India's No.1 Study Channel

Surveying
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Ministry of Railways
Railway Recruitment Boards

Surveying

Chapter 1: Fundamentals of Surveying

Surveying is an art of determining relative position of points on, below and above the earth surface, entering it graphically and numerically.

Objectives of Surveying

1. **To determine relative position of points**
2. **To Layout or mark out proposed structure on the ground**
3. **To measure relative quantities like area & volume**

Methods of Presenting measurements:-

- Numerically : AB = 260 km (examples)
- Graphically :

- Generally Graphical representation is done in the from of
- Plan $\xrightarrow{on}$ Large scale
- Map $\xrightarrow{on}$ Small scale

Methods of Presenting measurements:-

- Vertical distances on the plan (on) map can be shown with the help of contours and spot levels.
- Contours are imaginary line joining points of equal elevation on the earth surface.
- Spot levels are reduced level or height of individual points
- Contour gives better visualization of the area.

Basic Definitions

1. **<u>Shape of Earth</u>**
   a) **<u>Oblate spheroid</u> → slightly flattened at poles, polar axis is 43.5 km smaller than Equatorial axis**
   b) **<u>Ellipsoid</u> → Equatorial section is slightly elliptical in nature**
   c) **<u>Ovalloid</u> → Southern Hemisphere is slightly larger than Northern hemisphere**

- We can observe that no geometrical shape perfectly defines shape of earth.
- Therefore a new name has been given, i.e, "GEOID":-
- Or the ease in calculation the shape of earth is assumed to be "Spherical"

Basic Definitions

2. Level Surface

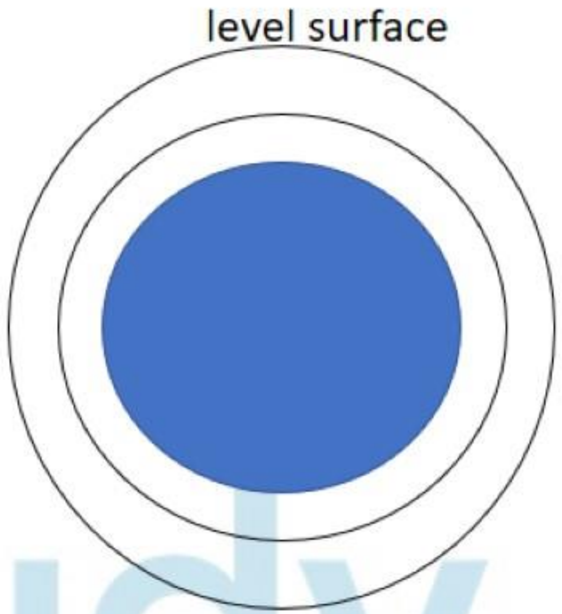
- **Level surface is a curved surface parallel to earth surface and every point, it is equidistant from the centre of the Earth, every element on the level surface is perpendicular to plumb line**

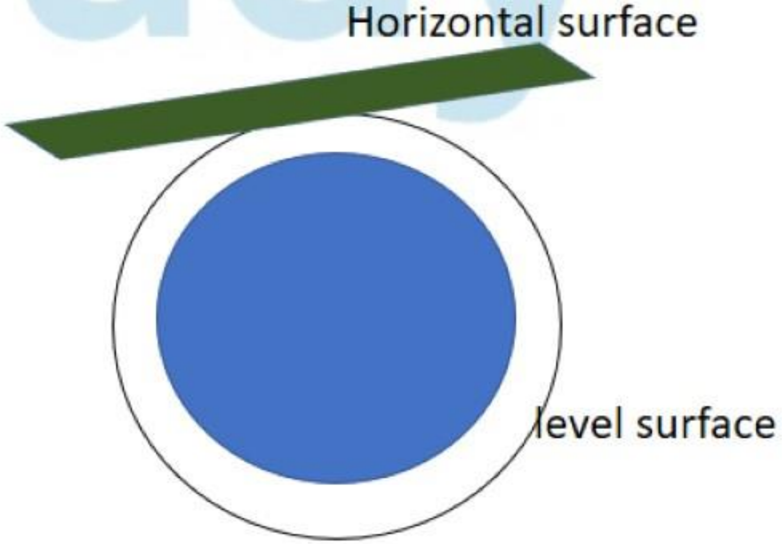
3. Level line

- **It is a line in the level surface**

4. Horizontal plane:

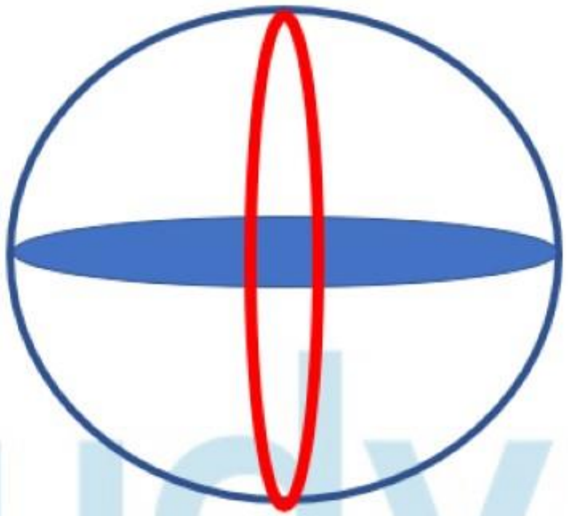
- **It is a plane tangential to Earth surface at any point.**
- **It is also normal to plumb line**





Basic Definitions

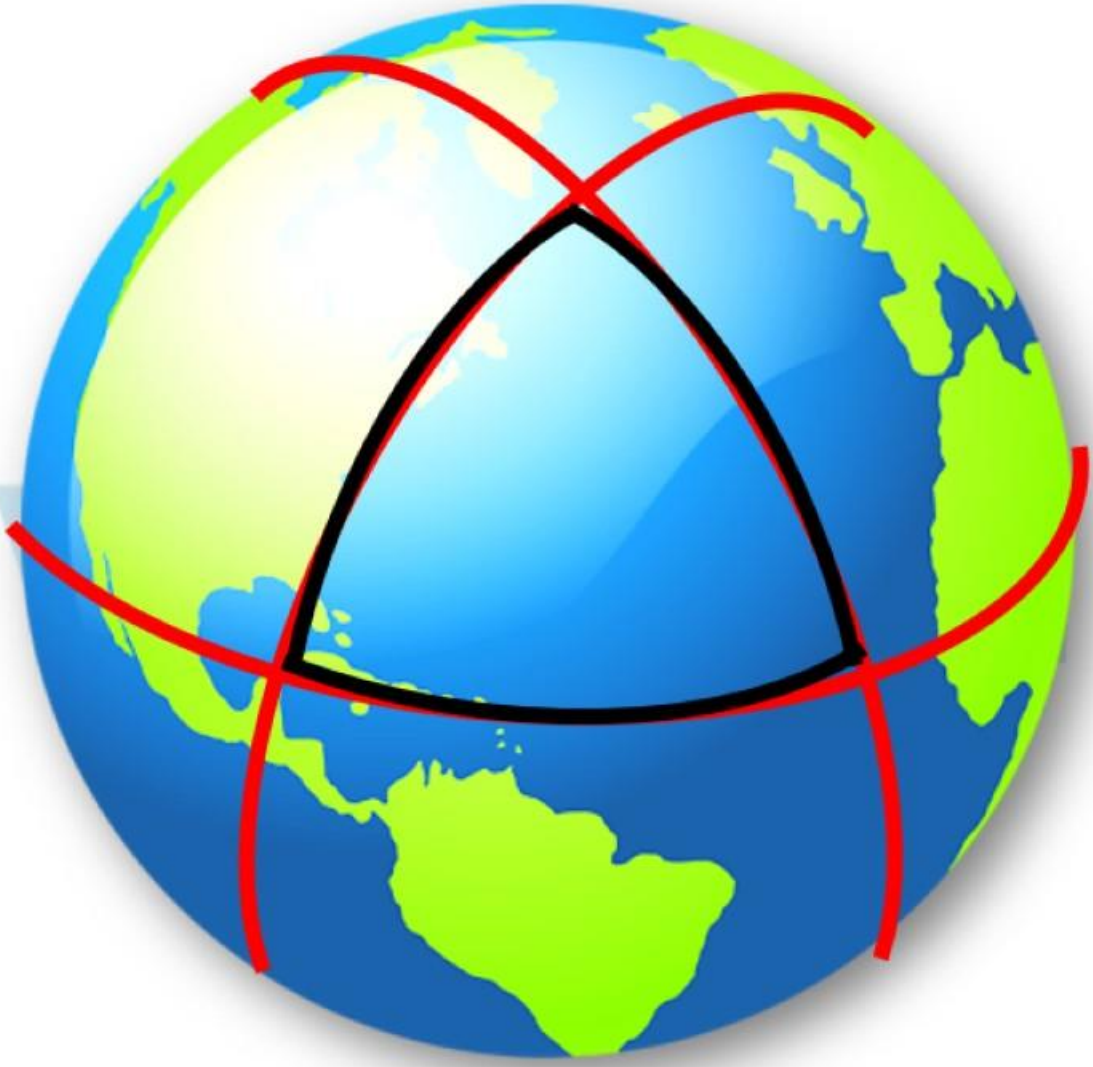
5. Great Circle:



- It is an imaginary circle passing through centre of the Earth
- A great circle divides earth into two equal parts
- Example : Equator and longitude

6. Spherical triangle:

- A spherical triangle is that triangle which is formed on the surface of a sphere by intersection of three arcs of great circle
- The Arcs enclosing the spherical triangle are called as its sides, and the angles in which these Arcs intersect are called as "Spherical Angle".



Basic Definitions

6. <u>Spherical triangle</u>:

- **A spherical triangle is that triangle which is formed on the surface of a sphere by intersection of three arcs of great circle**
- **The Arcs enclosing the spherical triangle are called as its sides, and the angles in which these Arcs intersect are called as “Spherical Angle”.**
- **Spherical Angle is defined as the angle between tangents to the great circle drawn at the point of intersection.**
- **Length of a side of a spherical triangle is defined as angle subtended by that side at the centre of the earth**

Basic Definitions

6. **Properties of Spherical triangle:**

- **Length of a side of a spherical triangle should be less than equal to 180°**
- **Each angle of a spherical triangle should be less than 180°**
- **Sum of three spherical sides should be in between 0° to 360°**
- **Sum of spherical angles should be in the range of 180° to 540°**

Note:-

- **Amount by which sum of the angles of a spherical triangle exceed by 180° is called as "spherical excess"**
- **Surface Area of a spherical triangle should be less than $2\pi r^2$ where r → radius of the Earth**

Classification of Surveying

Surveying can be classified into many types on the basis of instrument used, place of survey, purpose of survey etc.

But mainly surveying is classified as, Plane Surveying, Geodetic Surveying.

Plane Surveying	Geodetic Surveying
In the Plane Surveying we neglect the effect of Curvature and plotted Measurements are projected on Horizontal plane	Geodetic survey is done for large Area in which effect of Curvature of the Earth surface is considered
Area < 195.5 km^2	Area ≥ 195.5 km^2
It is done for local surveys	It is done by Survey of India to establish control points which serves the purpose of reference point for local surveys
Plane trigonometry	Spherical Trigonometry

Classification based on Purpose

1. Topographical survey:
   - **These surveys are used to obtain Maps which show details of maps and man made features on the Earth surface including elevation**
   - **Scale:- 1:2500 to 1:10,00,000 (No need to remember)**
   - **Ex: Mountains – water bodies woods valley, rivers etc.**
2. Engineering Survey:
   - **These are surveys used for Engineering works like Railway, Highway, Bridge etc.**
   - **Building:- 1:50 to 1:200**
   - **Bridge & other civil engineering works :- 1:500 to 1:2500**
   - **Highway:- 1:1250 to 1:50,000**

Classification based on Purpose

3. **Cadastral Survey:-**
   - **It is done to establish property boundaries**
   - **Scale:- 1:1000 to 1:5000**
4. **Hydrographic Survey:**
   - **These are the surveys done on (or) near the water body**
   - **Ex:- River, lake etc.**
5. **Astronomical Survey**
   - **With the help of this survey we can determine Latitude, longitude. Local mean time at any place on the Earth surface**

Classification based on Purpose

6. Geological Survey

- **It is done to determine information about various strata of earth surface**

Classification based on Instrument

1. **Chain Surveying:-**
   - **It is simplest type of surveying in which only linear measurements are done with the help of chain and tape and no angular measurements are done**
2. **Compass Surveying:-**
   - **It is the branch of Surveying in which horizontal angles and directions of lines are measured with compass and length of line are measured with chain and tape.**
3. **Theodolite Survey**
   - **In this Surveying Horizontal and vertical angles are measured with theodolite and distances are measured with chain on tape**

Classification based on Instrument

4. Levelling
   - In this type of Survey, elevations of various points are measured with the leveling instrument and a vertical staff
5. Plane table Surveying
   - In plane table Surveying, plan or Map is produced by determing directions of various points and taking linear measurements with chain on Tape.
6. Tachometric Surveying
   - In this Surveying horizontal & Vertical distances are measured with an instrument called "Tachometer".

