical angles using the total station in that particular format.

6) Determine the slope distance betn any two points in the other format of the instrument.

7) Recorded the readings for distances in feet or in meters and angular measurment are done by degrees mininutes or seconds.

Measuring horizontal angles:-

→ To measure horizontal angle AOB. The instrument is first set-up over the start point 'O' Back sight is taken on station 'A'. To do this The following operation is done.



(i) Loosening the horizontal and vertical lock.

(ii) Turning the telescope towards 'A' for approximate focussion.

(iii) Clamping both the locks

(iv) Confirming precise pointing towards 'A' using tangent screw.

(v) Setting up horizontal angle 0°0'0"

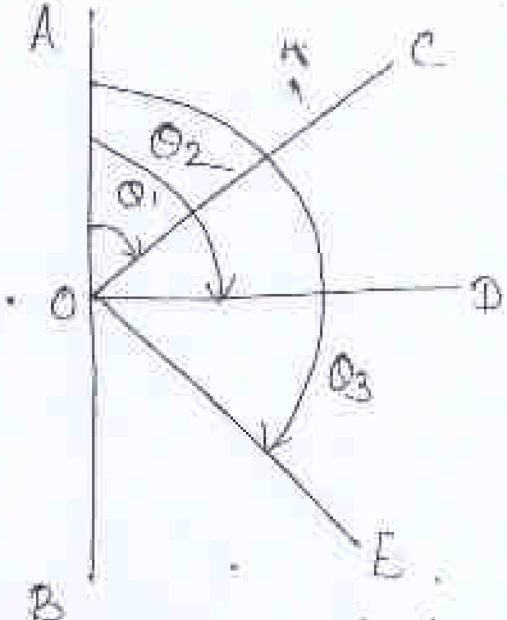
(vi) Release the horizontal screw rotated the telescope along horizontal plane to focus on the

(vii) clamp the screw. Use tangent screw for finner focusing

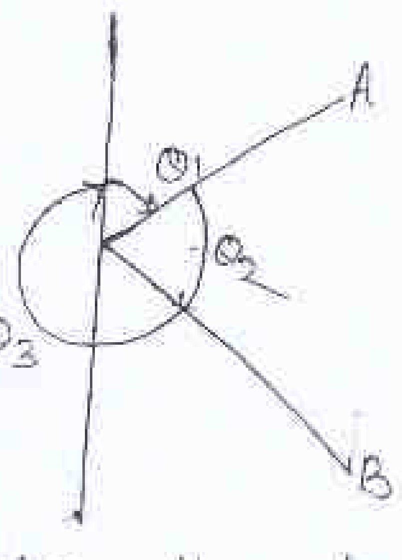
(viii) corresponding horizontal angle value will be displayed on the LCD screen

(ix) This method is known as repeatation method

(x) An other method is very common for measuring multples sets of horizontal angle in one setup known as directional method,



directional method

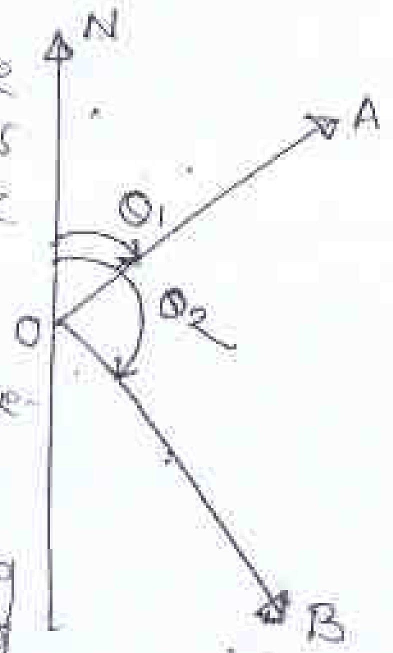


closing the horizon method.

(xi) To check the accuracy of the measuring angles an extra horizontal angle is measured from the last observation point to the fore sight point and this method is known as closing the horizon method.

Measuring of vertical angle (Azimuth):-

To measure the vertical angles of different inclinations of the telescope w.r.t the vertical axis 'N' like 'OA' (θ_1) OB (θ_2) etc. The following steps are taken.



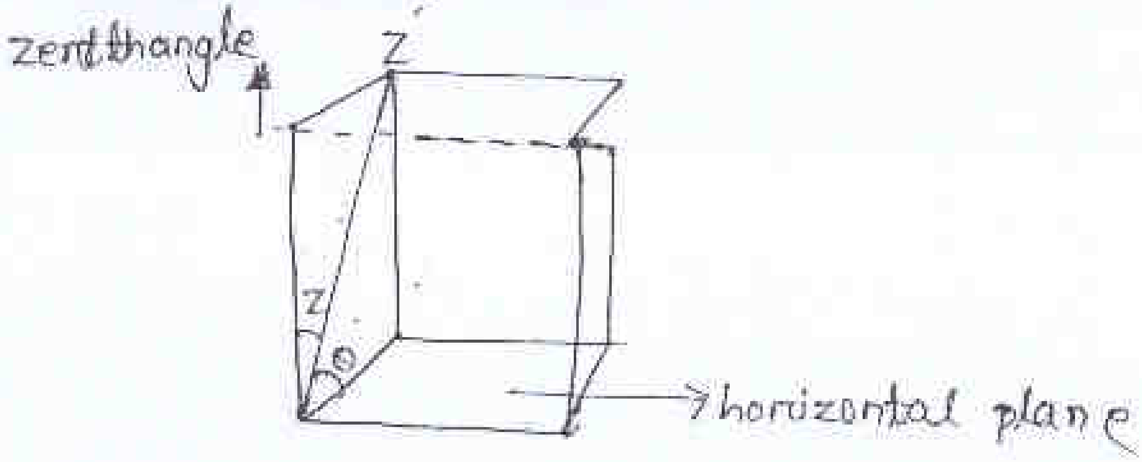
1. The total station is setup and levelled over the station 'O'
2. The instrument is focused along the north (N) (vertical axis) and set the vertical angle 0°0'0"
3. Turn the telescope clockwise from vertical axis for focusing towards A, B etc. and the vertical angles are displayed over the LCD screen,
4. The clamping and unclamping of vertical clamp screw and using of a tangent screw is similar to that of ordinary theodolite operation

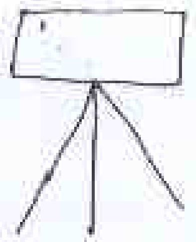
A vertical angle is measured above or below the horizontal plane. If the vertical angle is measured above the horizontal plane is known as angle of elevation. If the vertical is measured below the horizontal plane is known as angle of depression.

Incase of total station, the LCD displays zenith angle (Z) in place of vertical angle (θ) of a line. The relation in bet^n these two angles are.

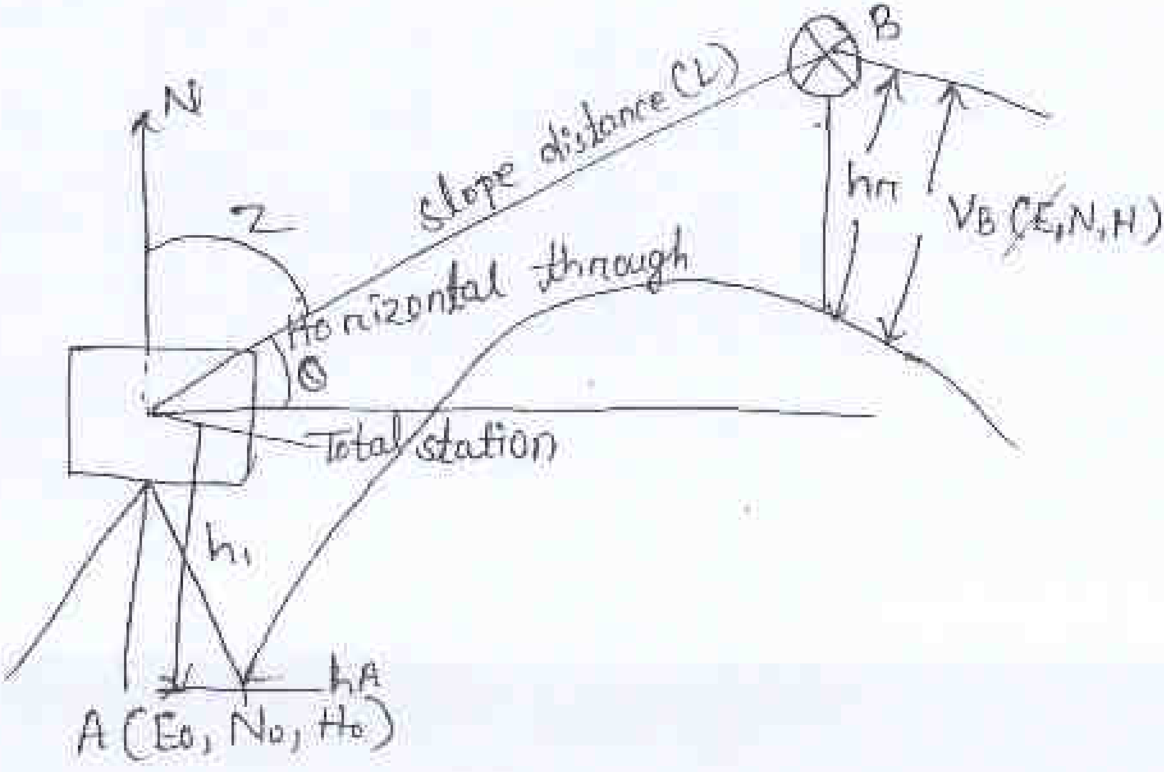
1. For direct method (i.e. clockwise)

2. For reverse method (i.e anticlock wise) $\theta = (z - 270)$





Measuring height :-



To determine the height by using total station z and θ be the zenith and vertical angle betⁿ 'A' and 'B' can be calculated.

$$H_B = H_A + h_1 + (V_{AB} - h_r)$$

h_r → Reflector height above 'B'

V_{AB} → L sin θ.

