# SURVEY

A1

## # Curve:

What is curve:

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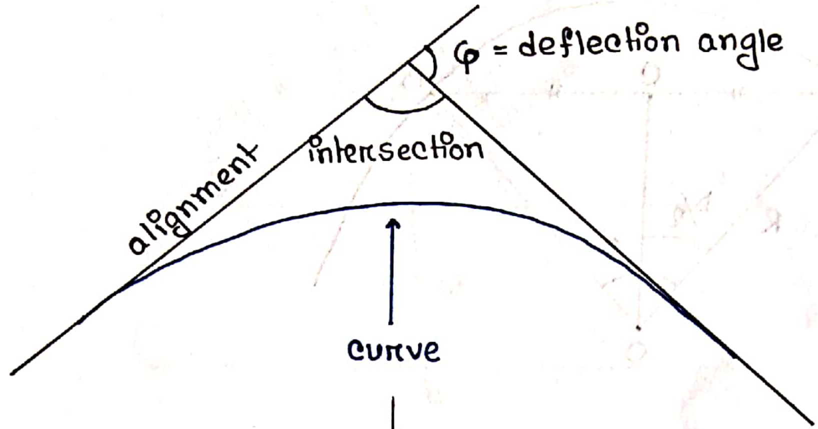
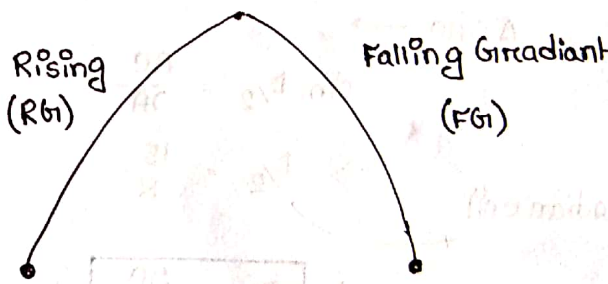
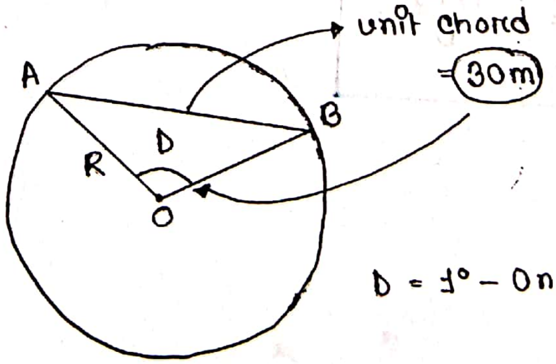



Curve
- horizontal
  - simple
  - compound
  - reverse
  - Transition
  - lemmiscate
- vertical




## # Different terms in curve:

### ① Degree of curve:




D = 1° – One degree curve

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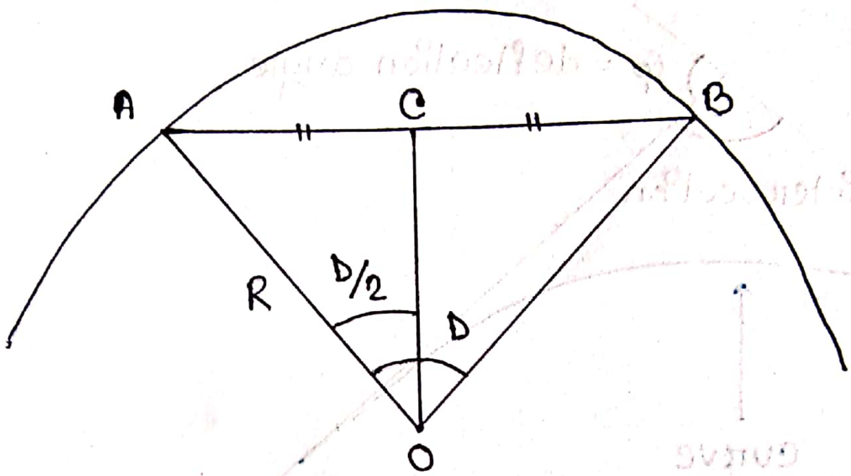
# Relation between Radious and degree of curve:




AB = 30 m

AC = BC = 15 m

$\angle AOC = D/2$

$\Delta OAC \longrightarrow$

$$\sin D/2 = \frac{AC}{OA}$$

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

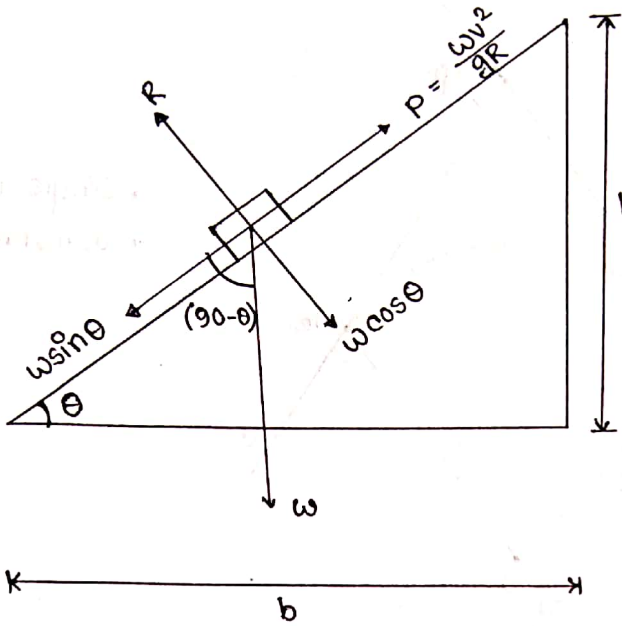
radian unit

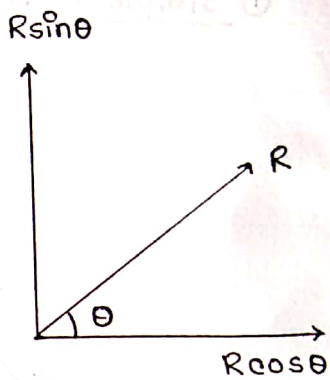
$$\Rightarrow \boxed{R = \frac{30}{D}}$$

$$\boxed{R = \frac{15}{D/2 \times \frac{\pi}{180}} = \frac{1719}{D}}$$

কেন্দ্রবিমুখী — centrefugel force
কেন্দ্রমুখী — centripetal force

# Super elevation:




h= superelevation

$$\omega \sin\theta = \frac{\omega v^2}{gR}$$

$$\Rightarrow \omega \tan\theta = \frac{\omega v^2}{gR}$$

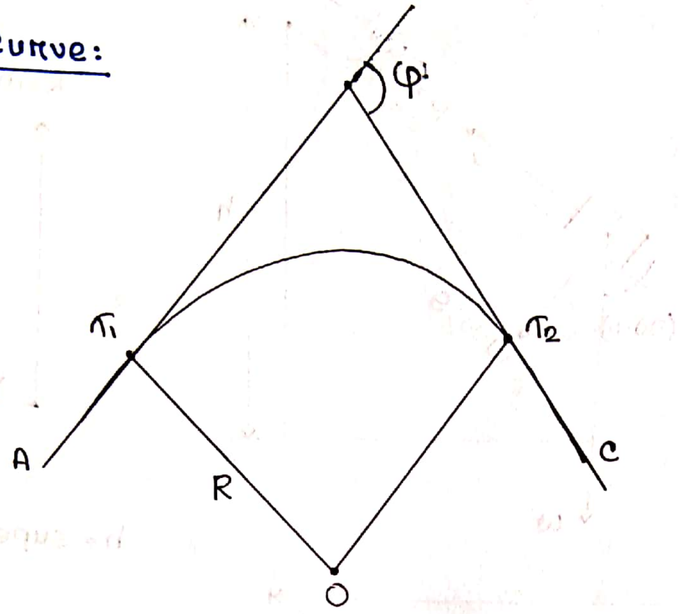
$$\Rightarrow \omega \times \frac{h}{b} = \frac{\omega v^2}{gR}$$

$$\Rightarrow \boxed{h = \frac{bv^2}{gR}}$$

R → Radious

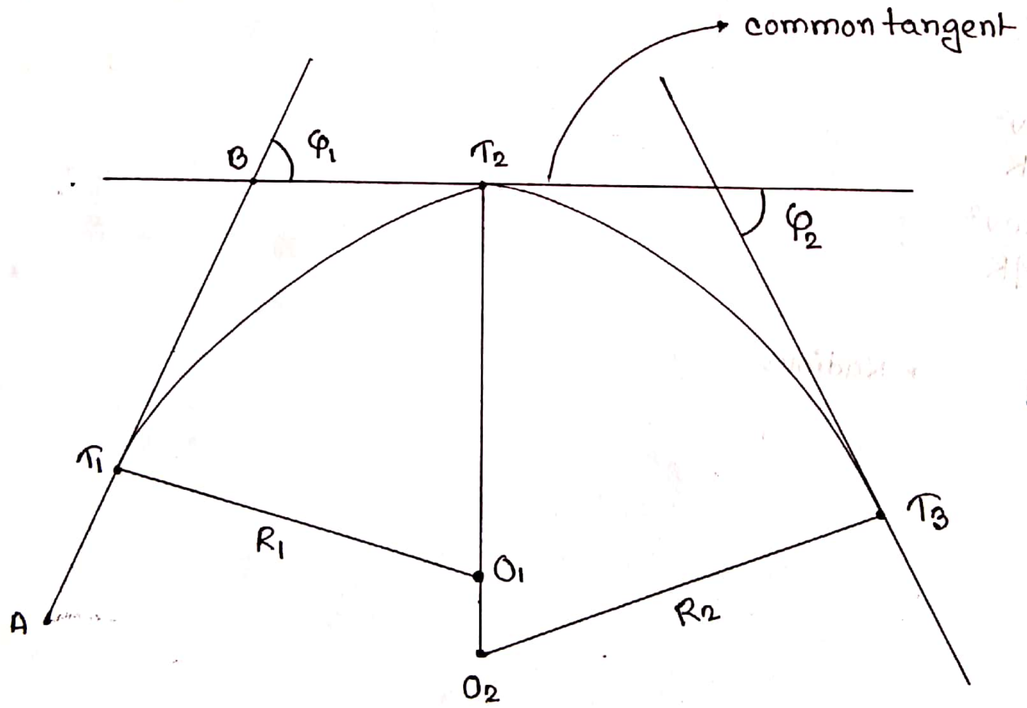
# Types of horizontal curves:

## (i) Simple Curve:



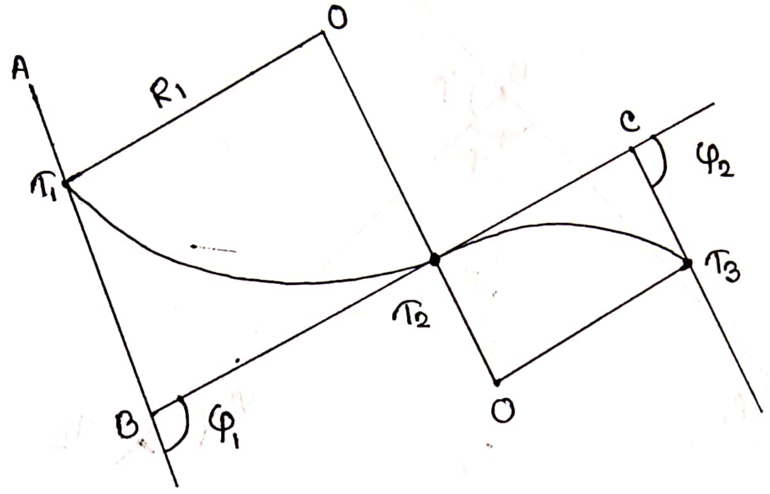

→ single arc
→ constant radious

## (ii) Compound Curve:



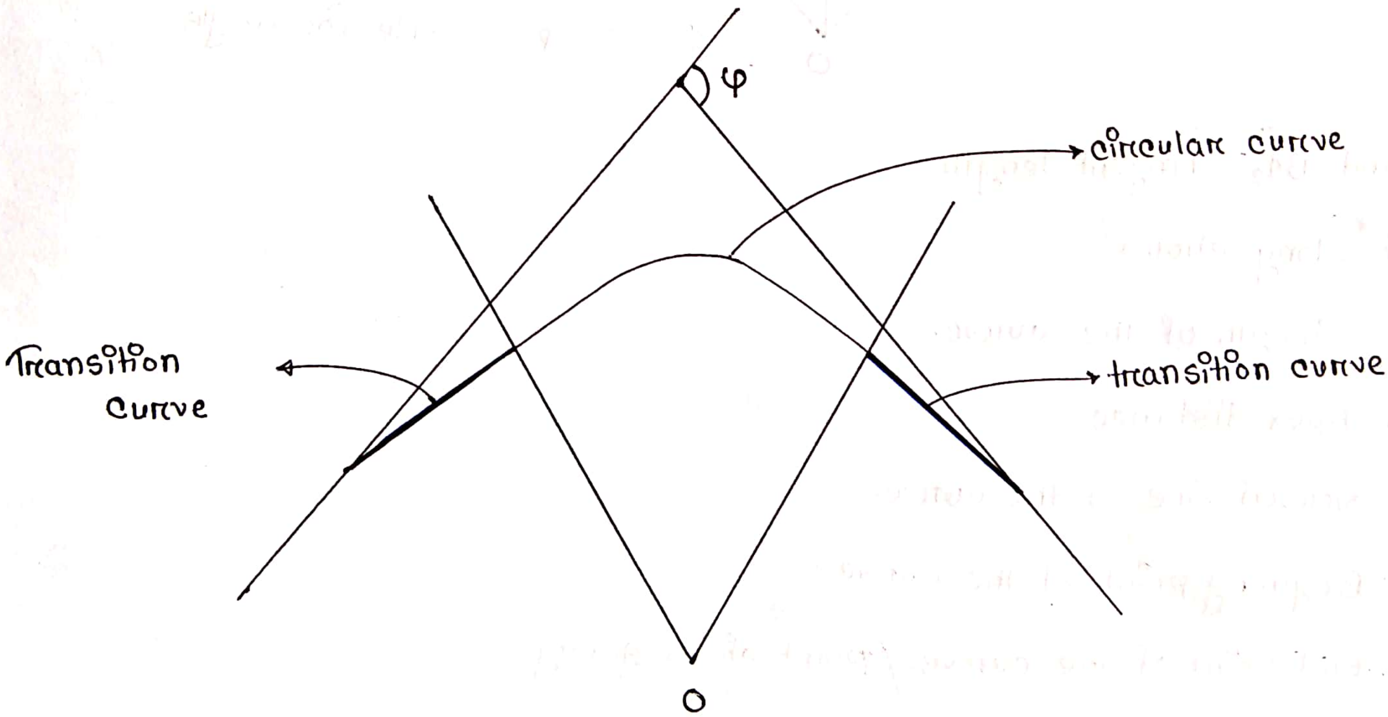

→ two or more arcs.
→ different radious.