Classification based on Instrument

7. Photogrammetric Survey
    - In this survey photographs are taken for an area which are inaccessible (or) line available is less and area to be Surveyed is large.

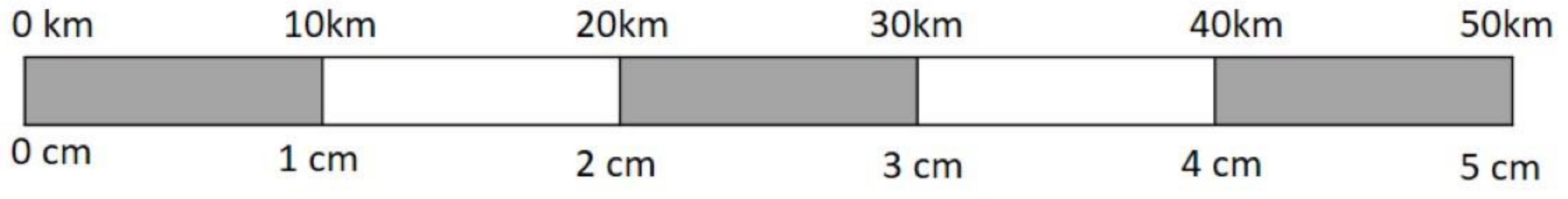
Principles of Surveying

- Working from whole to Part.
  - Main objective of working from whole to part is to localize the error where as if we works from part to whole error gets maximize
- Locating a point at least by 2 measurements.

SCALE

$$Scale = \frac{length\ of\ a\ line\ on\ Plan\ or\ Map}{length\ of\ same\ line\ on\ the\ ground}$$

1. Numerical Scale
   a) Representative Factor (RF) 1 cm= 10km (1: 10^6)
   b) Engineer Scale 1 cm= 10km
2. Graphical Scale



1 cm= 10km

SCALE

- Graphical scale has advantage over Numerical scale such that distance on the Plan (or) map can be determined by actual Scaling, Even though plane (or) Map is shrunk.
- In case of shrinkage of Map, Graphical scale also changes with the Map and therefore ratio is unaffected.

1 cm= 10km

Mistake and Error

- Mistake:
  - These are discrepancies caused due to carelessness, misunderstanding. Poor judgment
  - Ex:- miscounting of Tape length (or) 5 m reading recorded as 8m
- Error:
  - These are discrepancies other than mistakes
  - $E = M.V - T.V$
  - $C = T.V - M.V$
    - M.V → Measured value
    - T.V → True value
    - C → Correction

Mistake and Error

Errors are of two types:

1. Systematic error/ Cumulative error
   - These errors follow a definite mathematical on Physical law
   - They are cumulative in nature
2. Random Error/Accidental error
   - These are errors left out after mistake and systematic error are eliminated.

Theory of error

1. Gross error/Mistake:
   - Caused due to carelessness, misunderstanding and poor judgement (miscounting of tape length)
   - Can be avoided by careful work/standard procedure of work
2. Systematic error/Cumulative error
   - These errors follow a definite mathematical or physical law like expansion of steel tape
3. Random/compensating error
   - Random errors are those errors which are left out when mistakes and systematic errors are eliminated
   - These are beyond the control of surveyor
   - They are cancelled out as they have chances of equal positive and negative
   - They are analysed with the help of theory of probability

- Properties of Random Error
  - Random errors when plotted against their probability of occurrence we get a nominal distribution curve

  - Error= MV – ~~TV~~ MPV   Most probable value
  - Instead of true value, a value called most probable value is commonly used
  - MPV is that quantity which is close to the TV than any other value
  - Error= MV – MPV
  - The above difference is called as “Most probable error”, “Residual error” or “Variation”
  - MPV can be found out if the quantity is measured by a number of times

Note:

- Most probable error of mean $e_m = \pm \frac{e}{\sqrt{n}}$ $n = no.of\ observations$
- Standard error of mean/standard deviation of mean $\sigma_m = \pm \frac{\sigma}{\sqrt{n}}$

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a) large water bodies
b) heavenly bodies
c) mountainous region
d) canal system

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b) angular measurements only
c) both linear and angular measurements
d) all the above

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a) from part to the whole
b) from whole to the part
c) from higher level to the lower level
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a) longitudinal sections are required
b) cross sections are required
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a) $100\ km^2$

b) $160\ km^2$

c) $500\ km^2$

d) $260\ km^2$

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Que 7. A fixed point whose elevation is known

a) Bench mark

b) Change point

c) Reduced level

d) station

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Chapter 2: Linear Measurements

→ Main Purpose of surveying is to plot plan or Map of an Area.

→ As the map is plotted on a horizontal plane, the distances shown are horizontal projection on this plane

→ In surveying, the distance between two points is horizontal distance.

→ When slope distances are measured in field, they are always reduced to equivalent horizontal distances for the preparation of map

Methods of Linear / Horizontal distance measurement

1. Direct method → chain (or) Tape
2. Tachometric method → optical method
3. Electronic distance measuring instrument (EDMI)

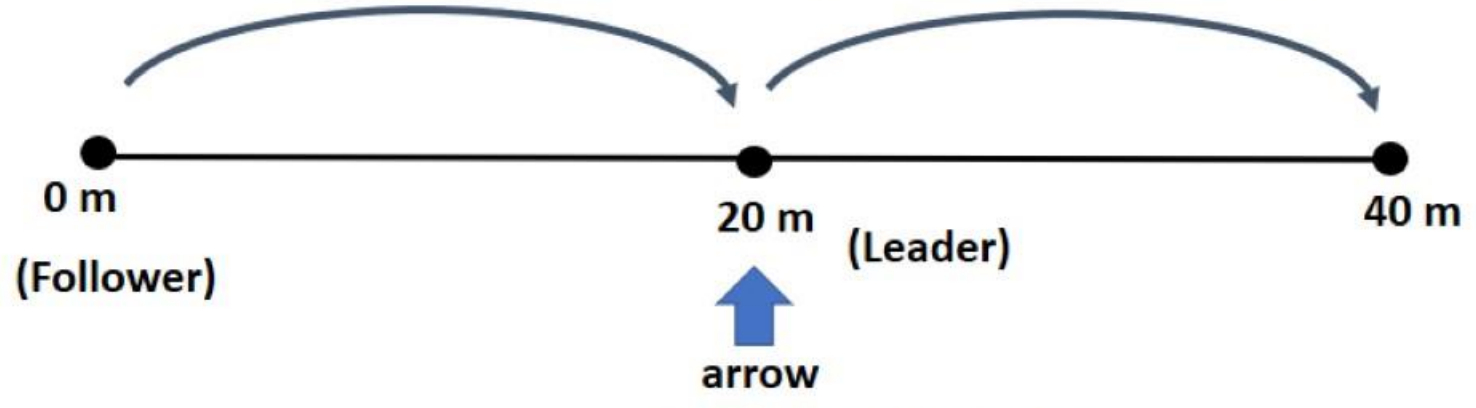
Note:-

→ EDMIs can be classified into 3 types based on carrier wave

1. Light wave → Geodimeter & Mekometer
2. Radio wave / Microwave → Distomat & Tellurometer (most precise instrument for measuring horizontal distances)
3. Infrared → Total station

Chain Surveying

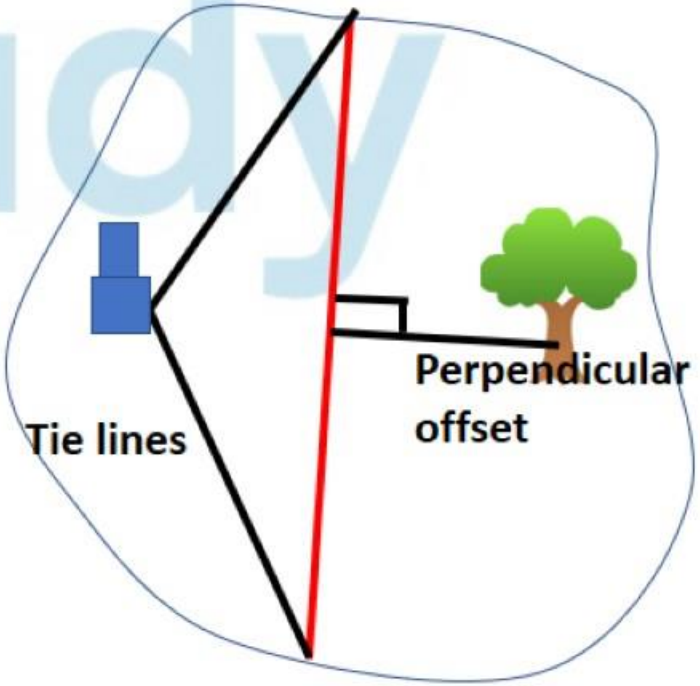
- It is the branch of surveying in which distances are measured with chain (or) Tape and this process is called as "chaining".
- Chain surveying is done for smaller Area.
- In the process of chaining the survey the team consist of Follower (0 m)and leader. (20 m (or) 30 m)
- Leader drives the Arrow and follower collects it
- No. of arrows with the follower signifies chain length measured



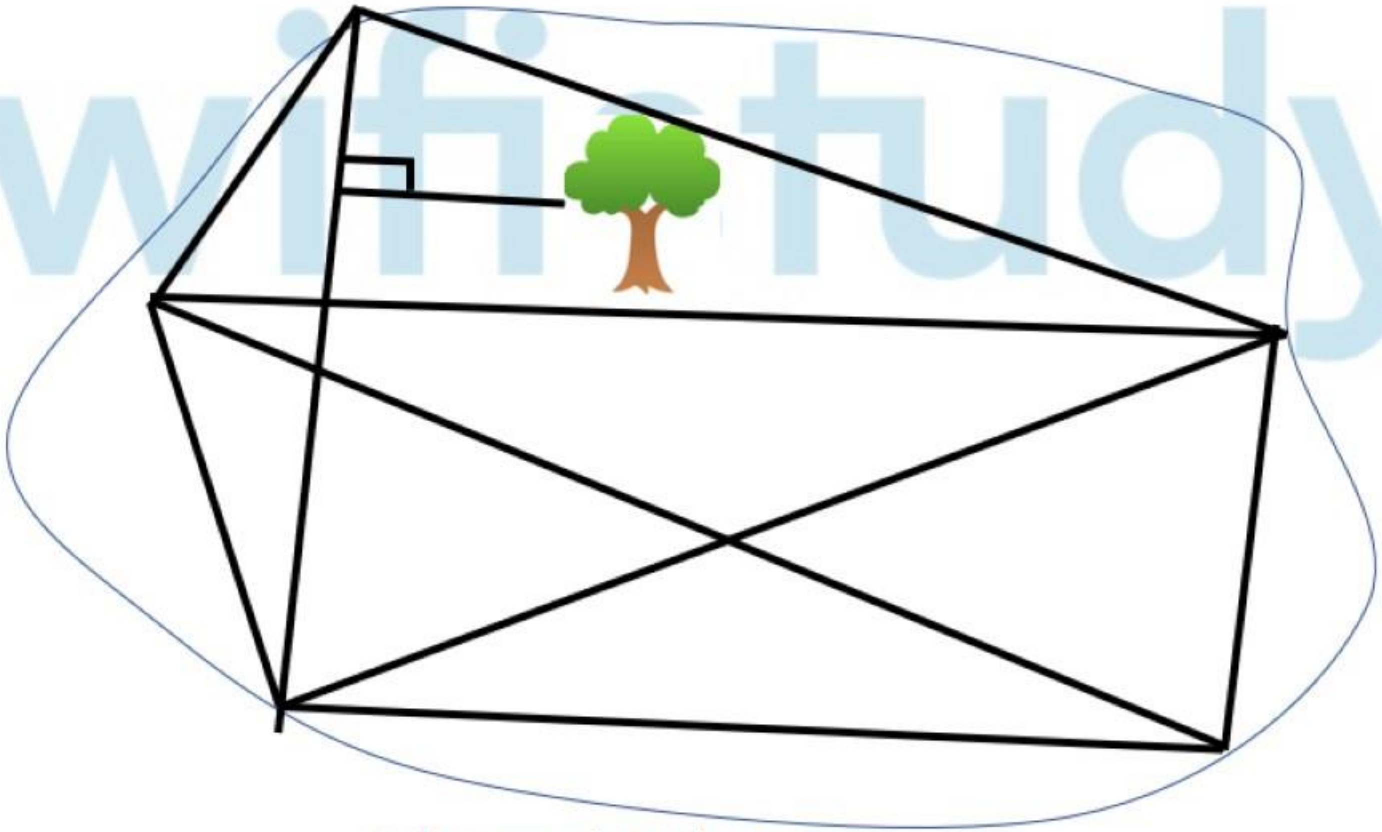
Chain Surveying

Procedure in chain surveying:-

- In chain surveying various points are located by measuring distance is the help of chain (or) Tape
- For smaller Area, details of various points can be collected using ties and offset.
- Note: → Offsets are lateral distances measured from a survey line to the point to information is to be collected.

