# Vikash Polytechnic, Bargarh

Vikash Polytechnic
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## Lecture Note
## on
# Land Survey II

## Diploma 6th Semester

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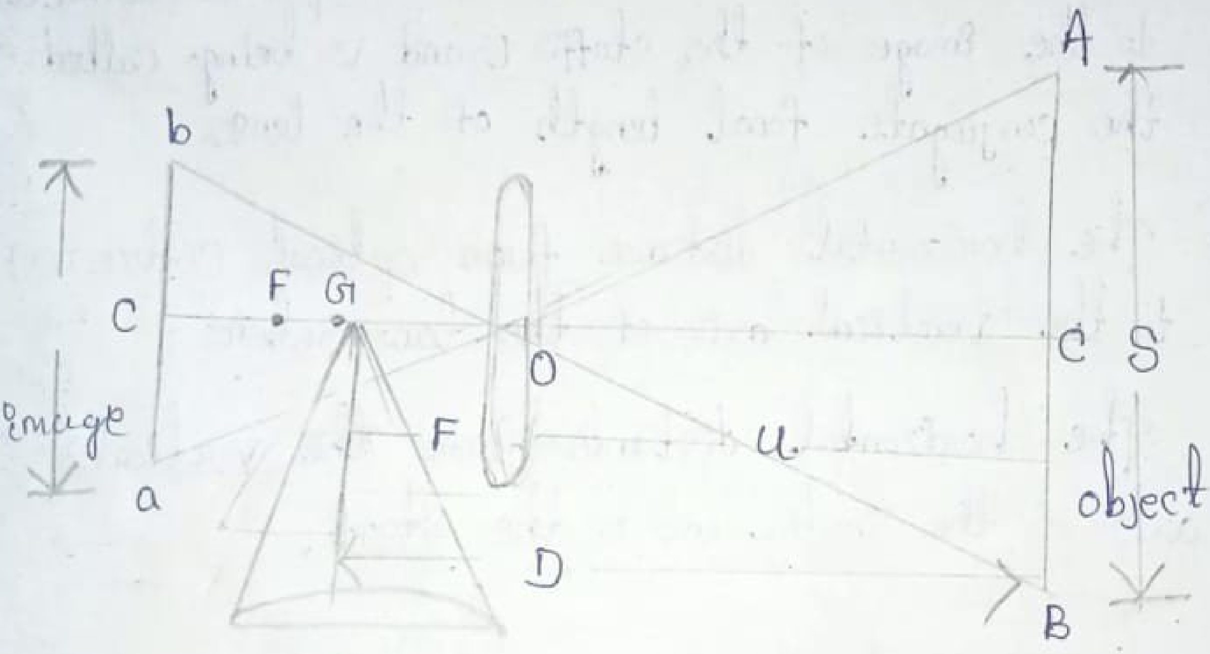
# TACHEOMETRY

Dt- 10.02.25

## Tacheometry :-

- It is a branch of Surveying in which the horizontal and vertical distance are determined by angular observations with tacheometer.




O = The optical centre of the object-glass

a, b and C = The bottom, top and central hairs at diaphragm

A, B and C = The points on the staff cut by the three lines

ab = i the interval between stadia lines

(ab is the length of the image of AB)

When degree of the curve D is given

$$\delta_1 = \frac{Dl_1}{60} \text{ degree}$$

$$\delta_2 = \frac{Dl_2}{60} \text{ degree}$$

$$\delta_n = \frac{Dl_n}{60}$$

$$x = \frac{T_1P_1}{2R}$$

$$\therefore O_1 = T_1P_1 \times \frac{T_1P_1}{2R}$$

$$O_1 = \frac{T_1P_1^2}{2R} = \frac{b_1^2}{2R}$$

$$O_2 = C_1P_2 = \frac{b_1b_2 + b_2^2}{2R}$$

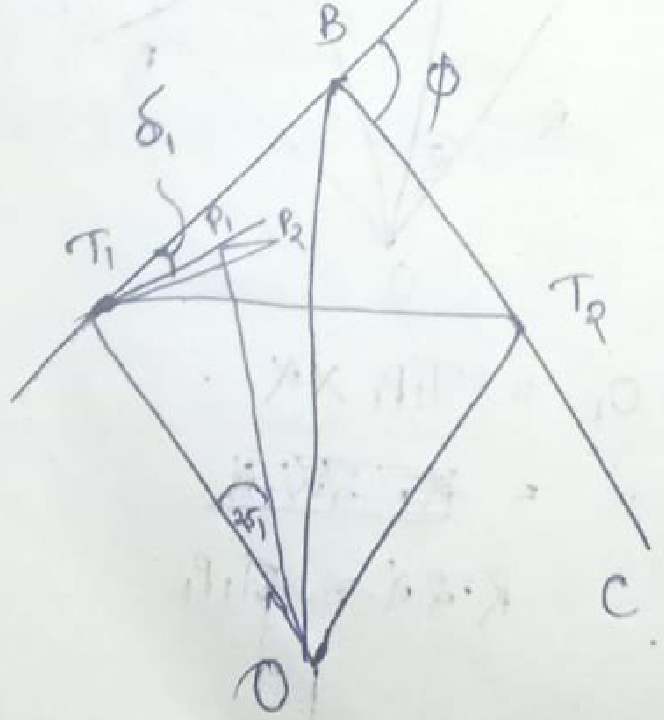
similarly $O_3 = \frac{b^3}{R}$

$$O_4 = \frac{b^4}{R} \quad (\text{as } b_2 = b_3 = b_4)$$

$$O_n = \frac{b_n\,(b_{n-1} + b_n)}{2R}$$

Deflection angle method or Rankine's method:-

AB and BC are two tangents at $T_1$ and $T_2$



Let $\angle BT_1P_1 = \delta_1$ and $\angle T_1OP_1 = 2\delta_1$

$$\frac{\angle T_1OP_1}{T_1P_1} = \frac{360}{2\pi R}$$

$$\Rightarrow \frac{2\delta_1}{l_1} = \frac{360}{2\pi R}$$

$$\Rightarrow \delta_1 = \frac{360}{2\pi R} \times \frac{l_1}{2} \text{ (degree)}$$