## (III) Reverse Curve:



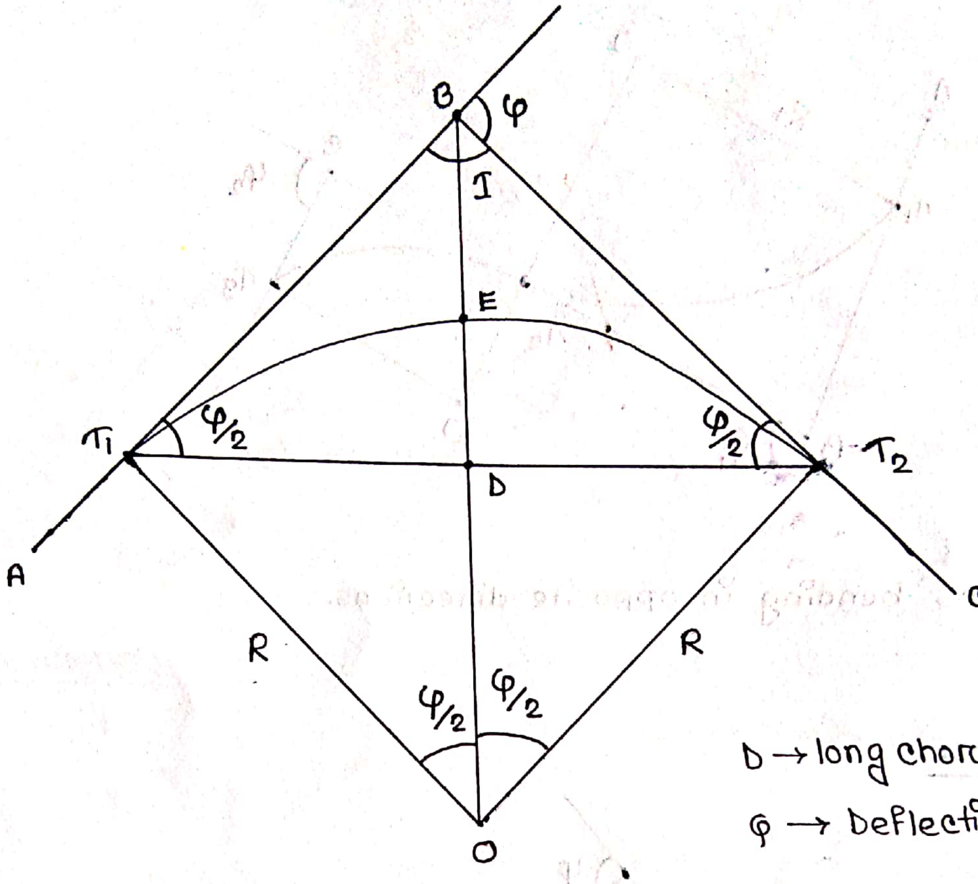

→ two arcs bending in opposite directions.

## (IV) Transition Curve:




→ varing Radious.

# Notation for circular curve:




D → long chord এর centre

$\varphi$ → Deflection angle

$BT_1$ and $BT_2$ = tangent length.

$T_1DT_2$ = long chord

$T_1ET_2$ = length of the curve.

BE = Apex distance.

DE = versed sine of the curve.

$T_1$ = Begining point of the curve.

$T_2$ = End point of the curve. / point of tangency.

## Properties of circular curve:

1. $\varphi = 180° - I$

2. Radius, $R = \dfrac{1719}{D}$ [D = Degree of curve]

3. Tangent Length, $BT_1 = BT_2 = R\tan\varphi/2$

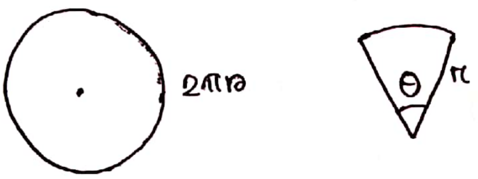
$\Delta OT_1B \Rightarrow$

$$\tan\varphi/2 = \frac{BT_1}{R}$$

$$\Rightarrow R\tan\varphi/2 = BT_1$$

4. Length of the curve $= R\varphi$ radians

$$= \frac{\pi R\varphi}{180}\ m$$




$S = r\theta$

5. Length of long chord $= 2T_1D$

$$= 2OT_1 \sin\varphi/2$$

$$= 2R\sin\varphi/2$$

6. Apex distance, $BE = OB - OE$

$$= R\sec\varphi/2 - R$$

$$= R(\sec\varphi/2 - 1)$$

7. Versed sine of curve, $DE = OE - OD$

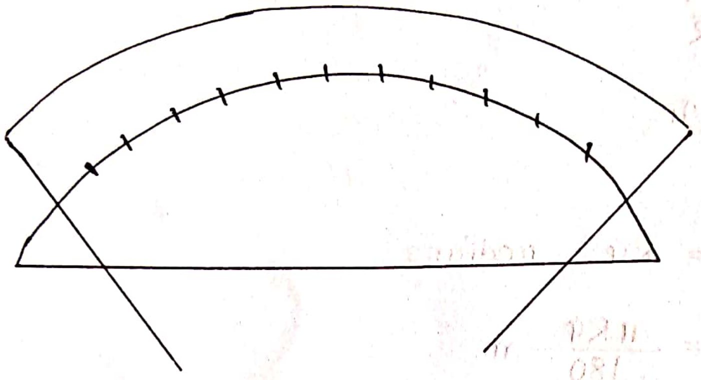
$$= R - R\cos\varphi/2$$

$$= R(1-\cos\varphi/2)$$

8. Full chord

Initial sub chord

Final sub chord



179 m

19 — Full (initial sub chord)

15 x 10 (full chord)

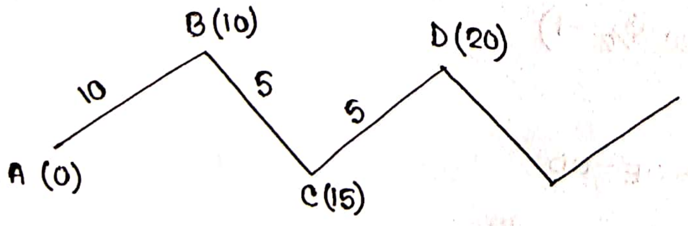
10 — Final (final sub chord)

9. Chainage of First tangent point:

chainage of intersection point — tangent point

$= AB - BT_1$

Chainage of second tangent point:

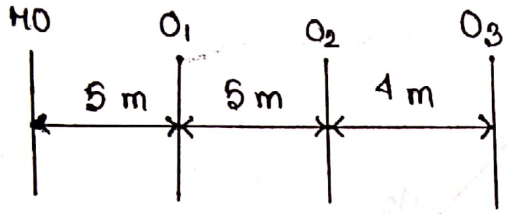


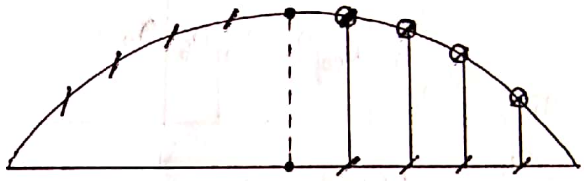

chainage of intersection point + tangent length.

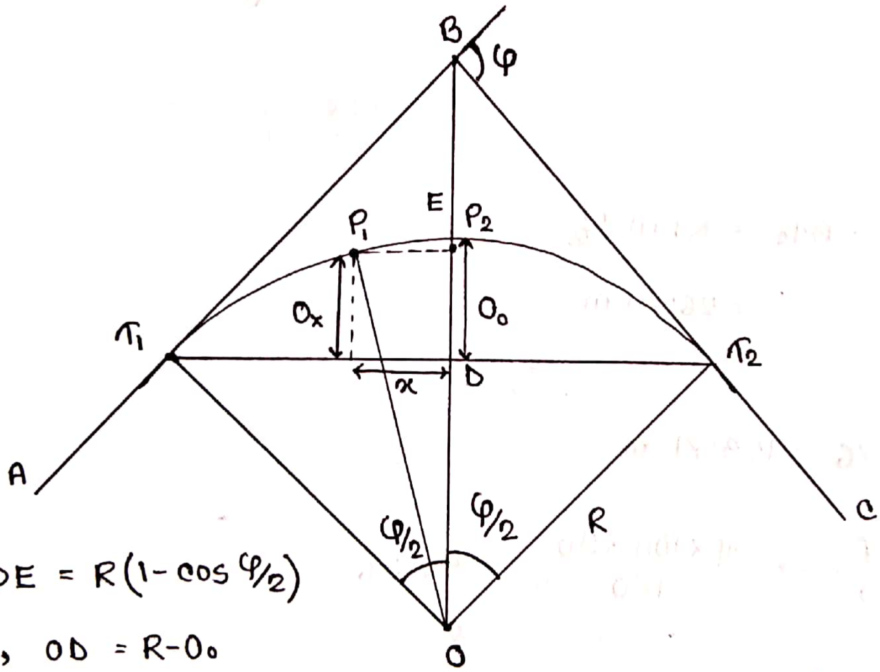
$= AB + BT_2$

# Horizontal curve setting by chain and tape method:

1. Taking offsets or ordinates from the long chord.
2. Taking offsets from the chord predeused.
3. Successively bisecting the arcs.
4. Taking offsets from the tangent.






$O_0 = DE = R(1-\cos \varphi/2)$

$OE = R$, $OD = R - O_0$

$OP_2 = (R - O_0) + O_x$

$\Delta T_1OD \Rightarrow$

$OT_1 = OD^2 + T_1D^2$

$\Rightarrow R^2 = (R-O_0)^2 + (L/2)^2$

$\Rightarrow \boxed{O_0 = R - \sqrt{R^2 - (L/2)^2}}$

$\Delta OP_1P_2 \Rightarrow$

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

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

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

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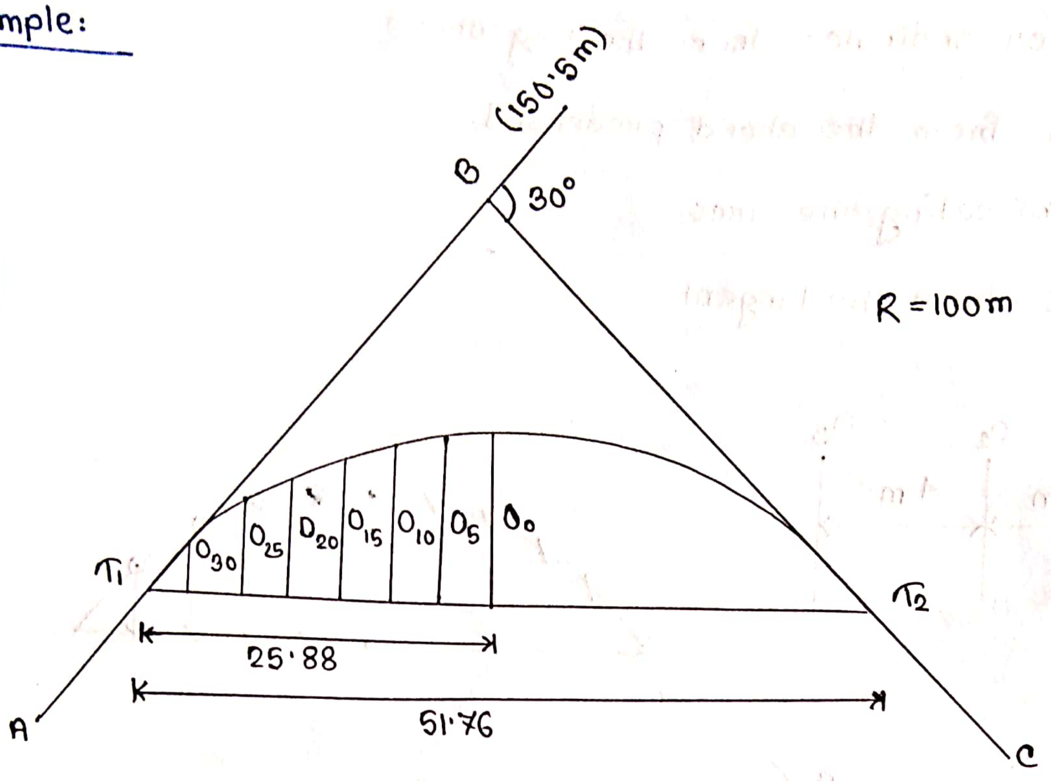
## Example:




## Sol$^n$:

① tangent length: $BT_1 = BT_2 = R\tan\phi/2$

$= 26.79$ m

② C.O.$T_1$ $= 150.5 - 26.76 = 123.71$ m

③ Curve length $= \dfrac{\pi R\phi}{180} = \dfrac{\pi \times 100 \times 30}{180} = 52.36$

④ C.O.$T_2$ $= 123.71 + 52.36 = 176.07$

⑤ Length of long chord, $L = 2R\sin\phi/2 = 51.76$ (AC)

$\therefore AD = 25.88$

$O_0 = R - \sqrt{R^2 - (L/2)^2} = 3.41$

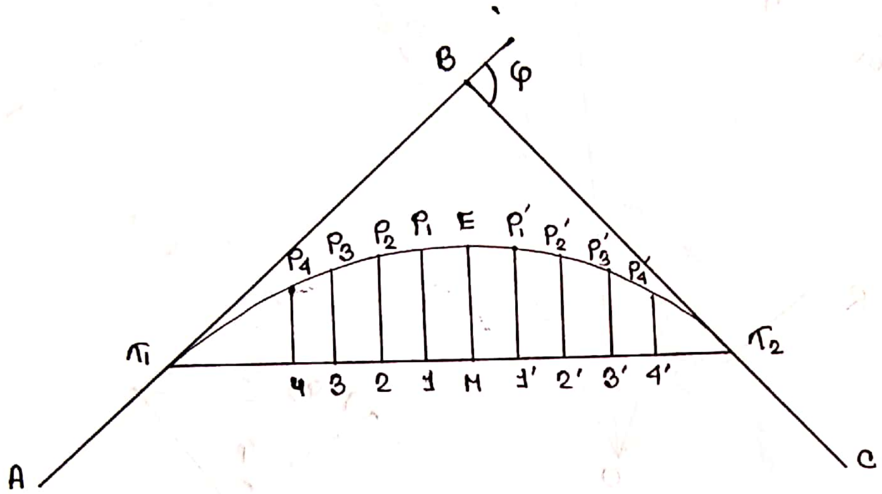
$O_5 = \sqrt{R^2 - x^2} - (R - O_0) = 3.26$