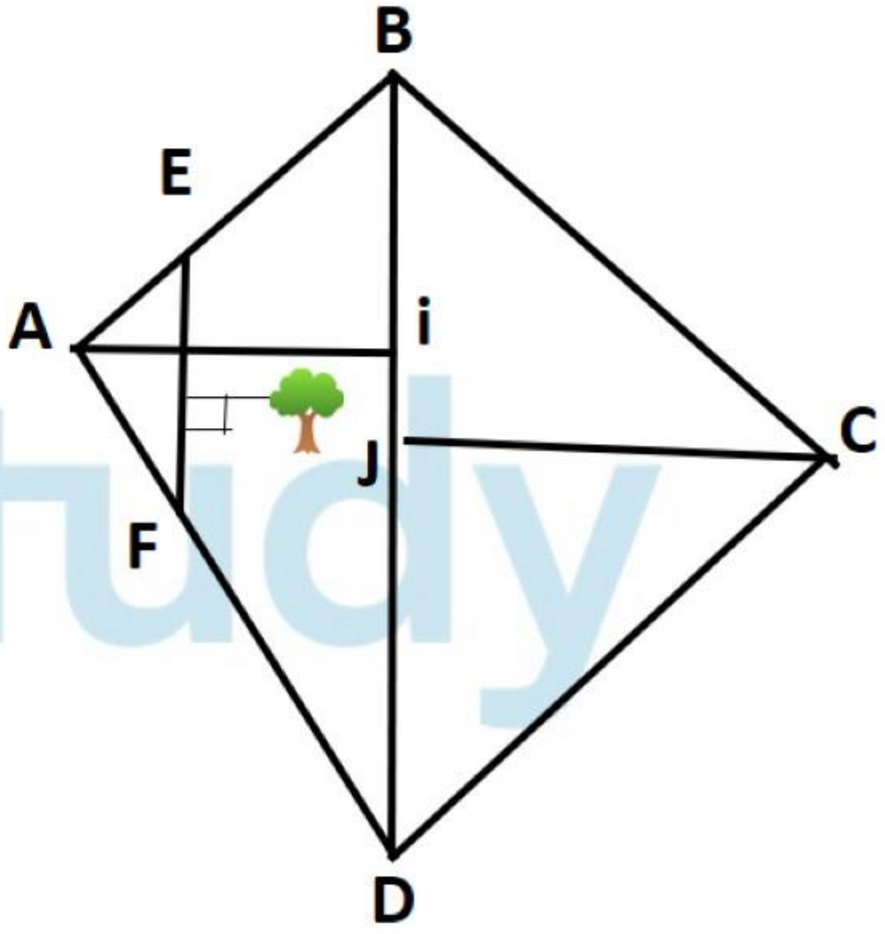


- But when Area is large, error introduced due to large offset will be more, therefore to overcome this difficulty large area is first of all converted into Network of small triangles and then these details are collected using ties and offset.



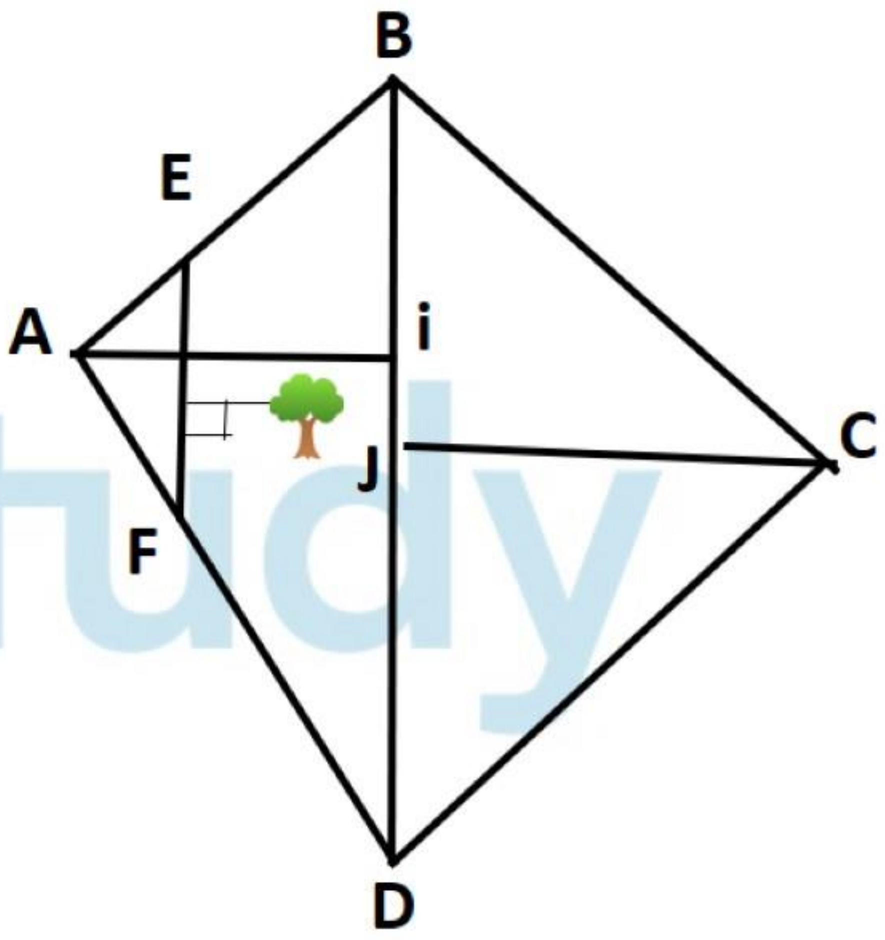
Basic definitions:-

1. **Main station:**
   - **main station is a point where two sides of a triangle meet and these stations decides boundary of the survey**
   - **Exp: A, B, C, D**
2. **Main survey line**
   - **These are the lines joining main survey stations**
   - **AB, BC, CD, DA, BD**
3. **The station / subsidiary station / Auxiliary station:**
   - **Tie station are station on the line joining main stations**
   - **Exp: E, F**



Basic definitions:-

4. **Tie line / Auxiliary line / Subsidiary line:**
   - These are the lines joining tie stations
   - These are helpful in locating inner details of the Area.
   - Exp: EF
5. **Base line**
   - It is longest main Survey line which generally passes through the central port of the Area.
   - Ex:- BD
6. **Check line / Proof line**
   - Check line is provided to check the Accuracy of the field work and plan work
   - It is not used for plotting of any point
   - Measured length of the check line should be equal to length scaled from the plan.
   - Ex:- Ai & Cj



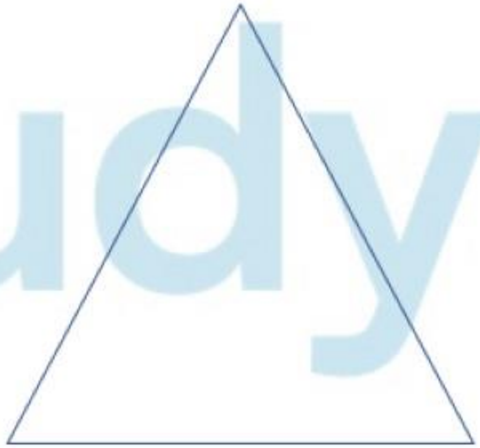
Basic definitions:-

7. **Chainage:**
   - **Chainage is the distance measured along the direction of progress of survey**
   - **It is the distance of a well defined point from the starting point.**
   - **Word Chainage is generally used in linear projects.**
   - **Ex:- Railway, Highway, Canal etc.**
   - **They are used to represent important features in the work**

Basic definitions:-

8. Well-conditioned Triangle

- In chain surveying attempt should be made to form a triangle such that intersection of lines is clear and distinct, for the purpose of plotting
- Hence for obtaining distinct intersection, the angle should be in the range of 30° to 120°
- Best possible well conditioned triangle is "Equilateral triangle



Equipments used in Chain Surveying

1. **Surveying chain:-**

A. **Revenue chain → 33 feet, 16 link**
B. **Gunter's chain → 66 feet, 100 link**
C. **Engineer's chain → 100 feet, 100 link**
D. **Metric chain →**
   a) **20 m, 100 link**
   b) **30 m, 150 link**

Note:

- 1 mile = 1.6093 km = 80 Gunter's chain
- 1 Acre = 4046.856 m^2 = 10x (Gunter's chain)^2 = 40 guntas = 43560 ft^2
- 1 yard = 3 feet = 0.9144 m

Tapes

1. **Cloth (or) Linen Tape:-**
   - It is made up of closely woven linen & synthetic material which is varnished to resist moisture.
   - This tape does not remains straight during strong winds.
2. **Metallic Tape:-**
   - It is made up of linen with brass and copper wire woven into it & varnished
   - This Tape gives better results than in comparison to cloth Tape because stretching is reduced.
3. **Steel Tape:**
   - It is made up of stainless steel

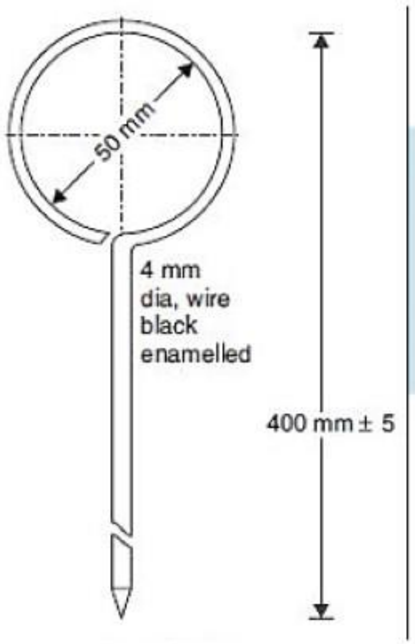
Tapes

4. Invar Tape

- Nickel : 36 %
- Steel : 64 %
- This Tape is highly accurate and have very small thermal coefficient of linear expansion
- But these tapes require much attention in the field because it is soft and deforms easily.