$$\Rightarrow \frac{360 \times 60 \times l}{4\pi R} \text{ (Minute)}$$

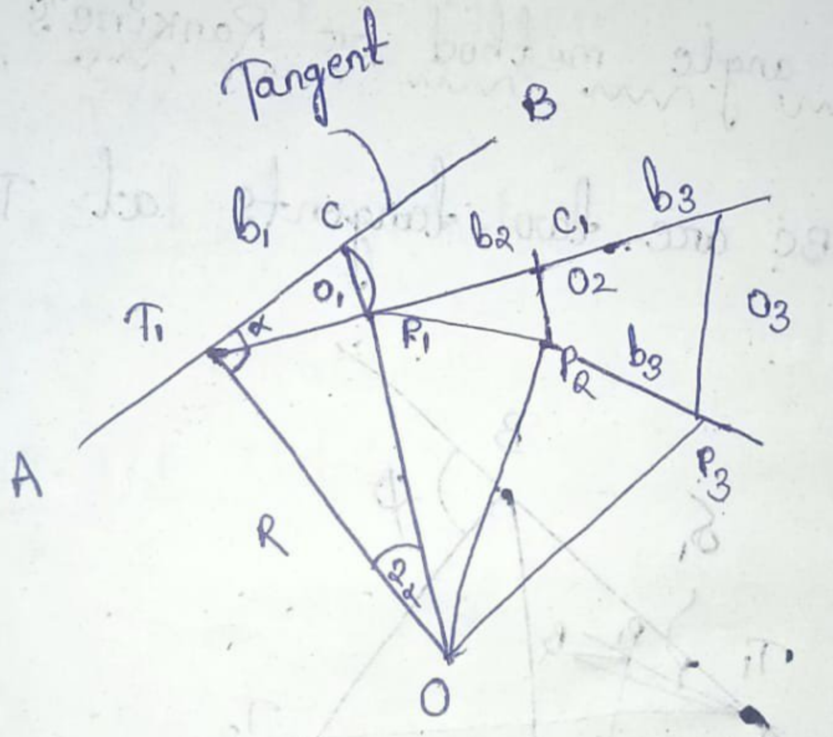
$$= \frac{1718.9 l_1}{R} \text{ (min)}$$

Similarly :- $\delta_2 = \dfrac{1718.9 l_2}{R}$

$$\delta_3 = \frac{1718.9 l_3}{R}$$

Date - 07.03.25

## offset from chord produced method :-




chord $CP_1 = O_1 = T_1P_1 \times \alpha$

$= \cancel{R \cdot / 2\alpha / \cdot \alpha}$

$R \cdot 2\alpha = T_1P_1$

In $\Delta$ $OEP_x$

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

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

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

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

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

- The distance Ox is set out along the perpendicular ~~and~~ at D and line point $P_x$ is marked.
- The process is repeated by chainging the value of x.

Q.

(1) what is tacheometry ? (2 mark)

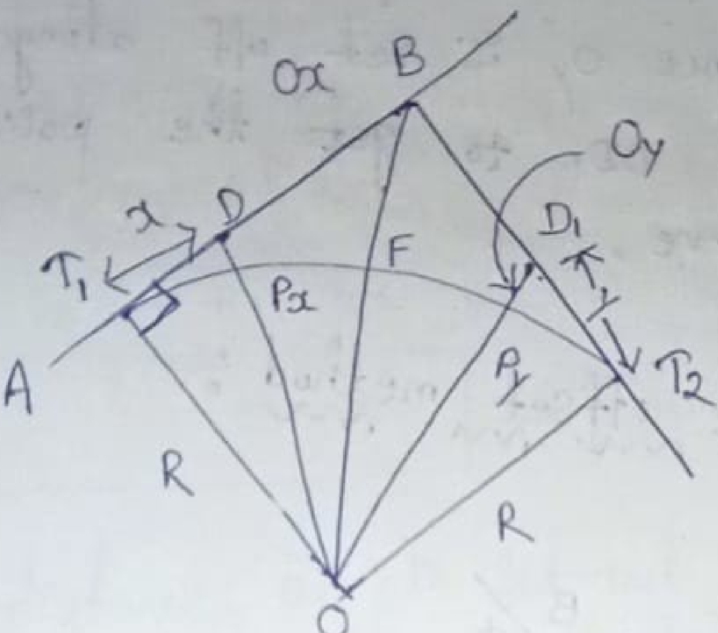
(2) what is are multiplaying constant and editing constant?

(3) what is degree of curve ?

(4) what is compount curve ?

(5) what is transition curve ?