⋮ ⋮

$O_{15} = \sqrt{R^2 - x^2} - (R - O_0) = 2.18$

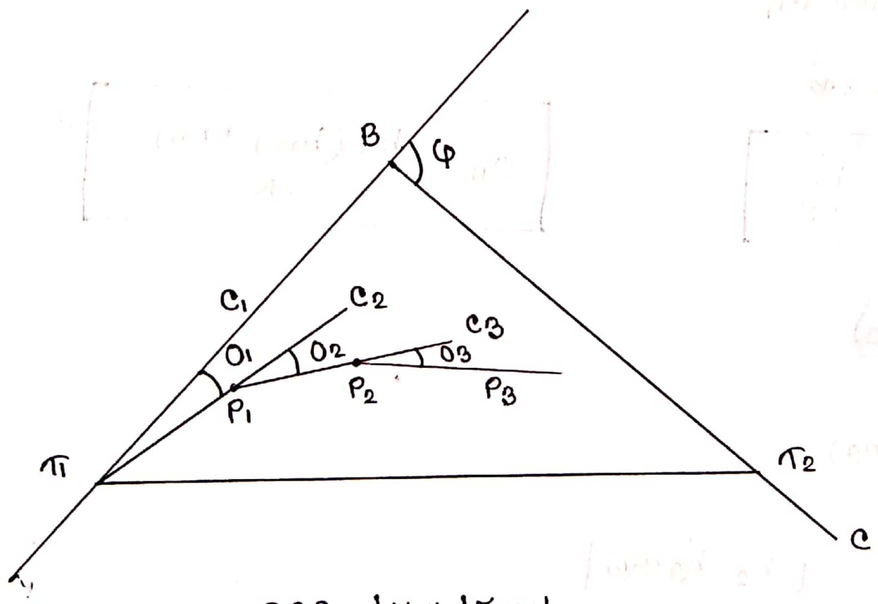
$O_{25.88} = 0$

# Field Procedure:




Peg

# offsets from chord produced:

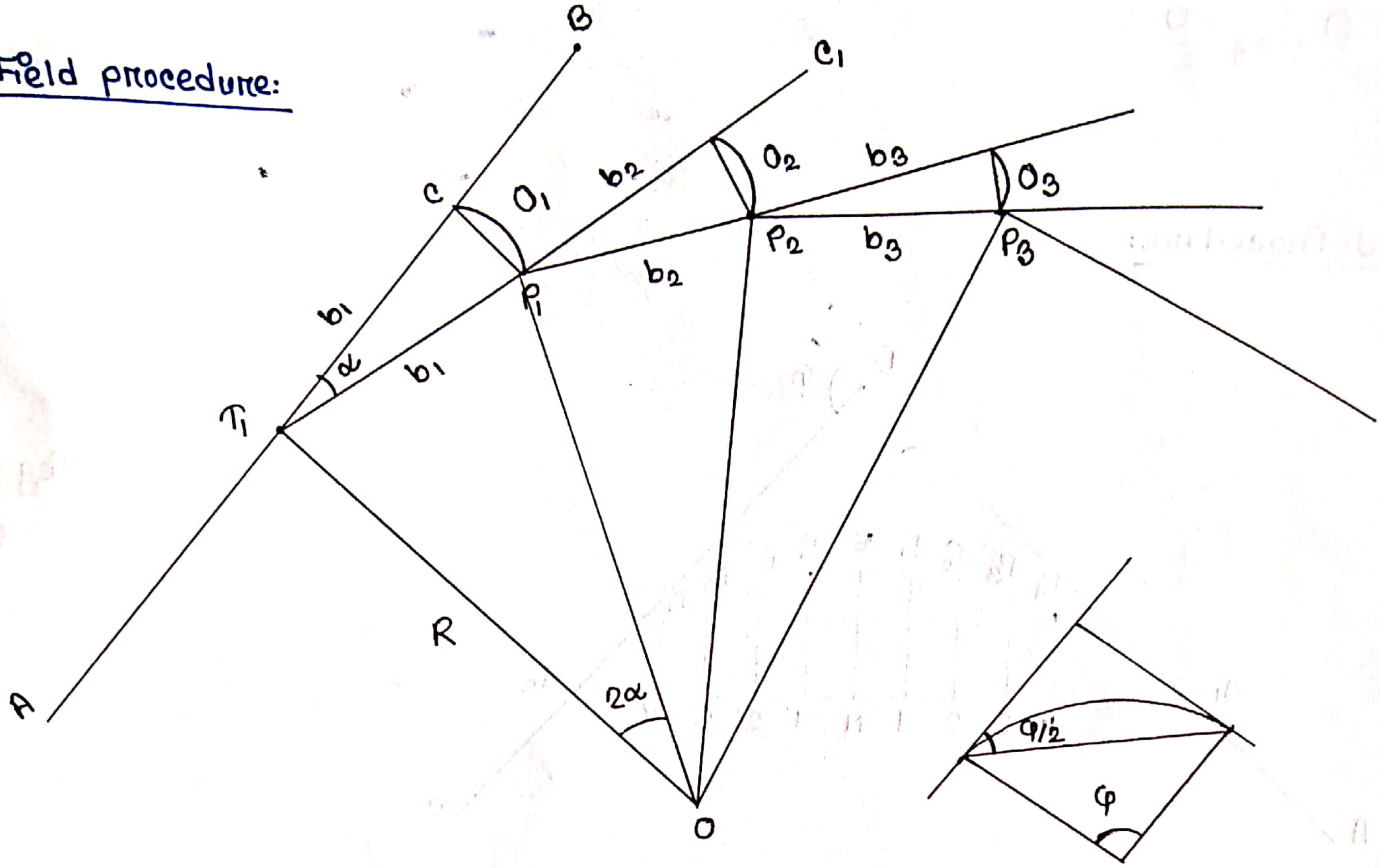



unknown → offsets length

Initial | Full | Final

o=offset

## Field procedure:




Chord $T_1P_1$ = arc $T_1P_1$ $= R \times 2\alpha$

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

chord $CP_1 \sim$ arc $CP_1$

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

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

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

$$O_2 = \frac{b_2(b_1+b_2)}{2R}$$

$$O_3 = \frac{b_3(b_2+b_3)}{2R}$$

$$= \frac{b_3 \times 2b_3}{2R} \quad [\, b_2 = b_3 \text{ হলে} \,]$$

$$= \frac{b_3^2}{2R}$$

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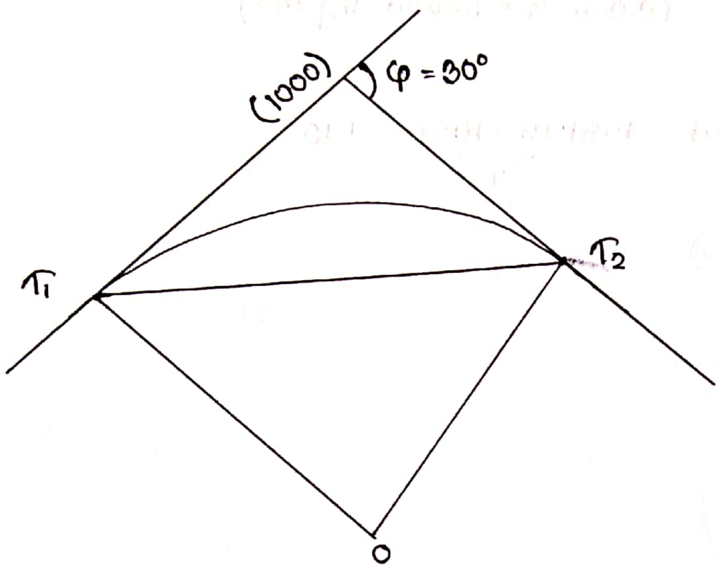
# Two tangents intersect at a chainage of ....




R = 200 m

Full chord = 20 m

→ (i) Tangent Length $= R \tan \varphi/2$

$= 200 \tan \frac{30°}{2}$

$= 53.589$ m

(ii) C.L $= \frac{\pi R \varphi}{180°}$

$= \frac{3.1416 \times 200 \times 30°}{180°}$

$= 104.72$ m

(iii) C.O. $T_1 = 946.42$

(iv) C.O. $T_2 = 1051.13$

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Number of full chord = $5 \times 20 = 100$ m

Length of initial sub-chord = $950 - 946{\cdot}42 = 3{\cdot}58$

(C.O.$T_1$ এর round figure)

Length of final sub-chord = $1051{\cdot}13 - 1050 = 1{\cdot}13$

total chord = 7 (7 offsets)

$b_1 = 3{\cdot}58$

$b_2 \rightarrow b_6 = 20$

$b_7 = 1{\cdot}13$

$$O_1 = \frac{b_1^2}{2R} = 0{\cdot}032$$

$$O_2 = b_2 (b_1 + b_2) / 2R = 1{\cdot}179 \quad [b_2 = 20]$$

$$\left.\begin{array}{l} O_3 = \dfrac{b_3^2}{R} \\ \vdots \\ O_6 = \dfrac{b_6^2}{R} \end{array}\right\} \text{chord length same} = 2$$

$$O_7 = \frac{b_n (b_{n-1} + b_n)}{2R} = 0{\cdot}06$$

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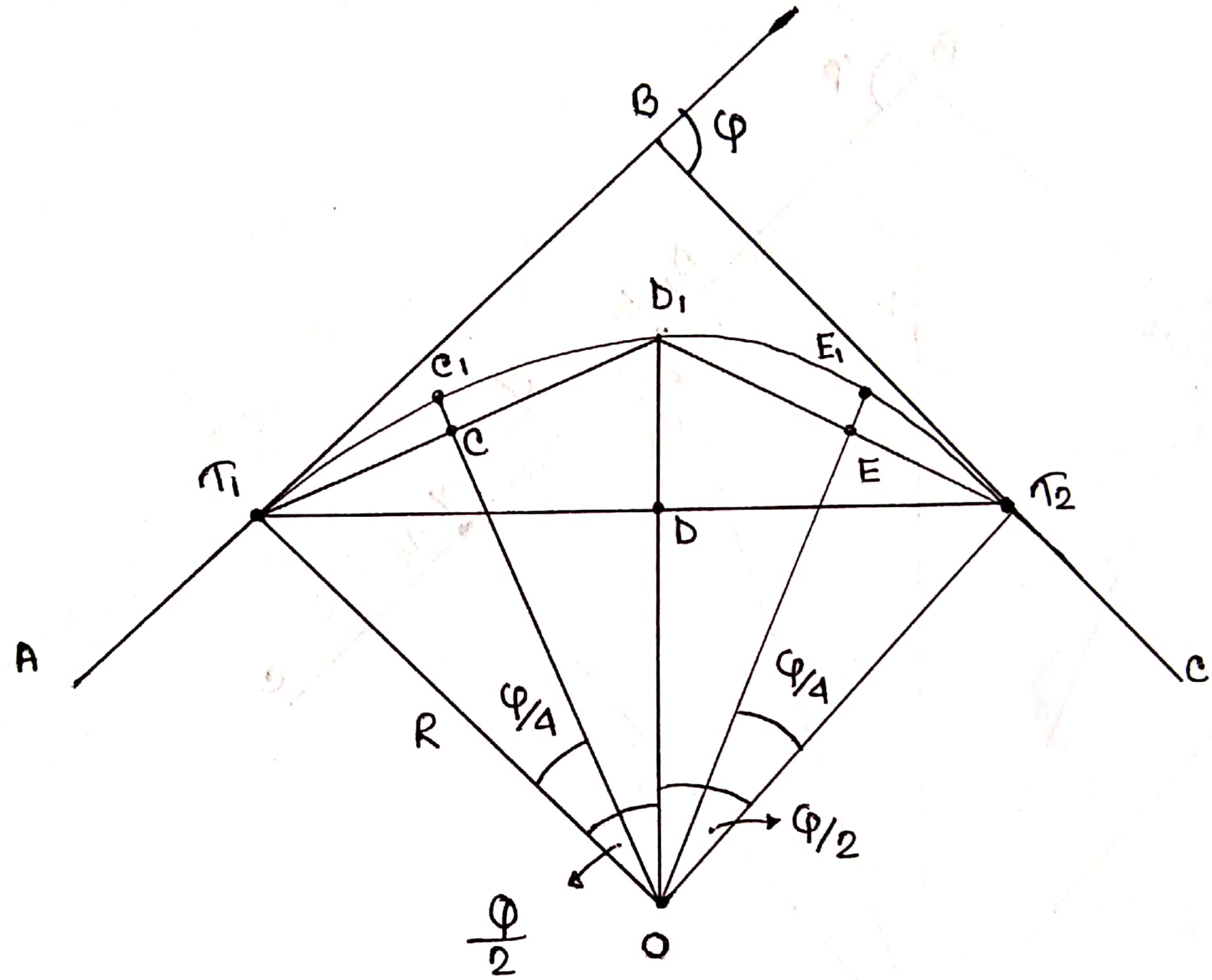
# Successive Bisection of arcs:




$$DD_1 = R\left(1 - \cos \frac{\varphi}{2}\right)$$

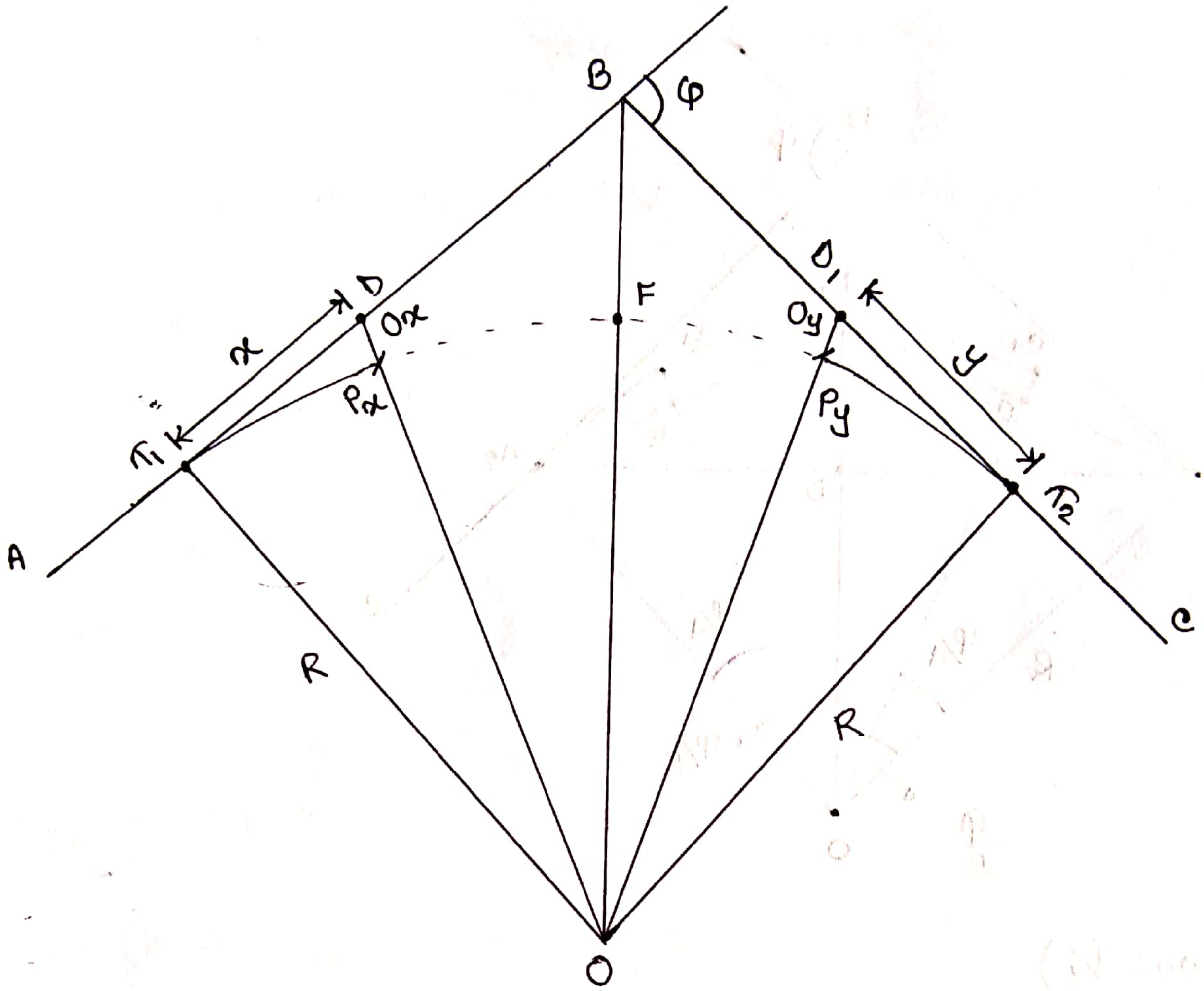
$$CC_1 = R\left(1 - \cos \frac{\varphi}{4}\right)$$

## Offsets from tangent:

(i) Radial offset

(ii) Perpendicular offset.

