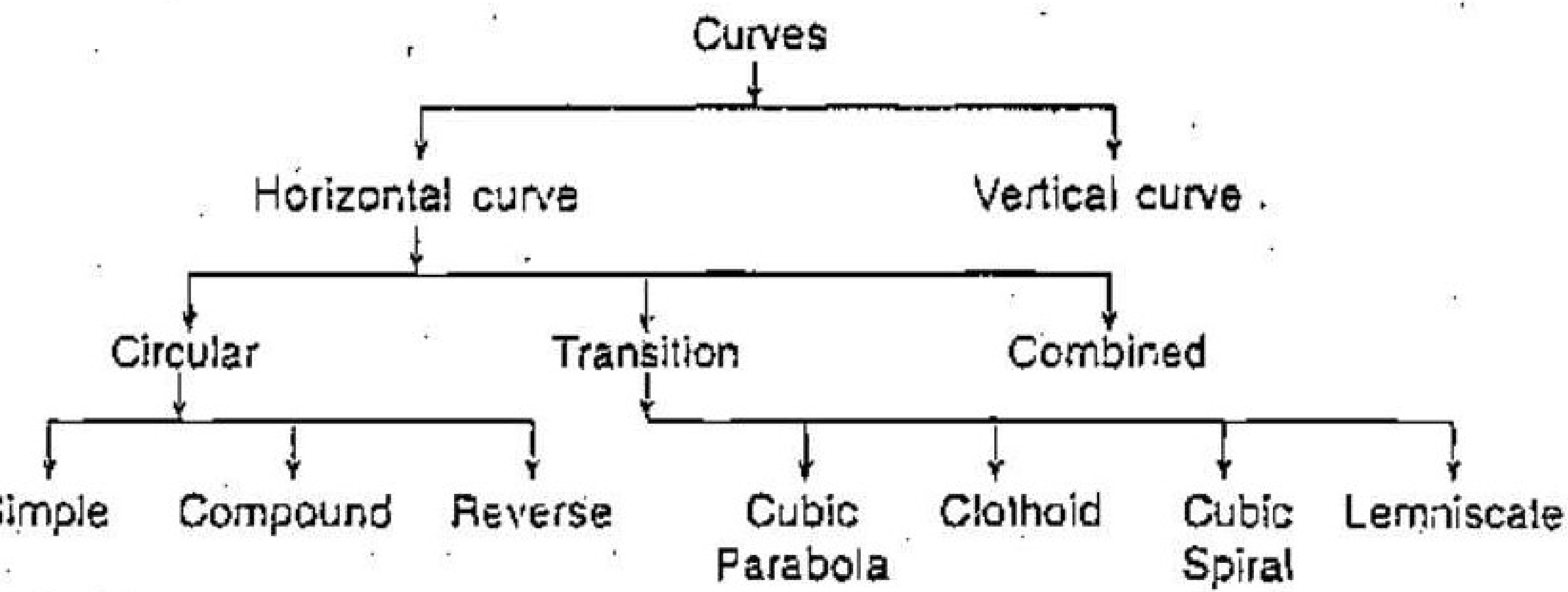
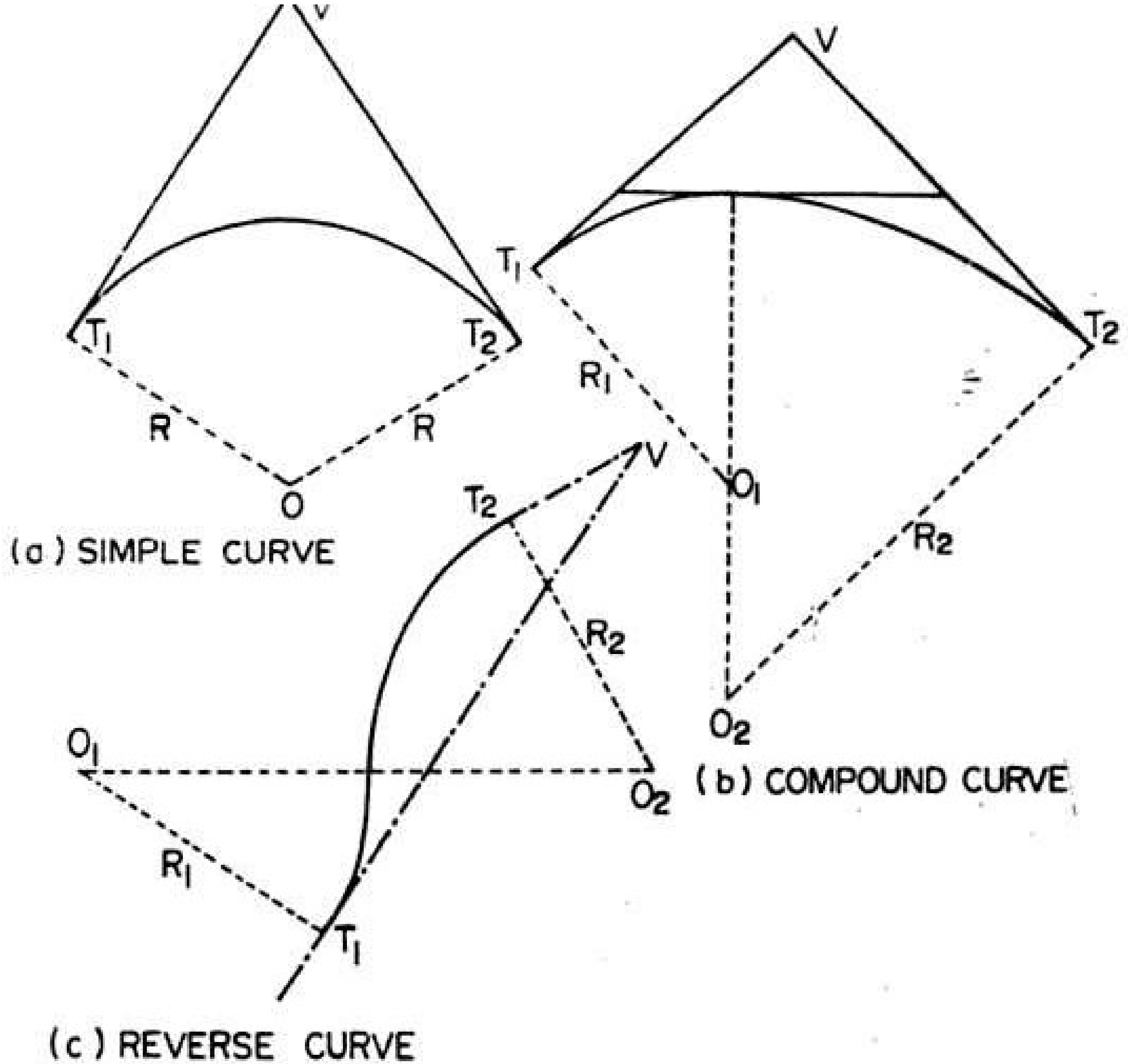
SURVEYING
Simple Circular Curves

Department of **CIVIL ENGG.**

ypes of Curves:





(a) SIMPLE CURVE

(b) COMPOUND CURVE

(c) REVERSE CURVE

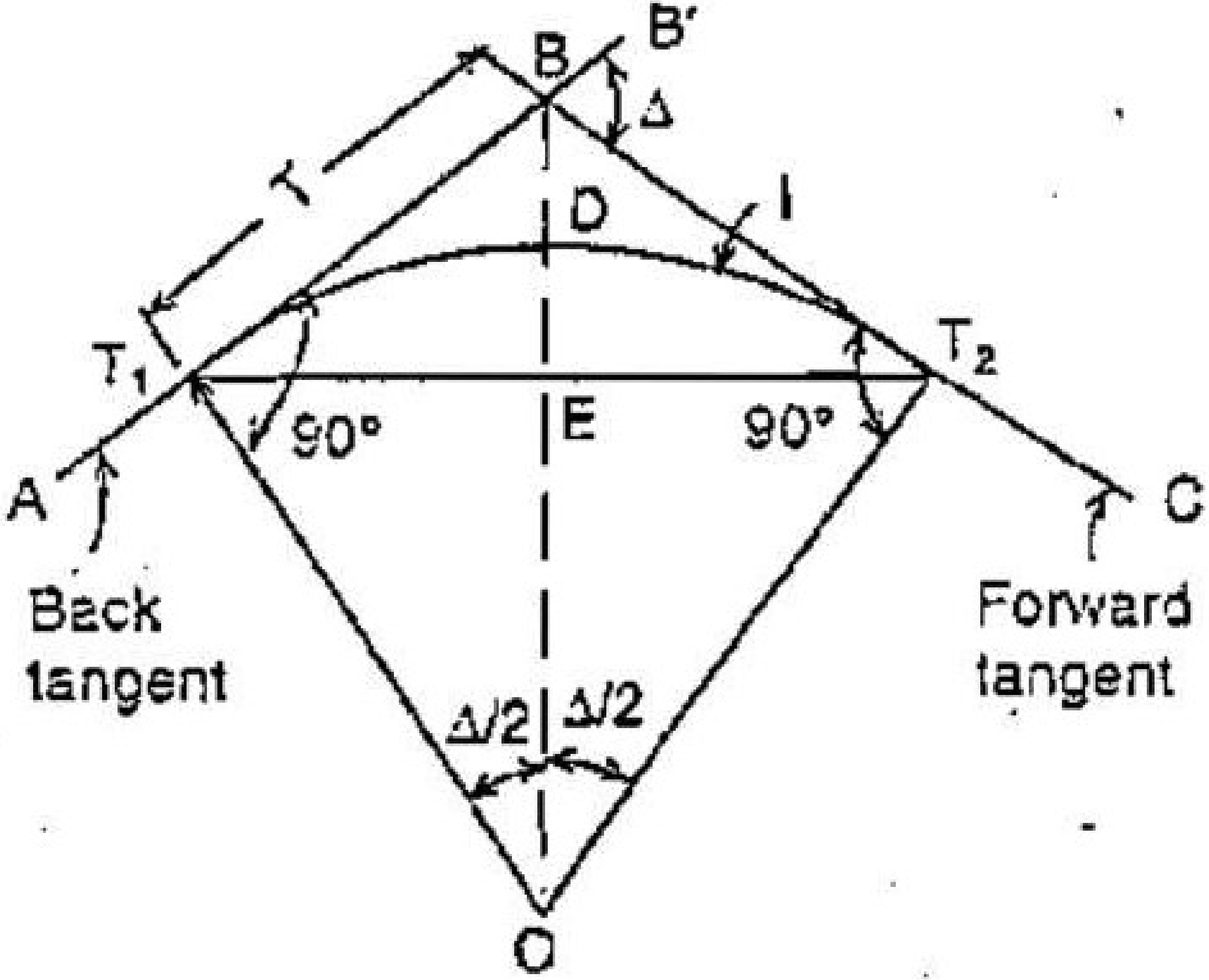


Fig. 12.1 Basic elements of a curve.

esignation of a Curve:

A) Arc definition:

DR

R*D*$\frac{\pi}{180}$

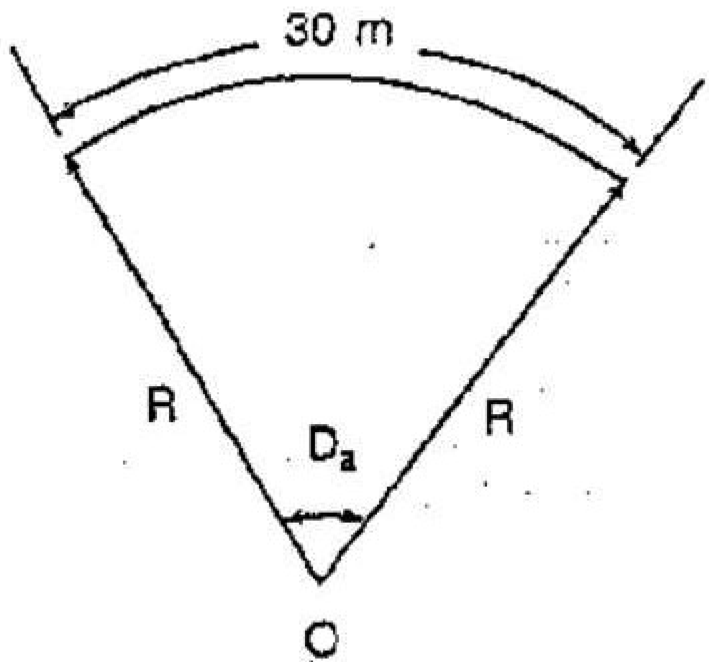
$\frac{L*180}{D*\pi}$

L=20m

(1145.92/D)

L=30m

(1718.87/D)



esignation of a Curve:

B) Chard definition:

Sin $\frac{D}{2} = \frac{L/2}{R}$

Small angle Sin $\frac{D}{2} = \frac{D}{2}$

$\frac{D}{2} * \frac{\pi}{180} = \frac{L/2}{R}$

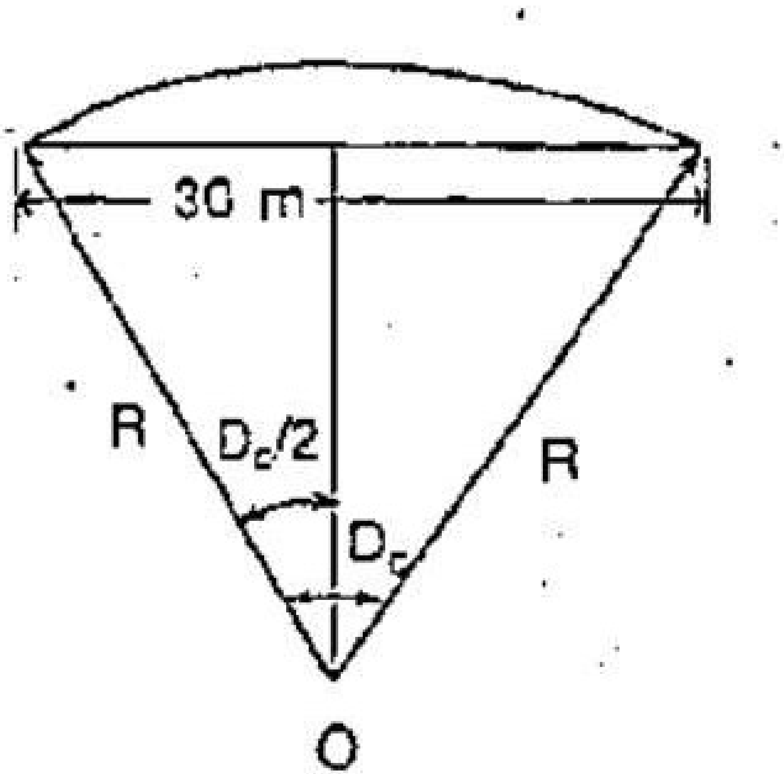
R=$\frac{L*180}{D*\pi}$

If L=20m

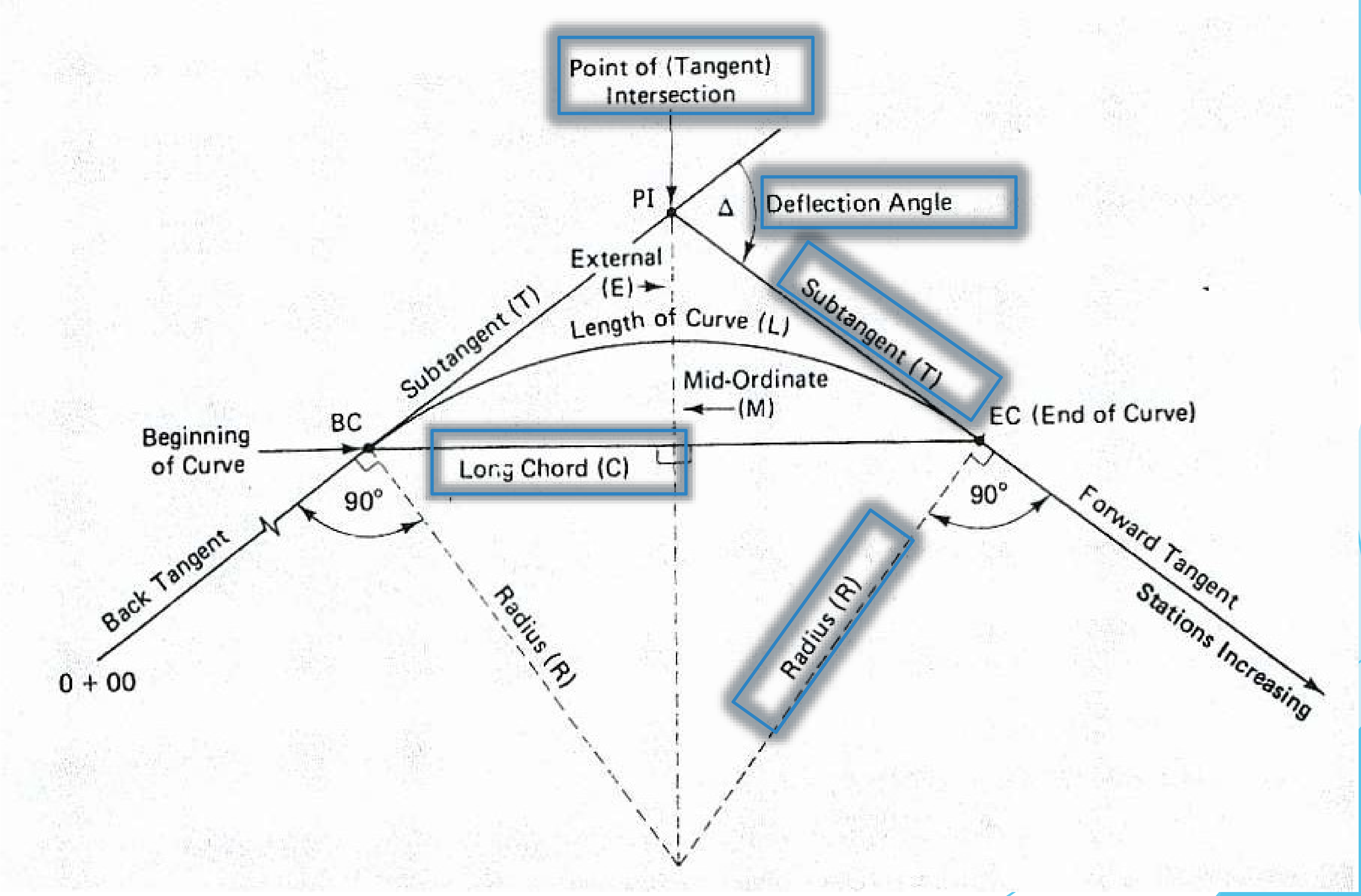
R=(1145.92/D)