(ii) Radial offset :-




1. Take a point D on AB such that

$T_1D = x$

ox is the radial offset at D.

In $\Delta$ $T_1OD$ $OT_1^2 + T_1D^2 = OD^2$

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

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

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

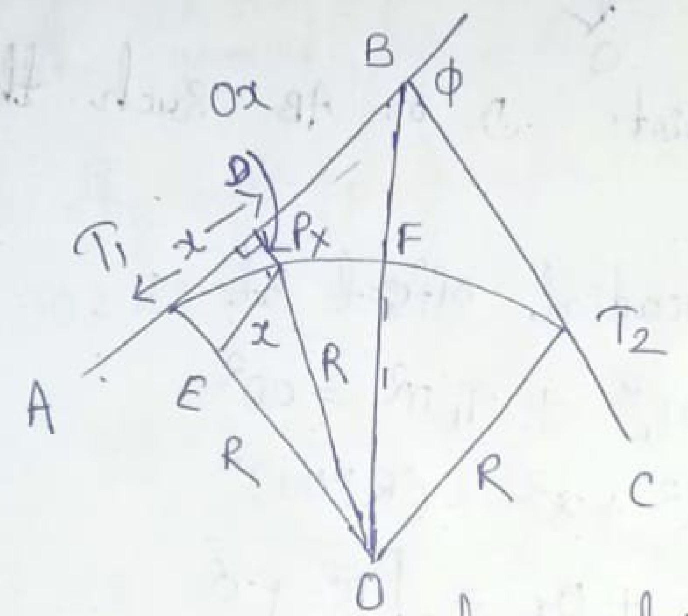
2. The calculated distance ox is cut off from the radial line OD to get the first point of the curve.

3. By increasing the value of x a number of offset are obtained.

4. Similarly $O_y = \sqrt{(R^2 - y^2)} - R$

5. The distance $O_y$ is set off along the radial line $OD_1$ to get the point $P_y$ on the curve.

## Perpendicular offset method :-




1. A point D is taken along AB at a distance $x$ from $T_1$.

$Ox$ be the perpendicular offset at D

2. $EP_x \parallel T_1D$

$OE = R - Ox$

$OP_x = R$

$EP_x = x$

1. $T_1 T_2$ is the long chord.

Tangent length $= R \tan \frac{\phi}{2}$ is calculated

Q. Describe the Successive bisection of areas method? (Imp 6 Mark)

2. Tangent point $T_1$ and $T_2$ are marked on ~~all~~ the ground by pegs.

3. D is the mid point of $T_1 T_2$ chord

$DD_1 = R(1 - \cos \frac{\phi}{2})$ is cut off

4. $T_1 D_1$ ~~and~~ $T_2 D_1 = R \tan \frac{\phi}{4}$ is measured

5. $CC_1 = EE_1 = R(1 - \cos \frac{\phi}{4})$ are cut off

6. The process in continued and free hand curve is drawn.

Date - 03.03.25

offset from tangenth:-

1. Radial offset

2. Perpendicular offset

or

$100 - \sqrt{100^2 - 25.88^2}$

$= 3.41m$

The offset one taken in every 5m from the mid point the chord.