## ① Radial offset:




$T_1D = x$

$O_x$ = Radial offset

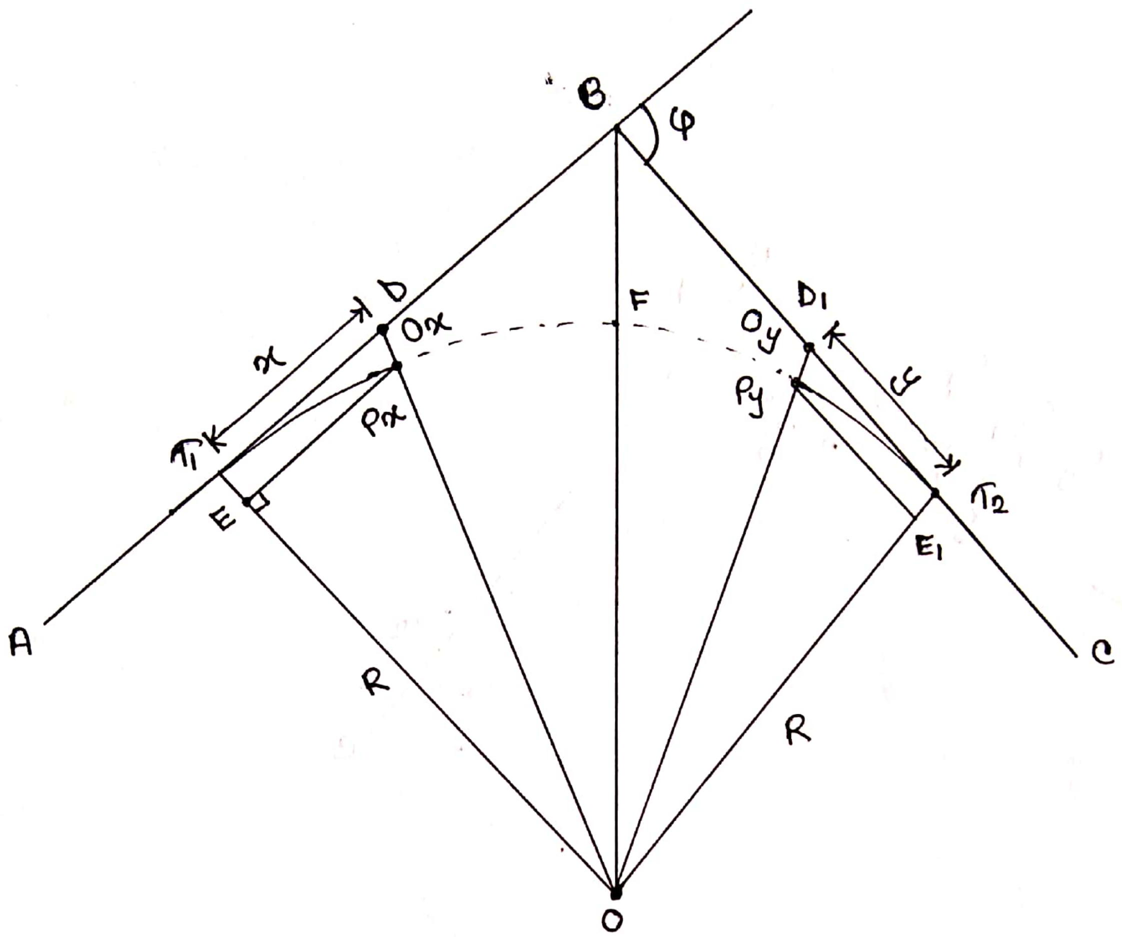
$\Delta T_1OD \Rightarrow OT_1^2 + T_1D^2 = OD^2$

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

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

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

## (11) Perpendicular offset:




$O_x$ = Perpendicular offsets

$OE = R - O_x$

$OP_x = R$

$EP_x = x$

$\Delta\ OP_xE \Rightarrow$

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

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

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

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

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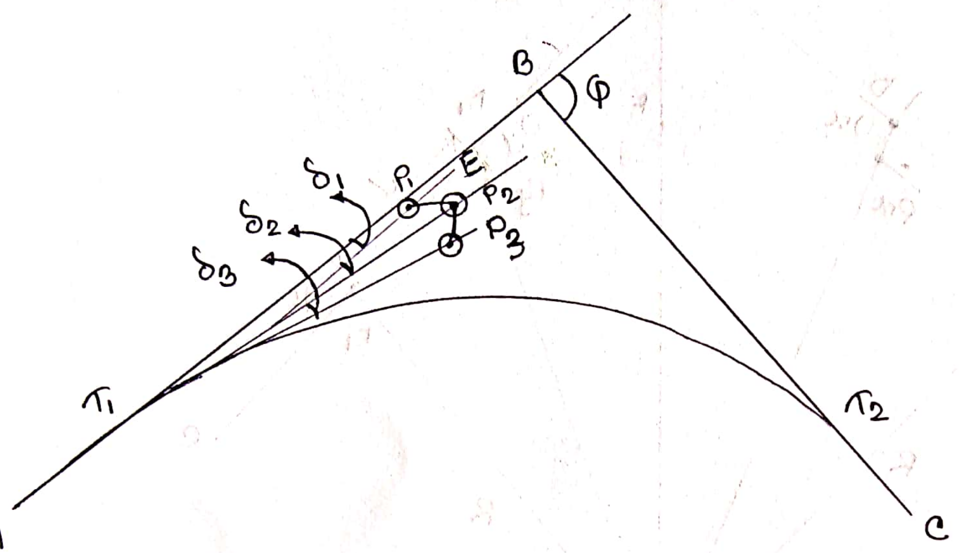
## (III) Instrumental method:

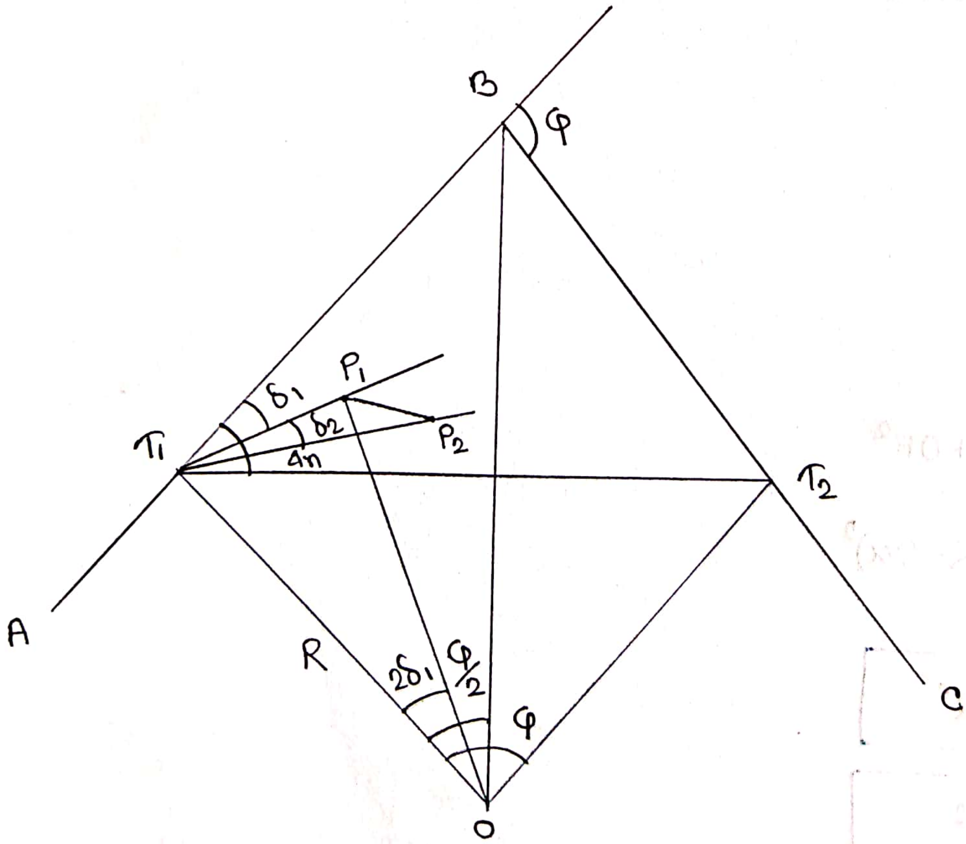
Horizontal Curve setting by Reflection Angle Method / RANKINE'S. Method:




Field procedure:

Theodolite ⟶ $T_1P_1$ = Initial cord

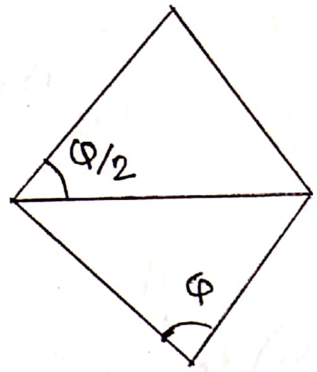
$P_1P_2 = P_2P_3$ = full chord



$T_1P_1 = l_1$ ; $P_1P_2 = l_2$

$\angle T_1OP_1 = 2 \times \angle B_1T_1P_1 = 2\delta_1$

chord $T_1P_1 \sim$ Arc $T_1P_1$




$$\angle T_1OP_1 = \frac{360^\circ}{2\pi R} \times l_1$$

$(2\pi R = 360^\circ)$

$$\delta = \frac{360^\circ}{2\pi R} \times l_1$$

$$2\delta_1 = \frac{360^\circ}{2\pi R} \times l_1$$

$$\delta_1 = \frac{360^\circ l_1}{2 \times 2\pi R} \text{ degree}$$

$$\delta_1 = \frac{360 \times 60 \times l_1}{2 \times 2\pi R} \text{ min}$$

$$\delta_1 = \frac{1718.9\, l_1}{R} \text{ min}$$

$$\delta_2 = \frac{1718.9\, l_2}{R} \text{ min}$$

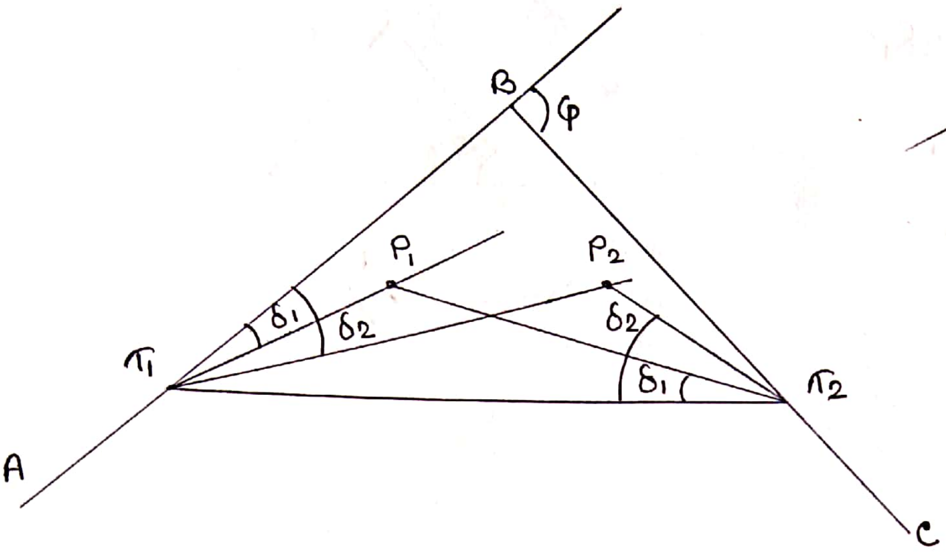
$\vdots$

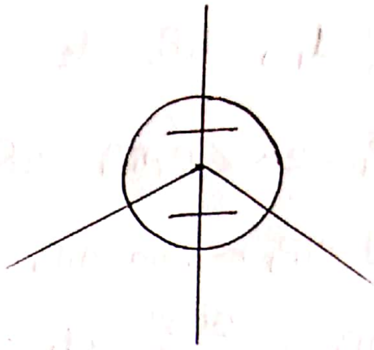
$$\delta_n = \frac{1718.9\, l_n}{R} \text{ min}$$

Cheak:

$$\delta_1 + \delta_2 + \delta_3 + \delta_4 + \cdots + \delta_n = \Delta n = \frac{\varphi}{2}$$

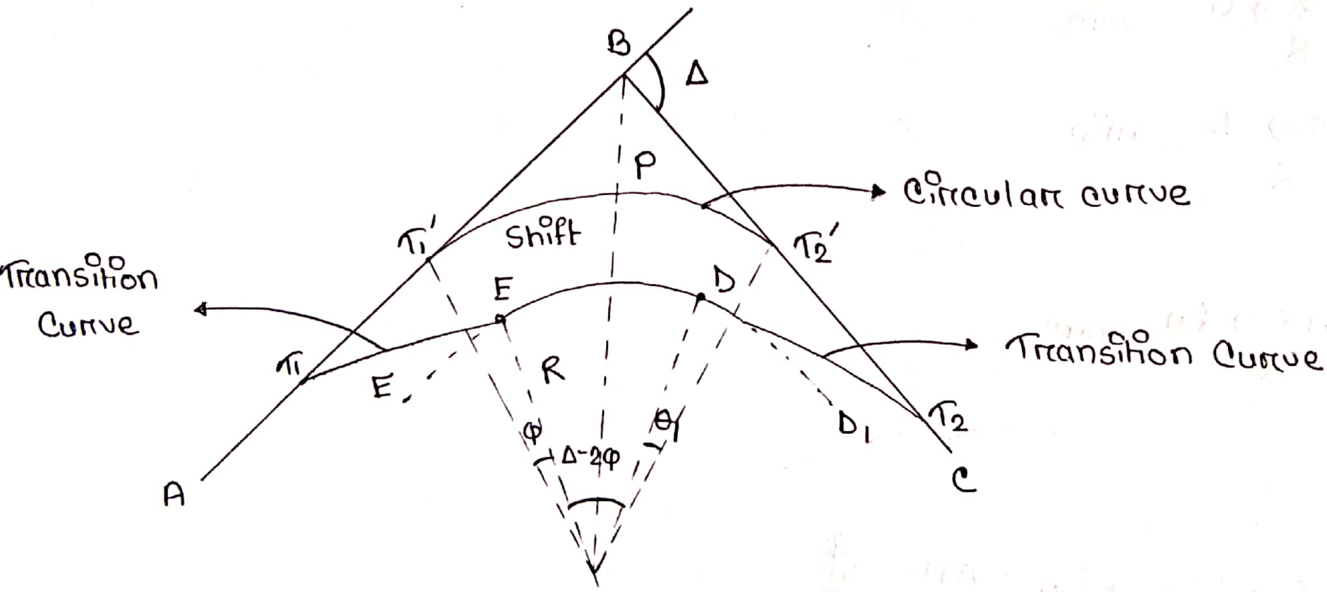
## Field procedure of two-Theodolite Method:



## Transition curve:

## Curve of varying radius:




## Objectives:

1. To avoid overturning.
2. To attain superelevation gradually from tangent point to junction point.

## Requirments:

1. Radius of T.C = radius of C.C at the junction point.
2. Specified amount of superelevation should be gained at the junction point.