If L=30m

R=(1718.87/D)



Circular Curve Geometry



Tangent: In triangle BC–O–PI,

$$\frac{T}{R} = \tan\frac{\Delta}{2}$$

$$T = R\tan\frac{\Delta}{2}$$

rd: In triangle BC–O–B,

$$\frac{1/2C}{R} = \sin\frac{\Delta}{2}$$

$$C = 2R\sin\frac{\Delta}{2}$$

Aidordinate:

$$\frac{\text{OB}}{R} = \cos\frac{\Delta}{2}$$

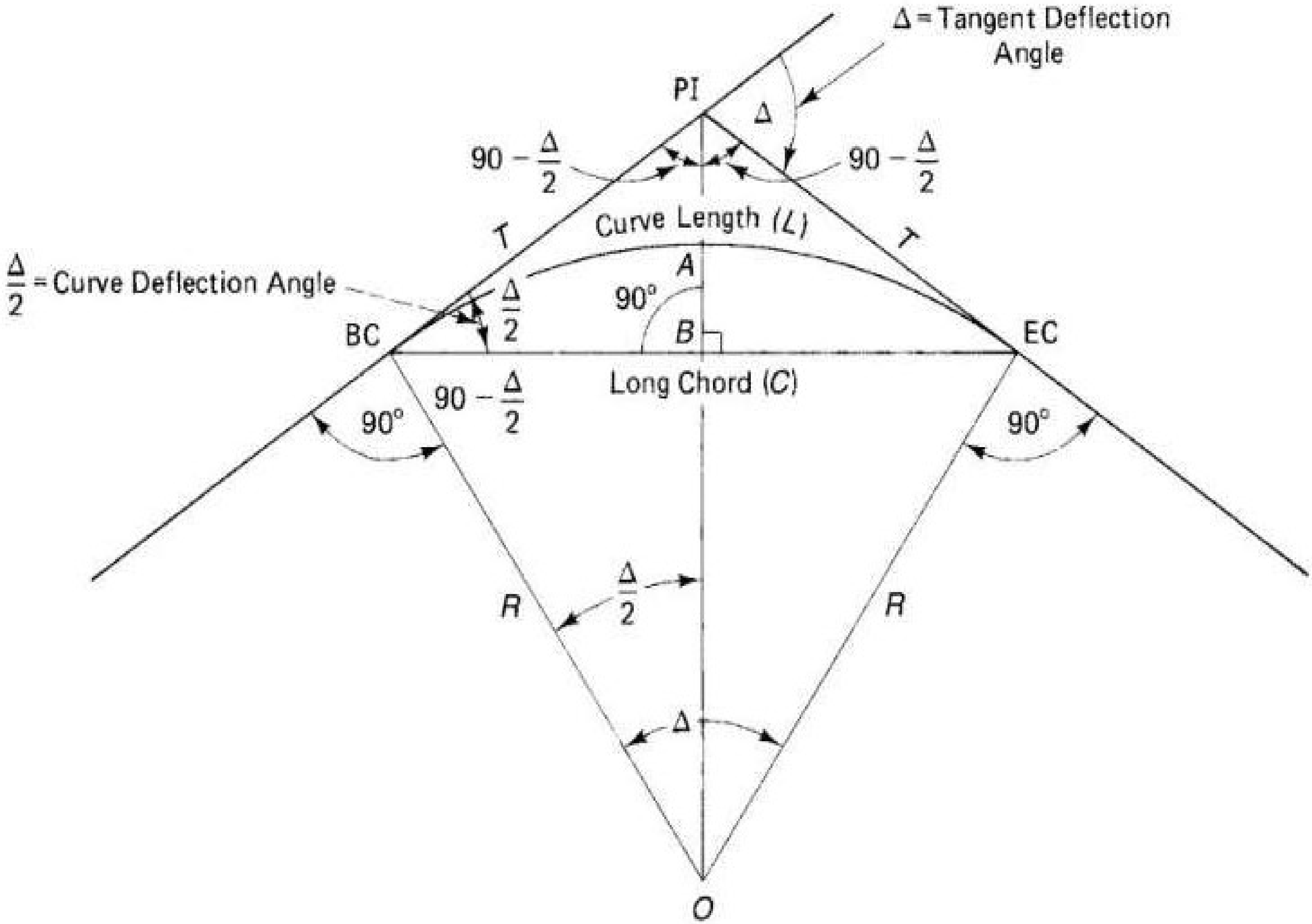
$$\text{OB} = R\cos\frac{\Delta}{2}$$

But:

$$\text{OB} = R - M$$

$$R - M = R\cos\frac{\Delta}{2}$$

$$M = R\left(1 - \cos\frac{\Delta}{2}\right)$$



Δ = Tangent Deflection Angle
PI
Δ
90 − Δ/2
90 − Δ/2
Curve Length (L)
T
T
Δ/2 = Curve Deflection Angle
A
Δ/2
90°
BC
B
EC
Long Chord (C)
90 − Δ/2
90°
90°
R
Δ/2
R
Δ
O

ternal: In triangle BC–O–PI, O–PI = $R + E$:

$$\frac{R}{(R + E)} = \cos\frac{\Delta}{2}$$

$$E = R\left(\frac{1}{\cos\frac{\Delta}{2}} - 1\right)$$

$$= R\left(\sec\frac{\Delta}{2} - 1\right) \quad \text{(alternate)}$$

ethods of setting out simple ircular curve

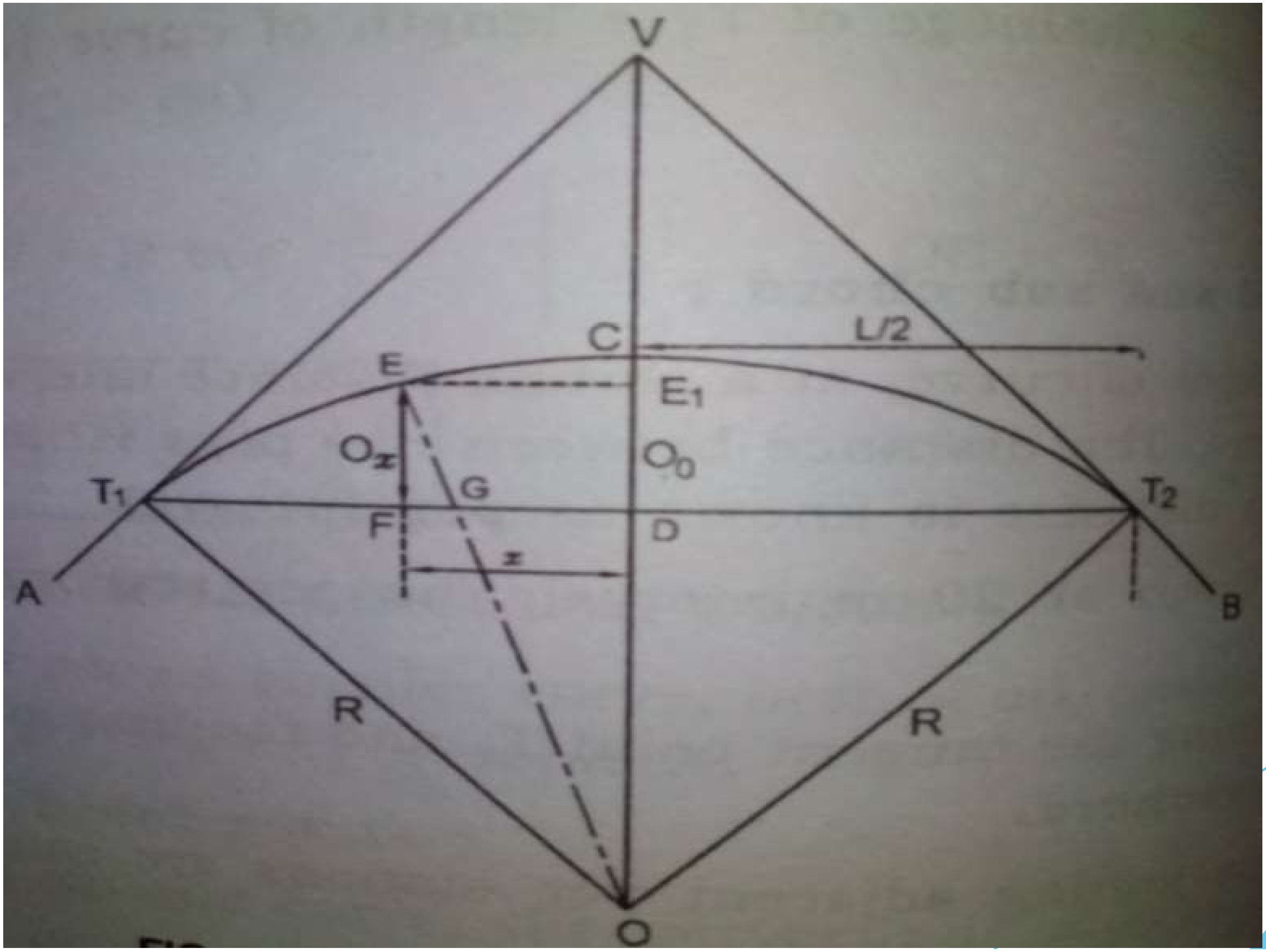
sed on the instruments used in setting out the curves on the ground there are o methods:

- Linear method
- Angular method

inear Method

- In these methods only tape or chain is used for setting out the curve . Angle measuring instrument are not used.
- Main linear methods are
- By offsets from the long chord.
- By successive bisection of arcs.
- By offsets from the tangents.

By offsets from the long chord



= Radius of the curve

= Mid ordinate

= ordinate at distance x from the mid point

of the chord

and T2 = Tangent point

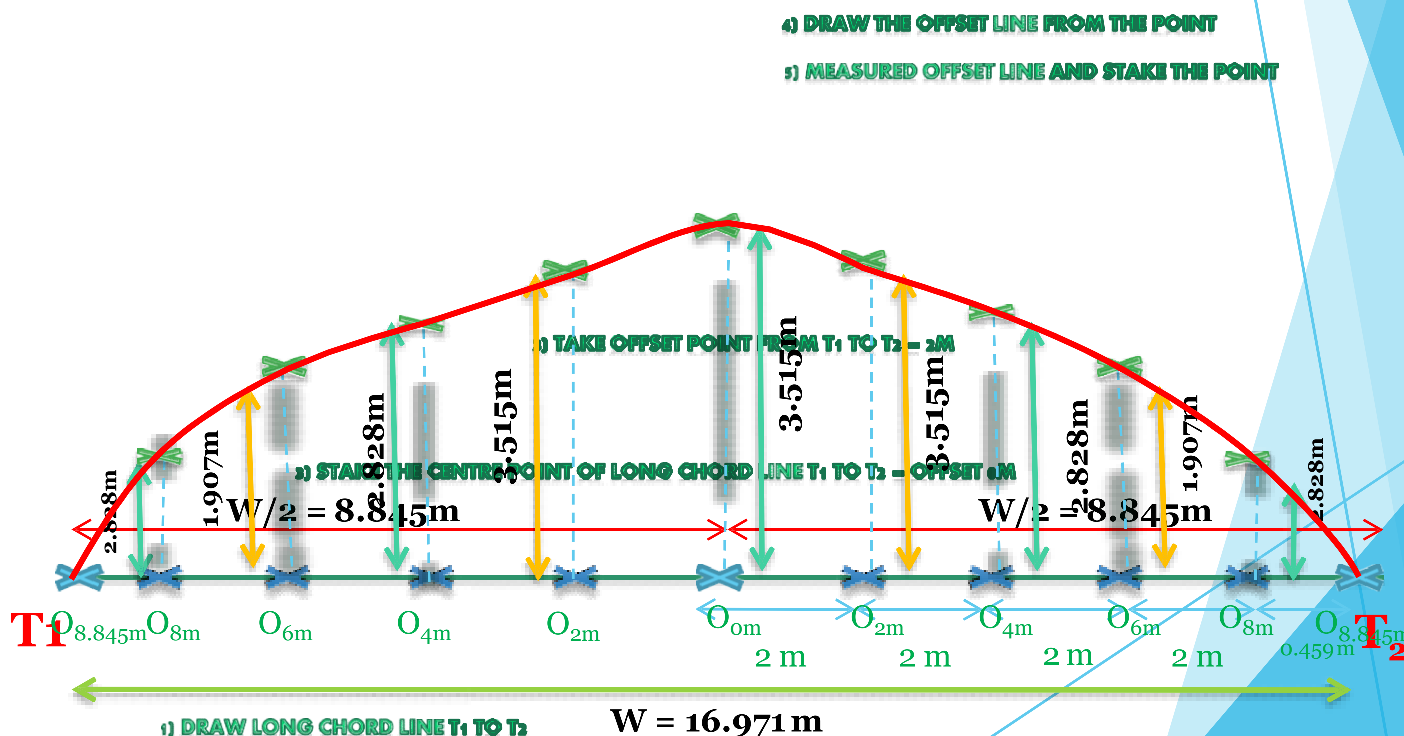
$$o = R - \sqrt{R^2 - \left(\frac{L}{2}\right)^2}$$

$$x = \sqrt{(R^2 - x^2)} - (R - 0o)$$

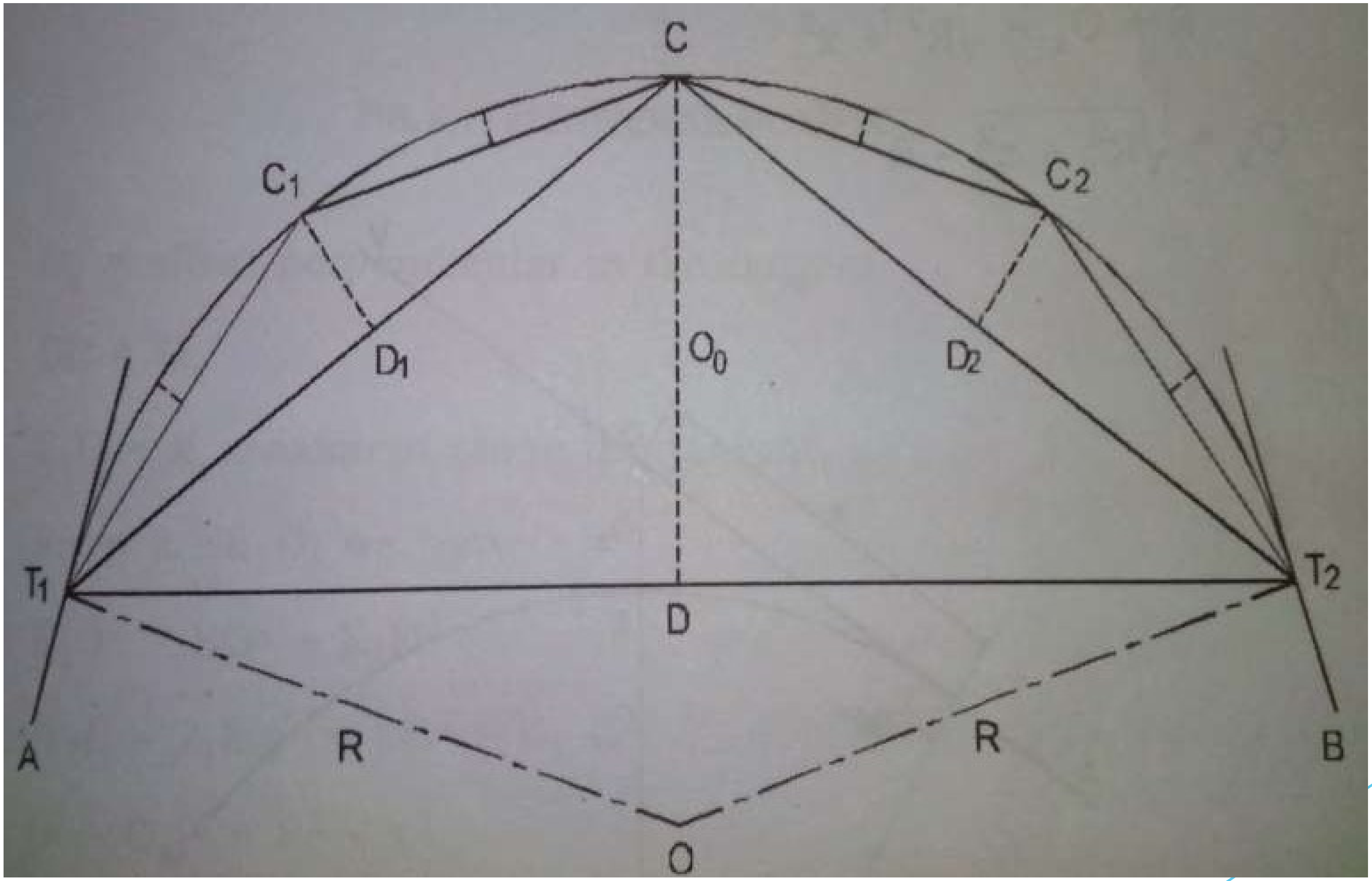
g chord length = 16.971
= 8.845m
set interval = 2 m

ffset, 0x	$(R^2 - x^2)$ - (R - 0o)
0	3.515
2	3.347
4	2.828
6	1.907
8	0.459
.485	0.000

Scale
1m : 1cm
1:100



By successive bisection of arcs



Join the tangent points T1,T2 and bisect the long chord at D.