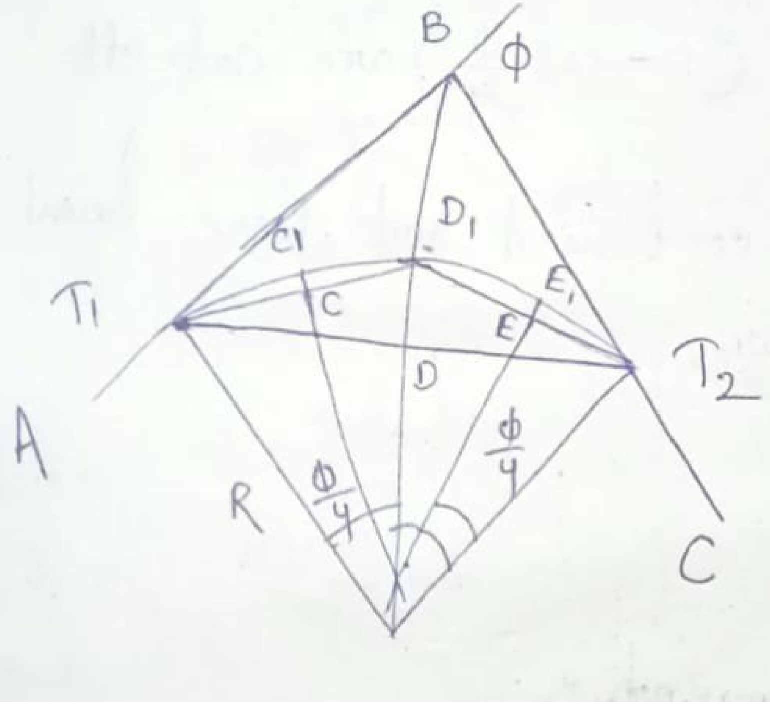
$O_x = \sqrt{R^2 - x^2} - (R - O_o)$

$O_5 = \sqrt{(100^2 - 5^2)} - (100 - 3.41) = 3.28m$

$O_{10} = \sqrt{100^2 - 10^2} - (100 - 3.41) = 2.91m$

$O_{15} = \sqrt{100^2 - 15^2} - (100 - 3.41) = 2.28m$

Successive bisection of arcs :-



$$\Rightarrow R - O_0 + O_x = \sqrt{R^2 - x^2}$$

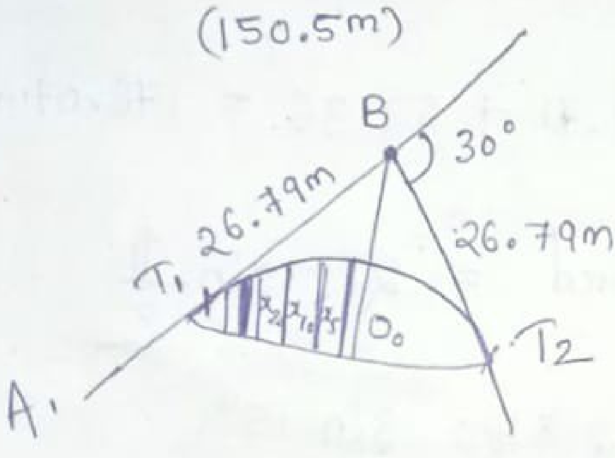
$$\boxed{O_x = \sqrt{R^2 - x^2} - (R - O_0)}$$

- Mid-ordinate

$$O_0 = R - \sqrt{R^2 - \left(\frac{L}{2}\right)^2}$$

Date- 27. 02. 25

Q. Two tangents AB and BC intersect at a point B at chainage 150.5m Radius of curve is 100m and deflection angle 30°. Calculate the ordinate by offsets method from long chord.




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

$$= 100 + \tan\left(\frac{30}{2}\right)$$

$$= 100 \times \tan 15^\circ$$

$$= 26.79m$$

- Chainage of $T_1$

$= 150.5 - 26.79$

$= 123.71\text{m}$

~~Chainage of $R_2$~~

$= \cancel{150.5 + 26.79}$

$= \cancel{176.79\text{m}}\ \cancel{176.29}$

- Curve length :-

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

$= 52.36\text{m}$

- chainage of $T_2 = 123.71 + 52.36 = 176.07\text{m}$

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

$L = 2 \times 100 \sin 15^\circ$

$= 51.76\text{ m}$

Mid - ordinate $O_0 = R - \sqrt{R^2 - \left(\frac{L}{2}\right)^2}$

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

$= 3.41\text{m}$

chainage of intersection point (B) - Tangent length ($BT_1$)

9. chainage of 2nd tangent point ($T_2$)
 = chainage of 1st tangent point ($T_1$)
 + curve length ($T_1 E T_2$)

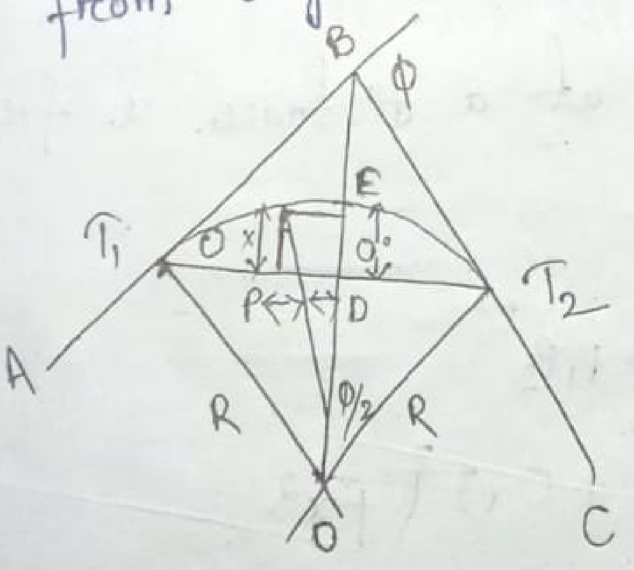
Date - 25. 02. 25

Horizontal curve tracing :-

There are 4 methods of curve tracing

1. Taking offsets from long chord.
2. Taking offsets from the chord produced.
3. Successively bisecting the arcs
4. Taking offset from the tangents.

Offset from long chord method :-



1. AB and BC are two tangent

$$AB = BC = R \tan(\phi/2)$$

2. Mark $T_1$ and $T_2$ on the ground.

3. Tangent length $T_1 E T_2 = \frac{\pi R \phi^\circ}{180}$ m

4. Length of Loup chord $T_1 T_2 = 2R \sin\left(\frac{\phi}{2}\right)$

5. $DE = R\left(1 - \cos\frac{\phi}{2}\right)$

$$OD = R - O_0$$

6. $OT_1^2 = OD^2 + T_1 D^2 = (R - O_0)^2 + \left(\frac{L}{2}\right)^2$

$$\Rightarrow R^2 = (R - O_0)^2 + \left(\frac{L}{2}\right)^2$$

$$\Rightarrow (R - O_0)^2 = R^2 - \left(\frac{L}{2}\right)^2$$

$$\Rightarrow R - O_0 = \sqrt{R^2 - \left(\frac{L}{2}\right)^2}$$

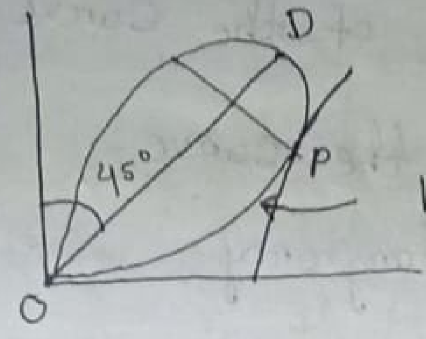
$$\phi_0 = R - \sqrt{R^2 - \left(\frac{L}{2}\right)^2}$$

Take at point p at a distance x from D.