Accessories used in chaining

1. **<u>Pegs</u>**
   - **There are used to mark a definite point temporarily (or) Semi- permanently**
2. **<u>Arrow</u>:**
   - **These are used to mark end point of a chain length**
   - **No. of arrows with the follower signifies number of chain length measured**
3. **<u>Ranging Rod</u>:**
   - **Ranging rods are used to establish intermediate points along a straight line and this process is called as "Ranging".**



Accessories used in chaining

4. Offset rod:

- **It is a Ranging rod with slots made at right angle and it helps to take perpendicular offset.**
- **Maximum length of an offset depends on**
  - **Scale of plotting**
  - **Nature of ground**
  - **Accuracy defined**

Accessories used in chaining

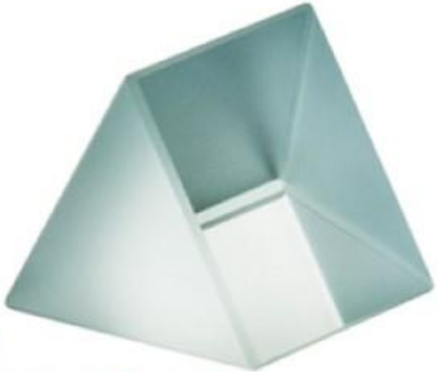
5. **Cross staff / open cross staff:**
   - **It is used for taking perpendicular offset along a survey line**

6. **French cross staff:-**
   - **It is used to take offsets at 45°, 90°, 135° from the survey line**
7. **Optical square:**
   - **It is used to setout right angles**
   - **It uses the principle of Double reflection.**
   - **Index mirror fully silvered , Horizon Mirror I half silvered and Top half**

Accessories used in chaining

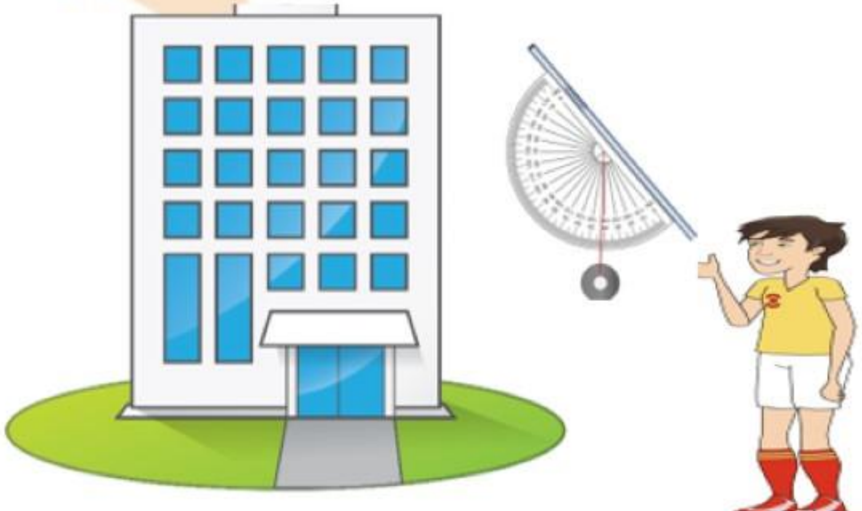
8. Prism square:-

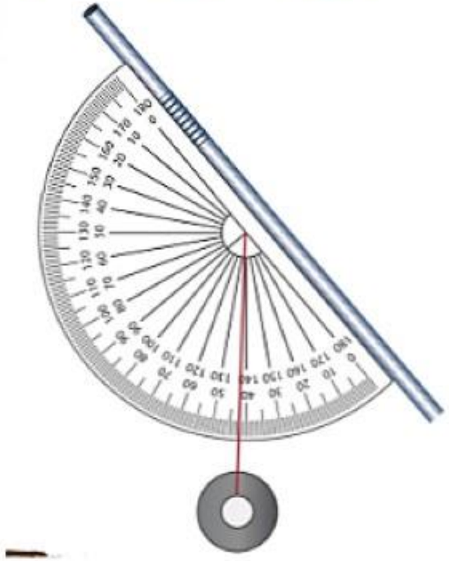
- **It has similar arrangement as compare to optical square with mirror replaced by prism**



9. Simple clinometer

- **It is used to measure slope of the ground and vertical angles**





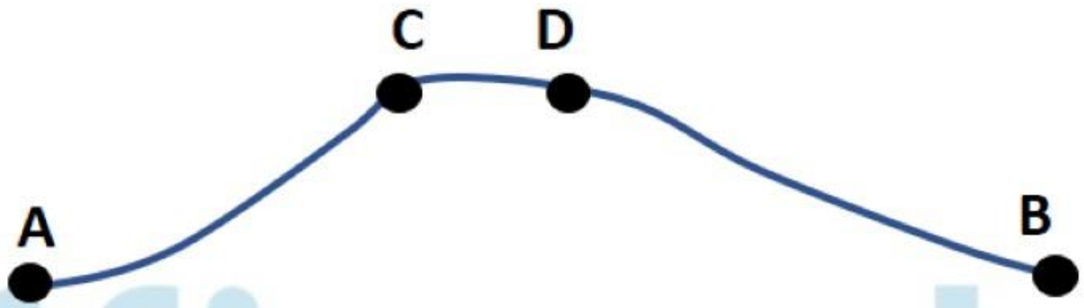
Ranging

- **It is the process of establishing intermediate points along a straight line**

<u>Types of Ranging;</u>

1. **Direct Ranging:**
    - **It is the process of establishing intermediate points along a chain line when end stations are intervisible**

Ranging



2. Indirect / Reciprocal / Repeated alignment Ranging:

- This method is used when end stations are not intervisible due to rising ground between them (or) due to long distance between them.
- During this process we select two intermediate stations (say C and D) Such that,
- From station C → station B & D are visible,
- From station D → station A & C are visible.

Corrections

<u>Chain</u>

- Correction for standardization
- Correction for slope

<u>Tape</u>

- Correction for standardization
- Correction for slope
- Correction for Pull
- Correction for Sag
- Correction for Temperature
- Correction for MSL
- Correction for misalignment.

Corrections

1. **Correction for standardization: (C_a)**
   - It is also called as correction for Absolute length.
   - If Actual length of the tape or not equal to Nominal length of the tape, then correction for standardization is required.
   - If tape is actually shorter than Nominal length then error will be positive because measured distance will be greater than correct distance
   - Therefore correction will be negative
   - Nominal Designated length → l' (20 m or 30 m)
   - Actual / Absolute length of tape → l (19 m)

Measured distance = L'

Correct distance = L

Note: if Tape is shorter then correction is subtractive

Corrections

1. Correction for standardization: (C_a)

- Nominal Designated length → l' (20 m or 30 m)
- Actual / Absolute length of tape → l (19 m)
- Measured distance = L'
- Correct distance = L

$$\text{Correct distance or TrueLength of line} = \text{Measured length of line} \times \frac{\text{incorrect or actual length of tape used}}{\text{designated or Nominal Length of tape}}$$

$$\boxed{TL \text{ or } CD = AL \times \frac{MD}{NL}}$$

$$\boxed{Correct\ area\ or\ True\ area = (Measured\ area) \times \left[\frac{incorrect\ or\ actual\ length\ of\ tape\ used}{designated\ or\ Nominal\ Length\ of\ tape}\right]^2}$$

Que 8 A line of True length 500 m when measured by a 20 m Tape was reported to be 502 m, then Actual length of the Tape is ------?

$$\boldsymbol{Correct\ distance\ or\ TrueLength\ of\ line = Measured\ length\ of\ line \times \frac{incorrect\ or\ actual\ length\ of\ tape\ used}{designated\ or\ Nominal\ Length\ of\ tape}}$$

$$500 = A.L \times \frac{502}{20}$$

$$\Rightarrow A.L = 19.92\ m.$$

Que 10. Length of a line measured with a chain was found to be 250 m. Determine True length of the line if;

a) Length was measured with a 30 chain and chain was 10 cm too long.

b) Length of the chain was 30 m in the beginning and 30.10 m at the end of the work.

$$\boldsymbol{Correct\ distance\ or\ True Length = Actual\ length \times \frac{Measured\ distance}{Nominal\ Length}}$$

a) $C.D = 30.10 \times \frac{250}{30}$

$= 250.833\ m$

b) $C.D = 30.05 \times \frac{250}{30}$

$= 250.417$ m

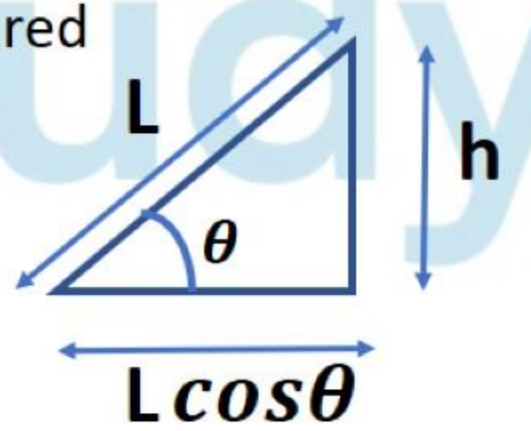
Corrections

2. <u>Correction for slope (C_g)</u>
   - We know that slope distance will always be greater than corresponding horizontal distance, therefore correction for slope will always be negative
   - <u>Case :</u> 1 When slope of the ground θ is measured

$$C_g = T.V - M.V$$

$$= L\cos\theta - L$$

$$C_g = -L(1 - cos\theta)$$



Corrections

2. Correction for slope (C_g)

Case II:- When height difference 'h' is measured.

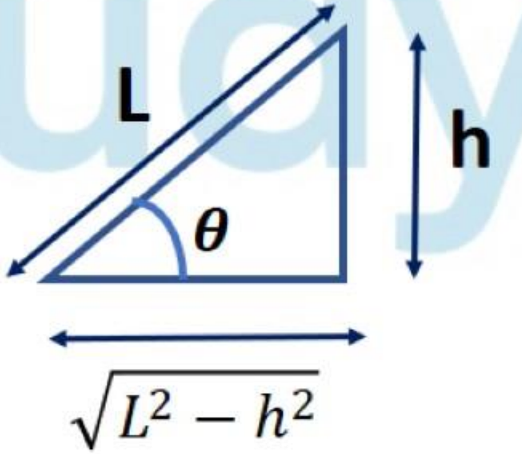
$$C_g = \sqrt{L^2 - h^2} - L$$

$$C_g = L\left[\left(1 - \frac{h^2}{L^2}\right)^{\frac{1}{2}} - 1\right]$$

$$C_g = L\left[\left(1 - \frac{h^2}{2L^2} - \frac{h^4}{8L^4} + \cdots\right) - 1\right]$$

$$C_g = \frac{-h^2}{2L} - \frac{h^4}{8L^3}$$

$$C_g = \frac{-h^2}{2L}$$



Que. 11 If downhill end of slope of a 2m tape is held 80cm too low, then determine the correction for slope.

Sol.

$$C_g = \frac{-h^2}{2L}$$

$$C_g = \frac{-0.8^2}{2(20)} = -0.016\text{m}$$

NOTE : SLOPE CORRECTION FOR $\theta \leq 3^{o}$ IS ALWAYS NEGLECTED

Corrections

3. Correction for pull

$$C_P = \frac{(P - P_0)L}{AE}$$

where

P_o → standard pull

P → Pull applied in the field

A → Cross-sectional Area of the Tape

E → Young's modulus of Elasticity

L → Nominal length of the tape/measured length of the line

If P > P_o → then correction for pull will be positive and vice-versa.

Que. 12 A steel tape 30 m long was standardized under a pull of 65 N. If pull at the time of measurement was 80 N. Determine Correct Tape length if wt. of the tape is 10 N, young's modulus, $E = 2 \times 10^5\ N/\ mm^2$

$$Y = 77.10\ kN/m^3$$

Sol:

$$W = \gamma AL$$

$$10 = 77.10 \times \frac{10^3}{10^9} \times A \times 30 \times 10^3$$

$$A = 4.32\ mm^2$$

$$C_P = \frac{(P - P_0)L}{AE}$$

$$C_P = \frac{(80-65)\times 30}{4.32\times 2\times 10^5} = +5.2 \times 10^{-4} m$$

Correct length of Tape$= 30 + 0.52 \times 10^{-3}$m

Corrections

4. **Correction for temperature** C_t

$$C_t = \alpha(t - t_o)L$$

α → **thermal coefficient of linear expansion**

t_o → **standard temperature**

t → **field temperature**

L → **Nominal length of the Tape/measured length of the line**

If t > t_o → then C_t will be positive

Que. 13 Determine correction for Temperature if measured lengthof the lines is 1000 m,$\alpha = 1.1 \times 10^{-5}$/°C, standard Temp is 27°C and field temp is 32°C

Sol. $C_t = \alpha\,(t - t_o)\,L$

$C_t = 1.1 \times 10^{-5}(32 - 27) \times 1000$

$= +0.055\,m$

Corrections

5. Correction for sag C_s

- When the Tape is supported between two ends, it takes the shape of catenary.
- If the Tape is standardized on Flat and used in catenary then correction for sag will be *negative*, because chord length will always be less than Arc length.
- For determination of correction for sag, the shape is assumed to be parabolic, instead of catenary.

$$C_s = \frac{-(wl)^2 l}{24\,p^2} = \frac{-W^2 l}{24\,p^2}$$

Where, w → wt. per unit length of the Tape

l → length of the Tape suspended between two supports

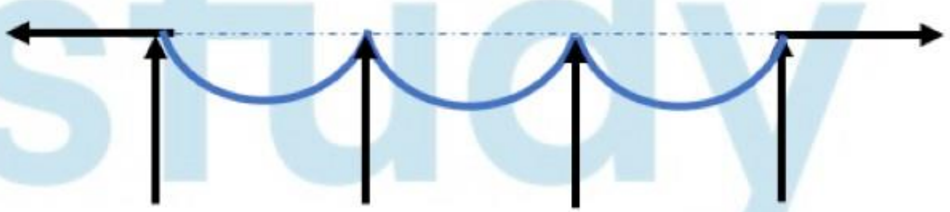
W → Total wt. of the Tape

P → Pull applied at the ends.