Erect perpendicular DC at D equal to the mid ordinate.

Join T1C and T2C and bisect them at D1 and D2 respectively.

D1 & D@ set out perpendicular offsets C1D1=C2D2=(1- $\cos\frac{\Delta}{4}$) and obtain points C1 and C2 on the curve.

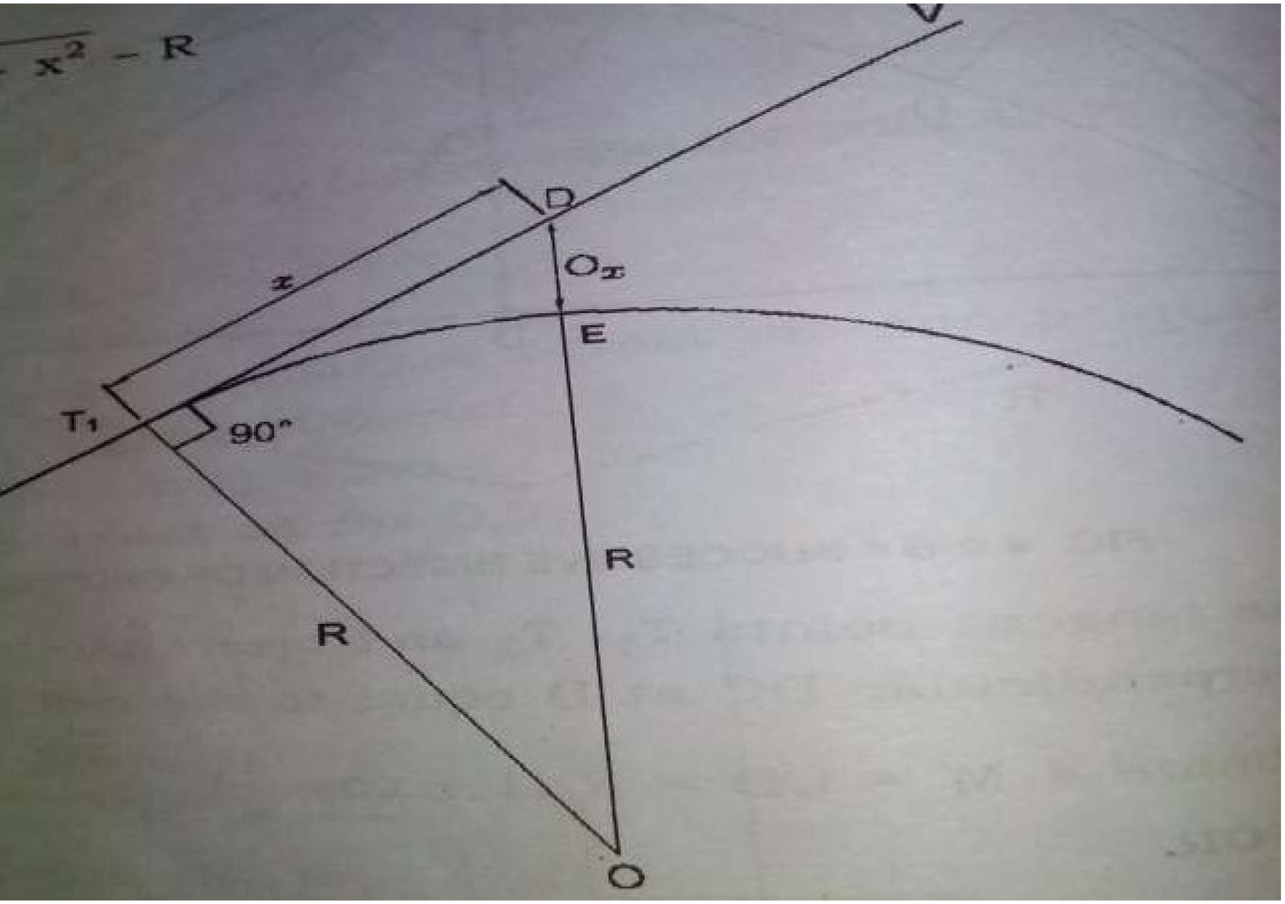
offsets from the tangents

The offsets from the tangents can be of two types

) Radial offsets

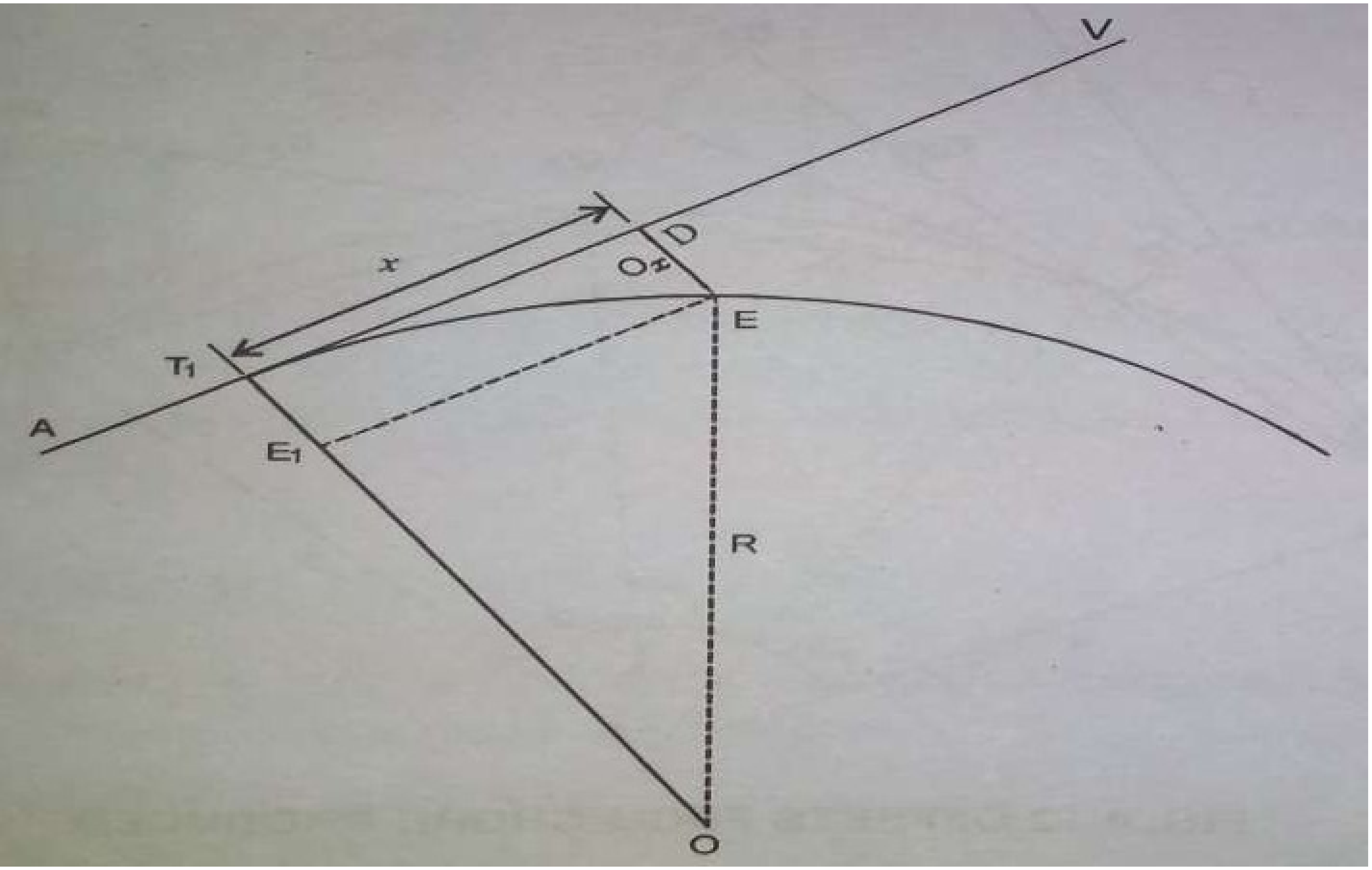
) Perpendicular offsets

) Radial offsets



$0x = \sqrt{R^2 + x^2} - R$

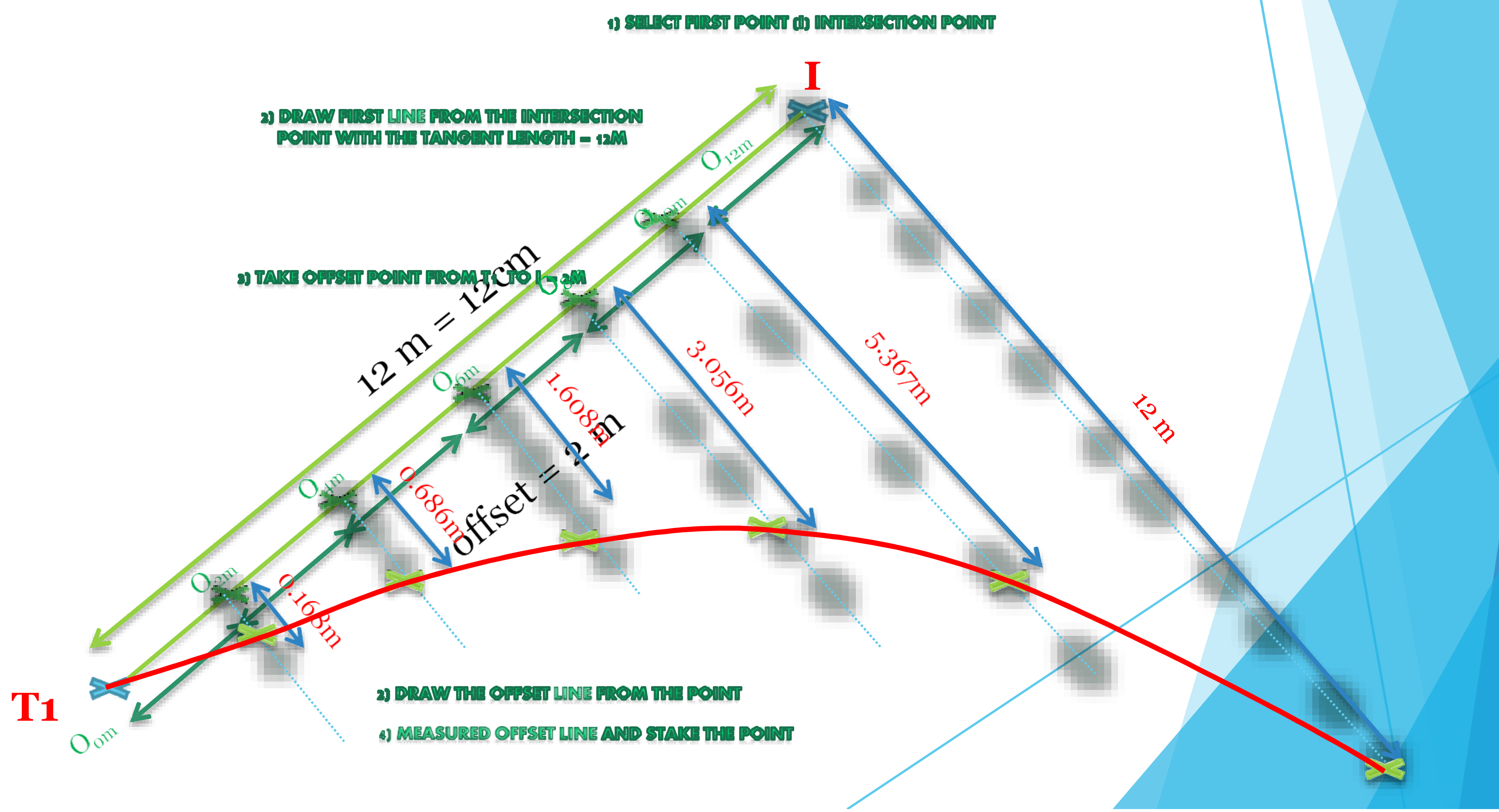
) Perpendicular offsets



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

nt length = 12m
= 2 m

R --	$R^2 - x^2$
	0.000
	0.168
	0.686
	1.608
	3.056
	5.367
	12.000



ngular Method

This methods are used when the length of curve is large.

The Angular methods are:

- Rankine method of tangential angles
- Two theodolite method
- Tacheometric method

Rankine method of tangential angles

this method also known as Tape and Theodolite method

"A deflection angle to any point on the curve is the angle at p.c. between the back tangent and the chord from p.c. to that point."

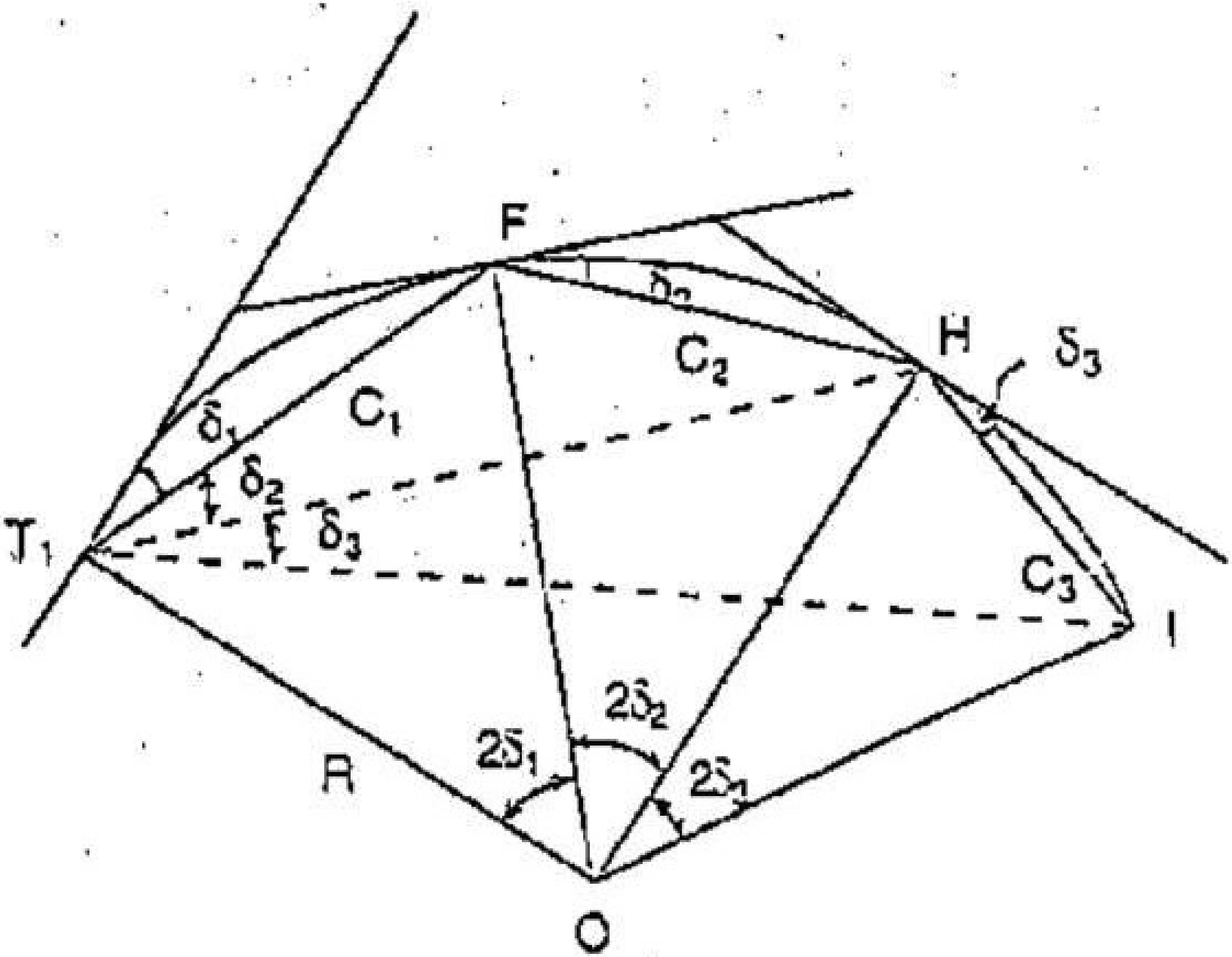
$$C_1 = 2\delta_1 R$$

$$\delta_1 = \frac{C_1}{2R} \text{ radian}$$

$$= \frac{C_1}{2R} \cdot \frac{180^\circ}{\pi}$$

$$= \frac{C_1}{2R} \cdot \frac{180 \times 60}{\pi} \text{ minute}$$

$$= 1718.87 \frac{C_1}{R} \text{ minute}$$



$$\delta_2 = 1718.87\,\frac{C_2}{R}\ \text{minute}$$

$$\Delta_3 = \delta_1 + \delta_2 + \delta_3$$

...

$$\Delta_n = \delta_1 + \delta_2 + \delta_3 + \ldots + \delta_n$$

Radius, R	24.7m
Deflection angle , θ	60^0
Offset	5m
Chainage intersection point, I	20 m