In $\Delta\, O P_1 P_2$

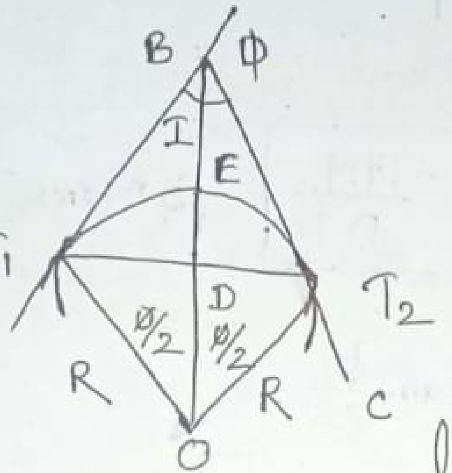
$$OP_1^2 = OP_2^2 + P_1P_2^2$$

$$\Rightarrow R^2 = (R - O_0 + O_x)^2 + x^2$$




lemniscate curve

## Properties of simple circular Curve :-




1. AB and BC are tangents.
2. B = point of intersection.
3. $\phi$ = angle of deflection
4. I = angle of intersection
5. $T_1$ & $T_2$ are tangent point
6. $BT_1$, $BT_2$ are tangent lengths
7. $T_1 D T_2$ – long chord.
8. $T_1 E T_2$ Length of Curve
9. E = Apex

10. BE = Apex distance

11. DE = Versed sine of the Curve

12. $T_1$ = point of the curve

13. $T_2$ - point of tangency

(1) $\boxed{\phi + I = 180}$

(2) $\boxed{R = \frac{1719}{D}}$ - formula

$\boxed{\text{for } 1^\circ \text{ Curve} = R = \frac{1719}{D}}$ - (2 Mark)

3.

(3) $BT_1 = BT_2 = R \tan\frac{\phi}{2}$

(4) Length of the curve $T_1ET_2 = \frac{\pi R \phi^\circ}{180}$ m

or $T_1ET_2 = \frac{30\phi}{D}$

(5) length of the chord $T_1T_2 = 2R \sin\frac{\phi}{2}$

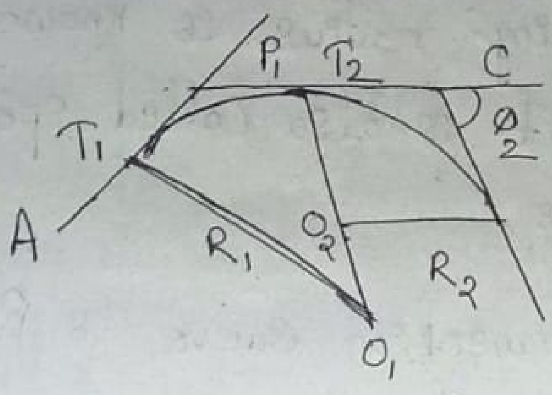
(6) Apex distance - $BE = R\left(\sec\frac{\phi}{2} - 1\right)$

(7) $\phi$ - Versed sine of the curve $= R\left(1 - \cos\frac{\phi}{2}\right)$

(8) ~~chaua~~ chainage 1st tangent point ($T_1$)

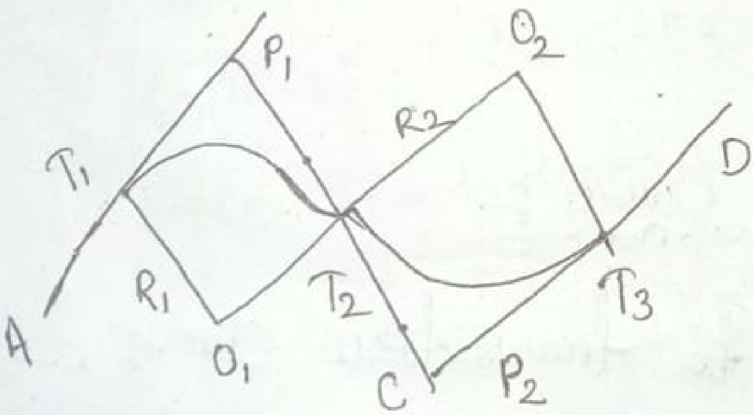
9.

2. Compond Curve :-




when a curve consists of two or more arcs with different radial it is called compond curve. The curves lie on the same side of common tangent

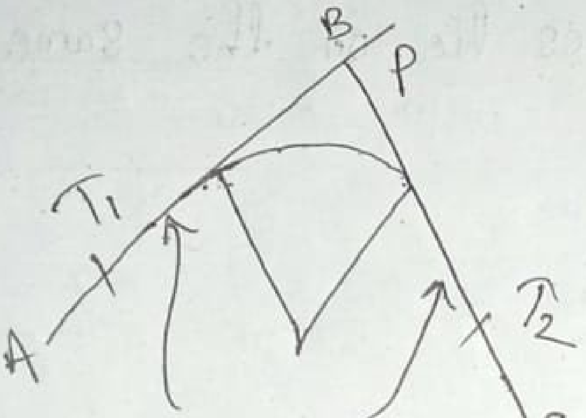
3. Reverse Curve :-




It consists of two arcs bending in opposite directions their centre lie in opposite sides of the curve.