If we try to determine any height other than a reflector

$$H_B = H_A + h_r + V_{AB}$$

If we take the reflection (r) and curvature 'c' into consideration

$$H_B = H_A + h_1 + V_{AB} + C - r$$

Components of a GIS:-

→ GIS have three important components namely.

1. Computer hardware.
2. Sets of application software modules.
3. a proper organisational set up.

→ These three components need to be in balance if the system is to function satisfactorily.

→ GIS run on the whole spectrum of computer systems ranges from portable personal computer to multi-user super computer.

→ Systems are available that are use dedicated and expensive work stations, with monitor digitising table built in.

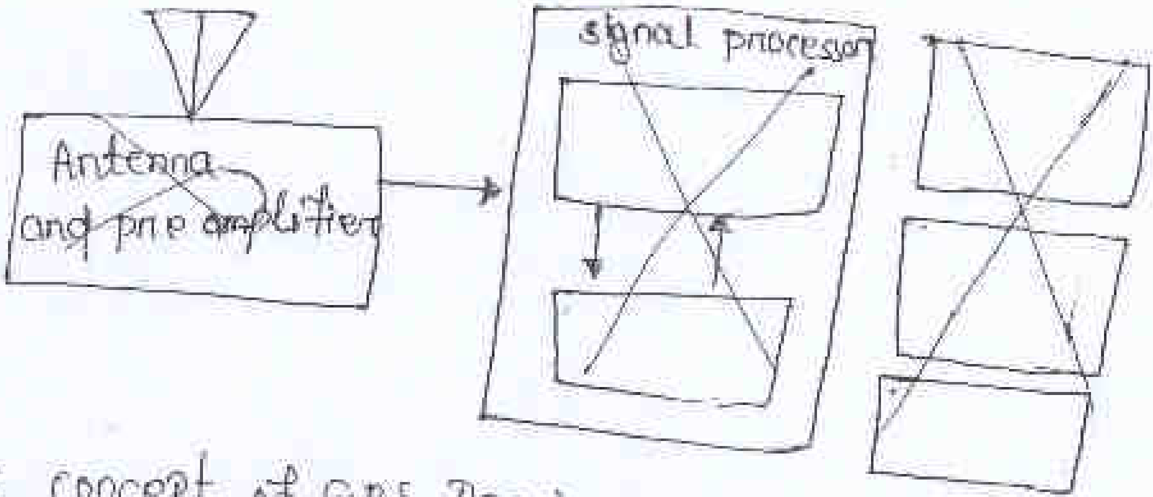
→ There are a number of elements that are essential ... GIS operations. These include the

(1) The presences of a processor with sufficient power to run the software.

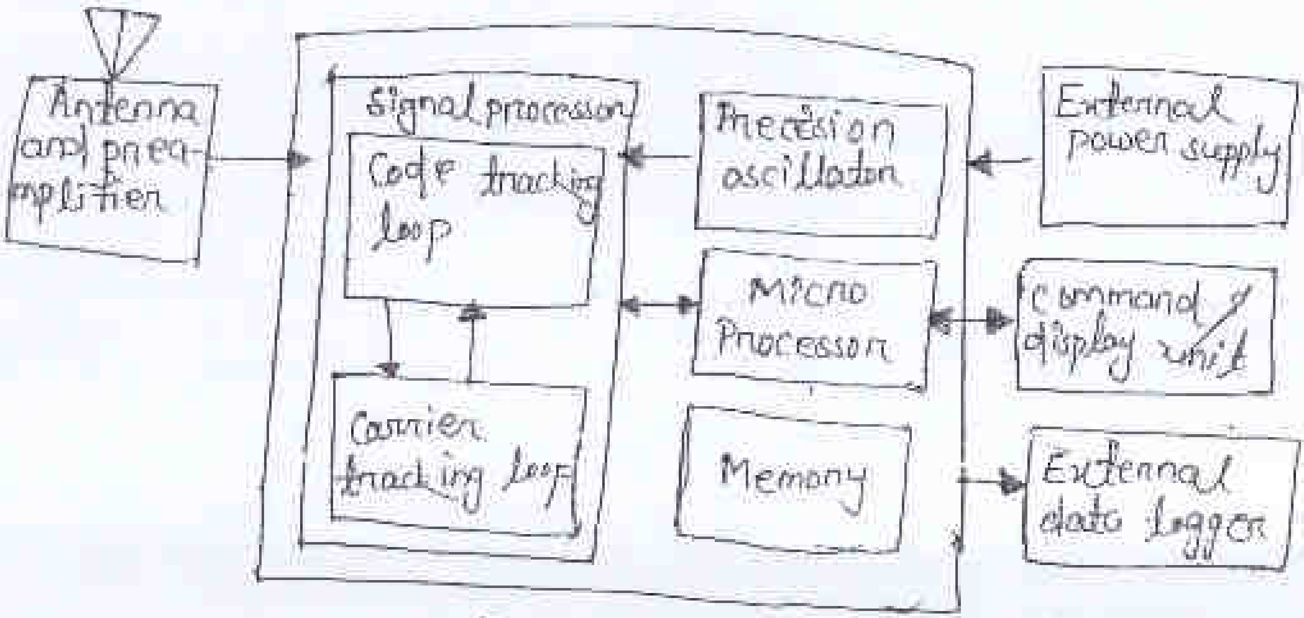
(2) sufficient memory for the storage of large volume of data.

> A good quality high resolution colour graphics screen

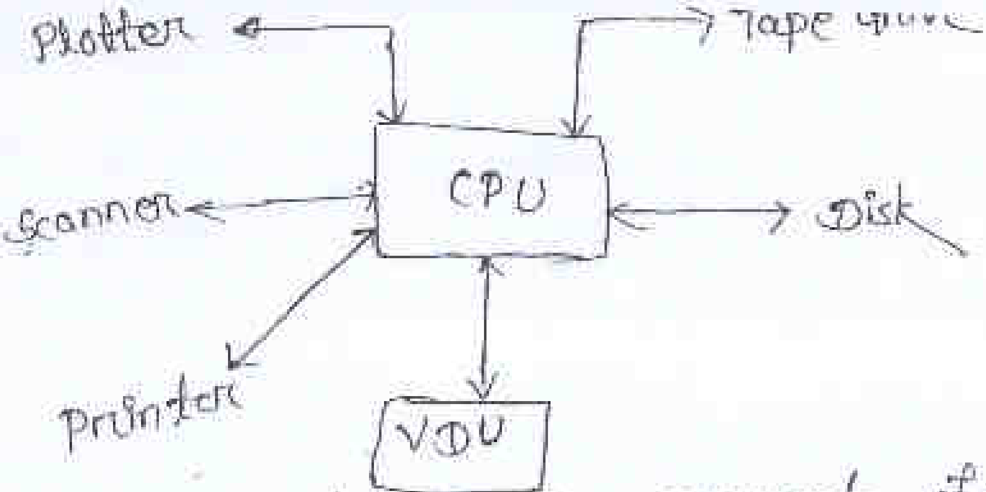
> Data input and output device like printer scanner, plotter etc.



Basic concept of GPS Receiver and Its Components



Major components of a GPS receiver



→ The general hardwork component of a GIS include control processing units which is linked to mass storage units such as hard disk devius and tape driver. peripherals such as scanner, printer and VDU.

IMP → There are a number of essential soft ware elements that must allow the user to input, store, manage, tranform, analyse and output data.

→ Therefore, the software package for a GIS consist of four basic technical modules. These basic modules are.