## Combined Curve:

### Combination of Transition Curve and circular curve:

Notation of combined curve:

Shift = $T_1'E_1$ and $T_2'D_1$

$\varphi$ = spiral angle

$\Delta - 2\varphi$ = central angle

$T_1EDT_2$ = length of the combined curve.

## Condition of an Ideal Transition curve:

Super elevation $h \propto L \propto P$

(a) $P \propto L$

$$\frac{wv^2}{gR} \propto L$$

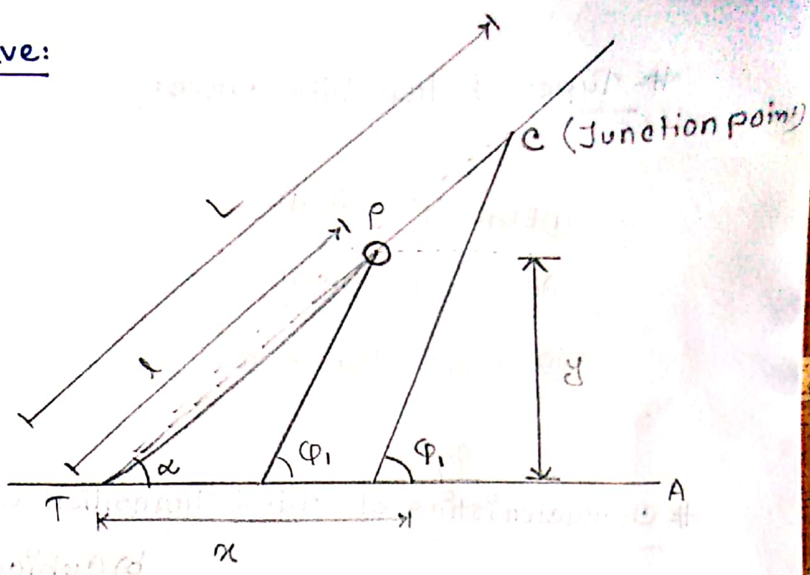
$$L \propto \frac{1}{R}$$

(b) $h \propto L$

$$h \propto L \propto \frac{wv^2}{gR}$$

$$L \propto \frac{1}{R}$$

# Equation of an Ideal Transition curve:




**Spiral angle:**

$$\varphi_1 = \frac{l^2}{2RL} \text{ radians}$$

when $\varphi_1 = \varphi$, $l = L$

$$\boxed{\varphi = \frac{L}{2R}}$$

**Deflection angle:**

At P, Deflection angle, $\alpha = \dfrac{l^2}{6RL}$ radians

at C, $l = L$

$$\alpha = \frac{L^2}{6RL}$$

$$= \frac{L}{6R}$$

$$= \frac{L}{2R} \times \frac{1}{3}$$

$$\boxed{\alpha = \varphi/3}$$

# Types of transition curve:

(i) Euler's spiral

(ii) Cubical spiral

(iii) Cubic Parabola

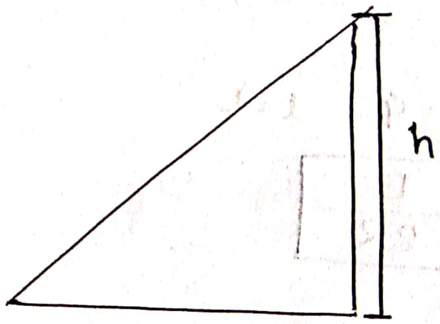
# Characteristics of Ideal Transition Curve:

a) length:

↳ (i) By considering definite rate of superelevation.

let,

$h$ = superelevation




rate of S.E $= \tan\theta = \frac{V}{H}$

$= 1 : n$

$= 1$ in $n$

↓ ver. ↓ hor.

$h \longrightarrow nh$

total length, $L = nh$

b) spiral angle

c) deflection angle

(iii) By considering time rate of superelevation:

let,

$h$ = S.E

$x$ = time rate of S.E. (cm/sec)

$$T = \frac{h}{x}$$

$$L = V \times \frac{h}{x} = \frac{hv}{x}$$ → vehicle speed

(iii) By considering rate of change of radial acceleration:

radial acceleration on circular path $= \frac{V^2}{R}$

Time to cover, $T.C = \frac{L}{V}$

let, $K$ = rate of change of R.A ($m/s^3$)

Time to attain maximum acceleration, $t = \frac{V^2}{RL}$

$$\frac{L}{V} = \frac{V^2}{RL}$$

$$\Rightarrow \boxed{L = \frac{V^3}{KR}}$$

① $L = ?$

$h = \cancel{15}\ 15\ cm$

$x = 3\ cm/s$

$v = 60\ Km/h = 16.67\ ms^{-1}$

$$L = \frac{hv}{x}$$

$$= \frac{.15 \times 16.67}{.03}$$

$$= 250000$$

ⓘ $K = 30\ cm/s^3$

$v = 60\ Km/h = 16.67\ ms^{-1}$

$R = 200\ m$

$$L = \frac{v^3}{KR}$$

$$= \frac{(16.67)^3}{}$$

Shift of the curve:

~~# Elements of combined curve:~~

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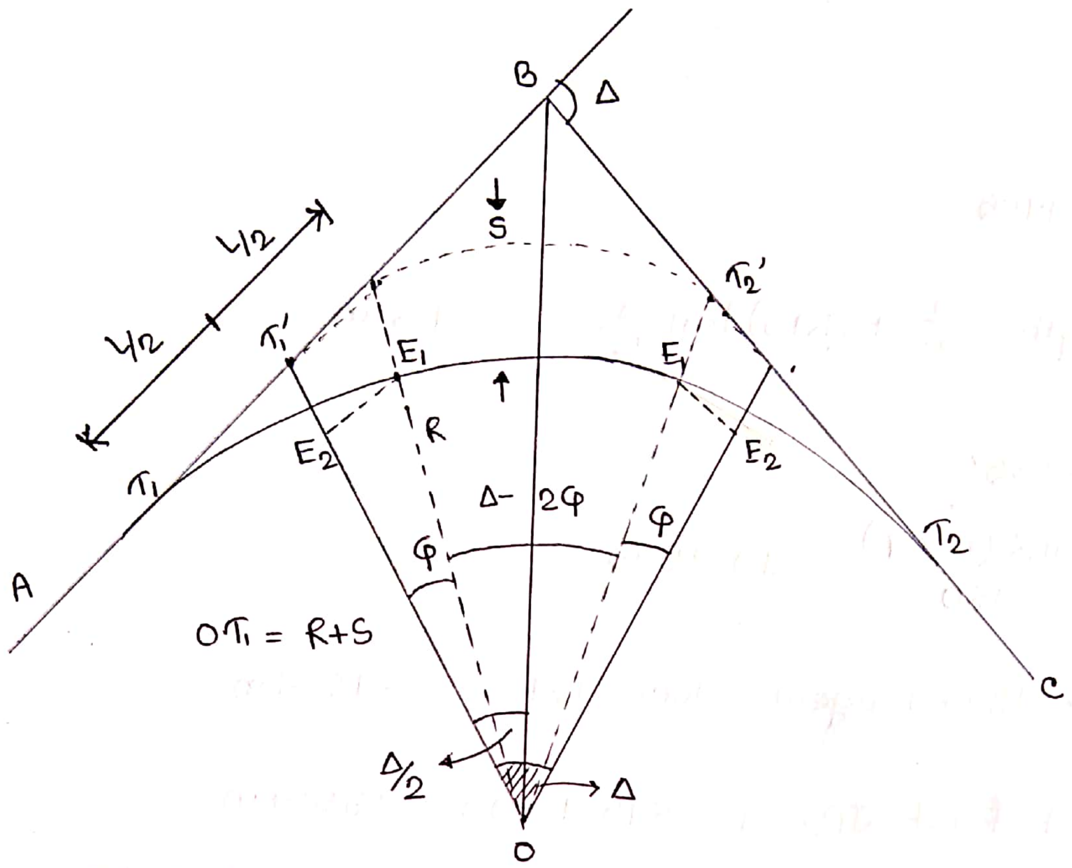
# Elements of combined curve:




① Length of the transition curve; $T.C.L = \frac{V^3}{KR}$

② Shift, $S = \frac{L^2}{24R}$

③ TL, $BT_1 = T_1T_1' + BT_1'$

$$= \frac{L}{2} + (R+S)\tan\frac{\Delta}{2}$$

④ Spiral angle, $\varphi = \frac{L}{2R}$ radian

⑤ L.O.C.C $= \frac{\pi R(\Delta - 2\varphi)}{180^\circ}$

⑥ L.O. combined curve $= T_1E_1 + E_1E_2 + E_2T_2$

$$= L + \frac{\pi R(\Delta - 2\varphi)}{180^\circ} + L$$

$$= 2L + \frac{\pi R(\Delta - 2\varphi)}{180^\circ}$$

Ex: $\Delta = 40°$, $R = 300\,m$, Transition curve, $L = 90\,m$.

(i) TL =

(ii) $S = \frac{L^2}{24R} = 1.125$

(iii) Tangent length $= \frac{L}{2} + (R+S)\tan\frac{\Delta}{2} = 154.6\,m$

(iv) $\phi = \frac{L}{2R} = 8°35'$

(v) L.O.C.C $= \frac{\pi R(\Delta - 2\phi)}{180} = 119.43\,m$

(vi) Chainage of first tangent $= 1000 - 154.6 = 845.4\,m$

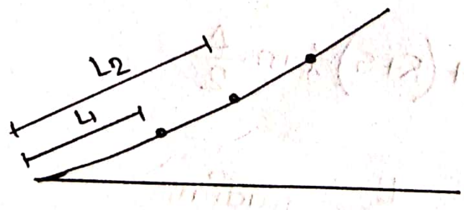
(vii) Chainage of first JP, $E_1 = 845.4 + 90 = 935.4\,m$

" " 2nd " $E_2 = 935.4 + 119.43 = 1054.83\,m$

(vi) " " 2nd TP $= 1054.83 + 90 = 1144.83\,m$

Deflection angle:

$$\alpha = \frac{573 l^2}{LR}$$




No full chord $= 4 \times 20 = 80$

Distance of 1st point from TP $= 850 - 845.4 = 4.6$

" " 2nd " " " $= 4.6 + 20 = 24.6$

" " 3rd " " " $= 24.6 + 20 = 44.6$

$60' = 1^\circ$

4th $\longrightarrow$ 64.6

5th $\longrightarrow$ 84.6

6th $\longrightarrow$

$$\alpha_1 = \frac{573\, l_1^2}{LR} = 0.45 = 27'$$

$$\alpha_2 = \frac{573\, L_2^2}{LR} = 12.8 = 12^\circ 48'$$

$$\alpha_3 = \frac{573\, L_3^2}{LR} = 42.21 = 42^\circ 12'$$

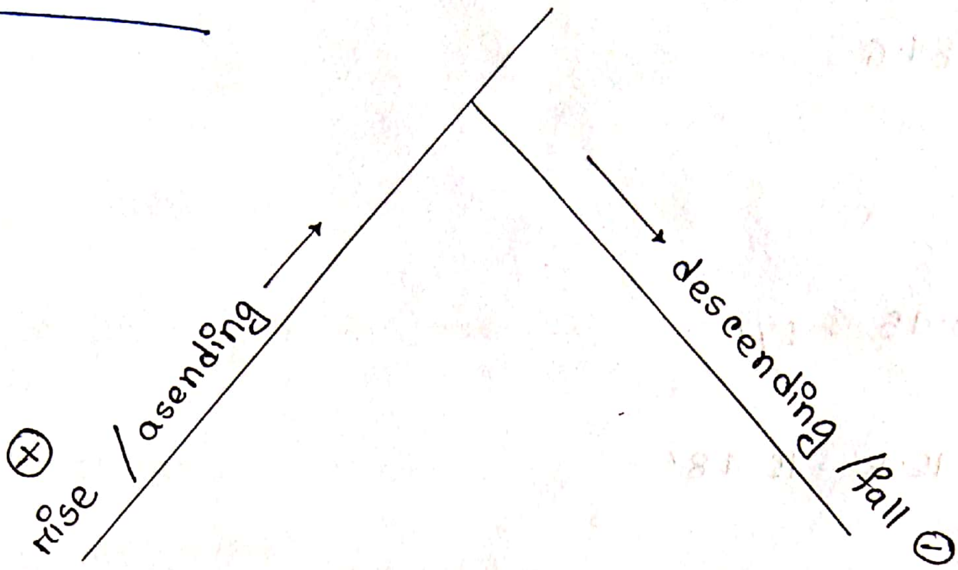
$$\alpha_4 = 88.6 = 88^\circ 36'$$

$$\alpha_5 = 151.89 = 151^\circ 53' 2''$$

$$\alpha_6 = 171.9 = 171^\circ 54'$$

$$\alpha = \phi/3$$

# Vertical curves:




Vertical curves going to through two different gradiants along a road surface is called vertical surface.

Gradient:

(i) Percentage — 1%, 2%

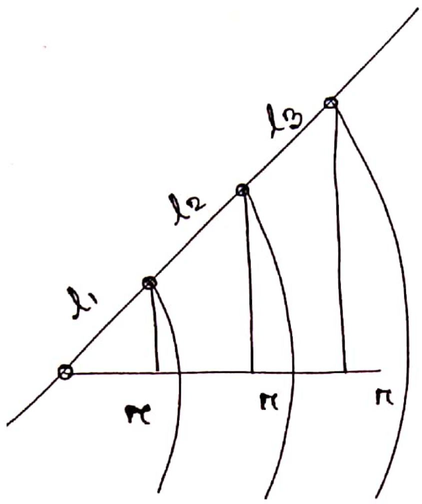
(ii) $\tan\theta = \frac{rise}{run}$

(iii) 1 : n , 1 in n

rising gradient is denoted by +ve sign.

falling " " " " −ve "

# Rate of change of grade:

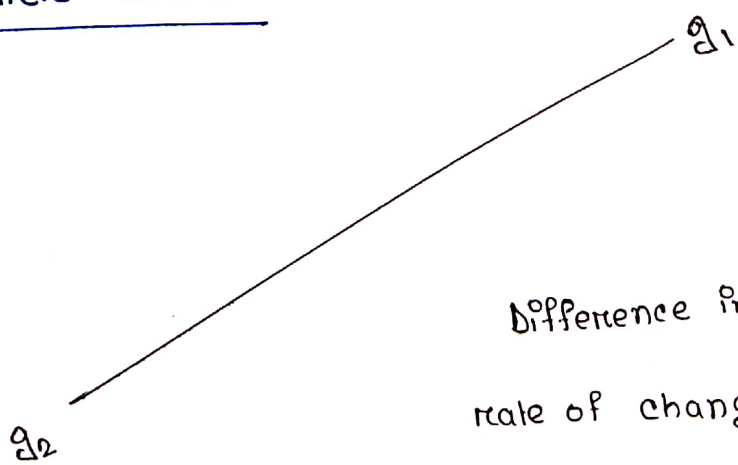



rate of change of grade $= \frac{r}{l}$

① 1% per 30 m at summits (up)

⑪ 0.05% per 30 m at sags (down)

# Length of verticle Curve:




Difference in gradient $= g_1 - g_2$

rate of chang of grade $= r.$(for $l$)