Tangent length = 14.261m

Chainage T_1 = 5.739m

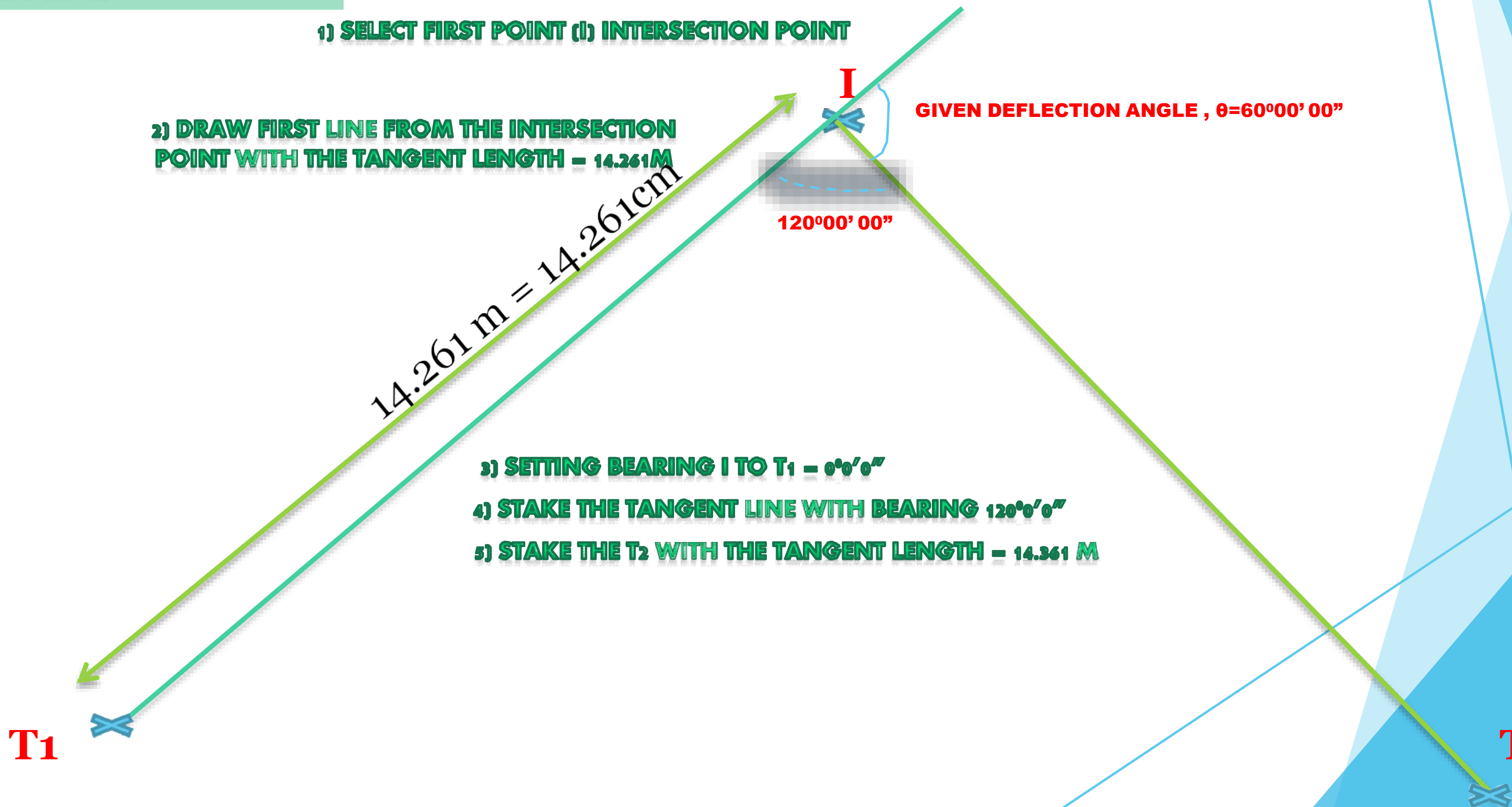
Arc length = 25.866m

Chainage T_2 = 31.605m

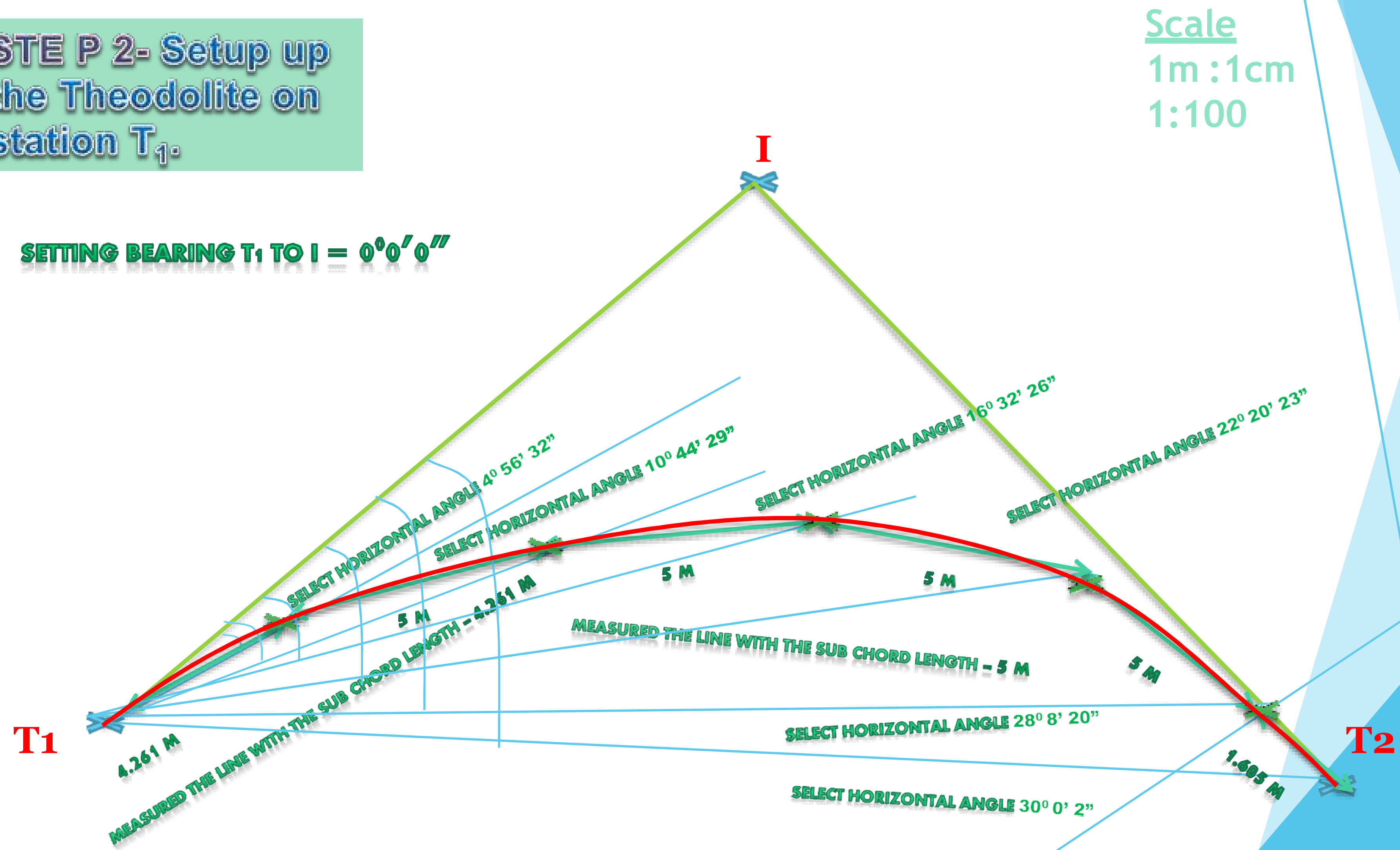
Stn.	Chainage	Chord length, C	Deflection angle, δ	Setting out angle, δ
T1	**5.739**	**0**	**0^0 0' 0"**	**0^0 0' 0"**
δ1	**10**	**4.261**	**4^0 56' 32"**	**4^0 56' 32"**
δ2	**15**	**5.000**	**5^0 47' 57"**	**10^0 44' 29"**
δ3	**20**	**5.000**	**5^0 47' 57"**	**16^0 32' 26"**
δ4	**25**	**5.000**	**5^0 47' 57"**	**22^0 20' 23"**
δ5	**30**	**5.000**	**5^0 47' 57"**	**28^0 8' 20"**
T2	**31.605**	**1.605**	**1^0 51' 42"**	**30^0 0' 2"**
		Σ = 25.866	**Σ = 30^0 00' 2"**	**θ / 2 = 60^0 / 2 = 30^0**

STE P 1- Setup up the Theodolite on station I.

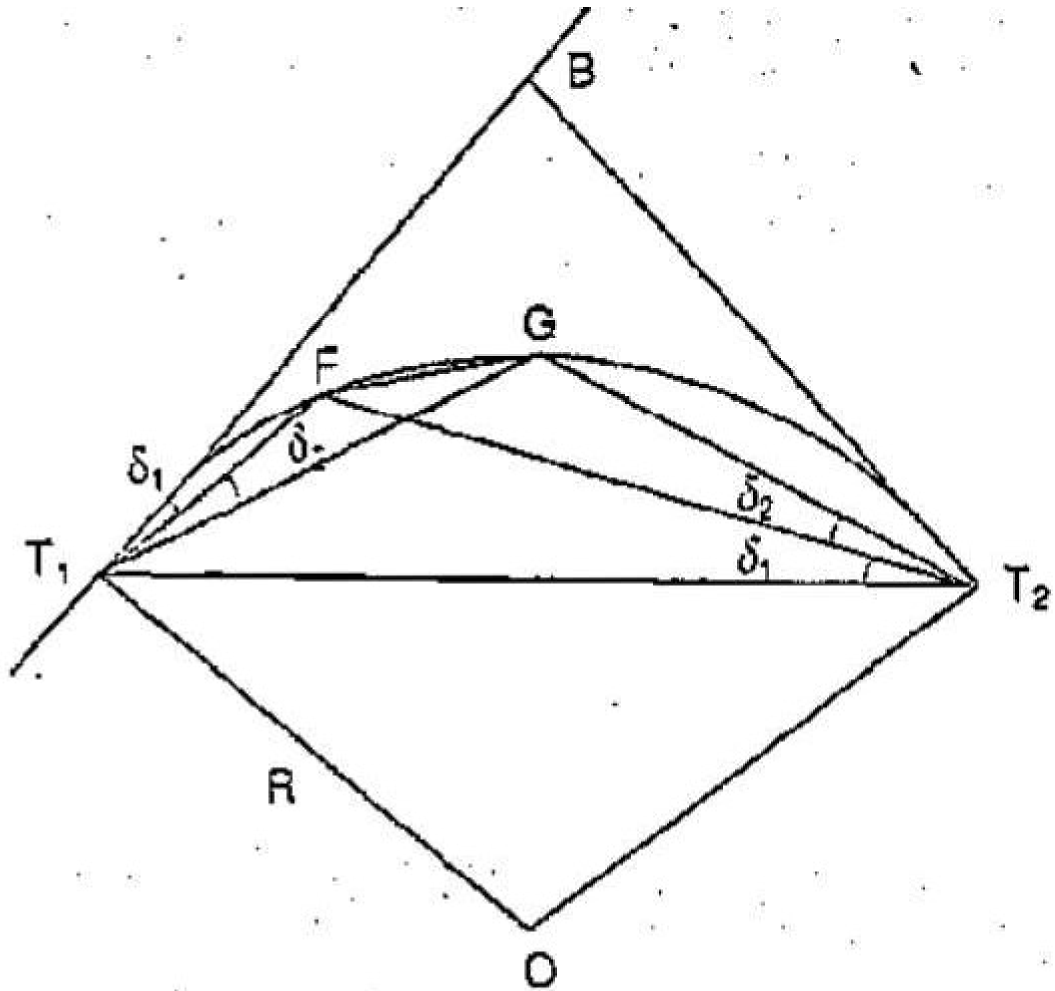
Scale
1m :1cm
1:100

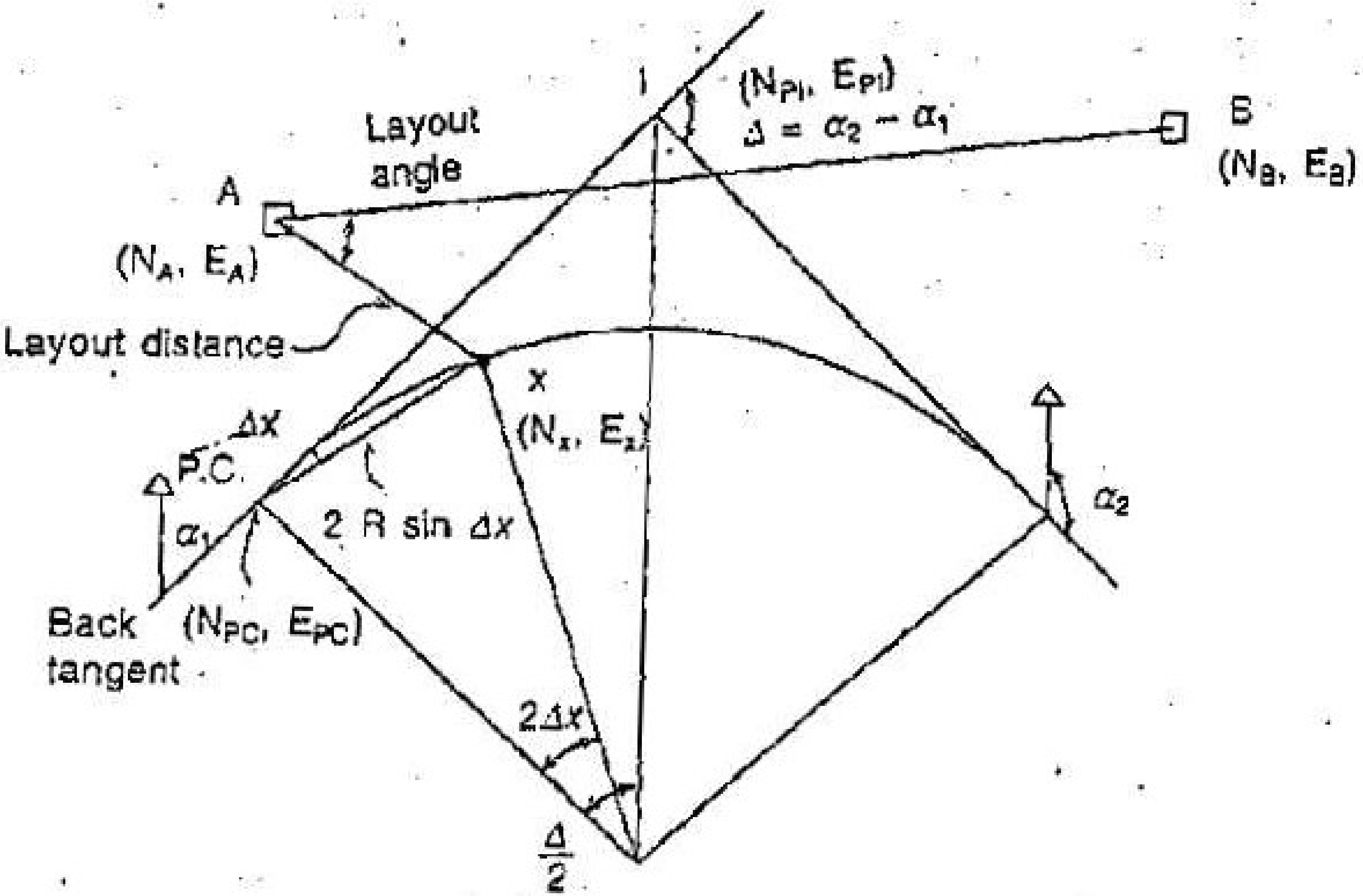


STE P 2- Setup up the Theodolite on station T_1.



Two theodolite Method





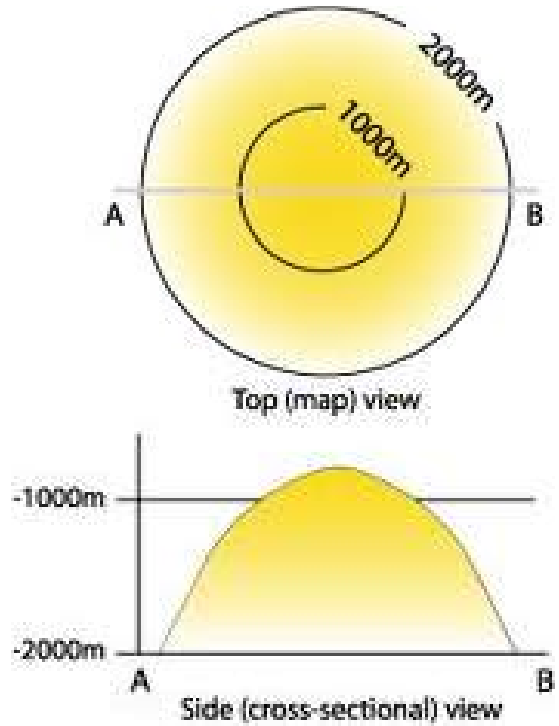
I
(N_{PI}, E_{PI})
$\Delta = \alpha_2 - \alpha_1$
B
(N_B, E_B)
Layout angle
A
(N_A, E_A)
Layout distance
x
(N_x, E_x)
Δx
P.C.
α_1
2 R sin Δx
α_2
Back tangent
(N_{PC}, E_{PC})
2Δx
$\frac{\Delta}{2}$

Thank You

CONTOURING

- **Contours**

A Contour is an imaginary line on the ground joining the points of equal elevation or reduced level.