4. Transition curve :-

- A curve of varying radius is known as transition curve. it is also called spiral curve or easement curve.
- In railways a transition curve is provided to minimise superelevation.




Transition curve

5. Lemniscate Curve :-

- it is similar to transition curve.
- it is adopted in city roads where the deflection angle is large.

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

$$\frac{f}{i} = 100 \qquad \Rightarrow 100 \times \frac{1.2 \sin(9^\circ)}{2} + 0$$

$$f+d = 0 \qquad \Rightarrow 9.386 m$$

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

$$= 100 \times 1.2 \times \cos^2 4.5^\circ$$

$$= 119.26 m$$

$$\left( 1^\circ = \frac{\pi}{180^\circ} \right)$$

$$V_2 = 100 \times 1.5$$

$$\tan\theta = \frac{V_1}{D_1}$$

$$\tan 45^\circ = \frac{9.386}{D_1}$$

$$D_1 = \frac{9.386}{\tan 45^\circ}$$

## Curves :-

- Curves mainly two types -

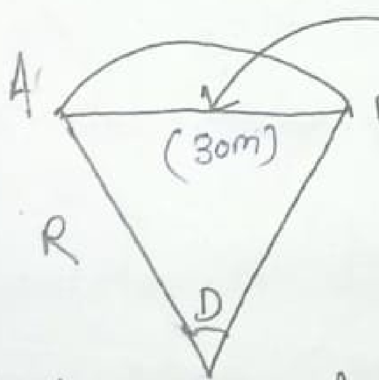
(i) Vertical Curve

(ii) Horizontal Curve

what are the different types of horizontal Curves ?

Horizontal curve —
- Simple Curve
- compound Curve
- Reverse Curve
- Transition Curve
- Lemniscate Curve

## Degree of a Curves :-

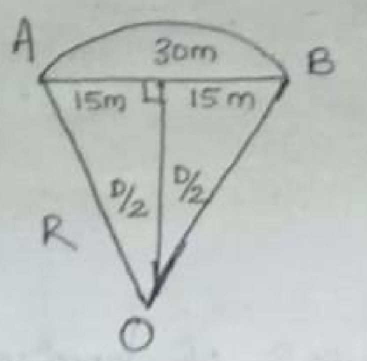



Unit chord (30m)

when a chord of length 30m Subtends and angle $D^{\circ}$ at the contre. it is called $D^{\circ}$ Curve.

Imp

## Relation between radius and degree of curve :-




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

$$R = \frac{15}{\sin D/2} = \frac{15}{\frac{D}{2}\times\frac{\pi}{8}}$$

$$= \frac{5400}{\pi D} = \frac{1719}{D}$$

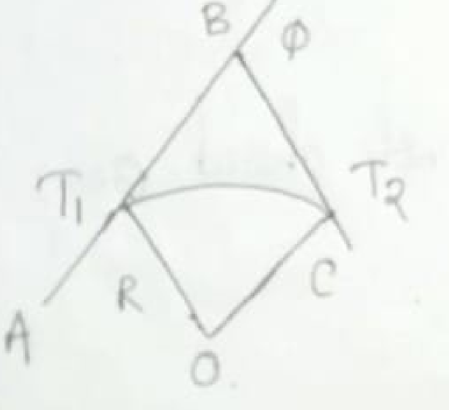
$$\therefore R = \frac{1719}{D}$$

$\boxed{\text{for } 1^\circ \text{ curve } \quad R = 1719\text{m}}$

Imp

## Types of horizontal curve :-

### 1. Simple circular curve :-




When a curve consist of a single arc with a constant radius connecting two tangents it called a simple circular curve.

Q.

| Inst stn | staff stn | Vertical angle | Hair reading (m) | Remark |
|---|---|---|---|---|
| C | BM (750.50) | $-5°20'$ | 1.150, 1.800, 2450 | 750.50m |
| C | D | $+8°12'$ | 0.750, 1.500, 2.250 | |

Calculate CD and RL of D

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

$f+d = 0.15$

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

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

$$\text{RL of } P = \text{RL of axis} + V - h$$

$$V = D\tan\theta$$

$$V_1 = 100(2.450 - 1.150)\frac{\sin 10°40'}{2} + 0.15\sin 5°20'$$

$$= 12.045m$$

$$V_2 = 100(2.250 - 0.750)\frac{\sin 16°24'}{2} + 0.15\sin 8°12'$$

$$= 21.197m \simeq 21.20m$$

RL of axis $= \text{RL of MB} + h_1 + V_1$

$$= 750.50 + 1.800 + 12.045$$

$$= 764.345m$$

RL of axis $+V_2 - h_2$

$= 764.345 + 21197 - 1.500$

$= 784.042m$

So $\left( D_2 = 100 \times 1.5 \cos^2 8^\circ 12' + 0.15 \times \cos 8^\circ 12' = 147.097 \right.$