Corrections

5. Correction for sag C_s

- To reduce sag correction we can increase no of supports.
- If Total length of the Tape suspended is 'l' which is supported between 'n' no of bays
- $C_s = -\frac{W^2 l}{24 n^2 p^2} = \frac{-(wl)^2 l}{24 n^2 p^2}$



Note:-

- If Tape is standardized in catenary and used on flat then correction for Sag will be positive
- Normal Tension (P_n) is that theoretical pull at which sag correction and pull correction cancel outs each other–

$$\frac{(P_n - P_o)l}{AE} = \frac{W^2 l}{24 P_n^2}$$

Que. 14 Determine sag correction for a 30 m steel Tape under a pull of 80 N. in 3 boys of 10 m each, cross-sectional Area of the Tape is 8 mm² and unit wt of the steel may be taken as 77 KN/m³

Sol. $$C_s = \frac{-W^2 l}{24\, n^2 p^2}$$

$$W = \gamma AL$$

$$= 77 \times \frac{10^3}{10^9} \times 8 \times 30 \times 10^3$$

$$= 18.48\, N$$

$$C_s = \frac{-18.48^2 \times 30}{24 \times 3^2 \times 80^2}$$

$$= -7.411 \times 10^{-3} m.$$

Que.15 Determine Normal tension for a steel tape supported between two supports 10 m apart, if the standard Tension is 65 N and wt. of the Tape is 0.62 N/m, $E = 2 \times 10^5$ and corss-sectional Area of the Tape is 8 mm²

Sol:

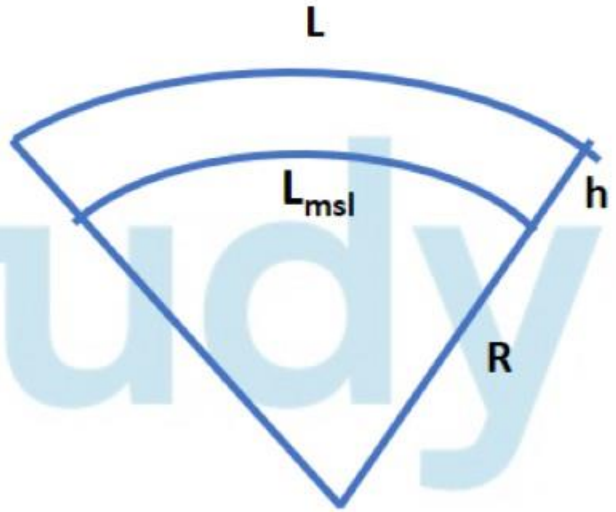
$$\frac{(P_n - P_o)l}{AE} = \frac{W^2 l}{24\, P_n^2}$$

$$\frac{(P_n - 65)}{8 \times 2 \times 10^5} = \frac{(0.62 \times 10)^2}{24\, P_n^2}$$

$$P_n = 162.29\ N$$

Corrections

5. Correction for MSL C_{MSL}



$$C_{MSL} = L_{MSL} - L$$
$$C_{MSL} = R\theta - (R + h)\theta$$
$$C_{MSL} = -h\theta$$
$$C_{MSL} = \frac{-hL}{R+h}$$

Since, h is very small in comparison to R, therefore we can neglect it,

$$C_{MSL} = \frac{-hL}{R}$$

Que. 16 Determine correction for MSL if measured length of the line is 1000 m and Average elevation of the line from MSL is 300 m. if R = 6370 km.

Sol:

$$C_{MSL} = \frac{-hL}{R}$$

$$= \frac{-300 \times 1000}{6370 \times 10^3}$$

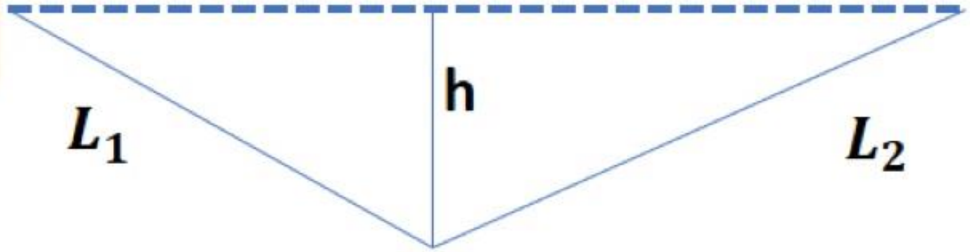
$$= -0.047m$$

Corrections

5. Correction for Misalignment C_m

$$C_m = \left(\sqrt{L_1^2 - h^2} + \sqrt{L_2^2 - h^2}\right) - (L_1 + L_2)$$

Error due to misalignment is always positive.



FIELD WORK IN CHAIN SURVEY

1. ***Reconnaissance survey***

It is preliminary inspection of the area to be surveyed to get some idea of the terrain and to identify principle features of the area

It helps the surveyor to decide upon best possible arrangement of triangles.

FIELD WORK IN CHAIN SURVEY

2. Marking of station

After completion of Reconnaissance Survey best suitable positions of Main stations are marked on the ground such that they can be easily identified afterwards if required.

3. Running of survey lines

Survey lines are run to measure the distance between main stations and to locate adjacent detail by taking offsets.

FIELD WORK IN CHAIN SURVEY

4. Taking offsets

Maximum length of offset depends on;

- Scale of plan (or) Map
- Accuracy desired
- Nature of ground

Degree of Accuracy of the offset depends on

- Length of offset
- Scale of plan (or) Map
- Importance of detail towards which offset is taken

OBSTACLES IN CHAINING

CASE I : Chaining round the obstacle is possible. (LAKE)

OBSTACLES IN CHAINING

CASE II : Chaining round the obstacle is not possible(RIVER)

CROSS STAFF SURVEY

It is a special type of chain survey which is used to locate boundary of the Area, to plot area on a suitable scale (or) to determine approximate Area of the field.

IMPORTANT POINTS

1. **Maximum tolerance in a 20 m & 30 m chain are ± 5 mm and ± 8 mm.**
2. **While measuring horizontal distance with chain on hills, it is better to measure the distance by "Stepping down slope".**
3. **Chainage in chain survey means "the distance of the object along the chain line from the zero end of the chain".**
4. **The allowable Length of an offset depends upon:**
   - **Degree of accuracy required**
   - **Method of setting out the perpendicular and nature of ground.**
   - **Scale of potting**

IMPORTANT POINTS

5. **In chain Surveying, field work is limited to "Linear measurements only"**
6. **The accuracy of Measurement in chain surveying, does not depend upon "general layout of the chain lines"**
7. **The double-line field book is most commonly used for recording "Ordinary chain Survey work".**
8. **Offset are lateral measurements made w.r.t. main survey lines in which line may be oblique (or) $\perp$ lar.**
9. **Correct methods of ranging employed to solve the problem of vision obstructed are:**

    i) Reciprocal ranging

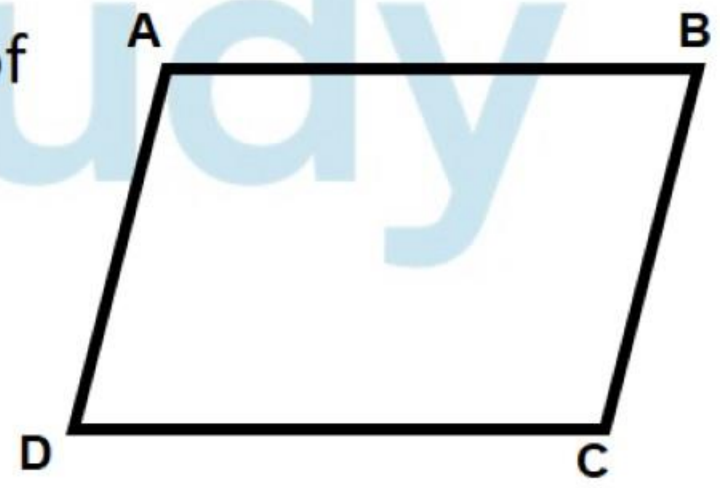
    ii) Random line method.

Chapter 3: Compass Surveying

It is branch of surveying in which direction of Survey lines are measured with a compass and length is determined with chain or tape

Compass Surveying

- It is branch of surveying in which direction of survey lines are measured with a compass, and length is determined with chain or tape.
- Generally, compass is used to set traverse in the field
- Traverse is a framework consisting of series of straight lines connected together forming a closed or open polygon



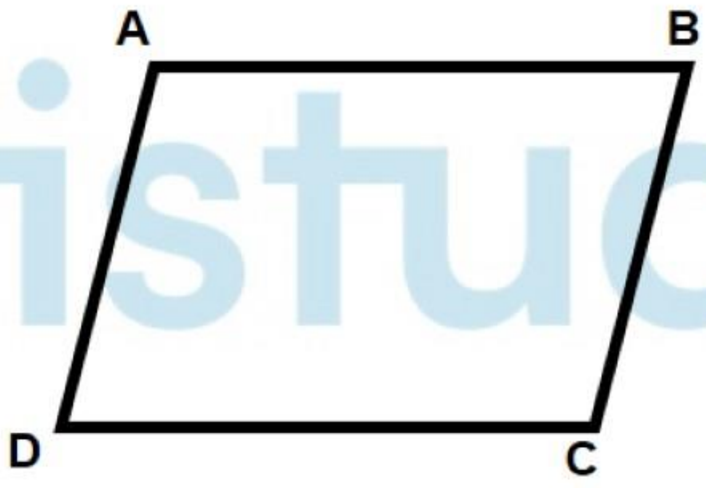
Points such as A, B, C,D are called traverse points and the line joining there points are called "Traverse line."

Depending upon instrument used, traverse can be classified as:

(i) Compass Traverse

(ii) Plane Table Traverse

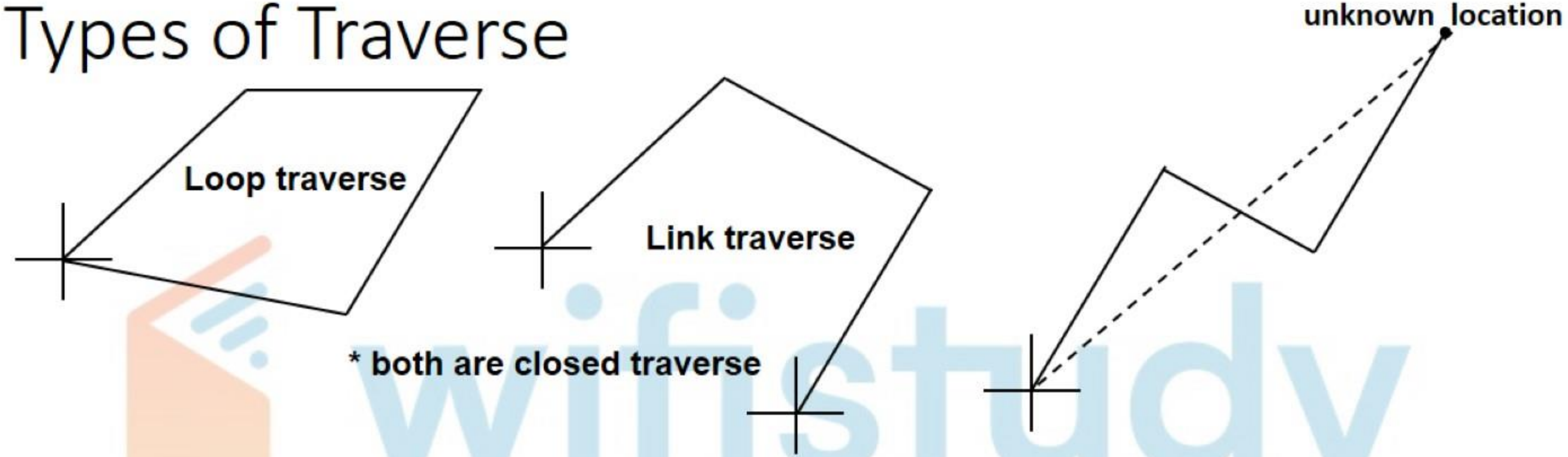
(iii) Theodolite Traverse



Difference between chain survey and Traverse Survey

Chain survey	Traverse survey
• Only linear measurements are done • framework consists of network of triangles • Check line or prop line are required to check accuracy of plot • Accuracy desired is low as it is used for small area	• Linear and angular measurements are done • Frame work consists of open or closed traverse of polygons • Check lines & proof lines are not required as accuracy is checked by method of Adjustment • Used for large area when accuracy desired is high.