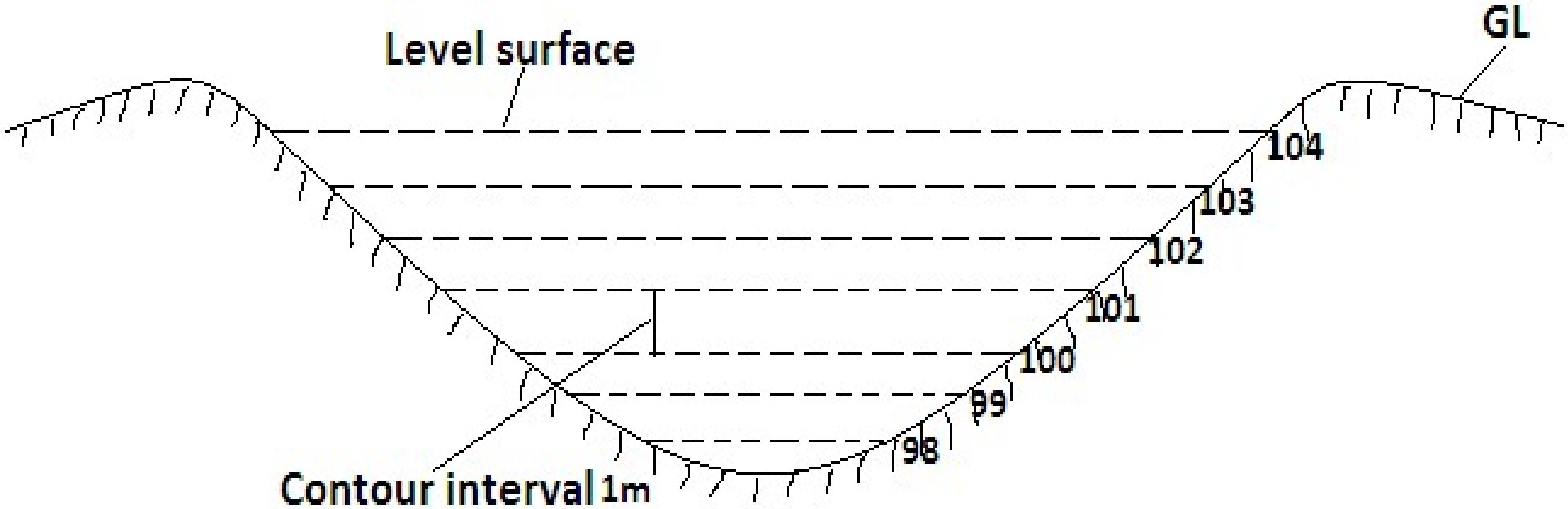


- **Contour line**

A contour line is a line on the map representing a contour.

Contour interval

The vertical distance between two successive contours is known as 'Contour interval'. It remains constant for a given map. The difference in R.L.'s of two contour gives contour interval.



COMMON VALUES OF THE CONTOUR - INTERVAL

i) For large scale maps of flat country, for building sites, for detailed design work and for calculation of quantities of earth work; 0.2 to 0.5 m.

ii) For reservoirs and town planning schemes;

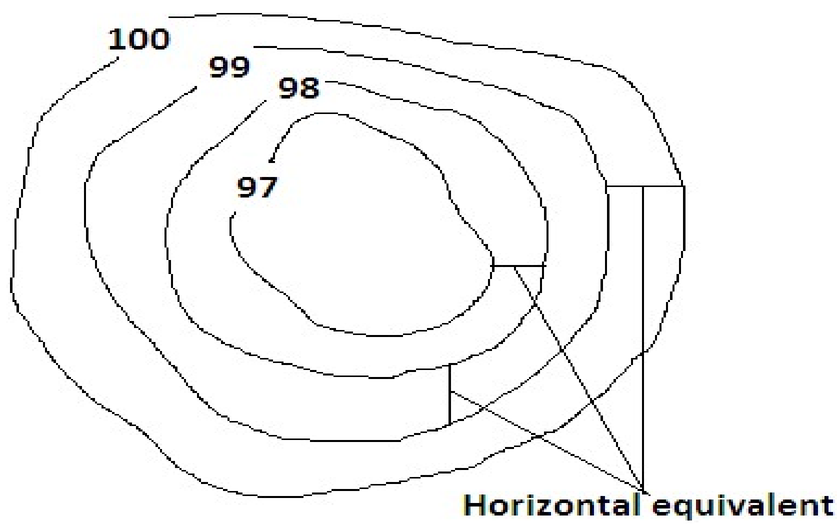
0.5 to 2m.

iii) For location surveys. 2 to 3m.

iv) For small scale maps of broken country and general topographic work; 3m,5m,10m,or 25m.

- **Horizontal equivalent**

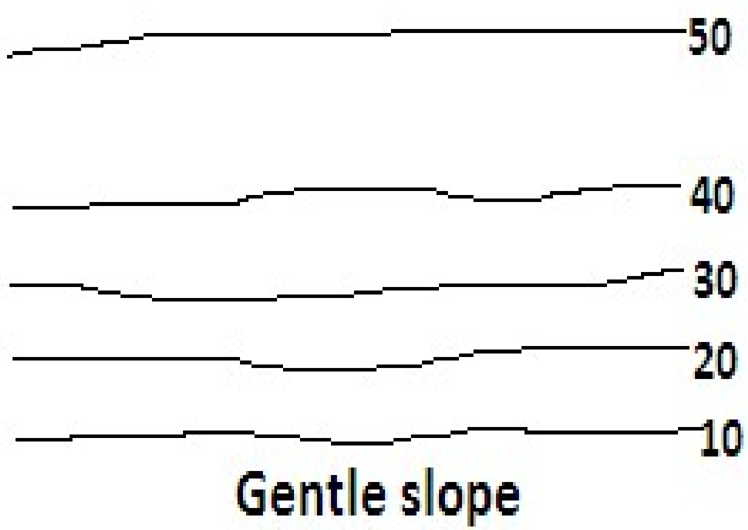
The horizontal distance between two successive contours is known as 'Horizontal equivalent'. It is not constant for a given map, it varies according to the steepness of the ground.

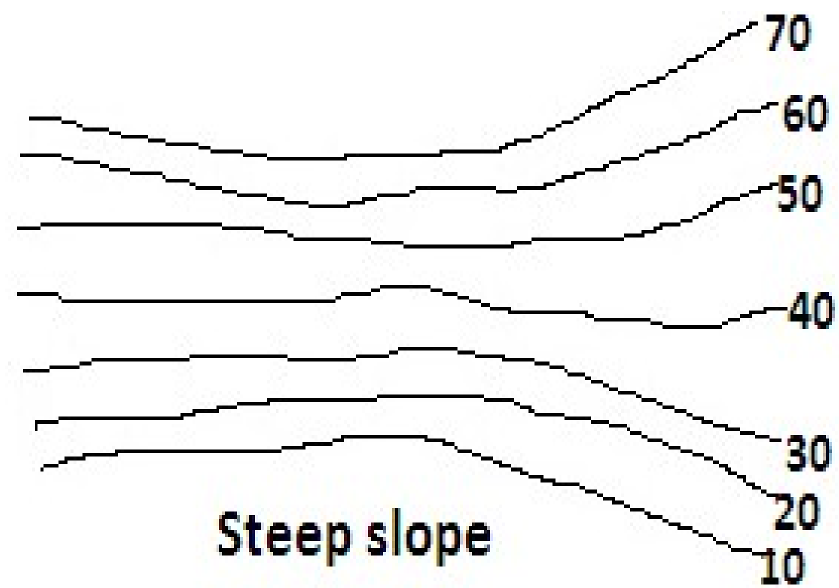


CHARACTERISTICS OF CONTOURS

i) All points in a contour line have the same elevation.

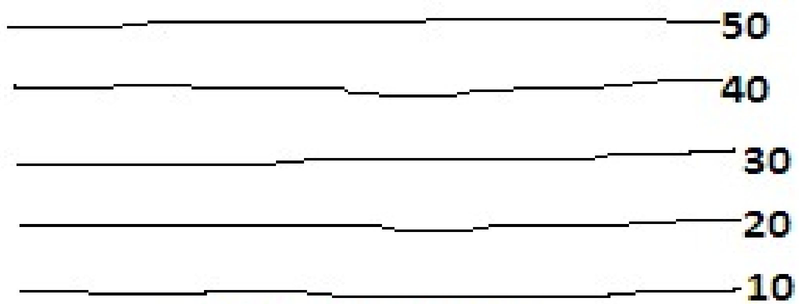
ii)Flat ground is indicated where the contours are widely separated and steep- slope where they run close together.





CHARACTERISTICS OF CONTOURS

iii) A uniform slope is indicated when the contour lines are uniformly spaced and



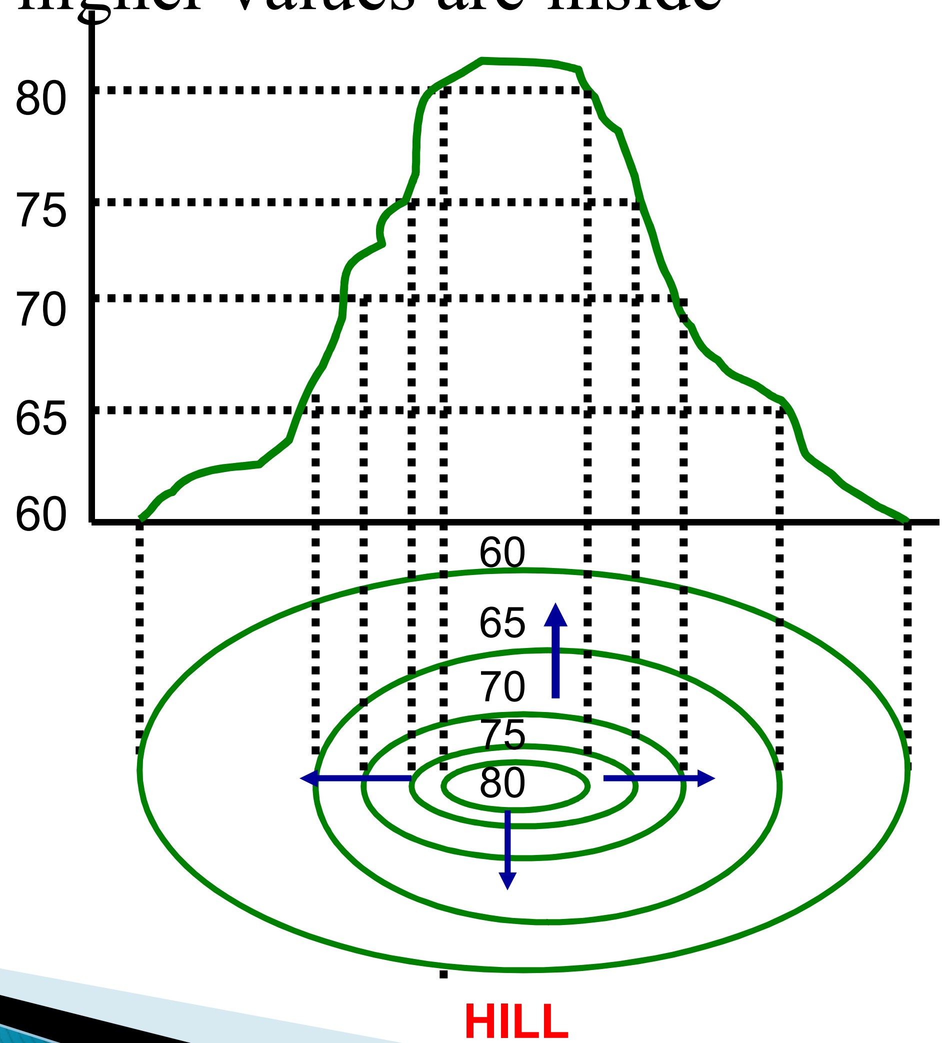
Uniform slope

iv) A plane surface when they are straight, parallel and equally spaced.

Plane surface

- **CHARACTERISTICS OF CONTOURS**

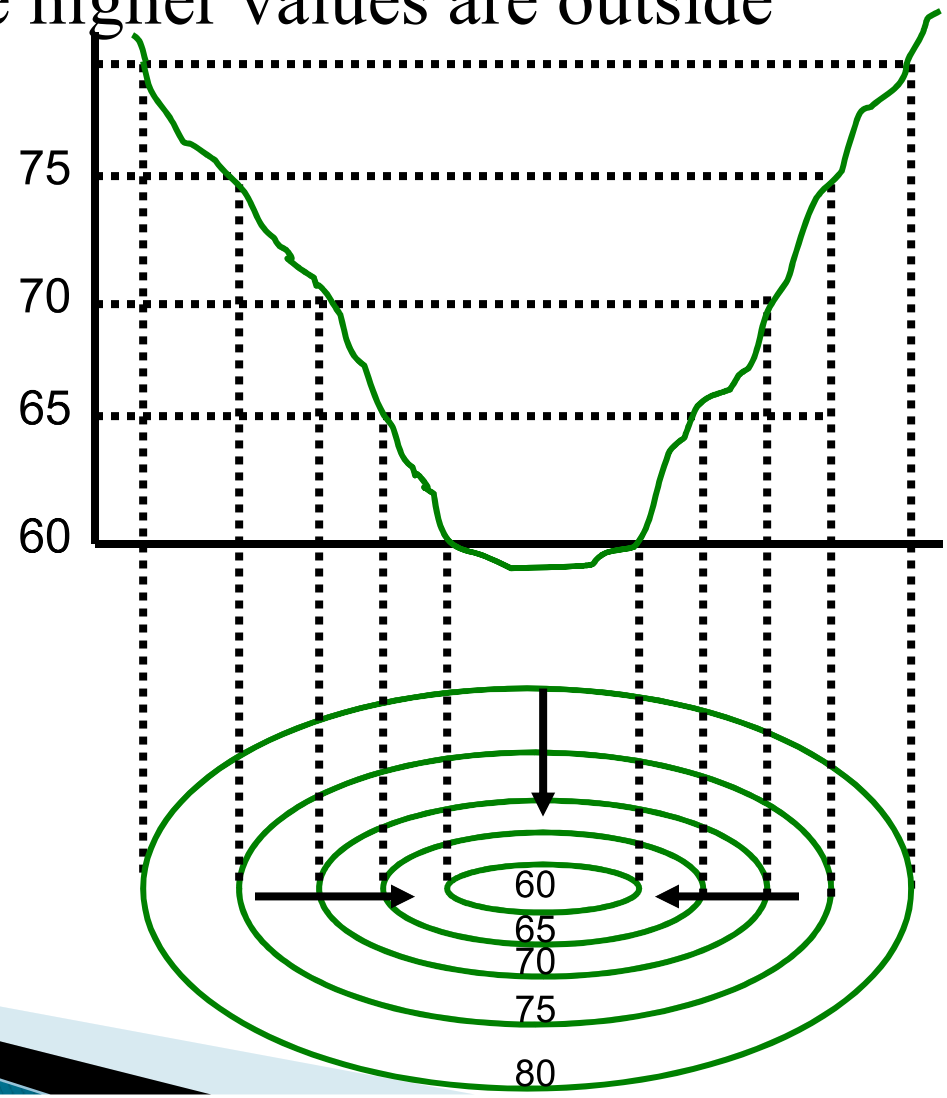
v) A series of closed contour lines on the map represent **a hill** , if the higher values are inside



CHARACTERISTICS OF CONTOURS

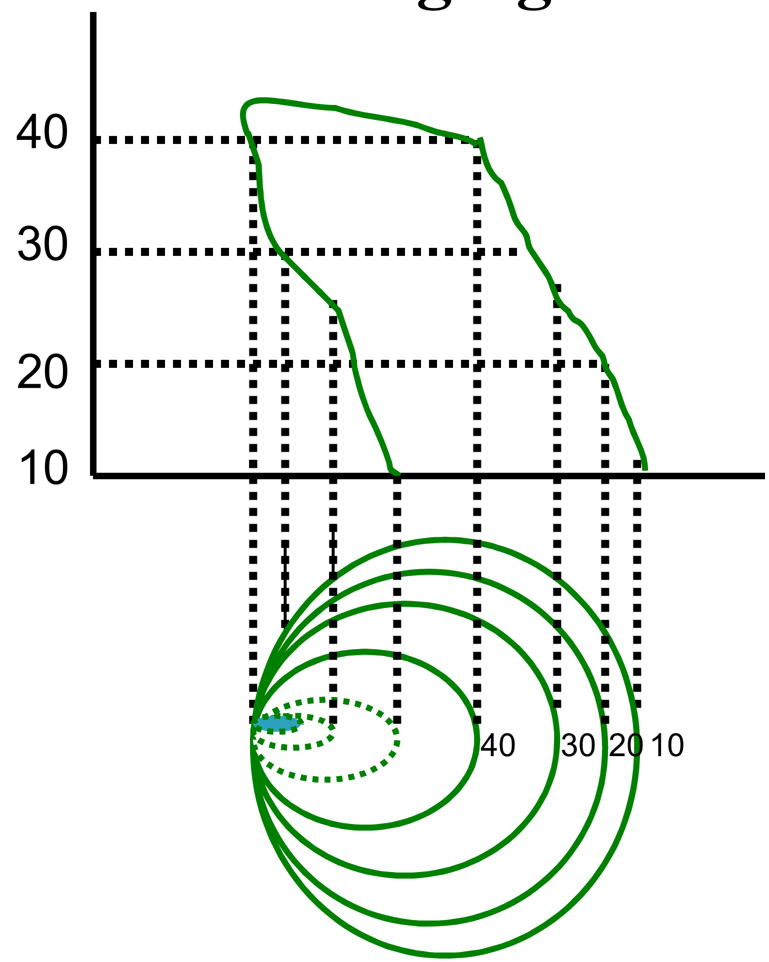
vi) A series of closed contour lines on the map indicate **a depression** if the higher values are outside