~~$D_2 = 147.097$~~

RL of $D = 784.042m$

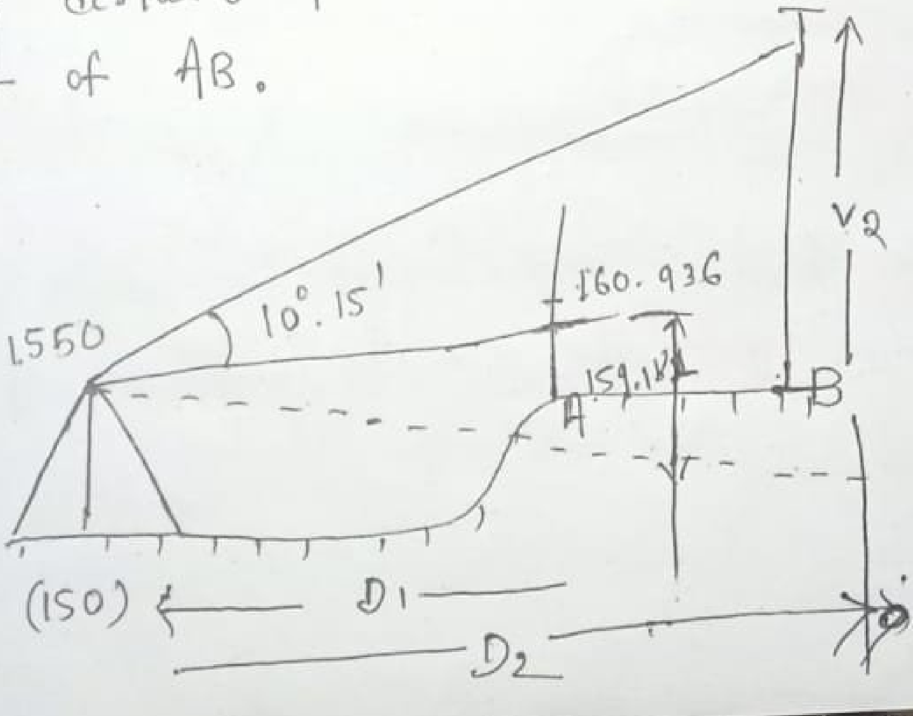
$CD = 147.097m$

Date - 18.02.25

Q. ~~Inst~~

| Inst stn | HI | Staff stn | WCB | Vertical angle | Hair reading | Remark |
|---|---|---|---|---|---|---|
| O | 1.550 | A | $30^\circ 30'$ | $4^\circ 30'$ | 1.155, 1.755, 2.355 | RL of O 150 m. |
| | | B | $75^\circ 30'$ | $10^\circ 15'$ | 1.250, 2000, 2.750 | |

calculate distance AB. and RLS of A and B and gradient of AB.




9

9.386 m

151.550

160.936

-1.755

159.181

Q) Find the tacheometry Constant? (10 mark)

| Station | Staff reading | Distance cm | Stadia lower | Reading upper |
|---|---|---|---|---|
| | A | 150 | 1.255 | 2.750 |
| O | B | 200 | 1.000 | 3.000 |
| | C | 250 | 0.750 | 3.255 |

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

We known

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

let $f+d = x$

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

$\therefore D = x+y$

$150 = x+y\ (2.750 - 1.255)$

$150 = x + 1.495y$ ------ (i)

$200 = x+y\ (3-1)$

$200 = x+2y$ —— (2i)

$250 = x+y\ (3.255 - 0.750)$

$250 = x+2\ 2.505y$ ——— (3)