Types of Traverse



1. Closed Traverse

- It is a traverse that starts from point of known location and closes at either same point or another point of known location.

2. Open Traverse

- It is a traverse which starts from a point of known location but closes at another point of unknown location.
- An open traverse can be checked by method of chords or astronomical observations.

Compass Traverse

- In compass traverse, compass is used to measure direction and horizontal angles
- Sides of traverse are measured with chain or tape

pass Traverse

Prismatic compass

- The Needle is of broad needle type.
- Graduated card ring is attached with the needle. The ring does not rotate along with the line of sight
- Graduations are engraved inverted
- Reading is taken with the help of prism provided at eye slit
- Tripod may or may not be provided

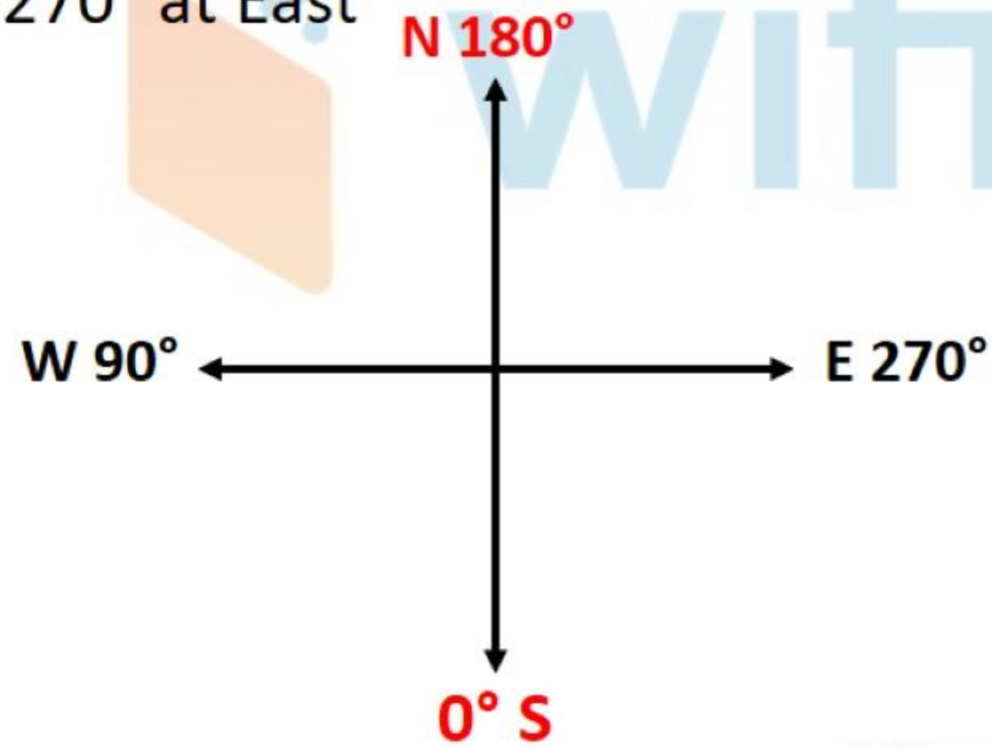
Surveyor's compass

- Needle is of edge bar type
- the graduated card is attached to the box and not to the needle. The card rotates along with the line of sight
- Graduations are engraved Erect.
- Reading is taken by directly seeing through top of glass.
- the instruments can not be used without a tripod.

pass Traverse

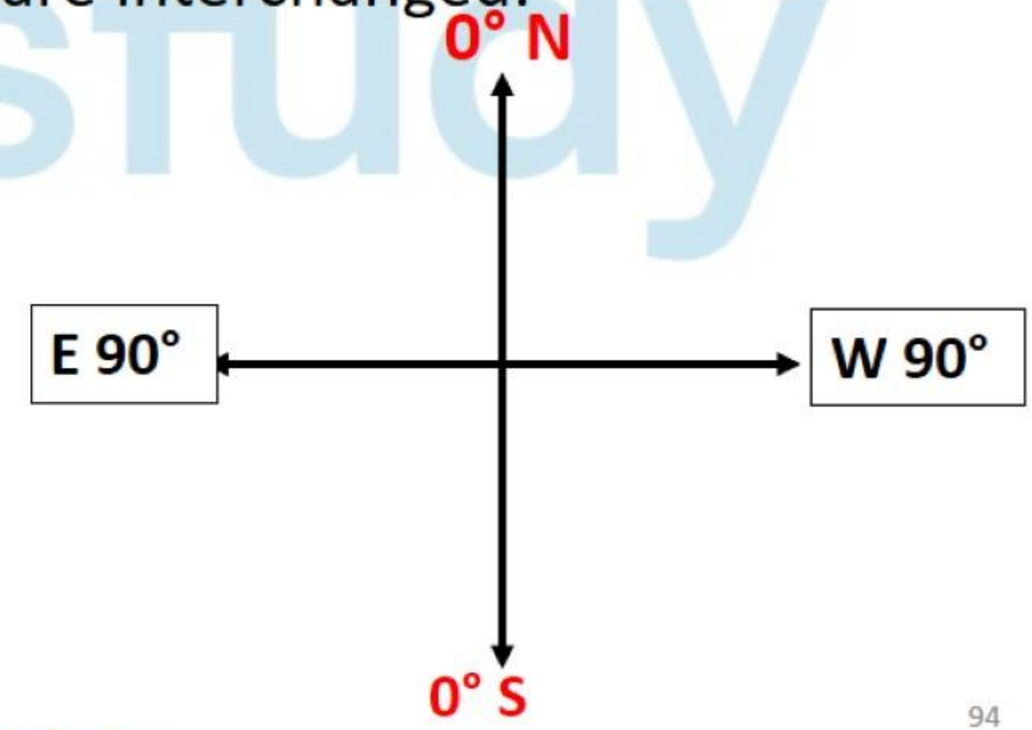
Prismatic compass

- The graduations are in W.C B system having 0° at south end, 90° at west 180° at North and 270° at East



Surveyor's compass

- The graduation are in QB system having 0° at North and south, 90° at East & West. East & West are interchanged.

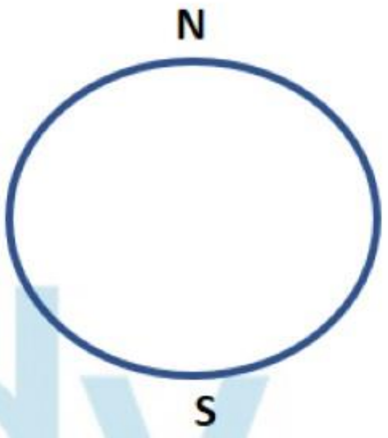


MEASUREMENT OF ANGLES

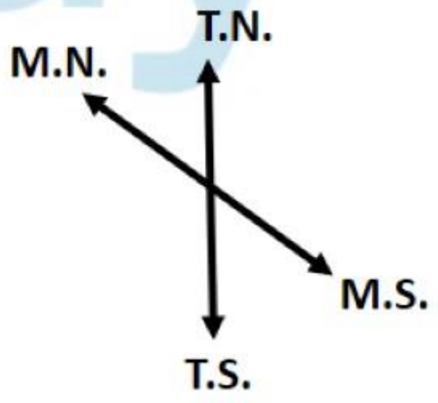
- Direction of survey lines can be defined in two ways :
  - Relative to each other
  - Relative to some fixed reference direction
- In surveying, this fixed reference direction is called as "Meridian"

TYPES OF MERIDIAN

1. **True meridian:**
   - True meridian at a point on the Earth surface is the line joining geographic North and geographic south at that point.
   - True meridian at a place is determined with the help of astronomical observation of sum and stars.
   - True meridian at a place does not change with passage of time.



2. **Magnetic Meridian**
   - Magnetic meridian at a point is the direction indicated by a freely suspended magnetic bar or needle provided that it should not be affected by magnetic forces other than that of Earth.
   - Magnetic meridian at a point changes with passage of time.



TYPES OF MERIDIAN

3. **Grid Meridian :**
   - **For survey of a country, they meridian passing through central place is taken as reference meridian for whole country and such a reference meridian is called as Grid meridian.**
   - **Example: 82.5° E (Allahabad)**
4. **Arbitrary Meridian :**
   - **It is meridian which is taken in any arbitrary direction**
   - **Generally it is taken in the direction from a traverse station to a well define point such as top of four, chimney, etc.**
   - **Sometimes direction of first traverse line is also taken as reference meridian.**

TYPES OF BEARINGS

- Bearing is the horizontal angle between fixed reference direction and survey line.
- Types of Bearing:
  - True Bearing
  - Magnetic Bearing
  - Grid Bearing
  - Arbitrary bearing

NOTE : For all important surveys true bearing is preferred over magnetic bearing

DESIGNATIONS OF BEARING

1. Whole circle Bearing : (WCB) / Azimuthal system

- **WCB of a line is the horizontal angle between the survey line and North End of reference meridian in clockwise direction**
- **Prismatic compass is used.**
- **It ranges from 0° to 360°**

DESIGNATIONS OF BEARING

2. Quadrantal Bearing system (Reduced Bearing)

- **Quadrantal Bearing is the acute Horizontal angle between reference meridian (N or S) and survey line.**
- **Surveyors compass is used.**

FORE BEARING AND BACK BEARING

- **Fore Bearing :**
  - **Fore Bearing of a line is Horizontal angle in the direction of progress of survey.**
- **Back Bearing:**
  - **Back Bearing of a line is the horizontal angle in the direction opposite of the progress of survey.**

$$BB = FB \pm 180°$$

Positive → FB → less than 180°

Negative → FB →greater than 180°

FORE BEARING AND BACK BEARING

Note : If Fore Bearing of line is given in quadrantal bearing system, then Back Bearing can be obtained by replacing

- **N → S**
- **S → N**
- **E → W**
- **W → E**

INCLUDED ANGLES

- Included Angles :
  - Included angle is the angle measured in clockwise direction from previous line to the next line .
  - Included angle = FB of Next line – BB of previous line
  - If negative value is obtained, then add 360°.

Que. The WCB of line AB and BC are 30° 15′ and 120°30′, determine included angle B.

Sol. By Geometry

$\angle B = 120°\,30' + 90° + 59°45' = 270°15'$

By Formula,

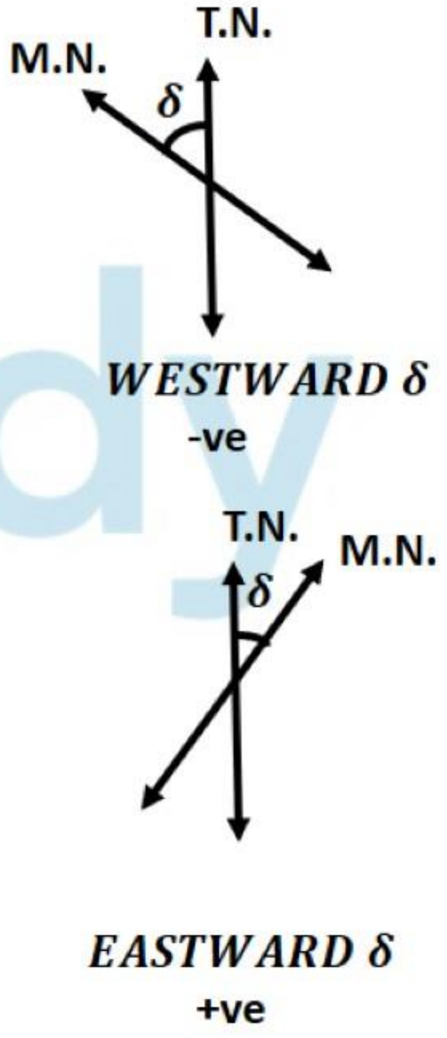
$$\angle B = FB\ of\ BC - BB\ of\ AB$$
$$= 120°\,30' - (30°\,15' + 180°) + 360°$$
$$= 270°15'$$

MAGNETIC FIELD OF EARTH

- **MAGNETIC FIELD OF EARTH**
  - **Earth acts as a powerful magnet with its magnetic lines of forces running from South end to North end.**
  - **Magnetic lines of forces are perpendicular at poles and parallel at equator**
  - **Magnetic needle when freely suspended about its CG, it is influenced by Earth's magnetic field and aligns itself parallel to magnetic force of Earth at that point.**
  - **The vertical angle between magnetic needle and Earth surface is called as Angle of dip–**
    - **At poles dip = 90°**
    - **At Equator dip = 0°**

MAGNETIC DECLINATION

- Generally, magnetic meridian and true meridian do not coincide with each other.
- Horizontal angle between the true Meridian and Magnetic Meridian at the time of observation is called as "magnetic declination" or simply declination.