$= \frac{r}{l}$

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$$r \longrightarrow l$$

$$1 \longrightarrow \frac{l}{r}$$

$$(g_1 - g_2) \longrightarrow \frac{(g_1 - g_2)\, l}{r}$$

$$= \frac{g_1 - g_2}{\frac{r}{l}}$$

$$L = \frac{\text{Change of grade}}{\text{Rate of change of grade}}$$

\# $g_1 = +0.5\%$

$g_2 = -0.4\%$

$r = 0.1\%$

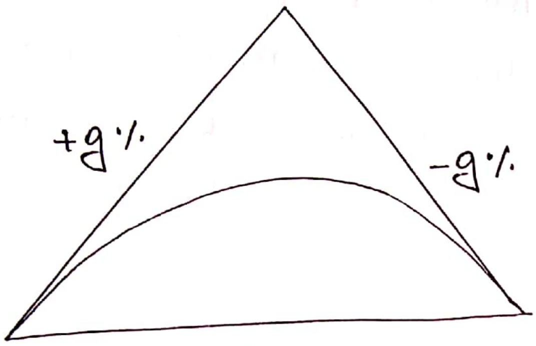
$l = 30\text{ m}$

$$L = \frac{g_1 - g_2}{r/l}$$

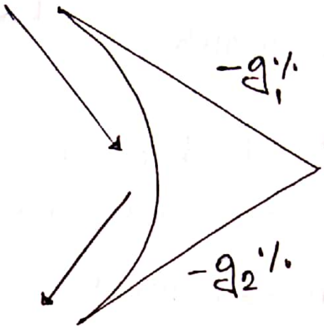
$$= 270 \text{ m}$$

# Types of verticle curve:

① Summit Curve (/up/apex)

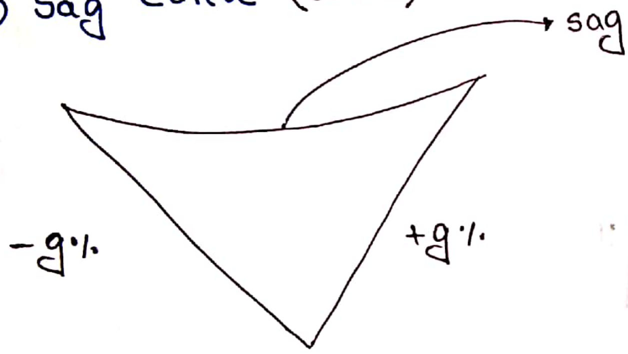



(a)

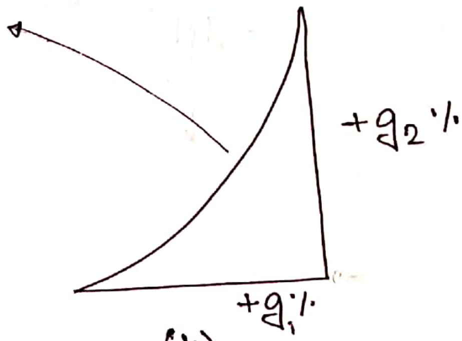



(b)

⑪ Sag curve (down)




(a)




(b)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## Chapter-5:

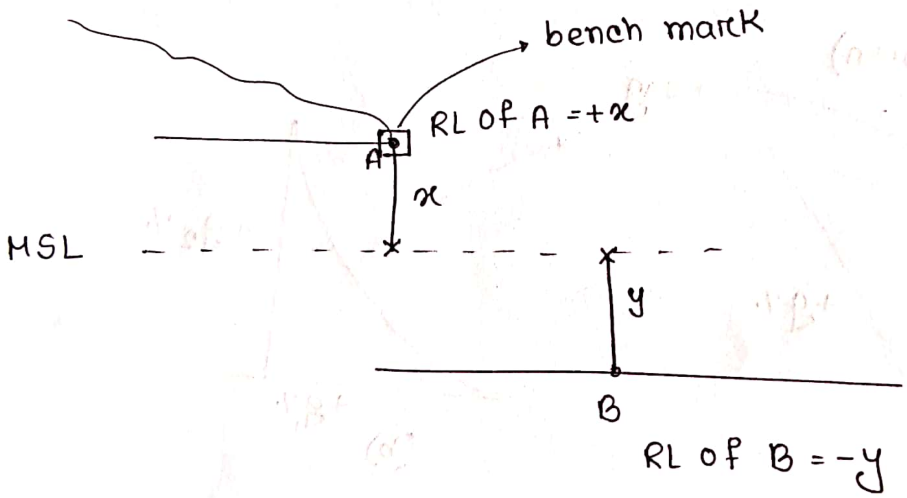
(i) Datum line : An imaginary line from which the verticle distances of different points are measured.

(ii) Reduced level (R.L) → The verticle distance of a point above or below the Datum line is called R.L. of that point

(iii) Bench mark

→ Fixed points on ~~marks of~~ known R.L marks of determined to the R.L with reference to the datum line.

MSL → mean sea level.




# Setting of the verticle line:

(i) Tangent Correction / offset method.

(ii) Chord Gradient Method.

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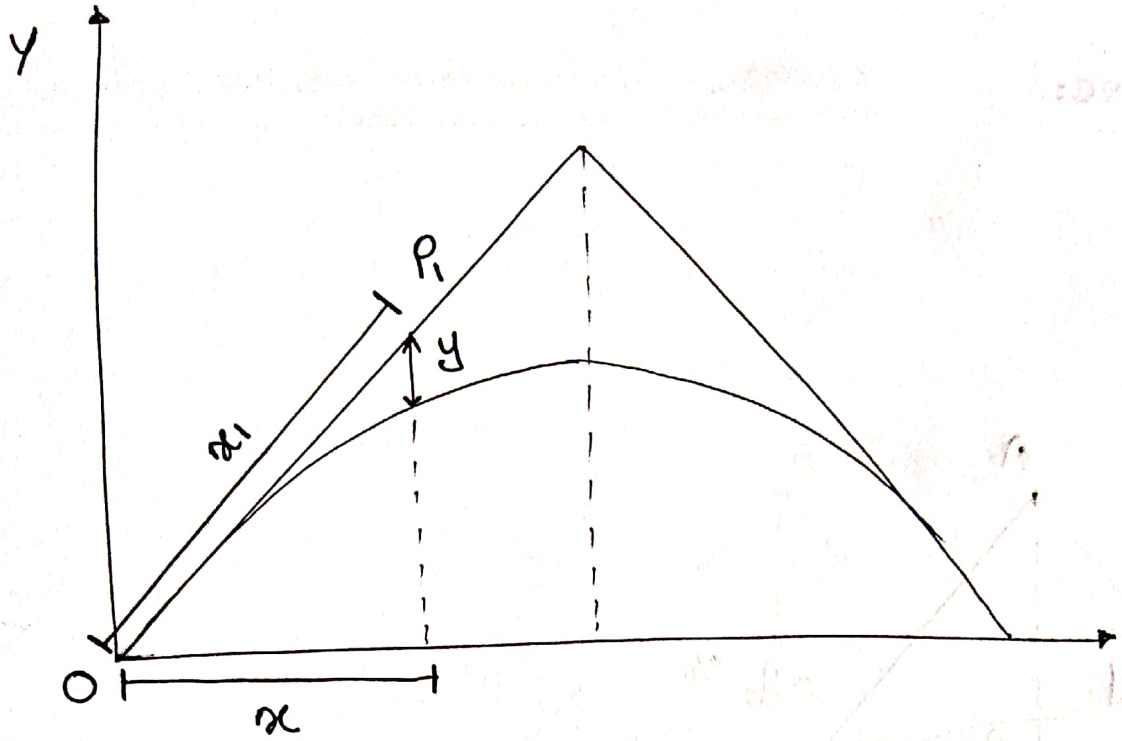
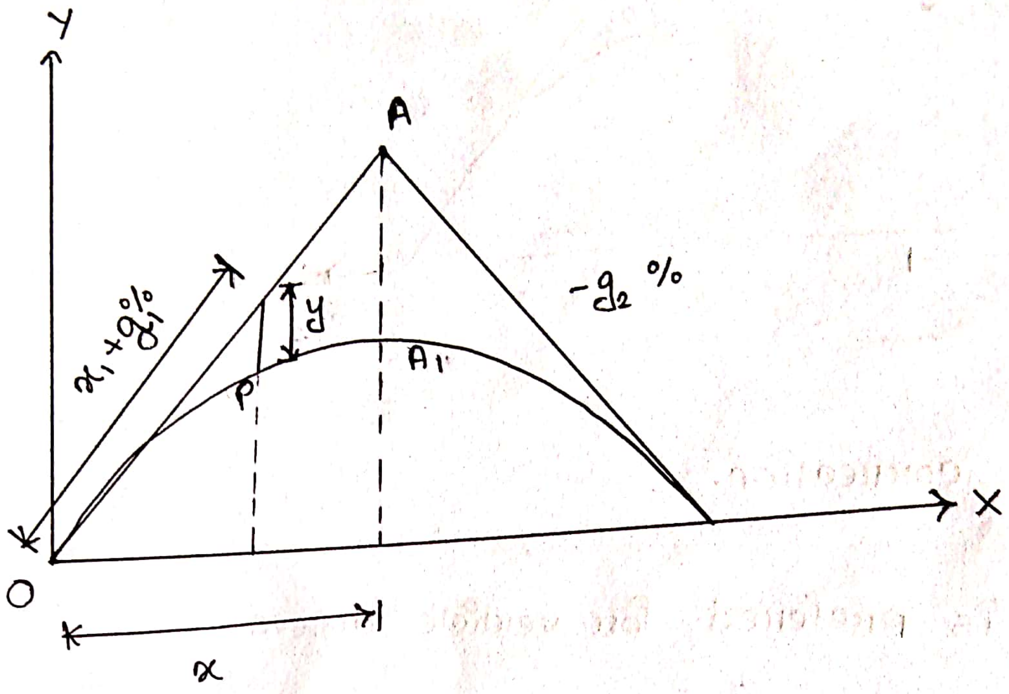



y = tangent correction.

* parabolic curve is preferred for verticle curve.

# Setting out of vertical curve:




Tangent correction method:

y = RL = tangent correction

Equation of curve, $y = cx^2$

$$c = \frac{g_1 - g_2}{400 \times l} x^2 \quad [c = \text{constant value}]$$

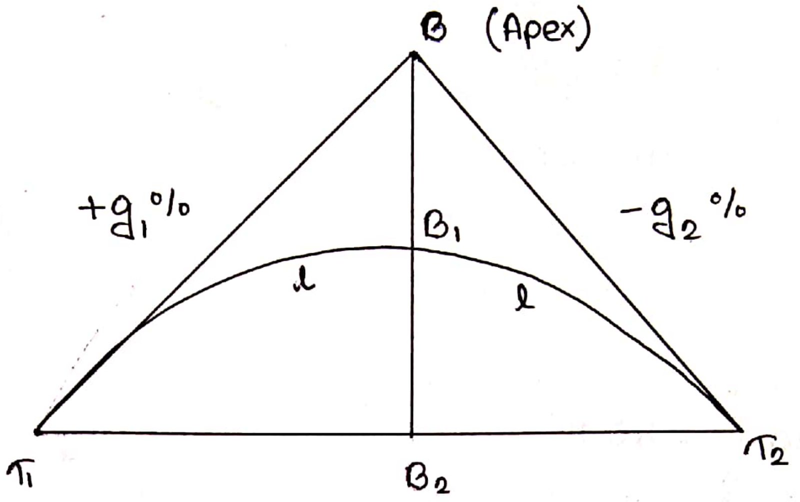
Tangent Correction, $y = \dfrac{g_1 - g_2}{400 \times l} x^2$

$$y_1 = \frac{g_1 - g_2}{400 \times l} x_1^2$$

⋮

$y_n$.

# Points for setting out vertical Curve:




① Length of the curve:

$$T_1B_1 + B_1T_2 = BT_1 + BT_2$$

$$= 2l$$

② Length, $L = \dfrac{g_1 - g_2}{r}$

③ $C.O.T_1 =$ Chainage of $B - BT_1$

④ $C.O.T_2 =$ Chainage of $B + BT_2$

⑤ $R.L$ of $T_1 = RL$ of $B \pm \dfrac{g_1}{100} \times l$

⑥ $R.L$ of $T_2 = RL$ of $B \mp \dfrac{g_2}{100} \times l$

⑦ R.L of $B_2 = \frac{1}{2}$ (RL of $T_1$ + RL of $T_2$)

⑧ RL of $B_1 = \frac{1}{2}$ (RL of B + RL of $B_2$)

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**Ex:**

① $L = \frac{0.6-(0.6)}{0.1} \times 30 = 360$ m

②. C.O. $T_1$ = $550 - 180 = 370$ m

③ C.O. $T_2$ = $550 + 180 = 730$ m

④ RL of $T_1$ = $325.50 - \frac{0.6 \times 180}{100} = 324.42$ m

⑤ RL of $T_2$ = $324.42$ m

⑥ RL of $B_2 = \frac{1}{2}(324.42 + 324.42) = 324.42$ m

⑦ RL of $B_1 = \frac{1}{2}(325.50 + 324.42) = 324.96$ m

$l = 180m$

$$y = \frac{g_1 - g_2}{400 \times l} x^2$$

$$\left\{ \begin{array}{l} x_1 = 30 \\ x_2 = 60 \\ x_3 = 90 \\ x_4 = 120 \\ x_5 = 150 \\ x_6 = 180 \end{array} \right.$$

$$y_1 = \frac{0.6 - (-0.6)}{400 \times 180} \times 30^2 = \cancel{2.7}\ 0.015$$

$y_2 = 0.06$

$y_3 = 0.135$

$y_4 = 0.24$

$y_5 = 0.375$

$y_6 = 0.54$

Transite theodolite

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Article - 9.2 (1-15 - definiation)

# Tacheometric Surveying:

11·1 → Introduction — Diff and application

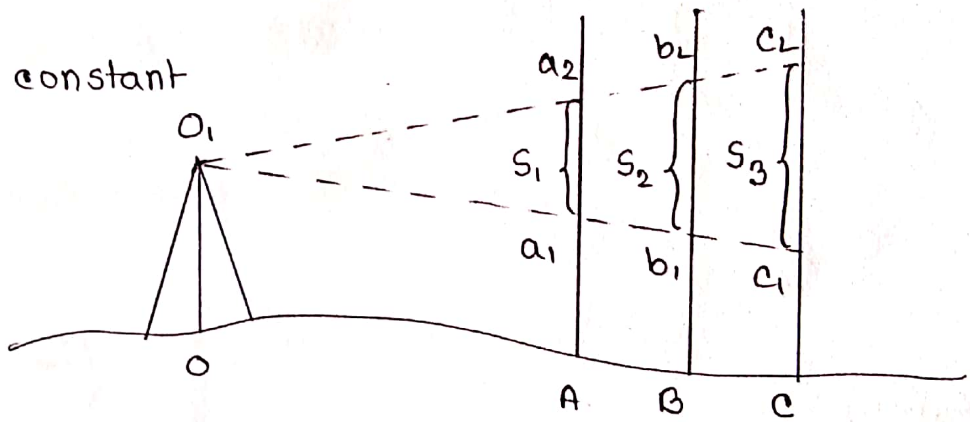
1. Instrument → staff, Theodolite

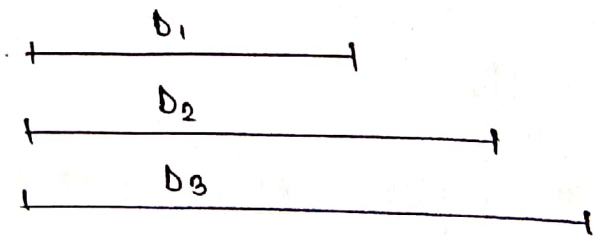
2. Characteristics.