DEPRESSION



CHARACTERISTICS OF CONTOURS

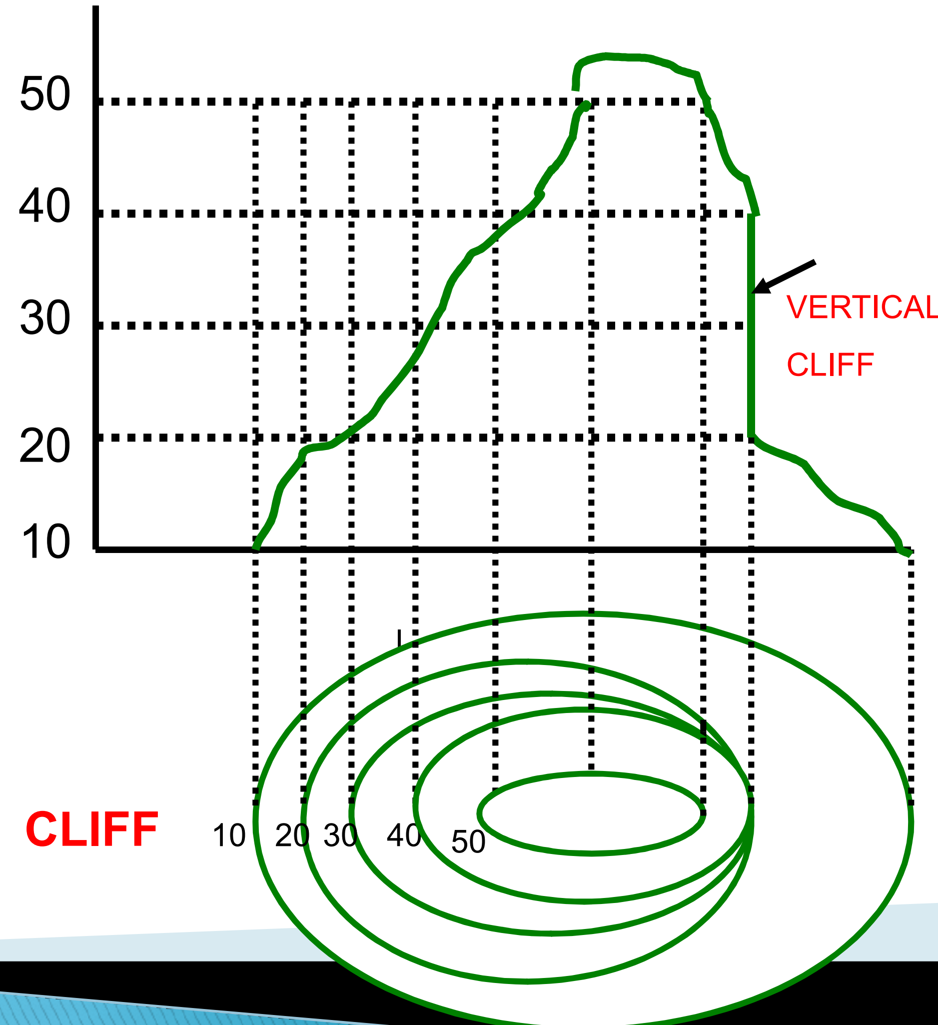
x) Contour lines cannot merge or cross one another on map except in the case of **an overhanging cliff.**



OVERHANGING CLIFF

CHARACTERISTICS OF CONTOURS

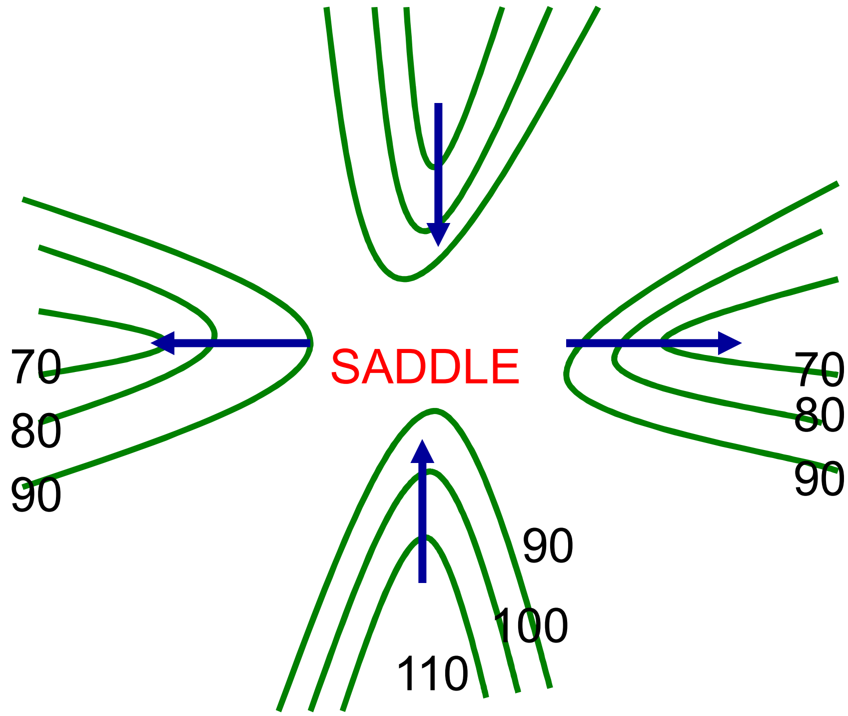
xi) Contour lines never run into one another except in the case of a vertical cliff. In this case ,several contours coincide and the horizontal equivalent becomes zero.



OVERHANGING CLIFF

CHARACTERISTICS OF CONTOURS

Xii) Depressions between summits is called **a saddle**. It is represented by four sets of contours as shown. It represents a dip in a ridge or the junction of two ridges.



METHODS OF CONTOURING

There are mainly two methods of locating contours:-

(1)Direct Method and

(2) Indirect Method.

a) by square method

b) by cross sections

c) by tacheometric method

INTERPOLATION OF CONTOURS

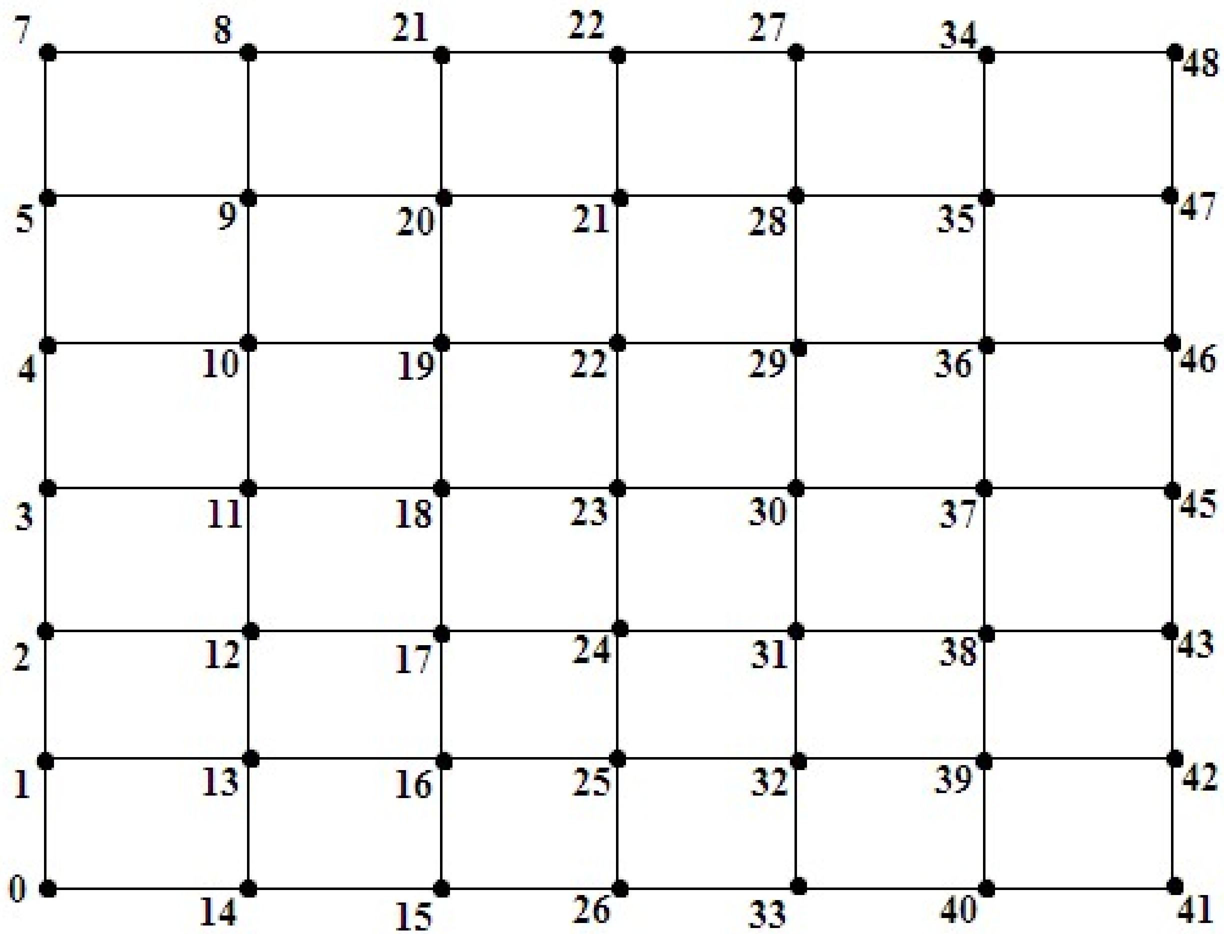
There are three main methods of interpolation:

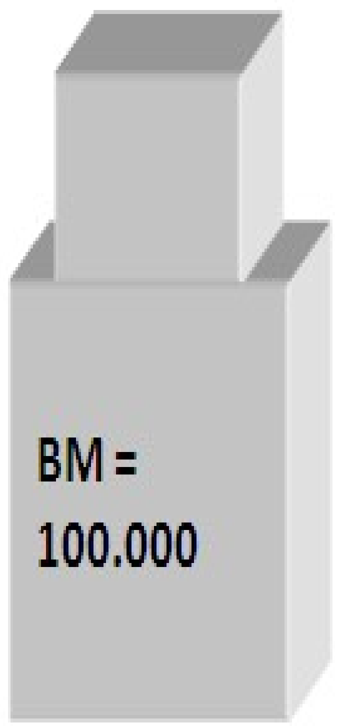
i) **By Estimation:-** The position of the contour points between ground - points are estimated roughly and the contours are then drawn through these points. This is a rough method and is suitable for small scale maps.

ii) **By arithmetical calculation:-** This is very tedious but accurate method and is used for small areas where accurate results are necessary. The contours are interpolated as under:

INTERPOLATION OF CONTOURS

ii) By arithmetical calculation:-

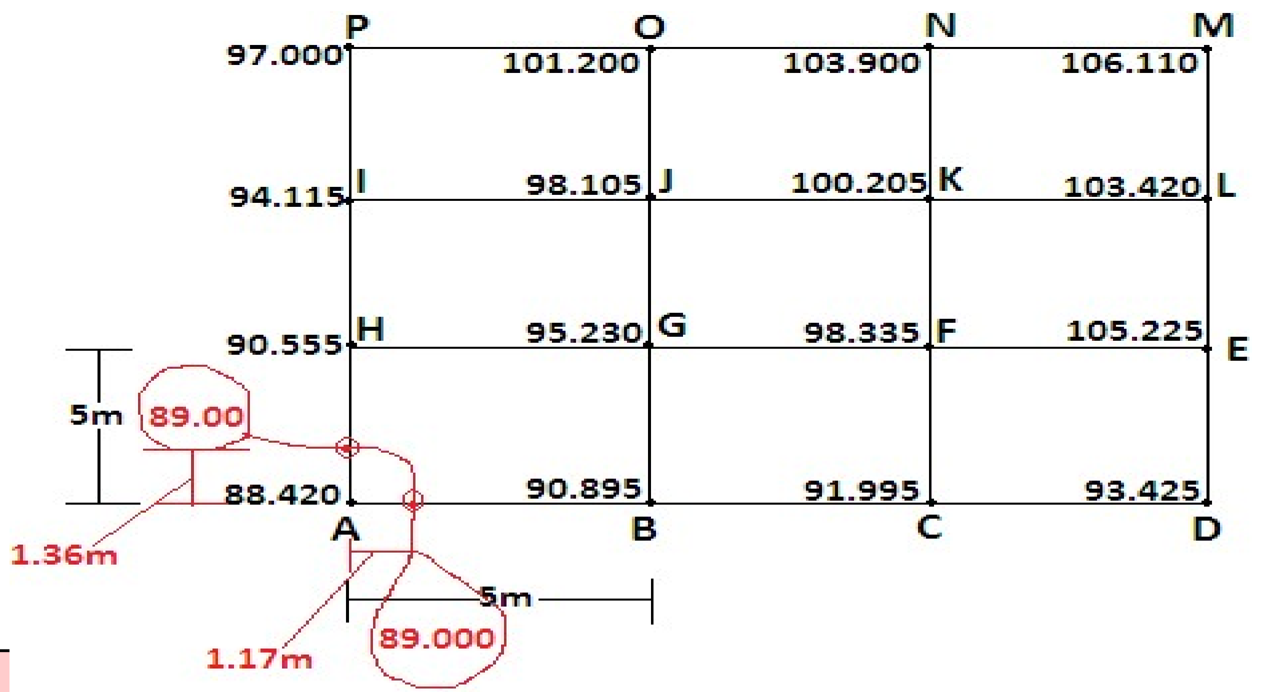




INTERPOLATION OF CONTOURS

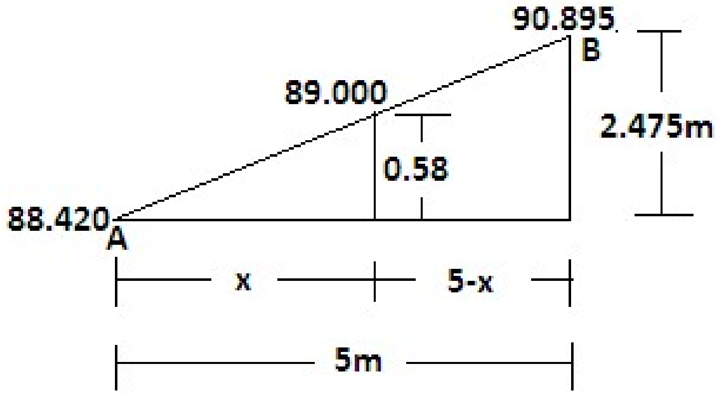
ii) By arithmetical calculation:-

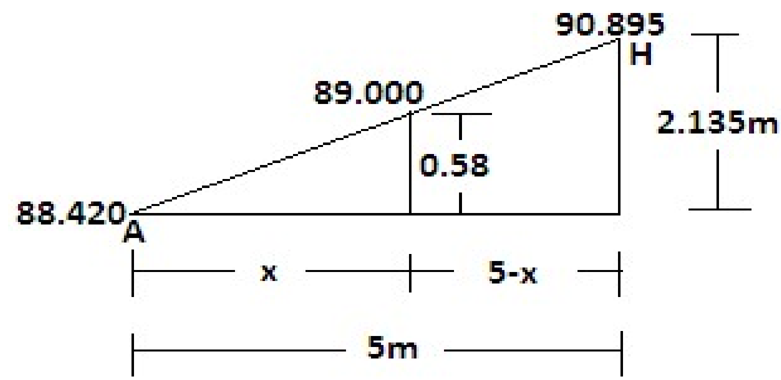
Now consider the ADMP is surveyed plot, then whole area is divided into no.of squares and RL are plotted at every spot. Then if the required contour is 89.000m, then consider small square ABGH.



INTERPOLATION OF CONTOURS

ii) By arithmetical calculation:-





Then the difference in elevation between A &B is (90.895 – 88.420 = 2.475m) in distance of 5m. Then by similar triangle method.

0.58/x = 2.475/5, x = 1.17m from point A.

Similarly of point A& H

0.58/x = 2.135/5, x = 1.358m from point A.

Then plot 89.000m contour by scale.

THEODOLITE TRAVERSING

INTRODUCTION

The system of surveying in which the angles are measured with the help of a theodolite, is called Theodolite surveying.

Theodolite is used to measure the horizontal and vertical angles.

Theodolite is more precise than magnetic compass.

Magnetic compass measures the angle up to as accuracy of 30’. However a vernier theodolite measures the angles up to and accuracy of 10’’, 20’’.

There are variety of theodolite vernier, optic, electronic etc.

USES OF THEODOLITE

- Measuring horizontal and vertical angles
- Locating points on a line
- Prolonging survey lines
- Finding difference of level
- Setting out grades
- Ranging curves
- Tachometric Survey
- Magnetic bearing (W.C.B.) measurement

DEFINITION

Centring

- The process of setting about the theodolite exactly over the station mark is known as centring.

Transiting

- The process of turning the telescope about its horizontal axis in a vertical plane through 180° is termed as transiting.

Face left

- If the vertical circle of the instrument is on the left side of the observer while taking a reading ,the position is called the face left.

Face right

- If the vertical circle of the instrument is on the right side of the observer while taking a reading ,the position is called the face right

DEFINITION

Changing face

- It is an operation of bringing the face of the telescope form left to right and vice versa.

Swinging the telescope

- It is the process of turning the telescope in horizontal plane.

Vertical axis

- The vertical axis is the axis about which the instrument can be rotation in a horizontal plane.