(i) data input and verification
(ii) data storage and data base management
(iii) Data transformation and manipulation
(iv) Data output and representation

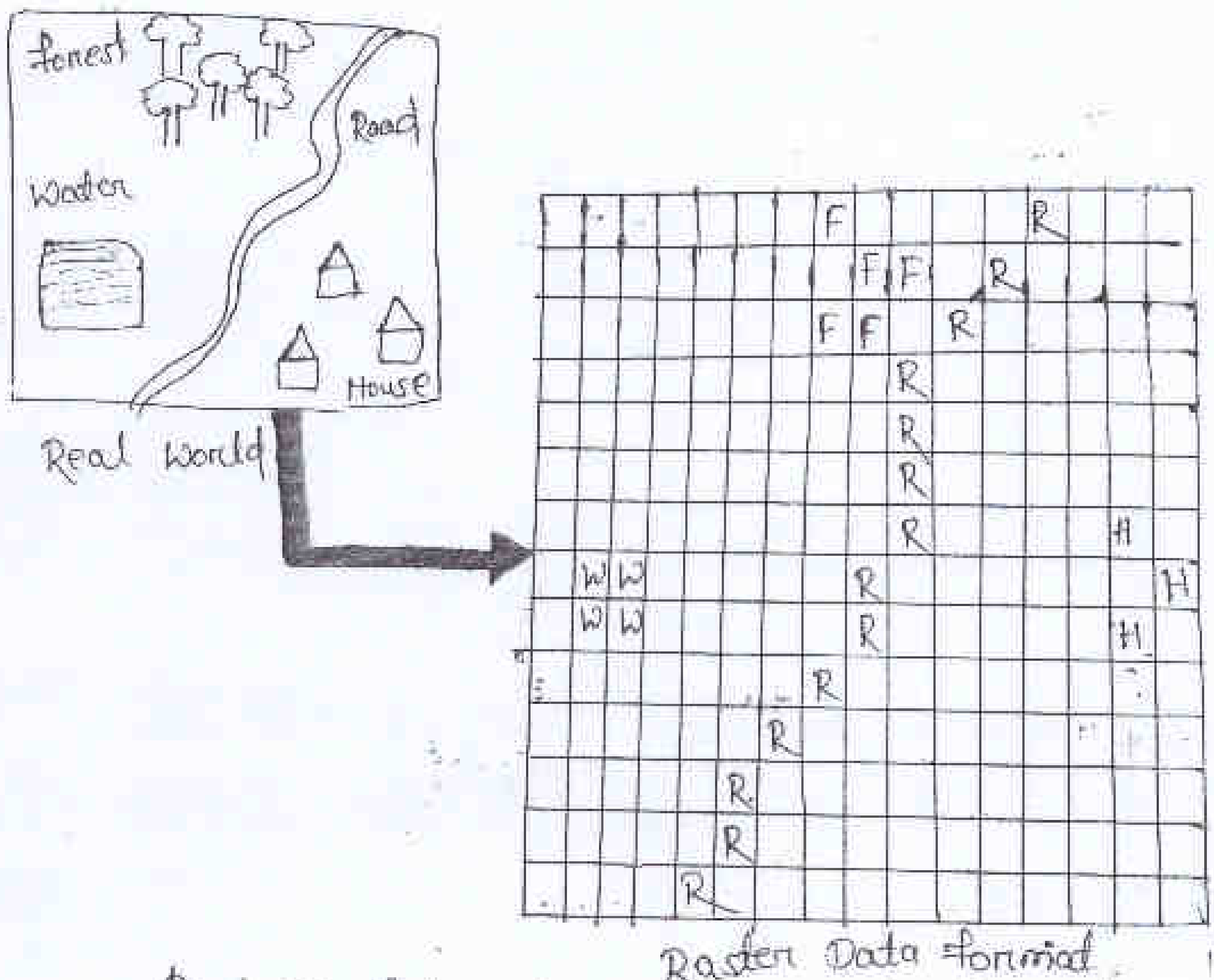
Spatial data model :-

→ Spatial data structures provide the information that the computer requires to reconstruct the spatial data model in digital form.

→ Although some lines act alone and contain specific attribute information that describes the character, other more complex collection of line called networks add dimension of attribute character

→ Thus not only does the road network contain information about the type of road or similar variable but it will also indicate that travel is possible in a particular direction.

→ This information must be extended to each connecting line segment to advise the user that movement can continue along each segment until the attributes change - perhaps until a one way street becomes a two way street



Real World Feature Representation in Raster Dat Format

Aerial Photogrammetry

Defn:-

Aerial photogrammetry is a technique of obtaining or collecting information about any point of interested such as objects, area or phenomenon with out any physical contact the same.

→ It is a method of surveying in which maps or plans prepared from photographs.

Object of aerial photogrammetry :-

→ To prepare the topographical map.

→ To make the topographical map.

→ For military purpose.

→ To make survey of inaccessible regions. for broken, properties, unhealthy regions like malarial or corona affected areas.

→ To make survey of hilly and mountainous areas having less no of tree.

→ To interpret the geology and soil details.

Advantages of Photogrammetry :-

1. Very high speed of coverage of an area
2. Relatively low cost as compared to others survey
3. Ease of obtaining topographic details especially in-accessible areas.
4. For preparing maps.

Uses of aerial photogrammetry:—

1. Photographic surveying is suitable for small scale mapping of open hilly or mountainous countries.
2. It is not suitable for flat or wooden country.
3. It is well adopted for topographic survey
4. This survey for road, railways, canals, harbours etc.
5. To prepare large scale maps.

→ For reservior planning
→ For land drainage and soil erosion.

Classification of photogrammetry

- Terrestrial photogrammetry
- Aerial photogrammetry

Terrestrial photogrammetry

→ The photogrammetry in which the photographs are taken by means of a special camera supported on the ground and a theodolite is known as terrestrial photogrammetry

→ points to be remembered while taking the terrestrial photogrammetry

① Photographs are taken from elevated grounded level.

2) Method is very similar the camera is instation any position.

3) Camera used in this method is called photo-theodolite as it will require same features as theodolite.

Aerial photogrammetry:-

→ The photogrammetry in which the photographs are taken from air is known as aerial photogrammetry (Air craft, Drone camera)

Equipments required in aerial photogrammetry:-

① An aeroplane

(2) An aerial camera.

(3) Accessories required for interpretation and plotting. This includes the followings.

1) Streoscope

2) Stereo projector.

3) Parallax bar

4) Pentograph.

5) Sereo-plotter.

Steps in aerial photogrammetry:-

→ The aerial photogrammetry generally include the folloing

(1) Photographing the terrain to be survey.
(2) Measuring the image of the object on process-ed photograph.
(3) Reducing the measurement of the image to some useful form such as plan or maps or sections.

Types of aerial photograph:-

→ Aerial photographs are usually classified into 3 types:-

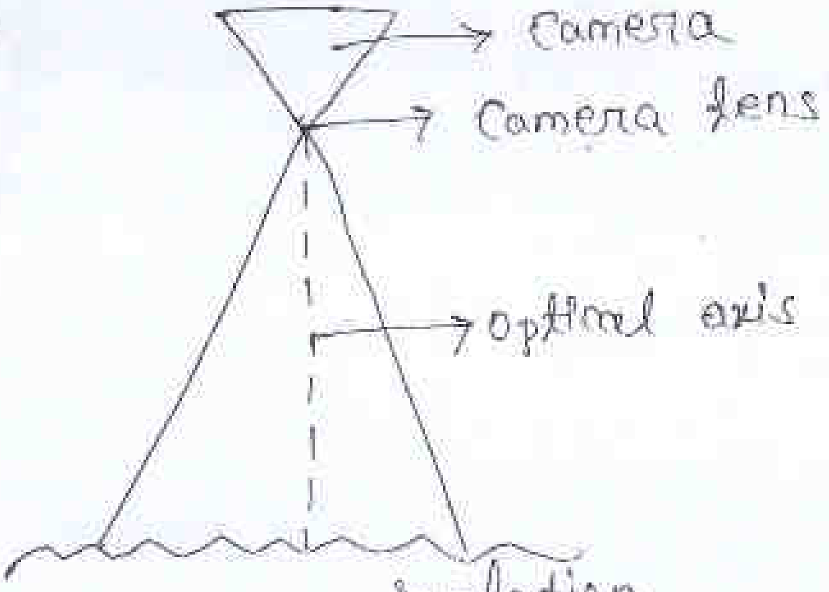
1. vertical photograph.
2. Oblique photograph.
3. Tilted photograph.

Vertical photograph:-

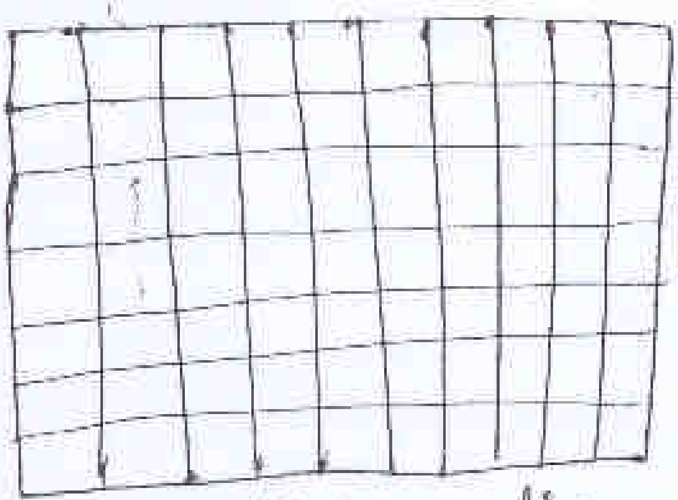
→ These are the photographs take with the camera axis nearly vertical as possible and don't have tilt more than 1°.

→ Vertical photographs are the main way of obtaining photo image from topographic mapping.

→ when the camera axis is perfectly verticale the photo plane is parallel to the datum and the resulting photographs are.