## Principle:

$$\frac{D_1}{S_1} = \frac{D_2}{S_2} = \frac{D_3}{S_3} = \frac{f}{i}$$

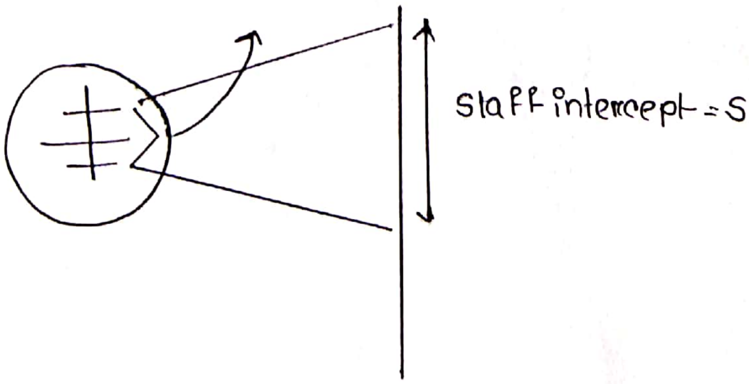
= multiplying constant



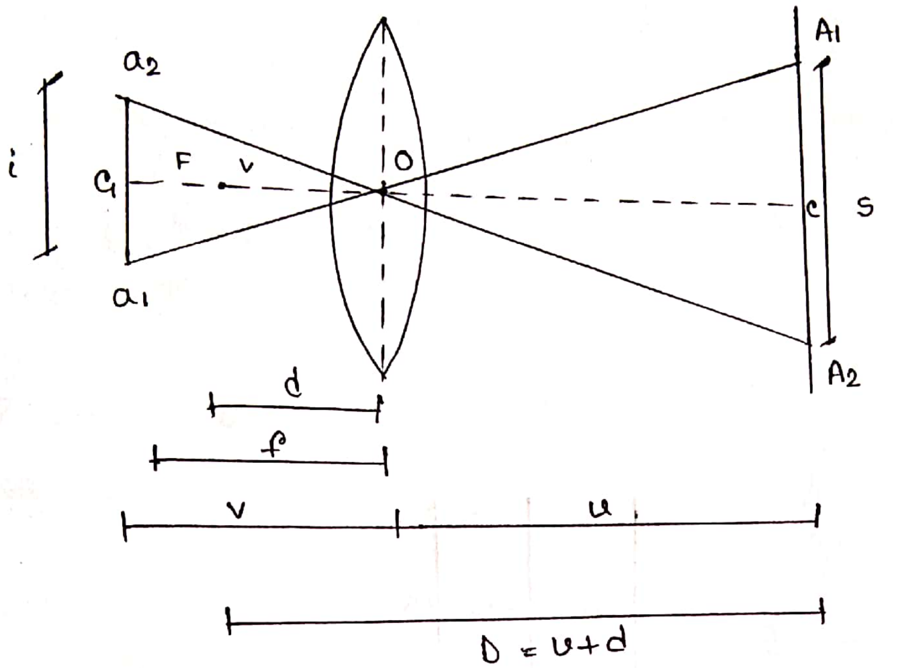




f = focallength

i = stadia intercept



# Theory of Stadia tacheometry:




$\Delta Oa_1a_2$ and $\Delta OA_1A_2$,

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

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

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

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

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

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

$$D = \underbrace{\left(\frac{f}{i}\right)}_{\text{multiply cons (100)}} \times s + \underbrace{(f+d)}_{\text{additive constant} \sim (0)}$$

tacheometry /stadia constant

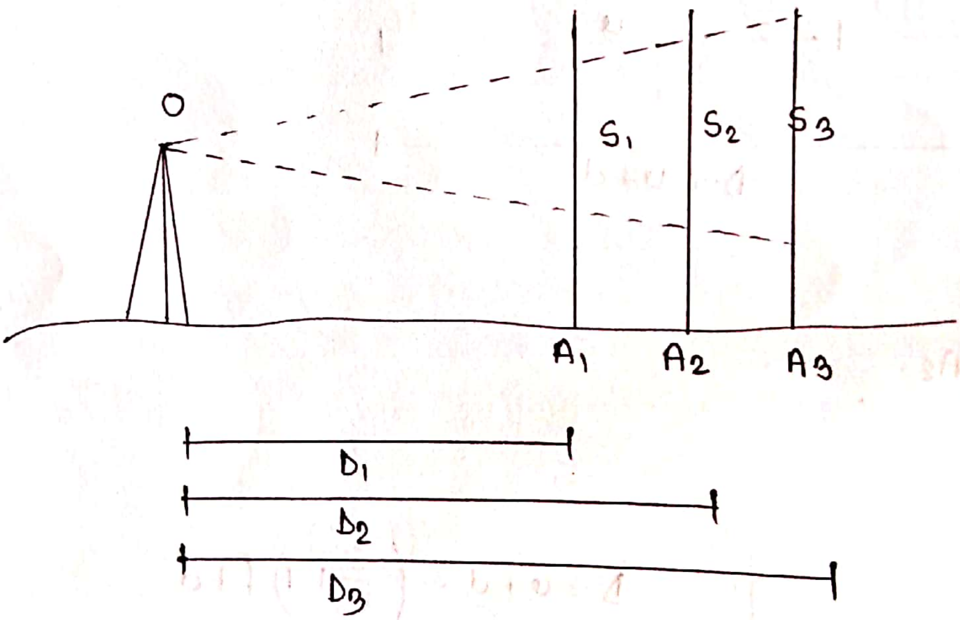
# Determination of stadia constant:

f, i, d

1. Laboratory measurement
2. Field measurement

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

2 ⇒




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

$$D_1=\left(\frac{f}{i}\right)S_1+(f+d)$$

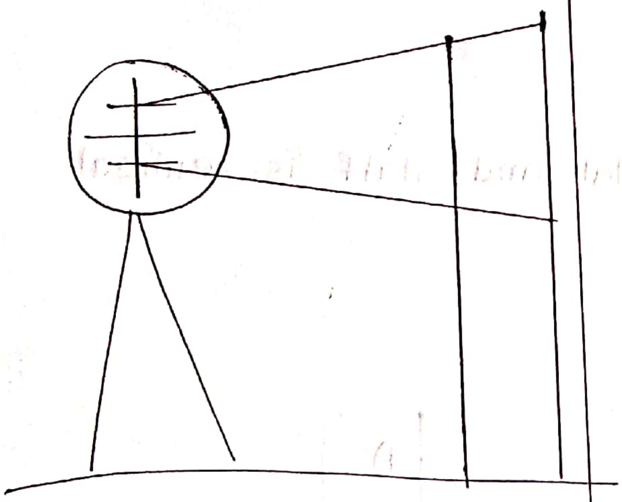
$$D_2=\left(\frac{f}{i}\right)S_2+(f+d)$$

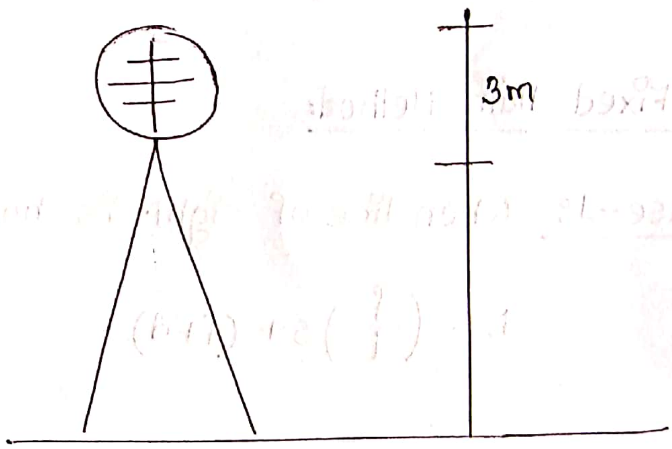
⋮

## 11·5 Methods of tachometry:

1. Stadia Method → Fixed Hair Method / Moveable Hair Method
2. Tangential Method

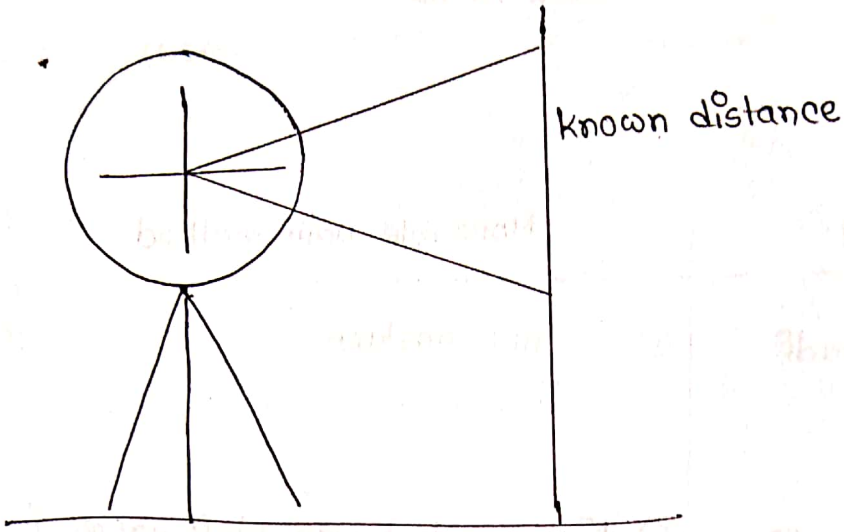
| Fixed Hair method | Moveable Hair method |
|---|---|
| ① Distance between stadia is constant. | ① . . . not constant. |
| ② distance between stuff reading is variable. | ② Distance between staff values is constant. |






| | |
|---|---|
| ③ More convenient | ③ Not so convenient. |

## Tangential method:




- → single Hair
- → Known distance of the staff reading.

## Fixed Hair Method:

**case-1:** When line of sight is horizontal and staff is vertical

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

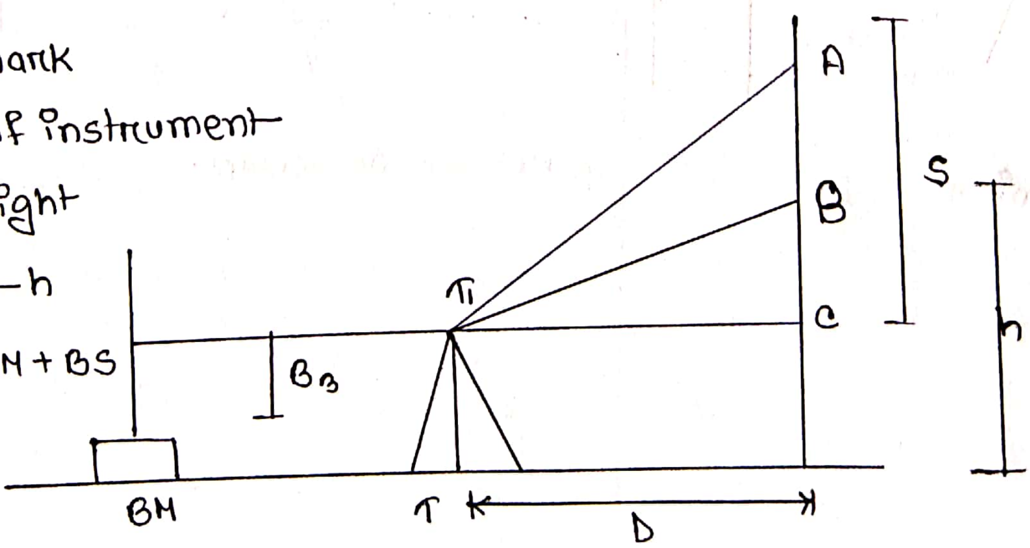
BM = Bench mark

HI = Hight of instrument

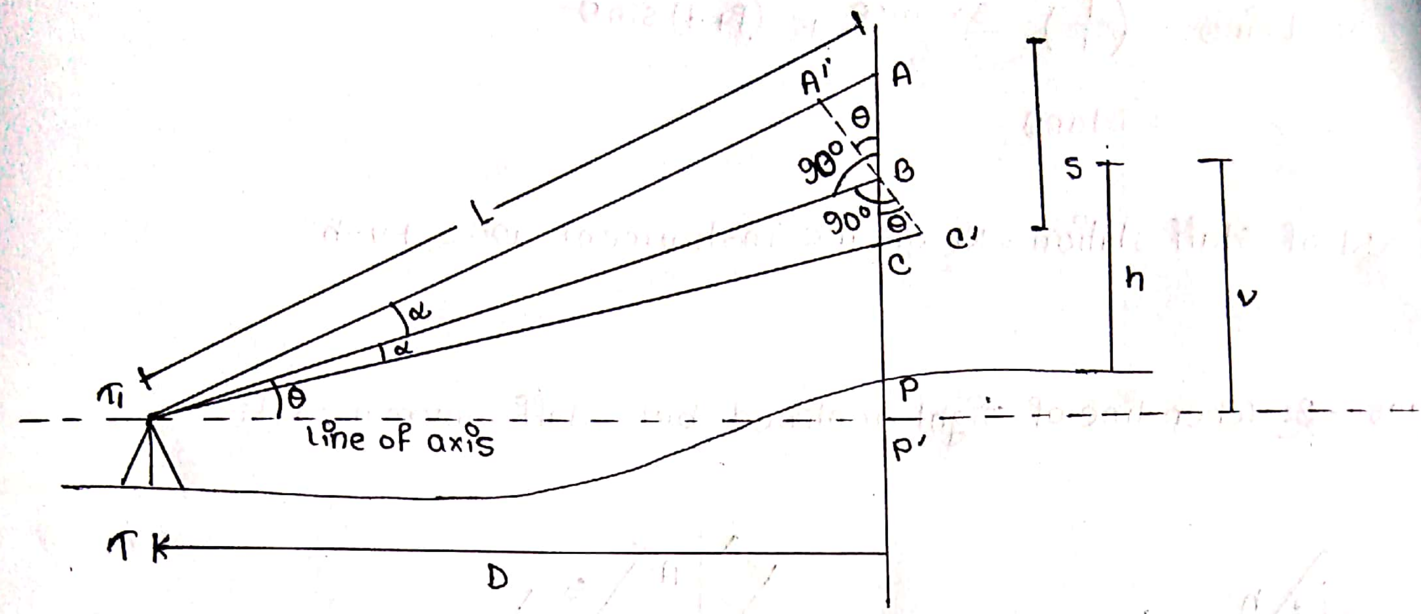
BS = Back sight

RL of P = HI − h

HI = RL of BM + BS

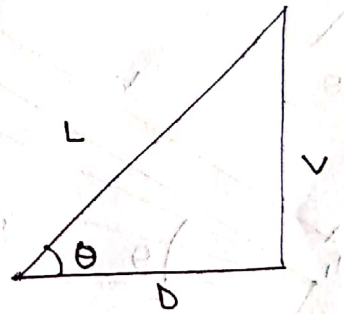


Case-2: When line of sight is inclined but staff is vertical




a) $\theta$ = Angle of elevation (positive)