MAGNETIC DECLINATION

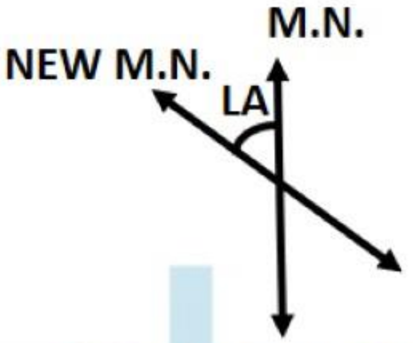
Note: Magnetic Declination in the field can be measured by determining magnetic Bearing and True Bearing of the same line

- **Declination of a time changes from time to time.**
- **Declination at a time changes from point to point.**
- **Variation of declination is shown by isogonic lines.**

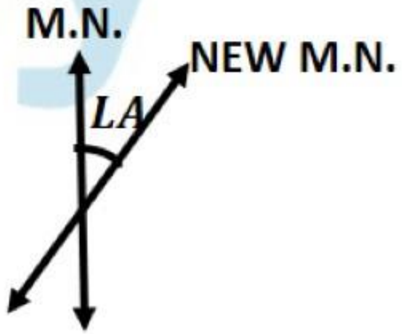
- **ISOGONIC LINES – line passing through points on the surface of the earth at which declination is same at a given point of time.**
- **A-GONIC LINES – these are special isogonic lines, which pass through points of 0 declination, also at all points on A-Gonic line, magnetic meridian will coincide with true meridian.**

LOCAL ATTRACTION

- Local attraction is the attraction of magnetic needle to a local magnetic field other than Earth's magnetic field.
- Under the influence of local attraction, magnetic needle will deviate from magnetic meridian which results in wrong magnetic Bearing of Traverse line.



WESTWARD LA
-ve



EASTWARD LA
+ve

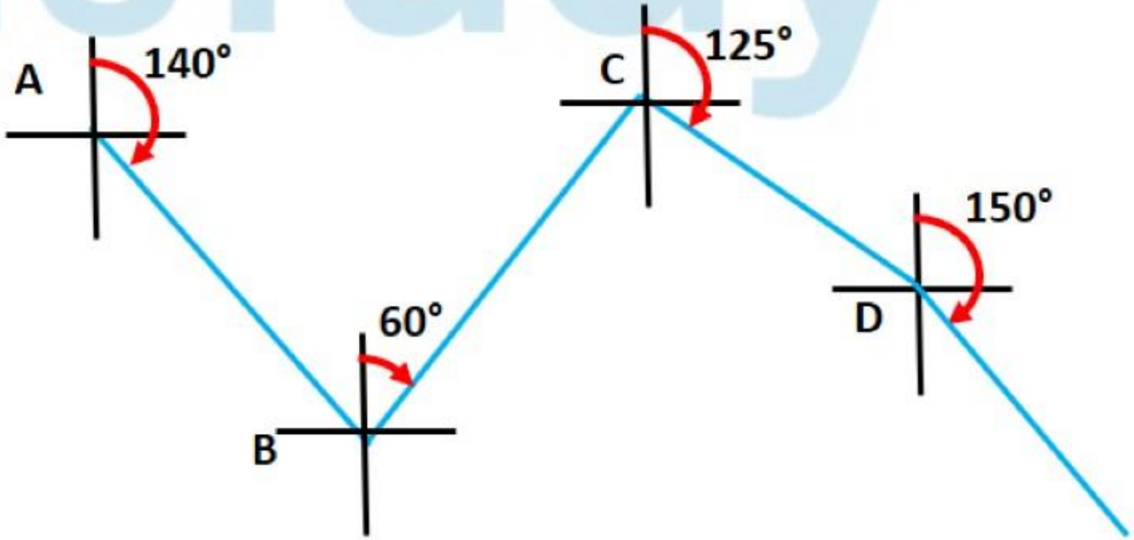
LOCAL ATTRACTION

- To determine local attraction, it is mandatory to take fore Bearing and Back bearing of Each traverse line
- It difference between FB and BB is next equal to 180°, then local attraction can be at
  - Either of the station (station A or B)
  - Both the station (station A & B)

Method 1: Correction for LA at each station

Line	FB	BB
AB	140°	318°
BC	60°	240°
CD	125°	302°
DE	150°	

- This method is suitable for open traverse
- This method will fail for closed traverse when instrumental error are present, i.e. theoretical sum of angles will not match actual sum



Step 1: Observe for a line whose FB and BB differs exactly by 180° (Here line BC)

Step 2: End station of such line are free from LA and all the bearings from this station are free from LA

- Correct BB of AB = 318°

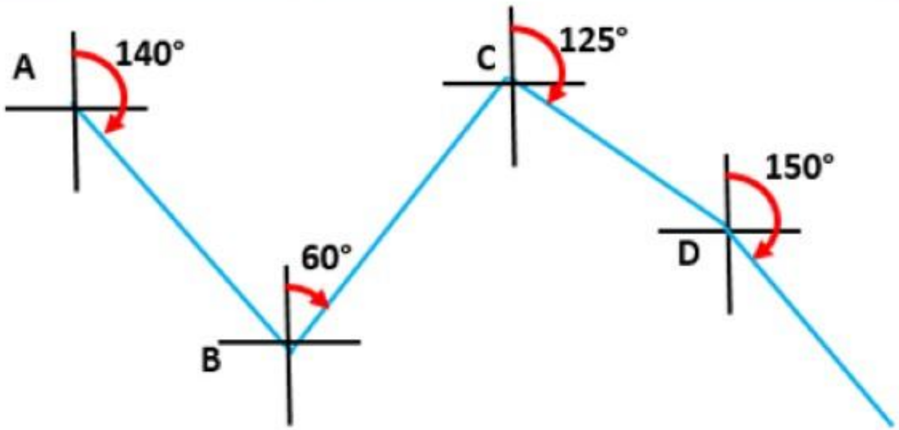
  Therefore, correct FB of AB = 318°-180° =138°

  Observed FB of AB = 140°

  Correction at station A= -2°

- Correct FB of the line CD=125°
  - Correct BB of CD=305°
  - Observed BB of CD=302°
  - Correction at station D= +3°
- Observed FB of DE=150°
  - So correct FB of DE=153°

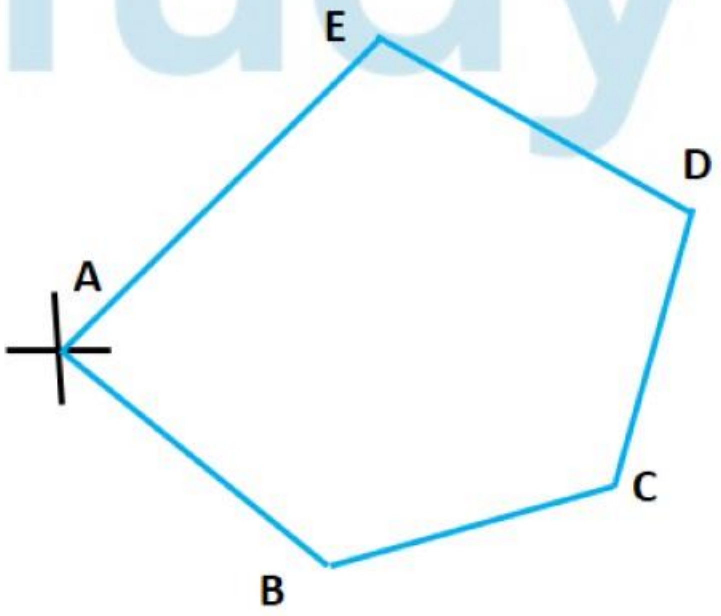
Line	FB	BB
AB	140°	318°
BC	60°	240°
CD	125°	302°
DE	150°	



Method 2: By Including angles

Line	FB	BB
AB	150°30′	329°45′
BC	78°	256°30′
CD	42°30′	223°45′
DE	315°45′	134°15′
EA	220°15′	40°15′

- This method is suitable for closed traverse
- As all the bearings taken at a station are affected equally and in one direction, therefore there is no effect of local attraction on included angles



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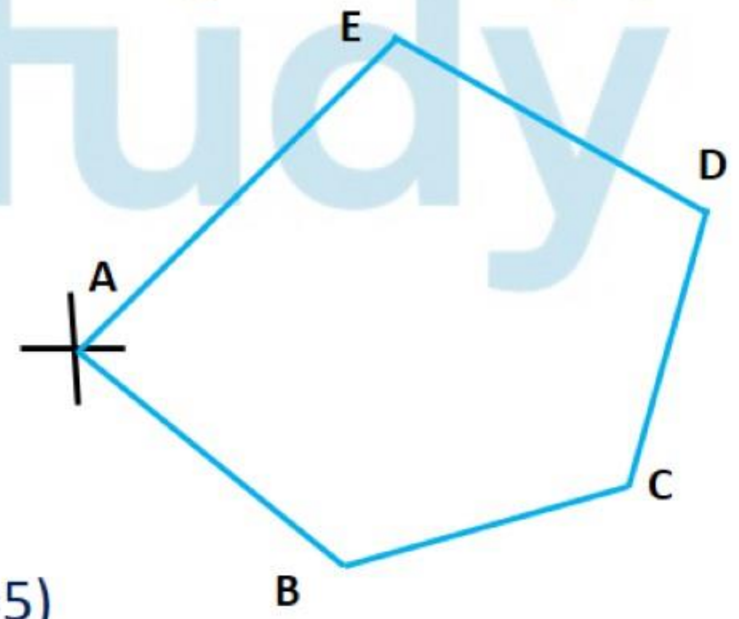
AB	150°30′	329°45′
BC	78°	256°30′
CD	42°30′	223°45′
DE	315°45′	134°15′
EA	220°15′	40°15′

- Step 1: Locate a line whose fore bearing and back bearing differs exactly by 180°
- Step 2: Calculate Included angles
  - $\angle A$ = **150°30′ - 40°15′ = 110°15′**
  - $\angle B$ = **78°0′ - 329°45′+ 360° = 108°15′**
  - $\angle C$ = **42°30′ - 256°30′ + 360° = 146°**
  - $\angle D$ = **315°45′ - 223°45′ = 92°**
  - $\angle E$ = **220°15′ - 134°15′ = 86°**
- Step 3: Actual Sum of angles = 542°30′
- Step 4: Theoretical Sum = (2n-4) x 90° = 540° (n=5)
- Step 5: Error = 542°30′ - 540° = 2°30′



- **Step 1: Locate a line whose fore bearing and back bearing differs exactly by 180°**
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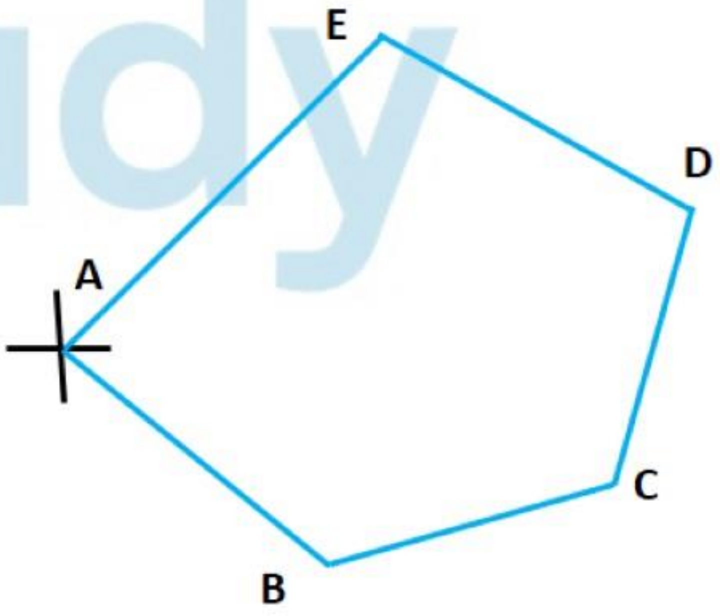
- **Step 3: Actual Sum of angles = 542°30'**
- **Step 4: Theoretical Sum = (2n-4) x 90° = 540° (n=5)**
- **Step 5: Error = 542°30' - 540° = 2°30' , correction = -2°30'**
- **Step 6: Correction per angle =** $\frac{-2°30'}{5} = -30'$
- **Step7: Corrected angles are**
  - $\angle A$ =109°45'
  - $\angle B$ =107°45'
  - $\angle C$ =145°30'
  - $\angle D$ =91°30'
  - $\angle E$ =85°30'