Camera orientation



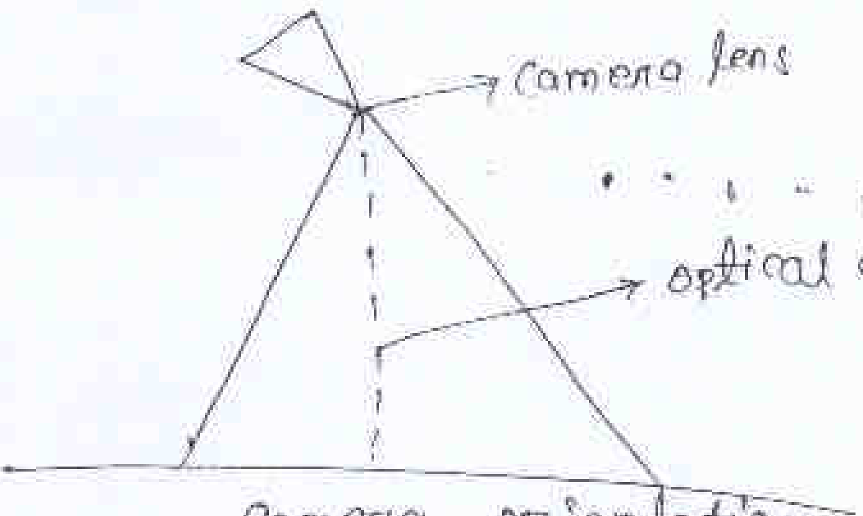
Gridle of the section. lines of the photo are vertical.

→ vertical photographs can produce most accurate maps is the variation in scale over the area is smaller are no area remains hidden.

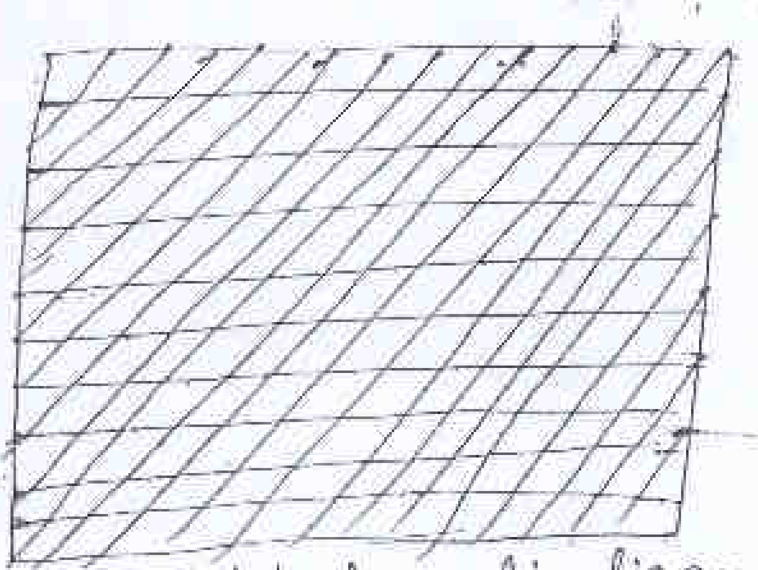
→ Howevers the details in the vertical photographs can't be easily in identied as the view offered is in familar to the eyes.

Tilted photographs:-

→ In spite of precautions taken small tilt generally less than 1° and rarely greter than 3° are invariabily present and the resulting photo are called near vertical or tilted photographs.

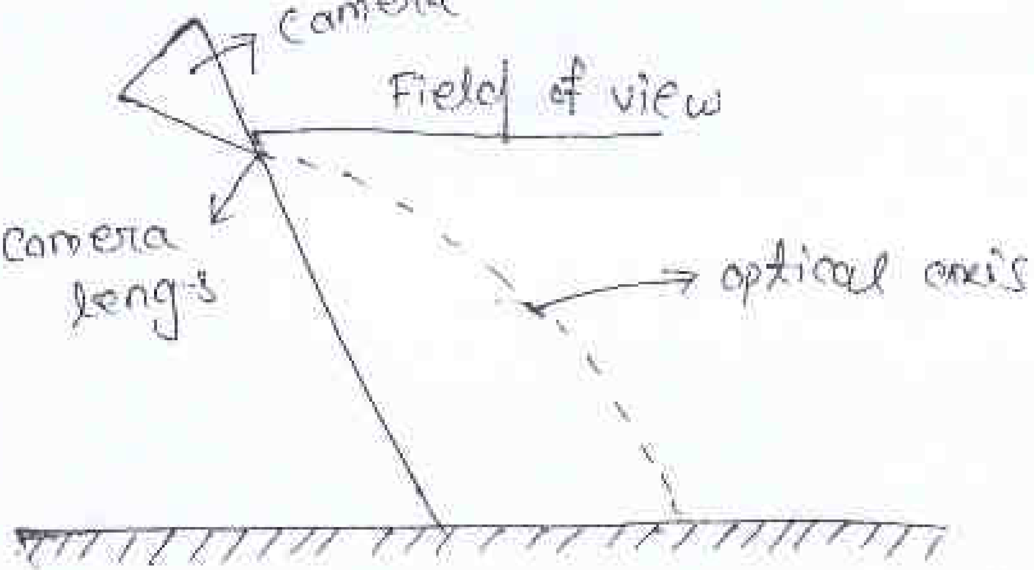


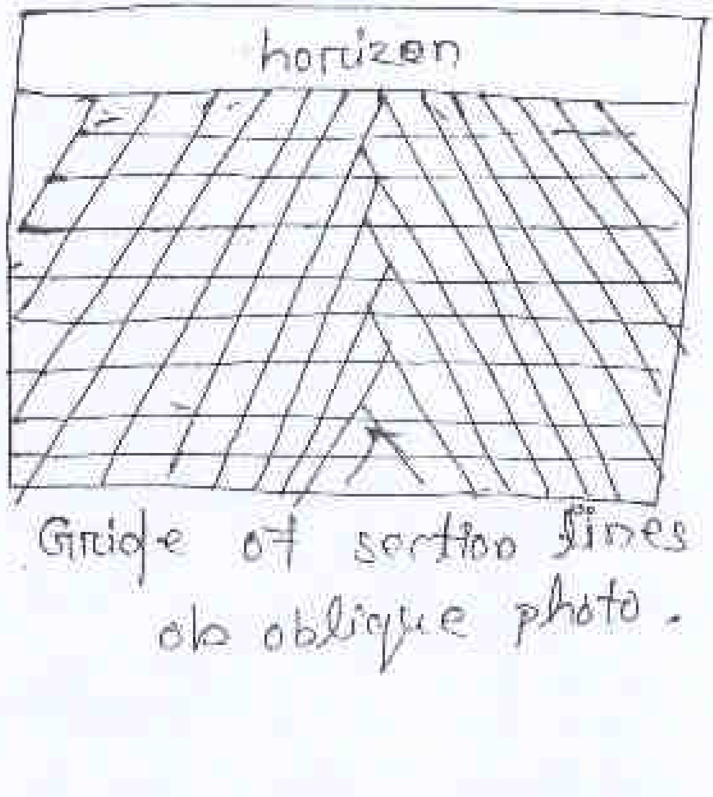
Camera orientation



Grid of section lines photograph.

→ Precise methods are available for analysing accuratly the tilted photograph.





Gride of section lines
ob oblique photo.

Oblique Photographs :-

21.01.20

→ These are produced by giving the camera axis intentional tilt up to 30° to the forward direction.

→ Oblique photograph is also called as high oblique.

→ When the image of the horizon is included and low oblique when horizon is not seen and the camera is tilted in excess of 3°

→ They provide the information of ~~the~~ enemy territory without crossing the border.

→ Features can be easily recognised from oblique plots as these provide ~~the~~ view familiar to the eye sight.

→ However some details remain hidden behind the tall structures.

→ The scale variation is large and therefore preparation of maps becomes more laborious.

Stereo-scope:-

→ It is difficult to view stereo-photograph without the aid of optical devices. These difficulties can be over-come by an instrument called stereo-scope.

→ There are number of stereo-scope are used for viewing the photographs But most commonly used are

(i) Pocket stereo-scope.

(ii) Mirror stereo-scope.