$$L = \left(\frac{f}{i}\right) A'C' + (f+d)$$




$D = L\cos\theta$

$V = L\sin\theta$

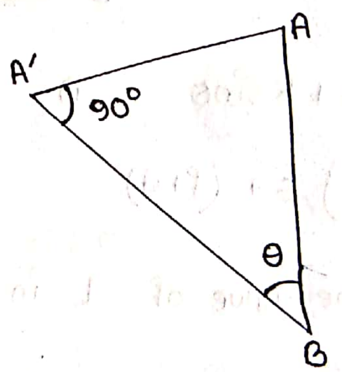
$A'C' = A'B + BC'$

$\Delta ABA'$ & $\Delta CBC' \rightarrow$

$\angle ABA' = \angle CBC'$

$\angle AA'B = 90° + \alpha$

$\angle BC'C = 90° - \alpha$




$\alpha$ negligible,

$\angle AA'B = 90°$

$\angle BC'C = 90°$

$A'B = AB\cos\theta$

$A'C' = AB\cos\theta + BC\cos\theta$

$= \cos\theta\,(AB + BC)$

$= AC\cos\theta$

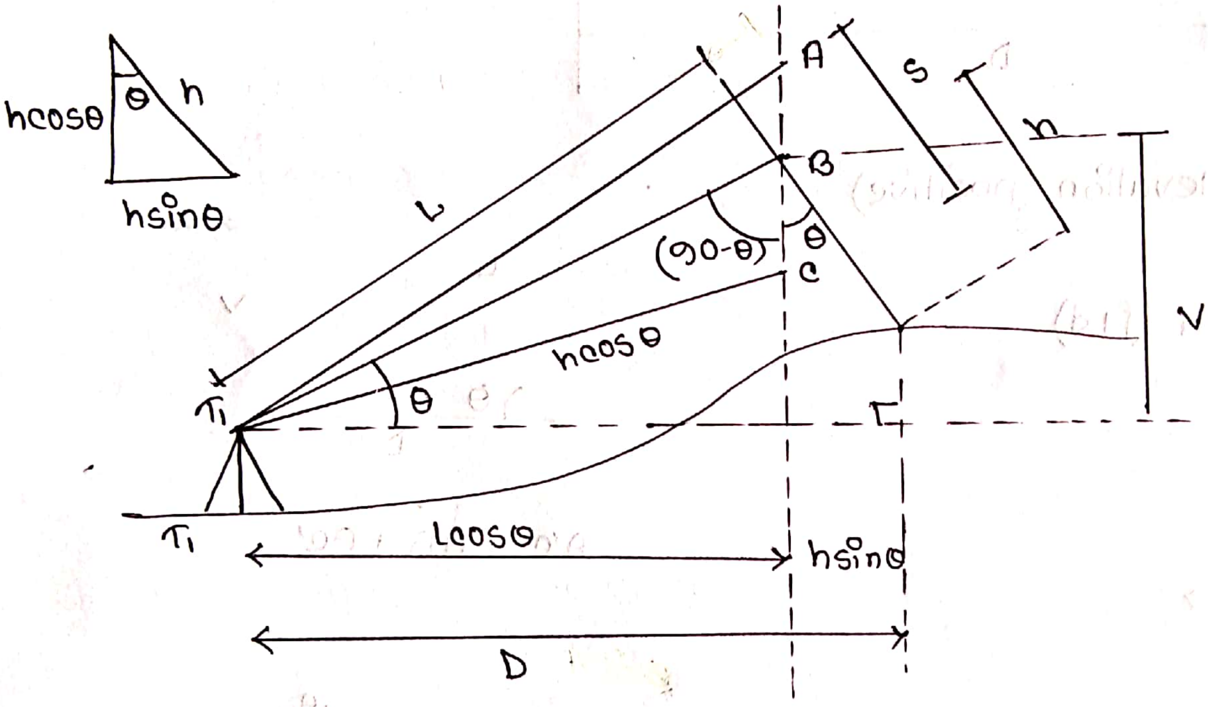
$$D = L\cos\theta = \left(\frac{f}{i}\right) s\cos^2\theta + (f+d)\cos\theta$$

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

$$= D\tan\theta$$

RL of staff station = RL of the instrument axis $+ v - h$

**Case-3:** When line of sight inclined but staff normal to it.




$$D = L\cos\theta + h\sin\theta \quad \text{——— (1)}$$

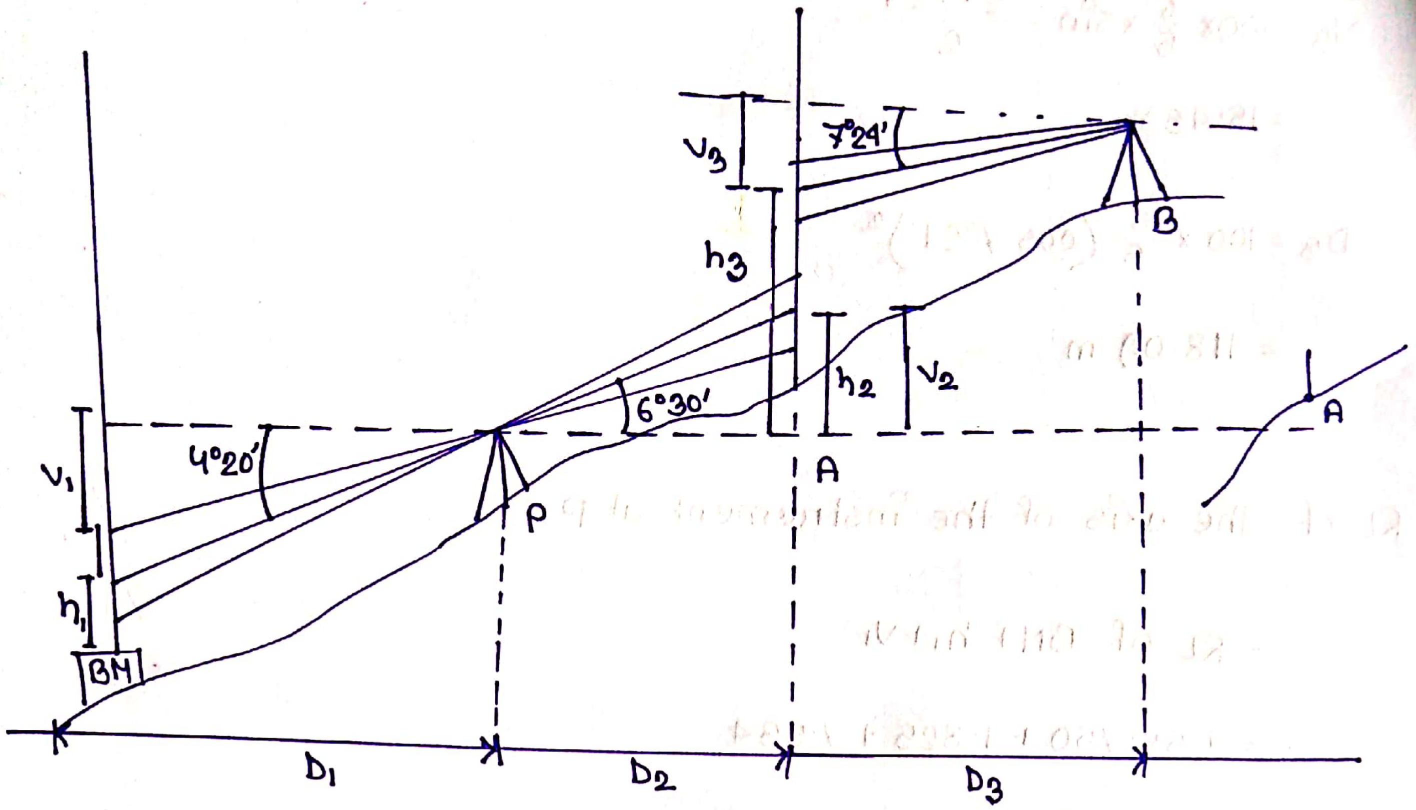
$$L = \left(\frac{f}{i}\right) s + (f+d)$$

Submitting the value of L in eqn (1) →

$$V = L\sin\theta$$

$$\text{RL of } P = HI + V - h\cos\theta$$

#




RL of B = ?

$D_3$ = ?

$h_1 = 1{\cdot}255$

$$V_1 = \left(\frac{f}{i}\right) s \frac{\sin 2\theta}{2} + (f+d)\sin\theta$$

$D_1$ = ?

$V_2$ = ?

$D_2$ = ?

$V_3$ = ?

$D_3$ = ?

$$V_1 = 100 \times (9{\cdot}325 - 1{\cdot}325) \frac{\sin 2 \times 4°20'}{2}$$

$$= 7{\cdot}534 \text{ m}$$

$$D_1 = \left(\frac{f}{i}\right) s\cos^2\theta + (f+d)\sin\theta$$

$$= 100 \times (2{\cdot}325 - 1{\cdot}325)(\cos 4°20')2$$

$$= 99{\cdot}43 \text{ m}$$

$$V_2 = 100 \times \frac{3}{2} \times \frac{\sin 2 \times 6°30'}{2}$$

$$= 16{\cdot}871 \text{ m}$$

$$D_2 = 100 \times \frac{3}{2} \times (\cos 6°30')^2$$

$$= 148{\cdot}08 \text{ m}$$

$$V_3 = 100 \times \frac{6}{5} \times \sin \frac{2 \times 7^\circ 24'}{2}$$

$$= 15.45 \text{ m}$$

$$D_3 = 100 \times \frac{6}{5} (\cos 7^\circ 24')^2$$

$$= 118.09 \text{ m}$$

RL of the axis of the instrument at P

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

$= 255.750 + 1.825 + 7.534$

$= 265.109$ m

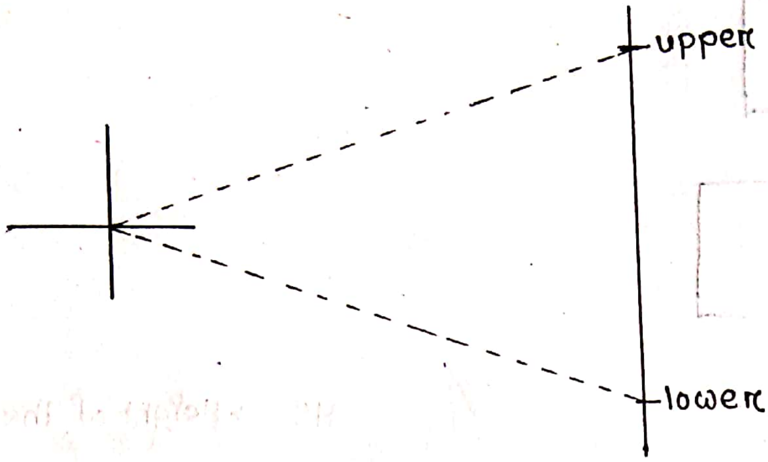
RL of A $= 265.109 + V_2 - h_2$

$= 280.380$ m

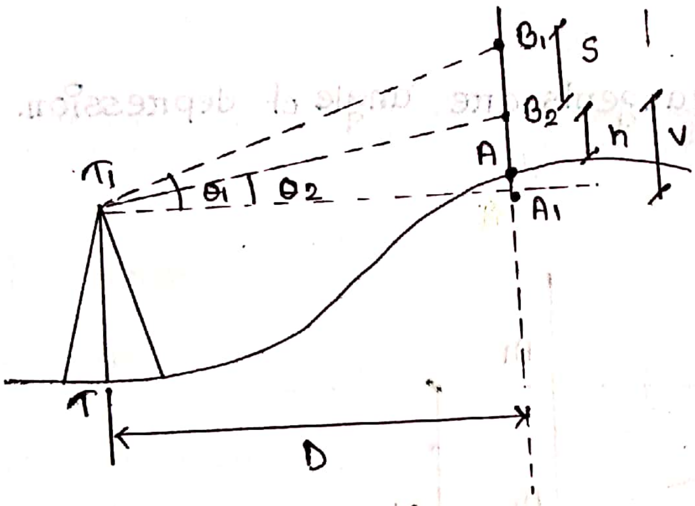
RL of B $= 280.380 + h_3 + V_3 - HI$

$= 296.571$ m

## 11.9 Tangential Method of Tacheometry




**case: 01** When both of the targets are angle of elevation.




$D = ?$

$V = ?$

RL of $A = ?$

$$\tan\theta_1 = \frac{V+S}{D}$$

$$\Rightarrow V+S = D\tan\theta_1 \quad \text{---} \quad (i)$$

$$\tan\theta_2 = \frac{V}{D}$$

$$\Rightarrow V = D\tan\theta_2 \quad \text{---} \quad (ii)$$

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

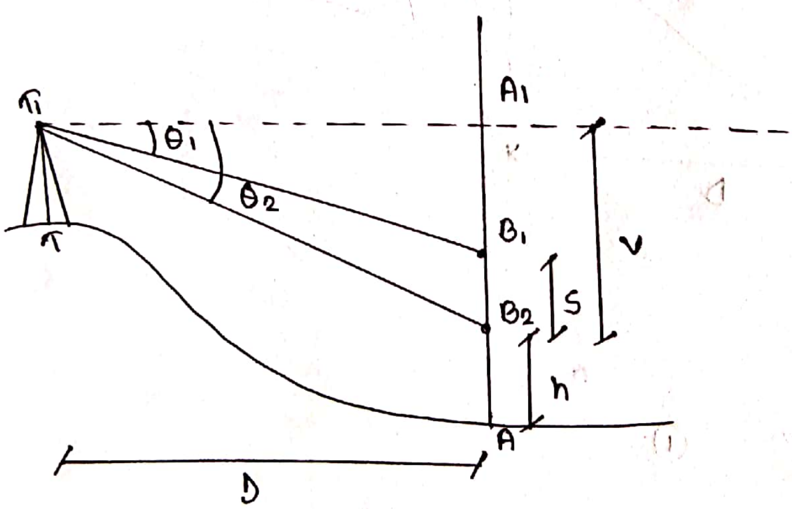
$$\Rightarrow \boxed{D = \frac{S}{(\tan\theta_1 - \tan\theta_2)}}$$

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

HI ⟶ Height of the instrument

$$\therefore \boxed{\text{RL of } A = HI + V - h}$$

**Case-2:** When both of the tangents are angle of depression.




$$\tan\theta_1 = \frac{V-S}{D}$$

$$\Rightarrow D\tan\theta_1 = V - S \quad \text{—— (i)}$$

$$\tan\theta_2 = \frac{V}{D}$$

$$\Rightarrow D\tan\theta_2 = V \quad \text{—— (ii)}$$

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Exp: 1, 2

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

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

$$\Rightarrow \boxed{D = \frac{S}{\tan\theta_2 - \tan\theta_1}}$$

$$\therefore \boxed{V = \frac{S\tan\theta_2}{\tan\theta_2 - \tan\theta_1}}$$

$\boxed{R.L \text{ of } A = HI - V - h}$

## 11·14 Errors and precision in stadia Tacheometry.

### A. Errors:

1. Instrumental error.

2. Error of observation.

3. Errors of natural cases.

### B. precision:

→ horizontal → (1-500) doesn't exist
→ verticle → 0·1 doesn't exist.