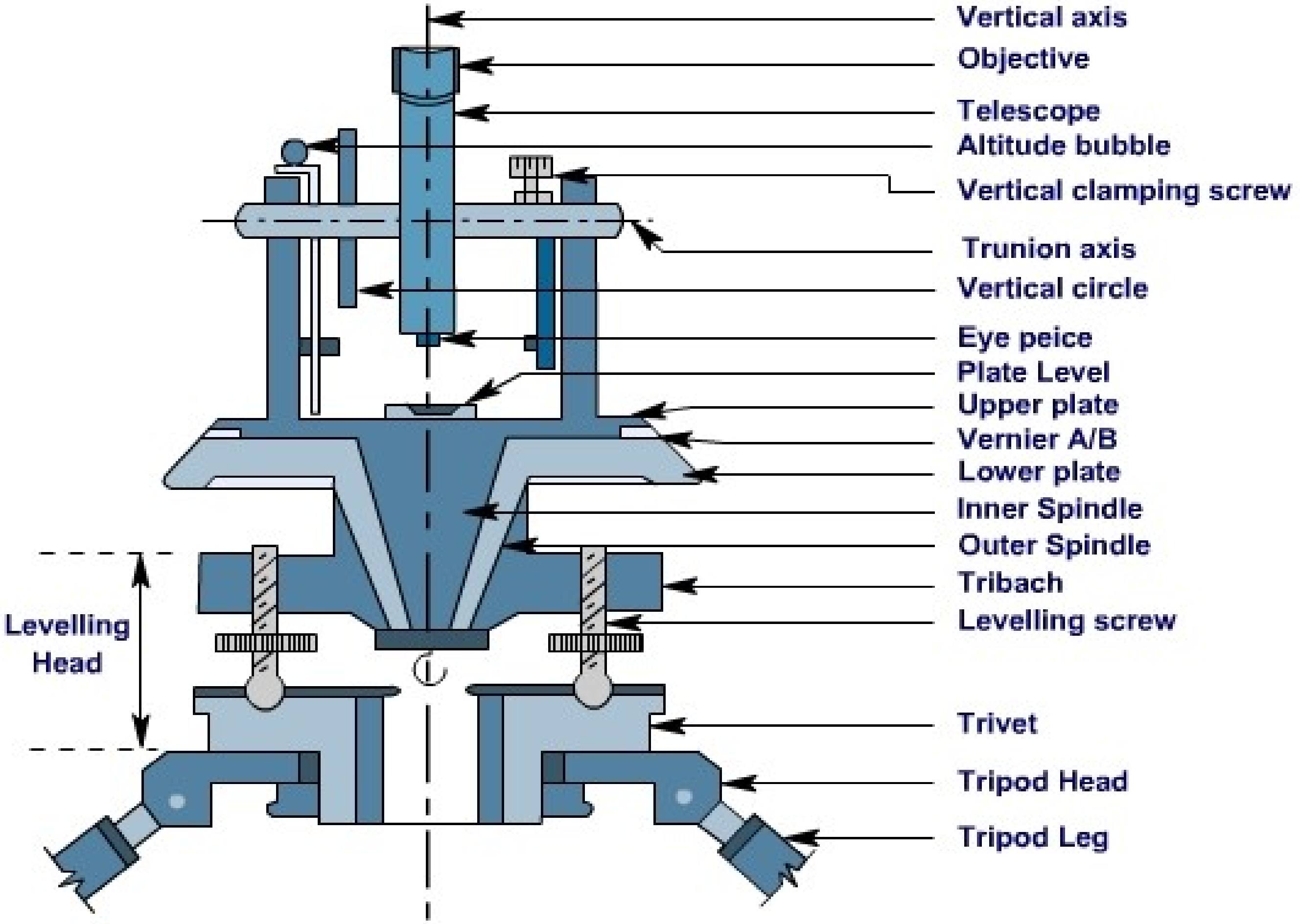
Line of collimation

- It is an imaginary line passing through the intersection of the cross hairs at the diaphragm and the optical centre of the object glass and its continuation.

Axis of the plate level

- It is the straight line tangential to the longitudinal curve of plate tube at its centre.

HE VERTICAL TRANSIT THEODOLITE



TEMPORARY ADJUSTMENT OF THEODOLITE

Before setting up the theodolite, it should be ensured that

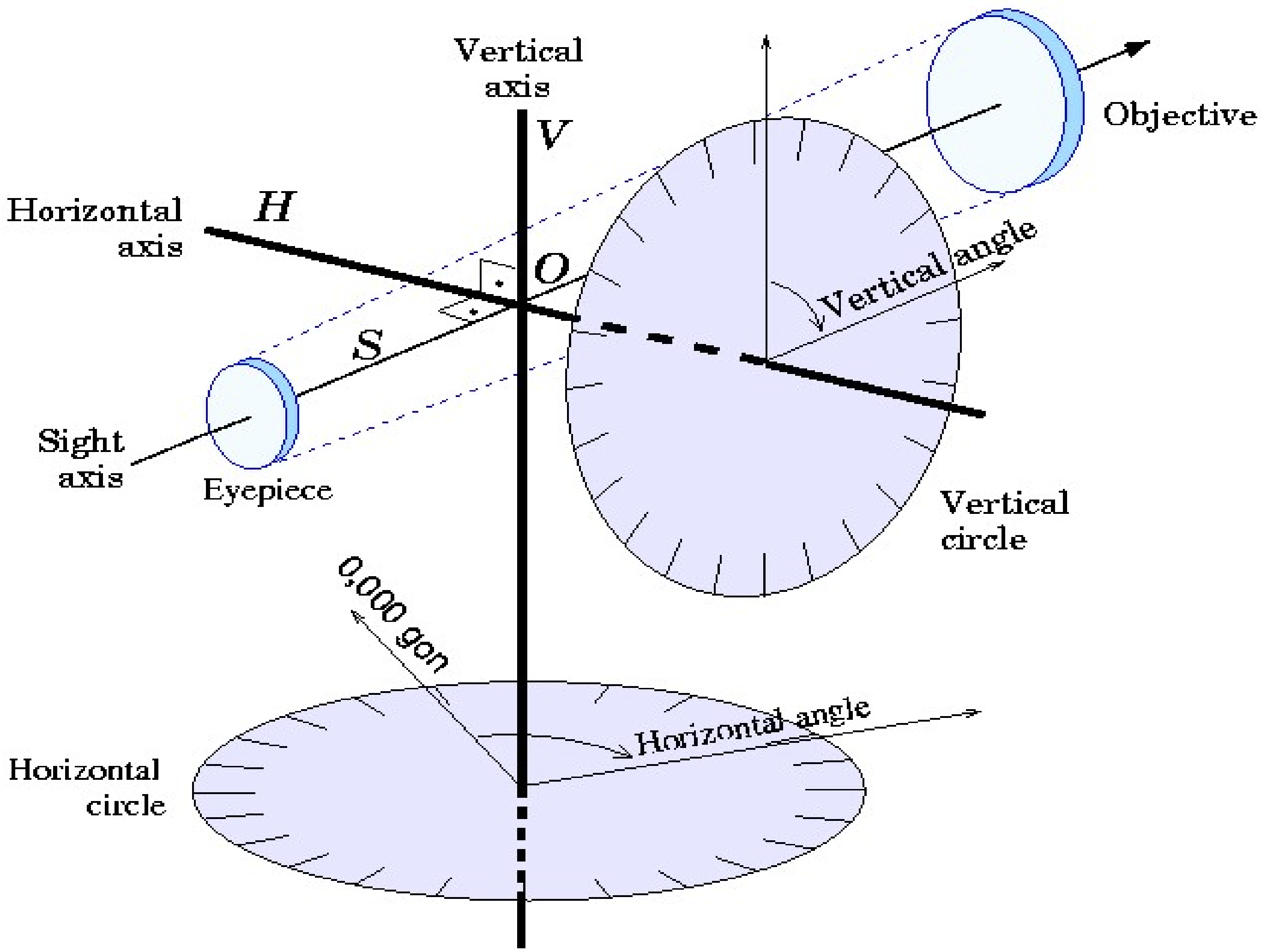
- The levelling screws are at the centre of their run.
- The shifting head of the theodolite is at its centre so that equal movement is possible in all the direction.
- The wing nuts on the tripod legs are tripod enough so that when raised, the tripod legs do not fall under their own weight.

TEMPORARY ADJUSTMENT OF THEODOLITE

Such adjustments involve the following steps

1) Setting up
2) Centring
3) Levelling up
4) Focusing the eye-piece
5) Focussing the object glass
6) Elimination of parallax

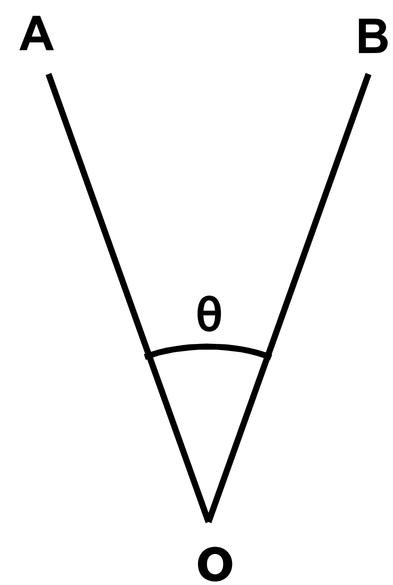
THE DESIRED RELATIONSHIPS



MEASURING HORIZONTAL ANGLE

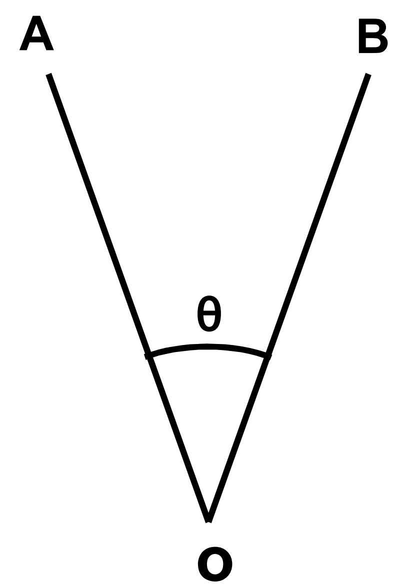
Ordinary Method To measure horizontal angle AOB

1) Set up the theodolite at station point O and level it accurately.
2) Set the vernier A to the zero or 360^0 of the horizontal circle. Tighten the upper clamp.
3) Loosen the lower clamp. Turn the instrument and direct the telescope towards A to bisect it accurately with the use of tangent screw. After bisecting accurately check the reading which must still read zero. Read the vernier B and record both the readings.
4) Loosen the upper clamp and turn the telescope clockwise until line of sight bisects point B on the right hand side. Then tighten the upper clamp and bisect it accurately by turning its tangent screw.



MEASURING HORIZONTAL ANGLE

- Read both verniers. The reading of the vernier a which was initially set at zero gives the value of the angle AOB directly and that of the other vernier B by deducting 180^0 .The mean of the two vernier readings gives the value of the required angle AOB.
- Change the face of the instrument and repeat the whole process. The mean of the two vernier readings gives the second value of the angle AOB which should be approximately or exactly equal to the previous value.
- The mean of the two values of the angle AOB ,one with face left and the other with face right ,gives the required angle free from all instrumental errors.



MEASURING HORIZONTAL ANGLE

There are two methods of measuring horizontal angles.

1) Repetition method
2) Reiteration method

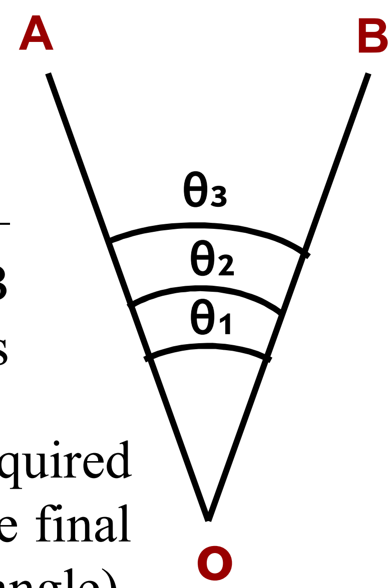
Repetition method

- This method is used for very accurate work. In this method ,the same angle is added several times mechanically and the correct value of the angle is obtained by dividing the accumulated reading by the no. of repetitions.
- The No. of repetitions made usually in this method is six, three with the face left and three with the face right .In this way ,angles can be measured to a finer degree of accuracy than that obtainable with the least count of the vernier.

MEASURING HORIZONTAL ANGLE

To measure horizontal angle by repetitions method

1) Set up the theodolite at starting point O and level it accurately.
2) Measure The horizontal angle AOB.
3) Loosen the lower clamp and turn the telescope clock – wise until the object (A) is sighted again. Bisect B accurately by using the upper tangent screw. The verniers will now read the twice the value of the angle now.
4) Repeat the process until the angle is repeated the required number of times (usually 3). Read again both verniers . The final reading after n repetitions should be approximately n X (angle). Divide the sum by the number of repetitions and the result thus obtained gives the correct value of the angle AOB.
5) Change the face of the instrument. Repeat exactly in the same manner and find another value of the angle AOB. The average of two readings gives the required precise value of the angle AOB.
6) The face of the instrument is chang and the previous procedure is followed.



IEASURING HORIZONTAL ANGLE

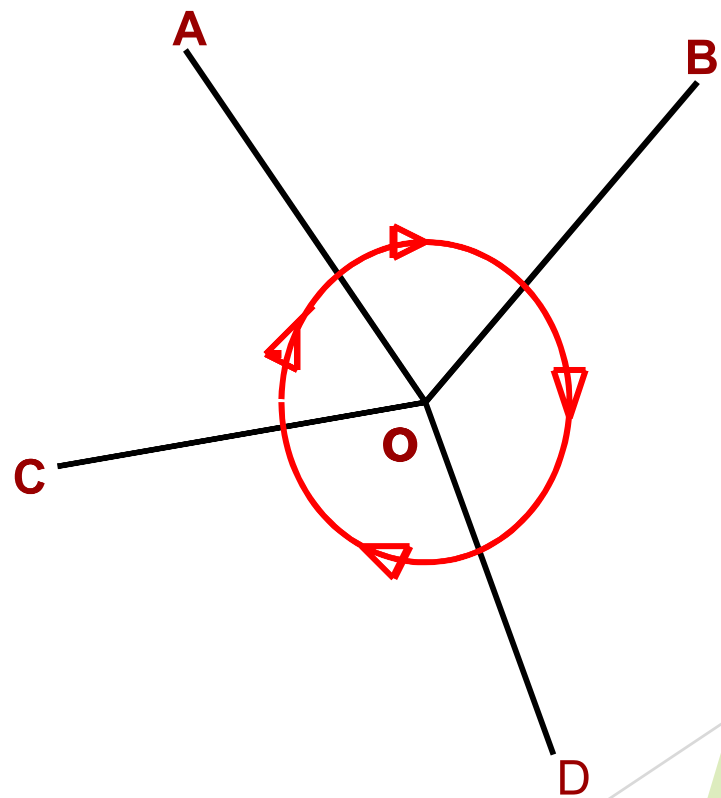
Reiteration method

- This method is another precise and comparatively less tedious method of measuring the horizontal angles.
- It is generally preferred when several angles are to be measured at a particular station.
- This method consists in measuring several angles successively and finally closing the horizon at the starting point. The final reading of the vernier A should be same as its initial reading.

MEASURING HORIZONTAL ANGLE

To measure horizontal angle by reiteration method

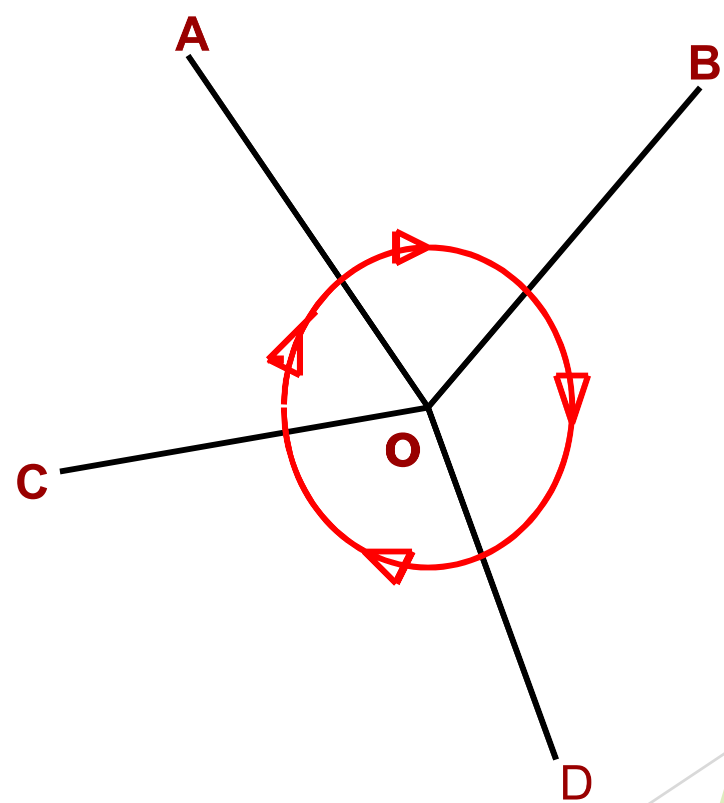
- Set up the instrument over station point O and level it accurately.
- Direct the telescope towards point A which is known as referring object. Bisect it accurately and check the reading of vernier as 0 or 360^0. Loosen the lower clamp and turn the telescope clockwise to sight point B exactly. Read the verniers again and The mean reading will give the value of angle AOB.
- Similarly bisect C & D successively, read both verniers at Procedure. each bisection, find the value of the angle BOC and COD.
- Finally close the horizon by sighting towards the referring object (point A).



MEASURING HORIZONTAL ANGLE

The vernier A should now read 360^0. If not note down the error .This error occurs due to slip etc.