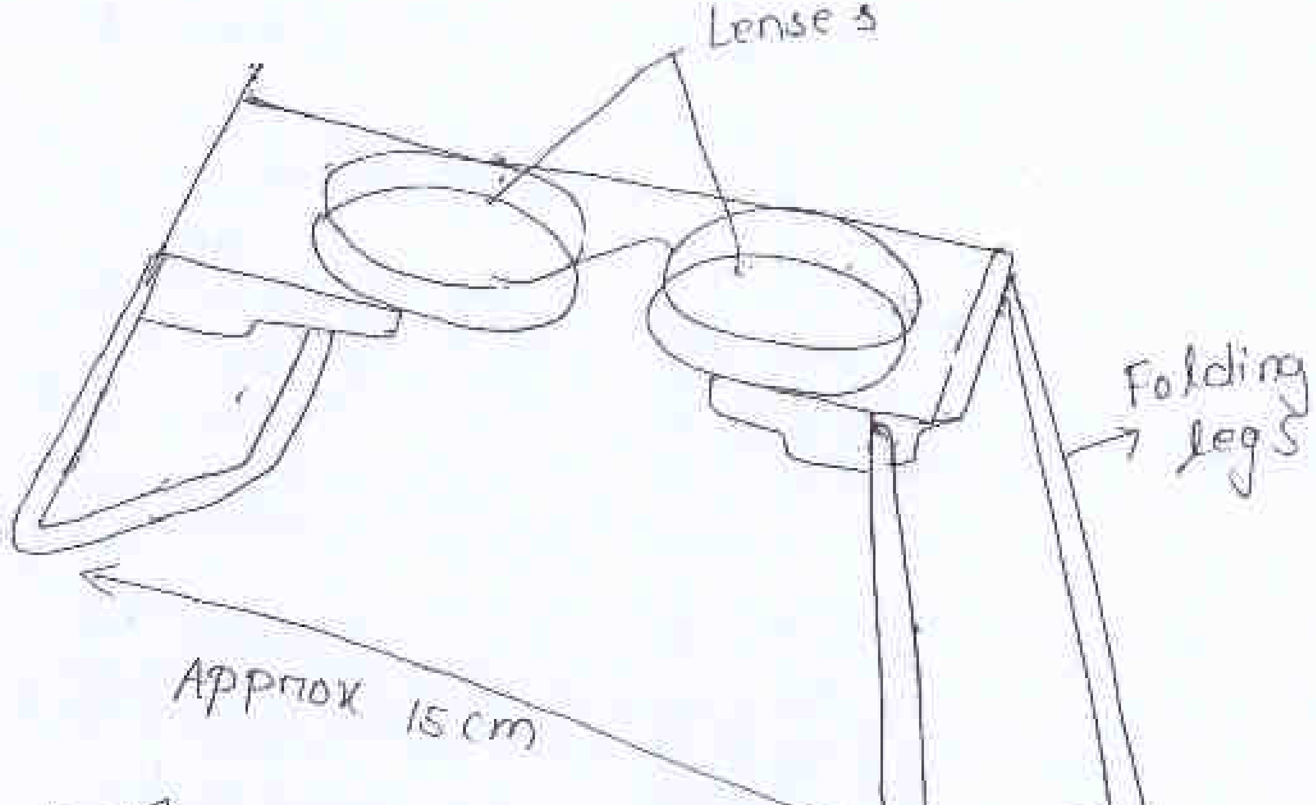
(i) Pocket stereo-scope:-

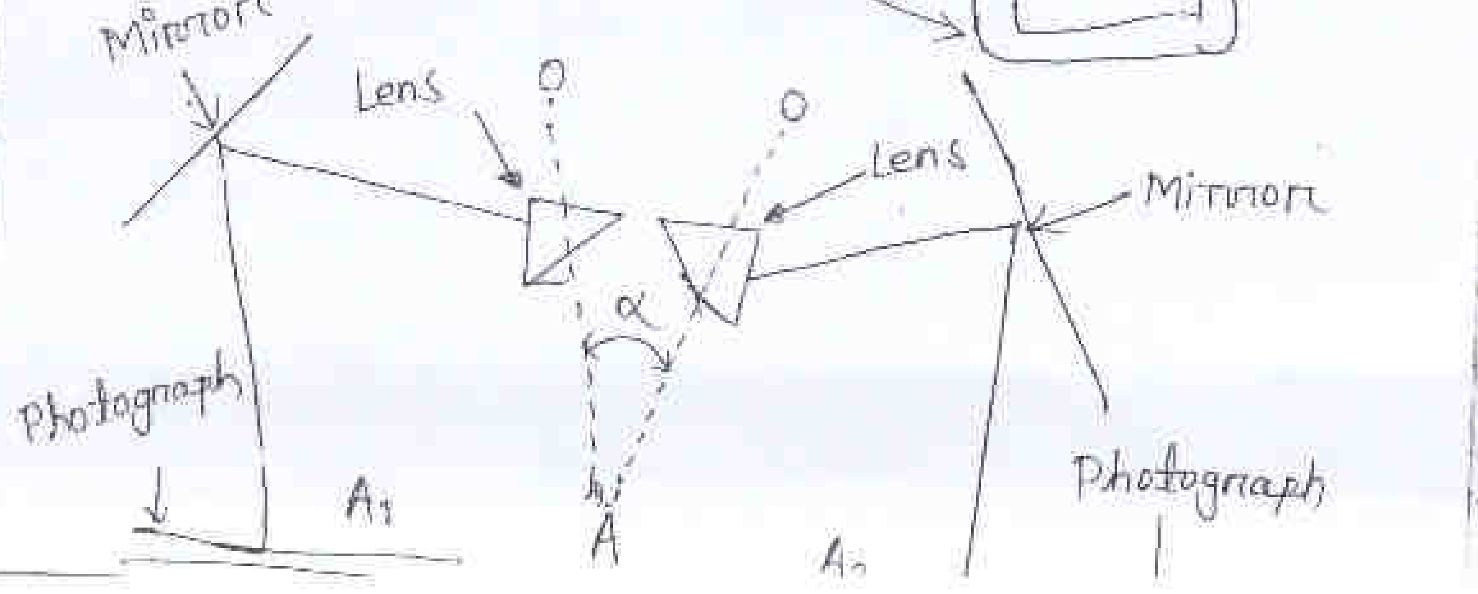
(i) Pocket stereoscope:-

→ Most commonly used, simple construction, consis of two simple convex lens. Mounted on a frame

→ The spacing betⁿ the lenses can be varied to accommodate various eye bases.

→ For stereo viewing of the photographs are placed so that the corresponding images are slightly less than the eye base apart two inches.





Mirror stereoscope:-

→ Mirror sterascope has two large wing mirror and two similar eye piece mirror.

→ The light rays from the photo points a_1, a_2 are reflected from the mirror surface.

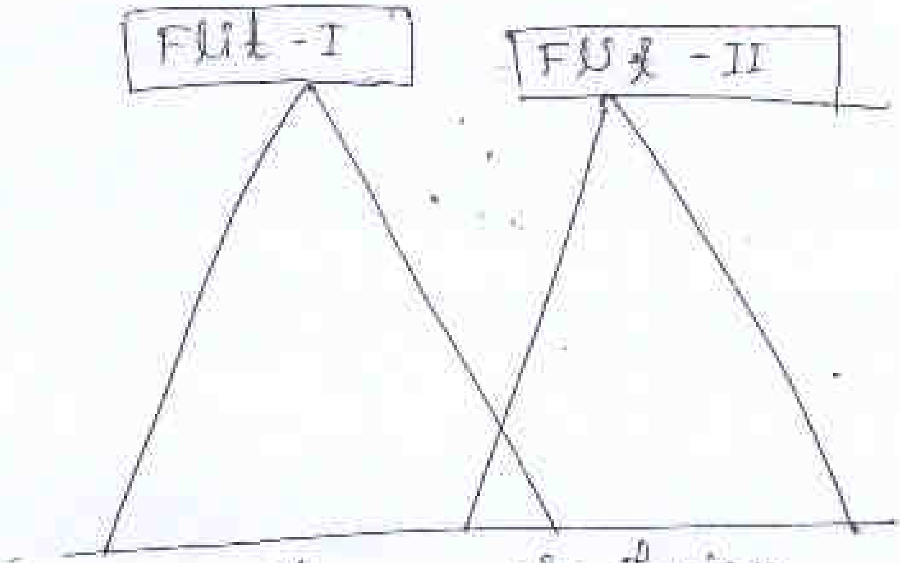
→ and according to the principle of reflection are recieved at the eyes from the parallatic angle θ_a similarly for point $b_1 b_2$ also forming parallatic angle θ_b

→ The brain automatically associates the depths of the point 'A' and 'B' with respect to parallatic angle θ_A and θ_B

→ This happens for the finit number of points reflect from the left and right photo which generates the 3D stereoscope veiwing of the overlapping area.

principle of stereoscope:-

→ Two separate photo veiwed in stereoscope the image of the left photograph veiwed by left eye and the image of right photograph veiwed by right eye is fused together in brain to provide 3 dimensional veiw this is called stereoscopic fusion.



stereoscopic fusion.

Stereoscopy :-

→ Some times called stereoscopic imaging is a technique used to enable a three dimension effect.

→ In aerial photography when photographs overlap on the some ground area is photogra-ph from two separate position forms a stereo pair used for three dimensional viewing