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

$$D = xs + y$$

$$180 = 1.275x + y$$

$$250 = 2.050x + y$$

$$70 = 0.775x$$

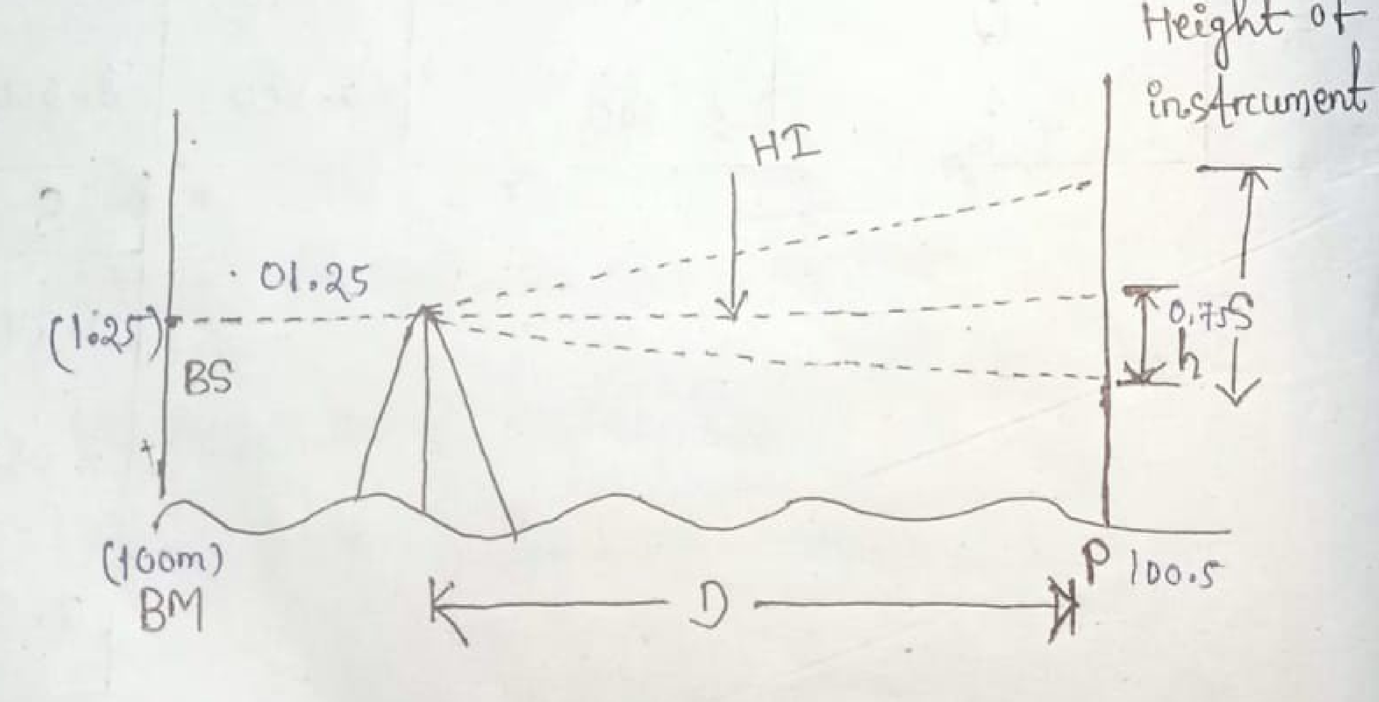
$$x = \frac{70}{0.775} = 90.3$$

$$Y = 180 - 1.275 \times 90.3$$

$$= 64.86$$

## Fixed hair method :-

Case-1 Line of sight is horizontal and staff is held vertically.



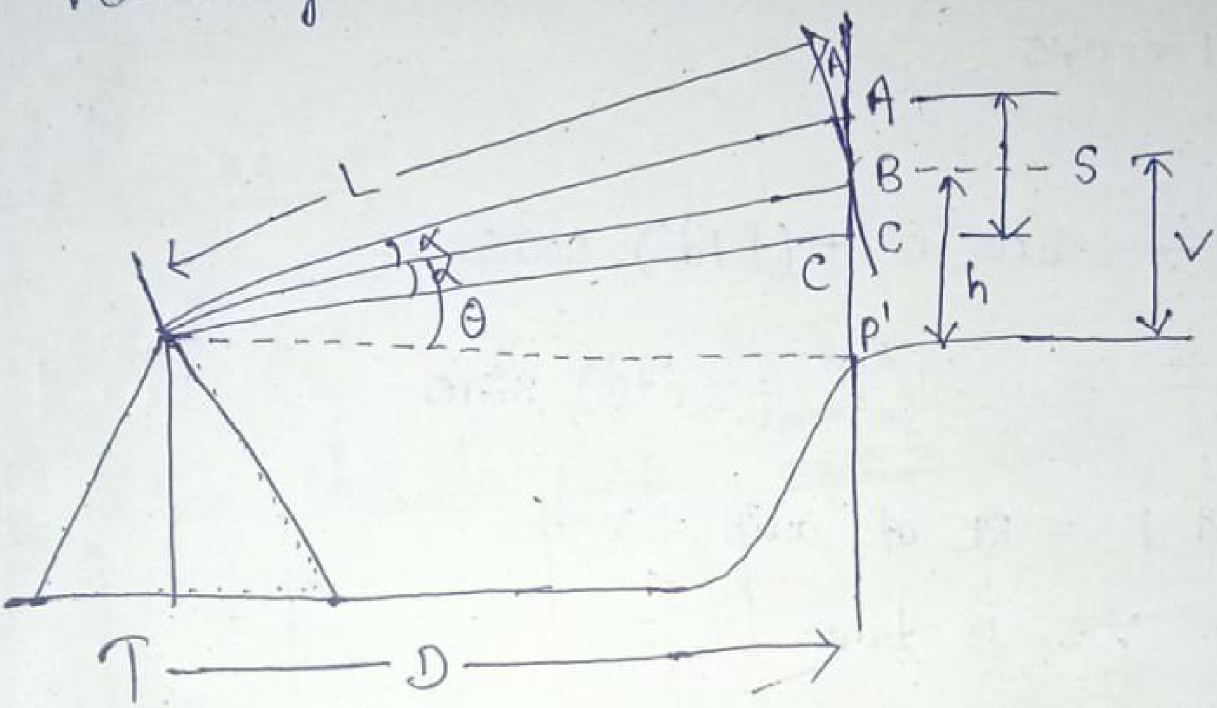
$HI = RL$ of $BM + BS$

$h$ = central hair reading

$RL$ = of staff station $P$

$= HI - h$

Case - 2 Line of sight is inclu. staff is vertically held.




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

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

RL of P = RL of Axis $+ V - h$

$V = D \tan\theta$

AB = S = The staff intercept (the difference of the stadia hair readings)

f = The focal length of object - glass i.e the distance between the optical centre (O) to the principal focus of the lens.

U = The horizontal distance from the optical centre (O) to the staff.

V = The horizontal distance from the optical centre (O) to the image of the staff U and V being called the conjugate focal length of the lens.

d = The horizontal distance form optical centre (O) to the vertical axis of the tacheometer

D = The horizontal distance from the vertical axis of the instrument to the staff.

$\Delta\, a_1 O a_2 \sim \Delta\, A_1 O A_2$

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

$\therefore v = \frac{iu}{s}$

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

$$\Rightarrow \frac{1}{2u/s} + \frac{1}{u} = \frac{1}{f}$$

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

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

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

we known $D = u+d$

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

$$= f + \frac{fs}{i} + d$$

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

$\frac{f}{i}$ and $(f+d)$ are tacheometric constant

$\frac{f}{i}$ is called multiplying

$(f+d)$ is called additive constant

$\frac{f}{i}$ in taken 100 and $f+d$ is taken 0