If the error is small, it is equally distributed among the several angles .If large the readings should be discarded and a new set of readings be taken.



MEASURING VERTICAL ANGLE

To Measure the Vertical Angle of an object A at a station O

- Set up the theodolite at station point O and level it accurately with reference to the altitude bubble.
- Set the zero of vertical vernier exactly to the zero of the vertical circle clamp and tangent screw.
- Bring the bubble of the altitude level in the central position by using clip screw. The line of sight is thus made horizontal and vernier still reads zero.
- Loosen the vertical circle clamp screw and direct the telescope towards the object A and sight it exactly by using the vertical circle tangent screw.
- Read both verniers on the vertical circle, The mean of the two vernier readings gives the value of the required angle.
- Change the face of the instrument and repeat the process. The mean of of the two vernier readings gives the second value of the required angle.
- The average of the two values of the angles thus obtained, is the required value of the angle free from instrumental errors.

COMPUTATION OF LATITUDE AND DEPARTURE

Latitude(L)

- The latitude of a line is its orthographic projection on the N-S axis representing the meridian. Thus, the latitude of a line is the distance measured parallel to the North-South line.
- Thus, Latitude(L)=$l \cos\theta$

Departure(D)

- The departure of a line is its orthographic projection on the axis perpendicular to the meridian. The perpendicular axis is also known as the E-W axis.
- Thus, departure(D)= $l \sin\theta$

Table 9.6 *Table for computing latitude and departure*

Line	Length (L)	Reduced bearing (θ)	Latitude ($L\cos\theta$)	Departure ($L\sin\theta$)
AB	L	N θ E	$+L\cos\theta$	$+L\sin\theta$
BC	L	S θ E	$-L\cos\theta$	$+L\sin\theta$
CD	L	S θ W	$-L\cos\theta$	$-L\sin\theta$
DA	L	N θ W	$+L\cos\theta$	$-L\sin\theta$

Check for closed traverse

1. The algebraic sum of latitudes must be equal to zero.
2. The algebraic sum of departures must also be equal to zero.

Table 9.7

Line	Length	Reduced bearing	Consecutive Coordinates			
	(L)	(θ)	Northing (+)	Southing (–)	Easting (+)	Westing (–)
AB	L	N θ E	$L\cos\theta$		$L\sin\theta$	
BC	L	S θ E		$L\cos\theta$	$L\sin\theta$	
CD	L	S θ W		$L\cos\theta$		$L\sin\theta$
DA	L	N θ W	$L\cos\theta$			$L\sin\theta$

Check for closed traverse

1. Sum of northings = sum of southings
2. Sum of eastings = sum of westings

Consecutive coordinates

- The latitude and departure of a point calculated with reference to preceding point are said to be the consecutive coordinates of that point.

Independent coordinates

- The coordinates of any point with respect to a common origin are called the independent coordinates of that point. The origin may be a station of the traverse or a point entirely outside the traverse.

BALANCING OF TEAVERSE

A traverse is balanced by applying corrections to latitudes and departures. This is called balancing a traverse.

The following are common methods of adjusting a traverse

1) Bowditch's rule
2) Transit rule
3) Third rule
4) Graphical construction method

BALANCING OF TEAVERSE

Bowditch's rule

- The Bowditch's rule, also termed as the compass rule, is mostly used to balance traverse when linear and angular measurement are equally precise.

$$\text{correction to latitude/departure of any line} = \frac{\text{length of that line}}{\text{perimeter of the traverse}} \times \text{total error in latitude/departure}$$

Transit rule

- The transit rule is used to balance a traverse in which the angular measurements are more precise than the linear measurements.

$$\text{correction to latitude/departureof any line} = \frac{\text{latitude of that line}}{\text{arithmetic sum of all latitudes/departure}} \times \text{total error in latitude/departur}$$

BALANCING OF TEAVERSE

Third rule

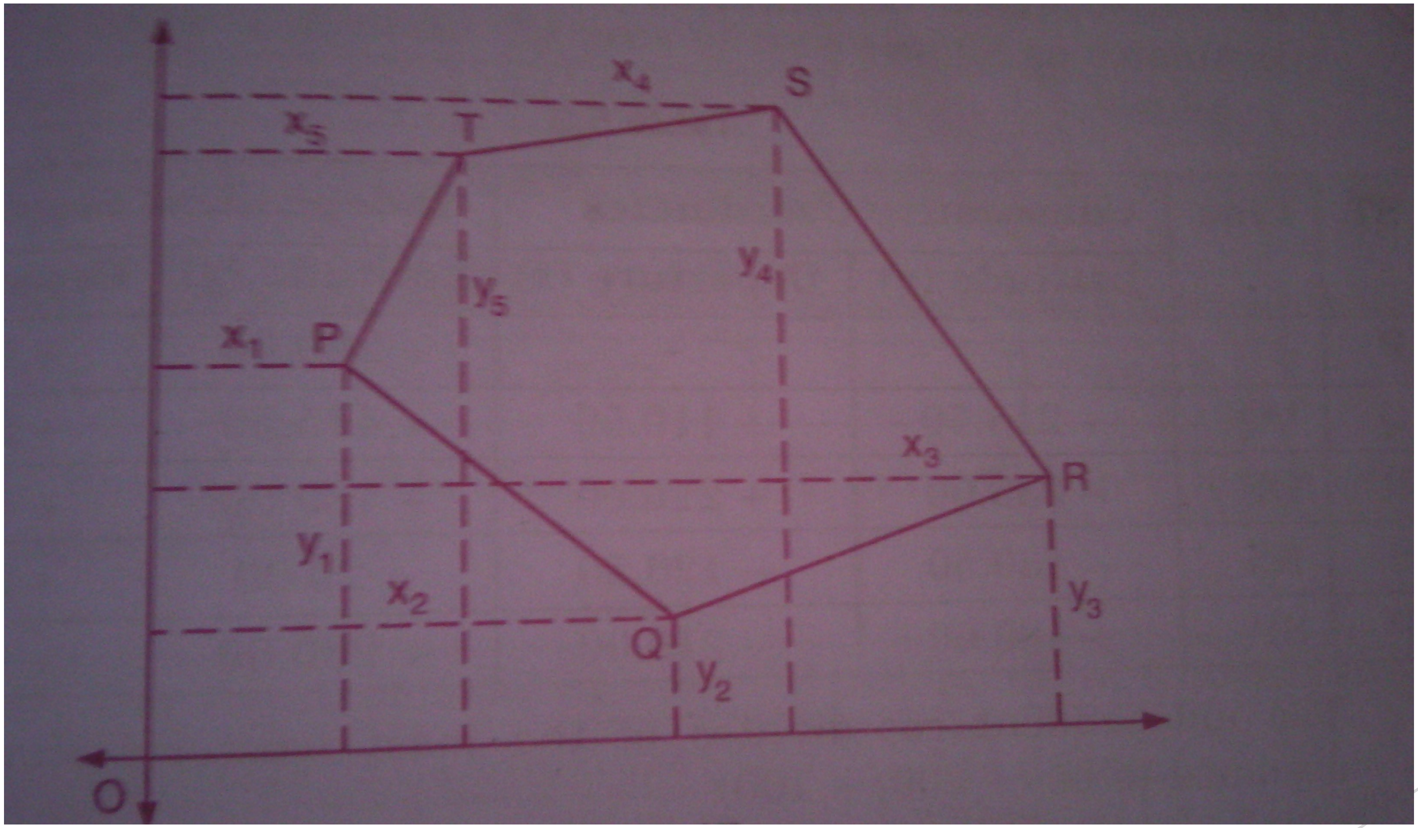
- If the correction are to be applied separately, then the third rule may be used

$$\text{correction to } northing\Big/southing\ of\ any\ line = \frac{\frac{northing}{southing}\ of\ that\ line}{sum\ of\ \frac{northing}{southing}} \times \frac{1}{2}(total\ error\ in\ latitud$$

$$\text{correction to } easting\Big/westing\ of\ any\ line = \frac{\frac{easting}{westing}\ of\ that\ line}{sum\ of\ \frac{easting}{westing}} \times \frac{1}{2}(total\ error\ in\ departure$$

TRAVERSE AREA

The coordinates method



THANK YOU

MINOR INSTRUMENTS IN SURVEYING

HAND LEVEL

A hand level is a simple compact instrument used for reconnaissance and preliminary survey, for locating contours on the ground and for taking short cross sections. It consists of a rectangular or circular tube, 10 to 15 cm long, provided with a small bubble tube at the top. A line of sight parallel to the axis of the bubble tube is defined by a line joining a pin hole at the eye end and a horizontal wire at the object end. In order to view the bubble tube at the instant the object is sighted, a small opening, immediately below the bubble is provided in the tube. The bubble is reflected through this opening on to a mirror, which is inside the tube inclined at 45° to the axis and immediately under the bubble tube.

TO USE THE INSTRUMENT :

1) Hold the instrument in hand at the eye level and sight the staff kept at the point to be observed.
2) Raise or lower the object end of the tube till the image of the bubble seen
in the reflector is bisected by the cross-wire.
3) Take the staff reading against the cross-wire.

ABNEY CLINOMETER

The Abney Level is a device that couples a protractor to a sighting tube. A bubble level is attached to an indicator (pointing) arm that moves around the arc of the protractor, and this level is visible through the top of the tube by means of a mirror prism. Half the field of view through the eyepiece shows the bubble, and the other half is the view of the target with stadia lines, and level line or cross hair.

In most Abney-style levels, the eyepiece is adjusted by sliding it forward or backward to focus the bubble image, the level line and the stadia lines. Some may have a threaded focusing mechanism, where turning the eyepiece lens moves it back or forward. The main body consists of a sighting tube that supports the lenses, prism, etc. The prism and the stadia and level line holder are located below the prism viewing port and are not visible. The scale plate (protractor) has both percent and degree scale graduations while the indicator or scale-pointing arm is provided with a Vernier scale. Like the eyepiece, the objective lens may be adjusted by sliding or by threaded focusing mechanism to focus the target. The bubble level on the main body is used to level the instrument.

USING THE INSTRUMENT

Measurement of vertical angle –

1)Keep the instrument at eye level and direct it to the object till the line of sight passes through it.

2)Since the line of sight is inclined the bubble will go out of centre. Bring the bubble to the center.

3) Read angle on the arc by means of the vernier.

INDIAN PATTERN CLINOMETER

It is used for determining difference in elevation between points and is specially adopted to plane tabling. The clinometer is placed on plane table which is leveled by estimation. It consists of :

1) A base plate carrying a small bubble tube and a leveling screw. Thus, it can be accurately leveled.
2) The eye vane carrying a peep hole. It is hinged at its lower end to the base plate.
3) The object vane having graduations in degrees at one side and tangent of the angles to the other side of the central opening.

USE WITH PLANE TABLE

1) Set the plane table over the station and keep the clinometer on it.
2) Level the clinometer with the help of leveling screw.
3) Looking through the peep hole, move the slide of the object vane till it bisects the signal at the other point to be sighted.
4) Note the reading, i.e. tangent of the angle against the wire. Thus the difference in elevation between eye and object = distance x tangent of vertical angle = $d \tan\alpha$

BUREL HAND LEVEL

This consists of a simple frame carrying a mirror and a plain glass. The mirror extends half-way across the frame. The plain glass extends to the other half. The frame can be suspended vertically in grimbles. The edge of the mirror forms vertical reference line. The instrument is based on the principle that a ray of light after being reflected back from a vertical mirror along the path of incidence, is horizontal. When the instrument is suspended at eye level, the image of the eye is visible at the edge of the mirror, while the objects appearing through the plain glass opposite the image of the eye are at the level of observer's eye.

FOOT RULE CLINOMETER

Foot rule clinometer consists of a box wood rule having two arms hinged to each other at one end, with a small bubble tube on each arm. The upper arm or part also carries a pair of sights through which the object can be sighted. A graduated arc is also attached to the hinge, and angles of elevations and depressions can be measured on it. A small compass is also recessed in the lower arm for taking bearings.

To sight an object, the instrument is held firmly against a rod, with the bubble central in the lower arm. The upper arm is then raised till the line of sight passes through the object. The reading is then taken on the arc.

Another common method of using clinometer is to keep the lower arm on a straight edge laid on the slope to be measured. The rule is then opened until the bubble of the upper arm is central. The reading is then noted.

FENNEL’S CLINOMETER

It is a precise clinometer for the measurement slopes. It consists of of following parts :

1) A telescope for providing line of sight.
2) Two plate levels for checking horizontality of the holding staff.
3) A vertical arc which rotates or tilts along with the tilting of the telescope.
4) A holding staff.
5) A target mounted on a holding staff of the same height.

This instrument is specially designed for finding the lines of highways with a predetermined percentage inclination (i.e. percentage slope) and for determination of the percentage amount of inclination of existing highways. It has a vertical arc allowing to read slopes up to + 40% or -40% with graduation to 0.5% thus making sure estimation to 0.1%

The design of the telescope, when inclined, admits the sighted object, the diaphragm with stadia lines and the first spirit level running parallel to the vertical arc can be simultaneously seen in the telescope. A second spirit level likewise is parallel to the tilting axis.

DE LISLE'S CLINOMETER

This is another form of clinometer, similar to that of Burel hand level, used for measuring the vertical angles, determining the slope of the ground, and for setting out gradients. This consists of the following:

1)a simple frame, similar to that of a Burel level, carrying a mirror extending half-way across the frame. The frame can be suspended in gimbles. The edge of the mirror forms a vertical reference line.

2)A heavy semi circular arc is attached to the lower end of the frame. The arc is graduated in gradients or slopes from 1 in 5 to 1 in 50. The arc is attached to the vertical axis to allow revolving to help measure the rising gradients or away from the observer to measure the falling gradients.

3)A radial arm is fitted to the Centre of the arc. The arm consists of a beveled edge which acts as index. By moving the arm along the arc, the mirror can be inclined to the vertical. The inclination to the horizontal of the line from the eye to the point at which it appears in the mirror equals the inclination of the mirror to the vertical.

TO MEASURE A GRADIENT :

1) Slide the weight to the inner stop of the arm. The arc should be turned forward for rising gradients and backwards for falling gradients.
2) Suspend the instrument from the thumb and hold it at arm's length in such a position that the observer sees the reflected image of his eye at the edge of the mirror.
3) Move the radial arm till the object sighted through the open half of the frame is coincident with the reflection of the eye. Note the reading on the arc against the beveled edge of the arm. The reading obtained will be in the form of gradient which can be converted into degrees if so required.

For better results, a vane or target of height equal to the height of observer's eye must be placed at the object and sighted.

CEYLON GHAT TRACER

It is a very useful instrument for setting out gradients. It essentially consists of a long circular tube having a peep hole at one end and cross wires on the other ends. The tube is supported by a A- frame having a hole at its top to fix the instrument to a straight rod or stand. The tube is also engraved to give readings of gradients. A heavy weight slides along the tube by a suitable rack and pinion arrangement. The weight at its top contains one beveled edge which slides along the graduations of the bar, and serves as an index. The line of sight is defined by the line joining the hole to the intersection of the cross wires and its prolongation. For elevated gradients, the weight is slided towards the observer.

a) TO MEASURE THE SLOPE:

1. fix the instrument on to the stand and hold it to one end of the line. Keep the target at the other end.
2. looking through the eye hole, move the sliding weight till the line of sight passes through the cross mark of the sight vane.
3. the reading against the beveled edge of the weight will give the gradient of the line.

b) TO SET OUT A GRADIENT:

1. Hold the instrument at one end.
2. Send the assistant to other end with the target.
3. Slide the weight to set it to the given gradient, say 1 in n.
4. Direct the assistant to raise or lower the target till it is bisected.

Drive a peg at the other end so that the top of the peg is at the same level as that the bottom of the target.

THE SEXTANT

The sextant is based on the principle that when a ray of light is reflected successively from two mirror, the angle between the first and last directions of ray is twice the angle between the planes of the two mirror.

The distinguishing feature of the sextant is the arrangement of mirrors which enables the observer to sight at two different objects simultaneously, and thus to measure an angle in a single observation. A sextant may be used to measure horizontal angle. It can also be used to measure vertical angles. The angle between mirrors is equal to half the actual angle between two objects.

OPTICAL REQUIREMENTS OF THE SEXTANT:

1. The two mirrors should be perpendicular to the plane of the graduated arc.
2. When two mirrors are parallel, the reading on the index should be zero.
3. The optical axis should be parallel to the plane of graduated arc and pass through the top of the horizontal mirror. If only a peep sight is provided in place of telescope, the peep sight should be at the same distance above the arc as the top of the mirror.

TYPES OF SEXTANT

1. **Box sextant:** it is a small pocket instrument used for measuring horizontal and vertical angles, measuring chain angles and locating inaccessible points. By setting the vernier to 90 , it may be used as an optical square.
2. **Nautical sextant:** it is specially designed for navigation and astronomical purposes and is fairly large instrument with a graduated silver arc of about 15 to 20 cm radius let into a gun metal casting carrying the main parts. With the help of vernier attached to the index mirror, readings can be taken to 20 " or 10".
3. **Sounding sextant:** it is also very similar to the nautical sextant, with a large index glass to allow for the difficulty of sighting an object from a small rocking boat in hydrographic survey.

PERMANENT ADJUSTMENT OF A SEXTANT

A sextant requires the following four adjustments:

1. to make the index glass perpendicular to the plane of the graduated arc.
2. to make the horizon glass perpendicular to the plane of graduated arc.
3. to make the line of sight parallel to the plane of the graduated arc.
4. to make the horizon mirror parallel to the index mirror when the vernier is set at zero (i.e. to eliminate any index correction).

In a box sextant, the index glass is permanently fixed at right angles to the plane of the instruments by the maker.

THANK YOU