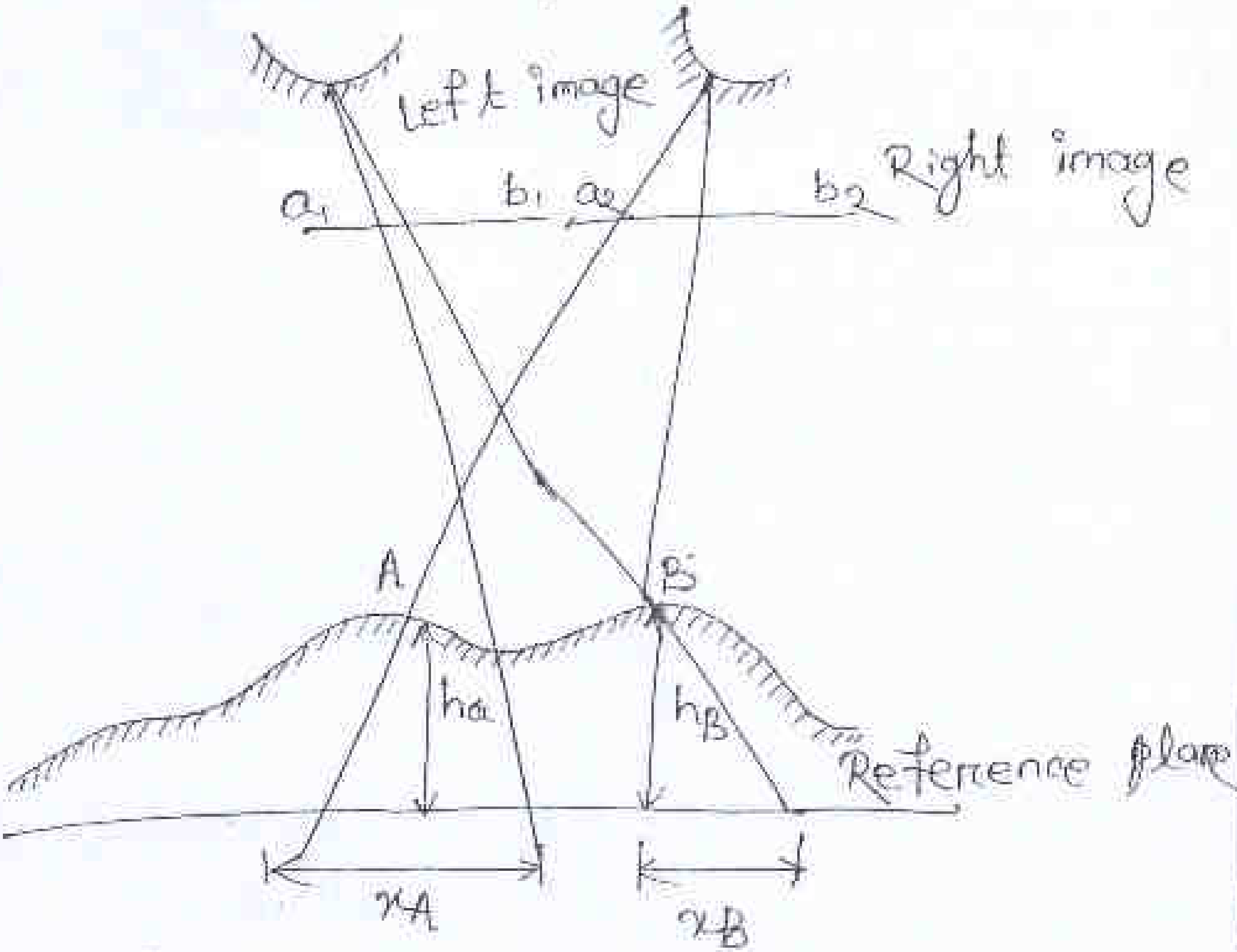
→ Thus obtaining pair ~~area for three dimen-sional veiwing~~ of stereoscopic photographs on images can be veiwed to determine parall and 3D veiwing.

Parallax:-

→ In normal binocular vision the apparent movement of a point veiwed first with one eye and then with the other is known as parallax.

→ Parallax is the displacement of two images in successive photographs.

Parallax measurement:-



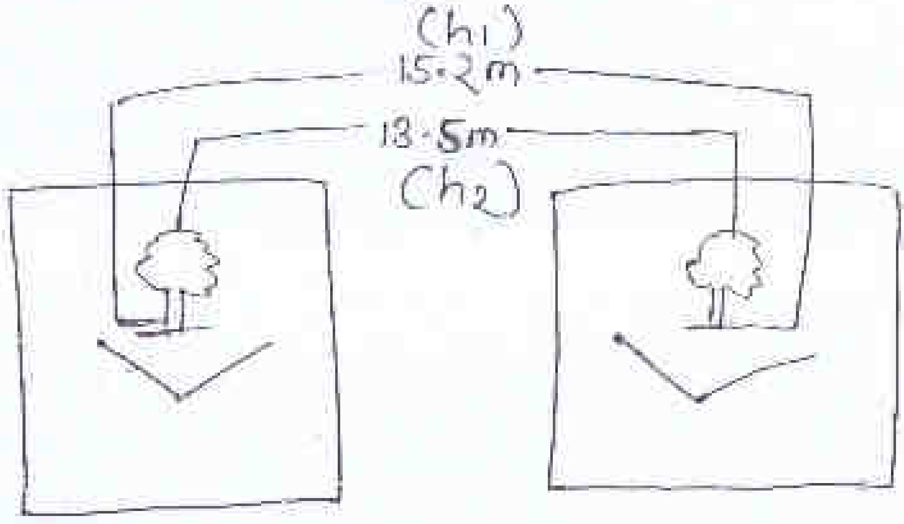
Parallax Measurement:-

(i) Stereoscopic parallax.
(ii) Differential parallax.

Stereoscopic Parallax:-

The displacement of an object caused by a change in the point of observation is called parallax. Stereoscopic parallax is caused by taking photographs of the same object but from different point of observation

Differential parallax:-



$$dp = 15.2 - 13.5 = 1.7m$$

$$\boxed{dp = h_1 - h_2}$$

It is the difference between the stereoscopic parallax at the top and base of the object.

DEM Generation:-
(digital elevation model)

→ DEM is a digital representation 3-dimensional information (x,y,z) of the continuous topography of the bare earth in a particular reference cordinate system.

DTM (Include all terrain geological climatic, climatology, meterology, oceanology)

↓

DSM (Include terrain and terrain features like natural features and man made features)

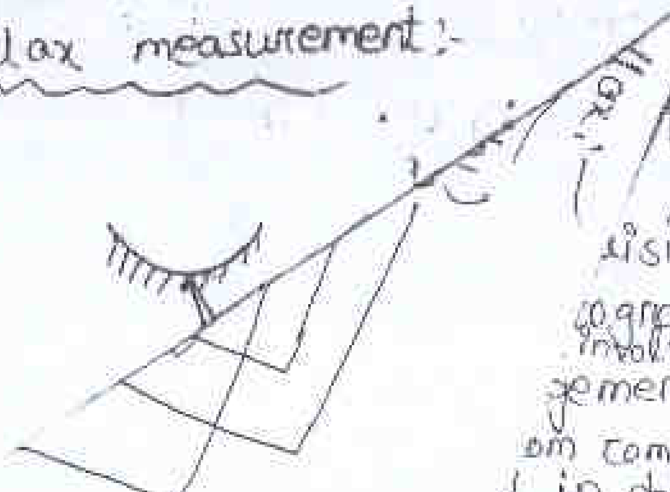
↓

DEM (Only bare terrain)

→ Initially elevation models were physical models made of rubber, plastic, clay sand)

→ Roberts was the first to propose DEM and Millar and Laflamme of MIT described the development in details.

Parallax measurement :-



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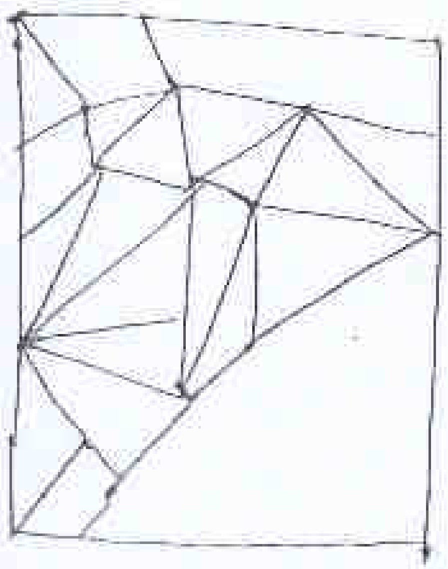
Data structure for DEM :-

There are two main data structure in which DEM data can be stored.

231	235	233	224
235	244	235	230
227	238	228	224

(Grid)



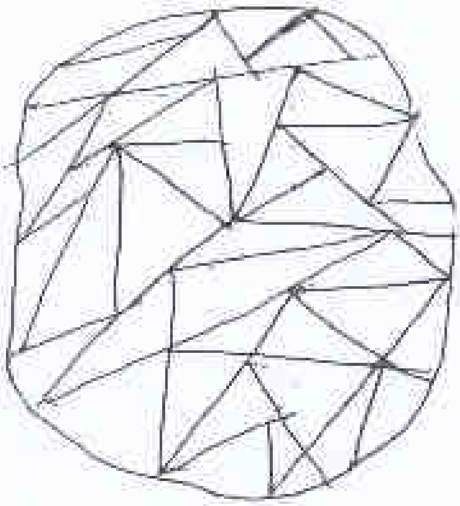
Tin

Grid structure :-

① Only elevation (z) each node of grid is recorded.
② All undulations of terrain can't be covered in a cell size grid
③ Very easy to analyse and manipulate data for algorithms
④ Redudancy of data :
⑤ Surface generated appear more natural.

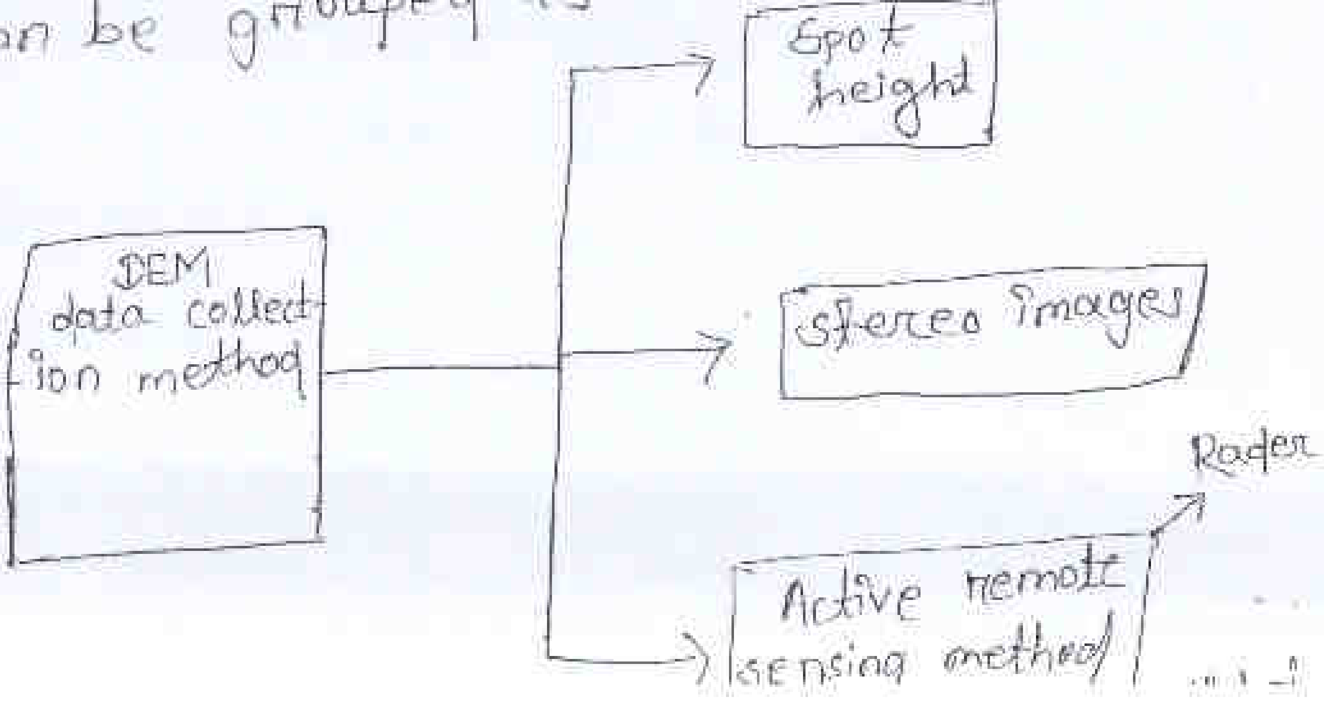
TIN structure :-

1. x, y, z at surface specific points of terrain is recorded.
2. Represent more ~~th~~ true surface.
3. Applying mathmetical model for TIN data.
4. Only surface specific point is recorded hence no redundency in data.
5. Doesn't appear natural due to edge of tringle.



Data source for DEM generation :-

various methods for collecting DEM data can be grouped as



spot height:-

→ This include all method in which 'x','y','z' condinates of a point can be found eg theo-dolite, total station. Global positioning system gps(etc).

→ Data can be collected in form of grider TIN better option is TIN as less no of points needs to be recorded and later TIN data for analysis perpous.

→ These are good and cheaper tools to obtain the point data to create highly accurate DE for small areas.

→ Topographic map generally prepared by these methods is also a good and cheeper source for DEM generation.

DEM from stereo images:-

→ when two images are captured from different locations (for same area). Then in the over lapped area can be seen in 3D and x,y,z for any point can be measured.

→ stereo images can be aerial satellite or rador images-

→ Images taken from areal platform have good resolution but less coverage.

→ satellite stereo images can be aquired either along path or across path of satellite orbit. Across path stereo images are obtained after revisit
and leads environmental condition (may

not be same.

→ VHR satellite general capture multi structural band of visible region

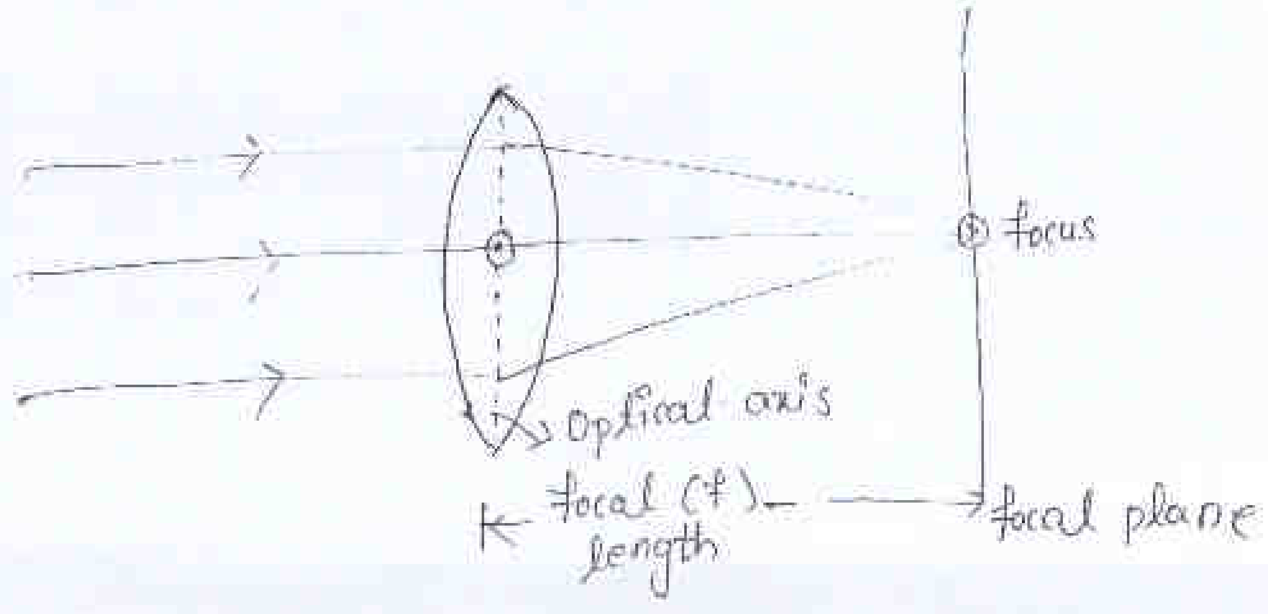
∴ Hence spatial resolution may reduce the error,

Active sensors/Remote sensing :-

→ In an active sensity device, the engineer can control the rate of pulsing of signal transmitted to the surface and the range of frequencies of radiation transmitted and received.

→ This means that the measurements can remain 'coherent'. From one measurements time to another, provided that the external conditions remain the same.

Geometry of a simple lens :-



→ A lens is formed by two curved surface. The imaginary straight lines that coincides the axis of the symmetry of the sperical curved surfaces called as optical axis of the lens.

→ The imaginary line which passes through the centre of curvature of the lens surface is called principal axis.

→ The rays close and parallel to the optical axis converge to a point on the principal axis called as focus point.

→ A plane at right angles to the principal axis passing through the the focal point is called a focal plane.

→ The point on the optical axis of the refractive optical element through which the rays pass without any deviation is called as optical centre.

→ The point of intersection of the optical axis and principal axis is called the pricipal point.

→ The distance betⁿ the principal point and the focal point is known as focal length.

→ It is usually written as $\frac{f}{10}$ meaning the entrance diameter is $\frac{1}{10}$ th of the focal length.

Photographic films:-

→ A photographic film consists of photosensitive photographic emulsion coated on a base for support.

→ The emulsion consists of silver halide crystals of different size embedded in a gelatin matrix.

→ When light is allowed to fall on the emulsion a photo chemical reaction takes place and a latent image is formed. from the area of the film. the light has not fallen.

The silver halid gets dissolved during developing process and the area remains transparent. A negative image is formed and positive image produced on a paper and transparent positive is obtained.

Types of films used for arial photography.

→ There are 3 types films used as follows.

1. Black and white film.
2. True colour film.
3. Colour infrared film.

~~Construction~~ of a ~~colour films~~:-

Principls, features and use of micro - optic theodolite and digital theodolite:-

Electonic digital theodolite:-

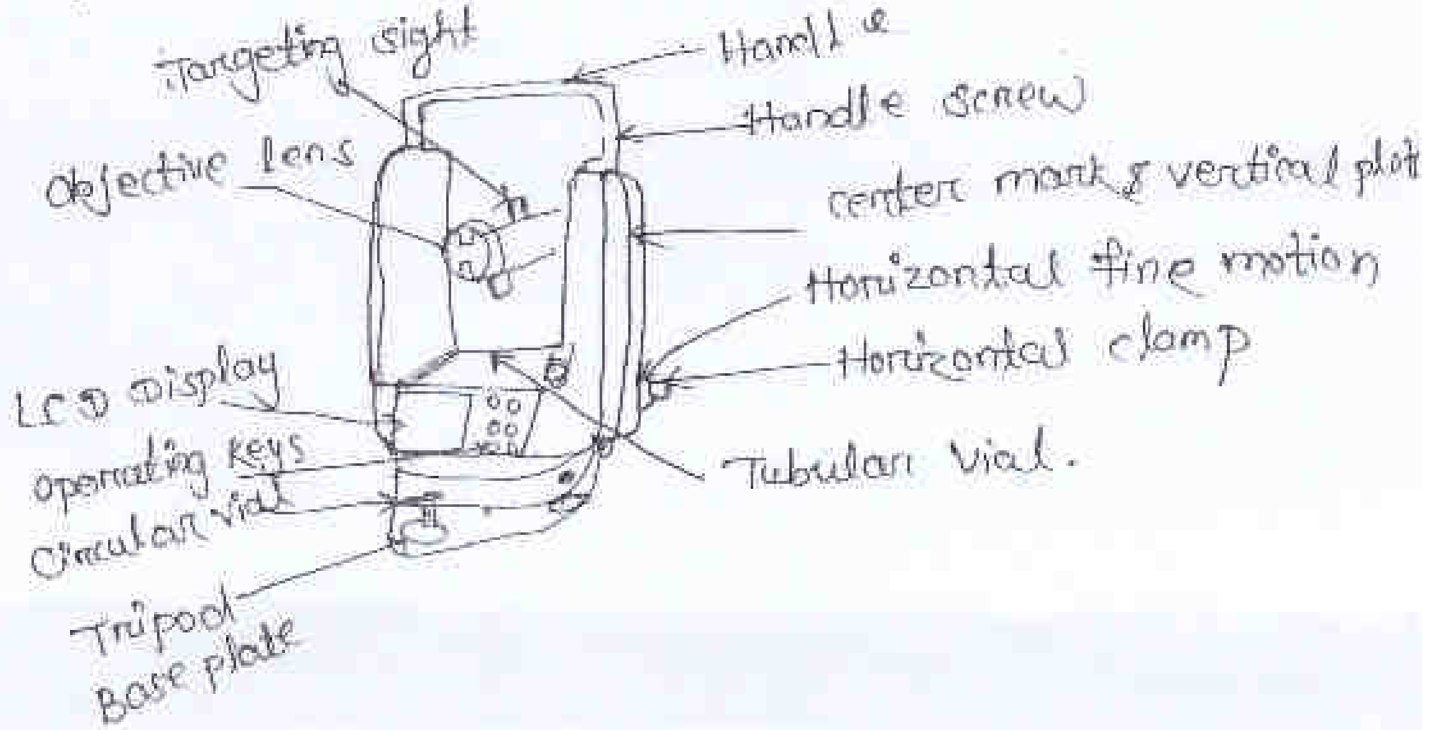
→ It is a precision instrument for measuring angular in the horizontal planes and have been adopted for specialised purposes in field like metorology and rocked lunch technology

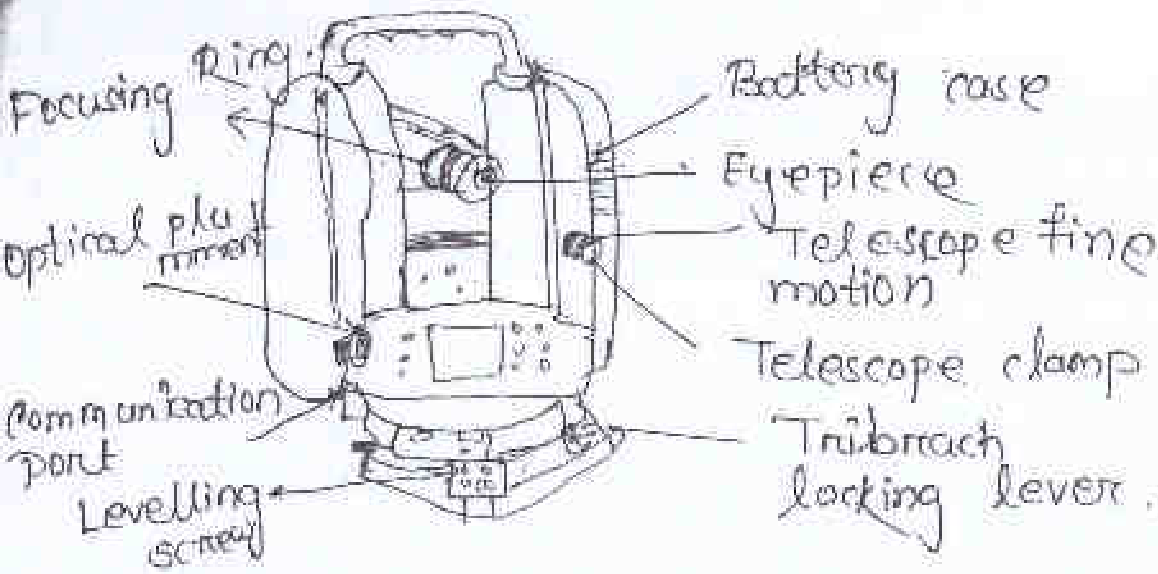
Principle of electonic digital theodolite:-

→ A theodolite works by combining optical plummet (or plumb balls), a spirit (bubble level) and graduated circles to find vertical and horizontal angle in surveying.

→ An optical plummet ensures the theodolite is placed as close exactly vertical above the survey point.

Components of electronic digital theodolite:-





Advantages :-

→ greater accuracy.
→ internal mangifying optical system.
→ Electonics reading.
→ Horizontal circle ~~reading~~ can be instantly zeroed or set to any other value.
→ Horizontal circle reading can be taken either to the left or right of zero.
→ Repeat readings are unnecessarary.

Micro-optic theodolite :-

These are traditional angle measurement instrument that are used in geotech survey and engineering measurement.

Features :-

→ Used in geoditic surveying.
→ Used in engineering measurement.
→ Used for all ~~rout~~ routine survey work in construction.

MCQ

Q1 The number of horizontal cross wires in a stadia diaphgram is ___.

1. One
2. two
3. Four
4. three ✓

Q.2 Calculate the horizontal distance of a point from the instrument, if the staff intercept is 2.5m. The micrometer reading of the drum of diaphragm is 3.2 and the micrometer screw has 100 theads in 1cm. The focal length of the objective glass is 200mm and the distance of the instrument axis from the centre of the object glass is 180 mm.

1. 972
2. 1367.4
3. 1562.8 ✓
4. 1721.6

IMP. MCQs related to GIS and GPS:-

1. Among the following which don't come under the components of GIS

ⓐ Hard ware

ⓑ soft ware

ⓒ complier

ⓓ Data

Ans - ⓒ - complier

2. Among the available formats which are most commonly used incase of GIS.

a) GIF

b) TIFF

c) JPEG

d) DXF

Ans - b - TIFF

3. The point data feature can be used to represent ____ ?

a) Location

b) Area

c) 3D area

d) Volume

Ans - a - Location

ve

4. Which is the following can be used for representin a real world feature on two dimensional surface.

a) Plan.

b) Drawing.

c) Scale.

d) Map.

Ans- d- Map

5. which of the following sets represent the correct set of map classification.

most a) Cadastral, thematic

b) Thematic, geographic

c) Cadastral, geographic

d) geographic, Topographic

Ans- a- Cadastral, thematic

6) which of the following is having same principle as that of determining the position in GPS.

nt a) Compass.

b) Traversing

c) Trisection

d) Regection.

Ans-: d- Resection.

7) which among the following is used to locate an object.

a) GPS

b) GIS

c) RS

d) IRS

Ans-: a- GPS

8- ~~Which among~~ In the process of GIS digitalizat is done for better output.

A- True
B - false

$\boxed{\text{Ans -A}}$ True

9- Which among the following is not related to GIS software.

A) CAD
B) Arc GIS
C) Arc veiw
D) stadd - pro

$\boxed{\text{Ans - D - stadd - pro}}$

10- The polygonal data feature uses which of the following data format.

a) scientific character.
b) Math.
c) character.
d) integer

$\boxed{\text{Ans - d - Integer}}$

11- Which of the following indicate topological primitive.

a) Polyline
b) Point
c) Node
d) Polygon

$\boxed{\text{Ans - C - Node}}$

:- Tacheometric surveying :-

Q-1 The number of horizontal cross wires in a stadi diaphgram is ......

1- One
2- two
3- four
4- three

Ans:- (4)- three

Q-2 Calculate the horizontal distance of a point from the instrument, if the staff intercept is 2.5m. The micrometer reading of the drum of the diaphragm is 3.2 and the micrometer screw has 100 threads in 1 cm. The focal length of the objective glass is 200 mm and the distance of the instrument axis from the centre of the object glass is 180 mm.

1- 972
2- 1367.4
3- 1562.8
4- 1721.6

Ans:- (3)- 1562.8

Q-3 Two distance 200m and 298m are measured from tacheometer instrument and corresponding staff intercepts are 2m and 3m respectively. Additive constant will be:

1- 2
2- 4
3- 98
4- 1

Ans:- (2)- (4)

Q-4 Which of these is not an error due to natural causes in case of stadia surveying?

1. Parallax
2. Bad visibility
3. Unequal refraction.
4. Unequal-expansion.

Ans- 1. parallax

Q-5 The anallactic lens provided in tachometer is a:-

1. Convex and concave lens
2. Convex lens.
3. Plane lens
4. concave lens.

Ans:- (2) – Convex lens.

Q-6 Tachometric formula for horizontal distance using inclined sights through θ is obtained by multiplying

1. the constants by $\sin^2\theta$
2. the constants by $\cos^2\theta$
3. the constants by $\cos\theta$
4. the multiplying constant by $\cos^2\theta$ and additive constant by $\cos\theta$

Ans:- 4 - The multiplying constant by $\cos^2\theta$ and additive constant by $\cos\theta$.

Q-7

In tacheometric surveying.

a) The intercept of the staff is maximum when the staff is normal to the line of sight.

b) In the tangential system, the staff is kept normal to the line of sight.

c) If a tachometer is fitted with an anallatic lens, its additive constant is non zero.

d) It is more convenient to hold the staff normal to the line of sight than to hold it vertical.

select the incorrect statement/s

1. (a) only.
2. (a) and (b) only
3. (a), (b) and (c) only
4. (a), (b), (c) and (d) only

Ans :- (4) - (a), (b), (c) and (d) only.

Q-8

In plane table survey, both horizontal and vertical distances will be obtained directly using ......

① tacheometer
② Plane alidade

1Q - High rate

15 - Low