Que 19. The curvature of the earth's surface is taken into account if the extent of survey is more than

a)100 km^2

b)160 km^2

c)500 km^2

d)260 km^2

Que 19. The curvature of the earth's surface is taken into account if the extent of survey is more than

a)100 km^2

b)160 km^2

c)500 km^2

d)260 km^2

Que 20. The limiting length of an offset not depend upon

a)accuracy of the work

b)method of setting out perpendiculars

c)Scale of plotting

d)indefinite features to be surveyed

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a)accuracy of the work

b)method of setting out perpendiculars

c)Scale of plotting

d)indefinite features to be surveyed

Que 21. The construction of optical squares is based on the principle of optical

a)reflection

b)refraction

c)Double refraction

d)Double reflection

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a)reflection

b)refraction

c)Double refraction

d)Double reflection

Que 22. The survey in which the curvature of the Earth is taken into account is called

a)Geodetic survey

b)Plane survey

c)Hydrographical survey

d)Topographical survey

Que 22. The survey in which the curvature of the Earth is taken into account is called

a)Geodetic survey

b)Plane survey

c)Hydrographical survey

d)Topographical survey

Que 23. In a metric chain, number of links per meter run can be

a)2

b)5

c)8

d)0

Que 23. In a metric chain, number of links per meter run can be

a)2

b)5

c)8

d)0

Que 24. Cross staff is used for:

a)Setting out right angle

b)Measuring horizontal angle

c)Both (a) and (b)

d)None of the above

Que 24. Cross staff is used for:

a)<u>Setting out right angle</u>

b)Measuring horizontal angle

c)Both (a) and (b)

d)None of the above

Que 25. The fixed point whose elevation is known, is called as

a)Benchmark

b)Change point

c)Reduced level

d)Station

Que 25. The fixed point whose elevation is known, is called as

a)Benchmark

b)Change point

c)Reduced level

d)Station

Que 26. Which of the following scales is the smallest one?

a)4 : 200000

b)1 cm = 5000 m

c)1 cm = 50 m

d)RF = m/50000

Que 26. Which of the following scales is the smallest one?

a)4 : 200,000

b)<u>1 cm = 5000 m</u>

c)1 cm = 50 m

d)RF = 1/50000

Que 27. When the curvature of earth is taken into account, the surveying is called as

a)Plane surveying

b)Preliminary surveying

c)Geodetic surveying

d)Hydrographic surveying

Que 27. When the curvature of earth is taken into account, the surveying is called as

a)Plane surveying

b)Preliminary surveying

c)Geodetic surveying

d)Hydrographic surveying

Que 28. Ranging is defined as

a)Measuring the distance from starting point

b)Establishing intermediate points on a chain line

c)The distance between end points

d)A point on a chain line

Que 28. Ranging is defined as

a)Measuring the distance from starting point

b)<u>Establishing intermediate points on a chain line</u>

c)The distance between end points

d)A point on a chain line

Que 29. A line joining some fixed points on the main survey lines is called as

a)Check line

b)Tie line

c)Chain line

d)Base line

Que 29. A line joining some fixed points on the main survey lines is called as

a)Check line

b)<u>Tie line</u>

c)Chain line

d)Base line

Que 30. The main principle of field surveying is to work from

a)Higher level to lower level

b)Lower level to higher level

c)Part whole

d)Whole to part

Que 30. The main principle of field surveying is to work from

a)Higher level to lower level

b)Lower level to higher level

c)Part whole

d)Whole to part

Que 31. “Offsets” are

a)Lateral measurements from chain line

b)Tie or check lines which are perpendicular to chain line

c)Sets of minor measurements in chain surveying

d)Chain lines which go out of alignments

Que 31. “Offsets” are

a)Lateral measurements from chain line

b)Tie or check lines which are propendicular to chain line

c)Sets of minor measurements in chain surveying

d)Chain lines which go out of alignments

Que 32. Which of the following statements in respect of a map A having scale 1 : 1000 and another map B having scale 1 : 5000 is true?

a)Map A is a large scale map compared to map B

b)Map B is a large scale map compared to map A

c)Map B is a more detailed map compared to map A

d)None of the above

Que 32. Which of the following statements in respect of a map A having scale 1 : 1000 and another map B having scale 1 : 5000 is true?

a)Map A is a large scale map compared to map B

b)Map B is a large scale map compared to map A

c)Map B is a more detailed map compared to map A

d)None of the above

Que 33. The correction to be applied to each 30 m chain length for a line measurement along a slope of θ is

a)-30 $(1 - \cos\theta)$

b)30 $(1 - \sin\theta)$

c)30 $(1 - \tan\theta)$

d)30 $(1 - \cot\theta)$

Que 33. The correction to be applied to each 30 m chain length for a line measurement along a slope of θ is

a) $-30\,(1 - \cos\theta)$

b) $30\,(1 - \sin\theta)$

c) $30\,(1 - \tan\theta)$

d) $30\,(1 - \cot\theta)$

Que 34. When 1 cm on a map represents 10 m on the ground, the representative fraction of the scale is:

a) $\frac{1}{10000}$

b) $\frac{1}{10}$

c) $\frac{1}{100}$

d) $\frac{1}{1000}$

Que 34. When 1 cm on a map represents 10 m on the ground, the representative fraction of the scale is:

a) $\frac{1}{10000}$

b) $\frac{1}{10}$

c) $\frac{1}{100}$

d) $\frac{1}{1000}$

Que 35. Mean sea level (MSL) adopted by Survey of India for reference, is located at

a)Kolkata

b)Mumbai

c)Karachi

d)Delhi

Que 35. Mean sea level (MSL) adopted by Survey of India for reference, is located at

a)Kolkata

b)Mumbai

c)Karachi

d)Delhi

Que 36. The distance between two brass rings in a surveyor’s chain is

a)20 cm

b)40 cm

c)75 cm

d)1 m

Que 36. The distance between two brass rings in a surveyor's chain is

a) 20 cm

b) 40 cm

c) 75 cm

d) 1 m

Que 37. Survey line provided to verify the accuracy of the framework is known as

a)Tie line

b)Base line

c)Subsidiary line

d)Check line

Que 37. Survey line provided to verify the accuracy of the framework is known as

a)Tie line

b)Base line

c)Subsidiary line

d)Check line

Que 38. The total number of links provided in a Gunter's chain is

a)132

b)100

c)66

d)50

Que 38. The total number of links provided in a Gunter's chain is

a)132

b)100

c)66

d)50

Que 39. Geodetic survey is different from plane surveying because of

a)Very large area is covered

b)The curvature of the earth is considered

c)Undulations of the topography

d)The large difference of elevations

Que 39. Geodetic survey is different from plane surveying because of

a)Very large area is covered

b)The curvature of the earth is considered

c)Undulations of the topography

d)The large difference of elevations

Que 40. Difference in length of an arc and its subtended chord on earths surface for a distance of 12 km is

a)10 mm

b)15 mm

c)22mm

d)100 mm

Que 40. Difference in length of an arc and its subtended chord on earths surface for a distance of 12 km is

a)10 mm

b)15 mm

c)22mm

d)100 mm

Que 41. Chain surveying is most suitable when

a)The ground is fairly levelled and open with simple details

b)The area is small in extent

c)Plans are required on a large scale

d)All options are correct

Que 41. Chain surveying is most suitable when

a)The ground is fairly levelled and open with simple details

b)The area is small in extent

c)Plans are required on a large scale

d)<u>All options are correct</u>

Que 42. Every 20 m chain should be accurate to within

a)± 2 mm

b)± 5 mm

c)± 8 mm

d)None of the above

Que 42. Every 20 m chain should be accurate to within

a)± 2 mm

b)± 5 mm

c)± 8 mm

d)None of the above

Que 43. Method used for chaining on sloping ground is

a)By stepping method

b)By hypotenuse allowance method

c)By clinometer method

d)Both stepping method and hypotenuse

Que 43. Method used for chaining on sloping ground is

a)By stepping method

b)By hypotenuse allowance method

c)By clinometer method

d)Both stepping method and hypotenuse

Que 44. Maximum allowable limit upto that a measurement may very from the true value is known as

a)Permissible error

b)Residual error

c)Expected error

d)Sale error

Que 44. Maximum allowable limit upto that a measurement may very from the true value is known as

a)Permissible error

b)Residual error

c)Expected error

d)Sale error

Que 45. Number of links in a 30 m metric chain is

a)100

b)150

c)180

d)200

Que 45. Number of links in a 30 m metric chain is

a)100

b)150

c)180

d)200

Que 46. Positive error is caused if

a)Length of chain is shorter than the standard

b)Slope and sag correction is not applied

c)Measurements are made along the incorrectly aligned line

d)All options are correct

Que 46. Positive error is caused if

a)Length of chain is shorter than the standard

b)Slope and sag correction is not applied

c)Measurements are made along the incorrectly aligned line

d)<u>All options are correct</u>

Que 47. A well-conditioned triangle has angles not less than ______ and more than ______ respectively

a)10°, 90°

b)20°, 120°

c)90°, 120°

d)None of these

Que 47. A well-conditioned triangle has angles not less than ______ and more than ______ respectively

a)10°, 90°

b)20°, 120°

c)90°, 120°

d)<u>None of these (30° -120°)</u>

Que 48. Compensating errors in chaining are ________.

a)Proportional to the length of line

b)Proportional to the square root of the length of line

c)Inversely proportional to the square root of the length

d)Inversely Proportional to the length of the line

Que 48. Compensating errors in chaining are ________.

a)Proportional to the length of line

b)<u>Proportional to the square root of the length of line</u>

c)Inversely proportional to the square root of the length

d)Inversely Proportional to the length of the line

Que 49. If a chain is found very short on testing, it can be adjusted by _______.

a)Straightening the links

b)Inserting additional circular rings

c)Flattening the circular rings

d)Any of the options

Que 49. If a chain is found very short on testing, it can be adjusted by _______.

a)Straightening the links

b)Inserting additional circular rings

c)Flattening the circular rings

d)<u>Any of the options</u>

Que 50. Permissible limits of error in chaining for measurement on rough or hilly ground is ________.

a)1 : 2000

b)1 : 1000

c)1 : 500

d)1 : 250

Que 50. Permissible limits of error in chaining for measurement on rough or hilly ground is __________.

a)1 : 2000

b)1 : 1000

c)1 : 500

d)1 : 250

Que 51. During chaining with a straight line, the leader of the survey party has three arrows and while the follower has five arrows, the distance of the follower from the starting point will be _______.

a)Three Chains

b)Four Chains

c)Five Chains

d)None of these

Que 51. During chaining with a straight line, the leader of the survey party has three arrows and while the follower has five arrows, the distance of the follower from the starting point will be _______.

a)Three Chains

b)Four Chains

c)Five Chains

d)None of these

Que 52. Invar tape are made of an alloy of _________.

a)Nickle and steel

b)Copper and steel

c)Tin and steel

d)Aluminum and steel

Que 52. Invar tape are made of an alloy of ________.

a)Nickle and steel

b)Copper and steel

c)Tin and steel

d)Aluminum and steel

Que 53. Chainage is the distance measured

a)Along a chain line

b)Perpendicular to a line

c)Perpendicular to a tie line

d)None of these

Que 53. Chainage is the distance measured

a)Along a chain line

b)Perpendicular to a line

c)Perpendicular to a tie line

d)None of these

Que 54. In chain survey execution, the first step taken is ________.

a)Reference sketches

b)Marking stations

c)Running survey line

d)Reconnaissance

Que 55. In chain survey execution, the first step taken is _________.

a)Reference sketches

b)Marking stations

c)Running survey line

d)Reconnaissance

Que 56. In the surveys, the slope correction applied to the base line is

a)Always cumulative

b)Always compensating

c)Sometimes cumulative, sometimes compensating

d)None of these

Que 56. In the surveys, the slope correction applied to the base line is

a)Always cumulative

b)Always compensating

c)Sometimes cumulative, sometimes compensating

d)None of these

Que 57. The type of surveying in which the curvature of the earth is taken into account is called

a)Geodetic surveying

b)Plane surveying

c)Preliminary surveying

d)Topographical surveying

Que 57. The type of surveying in which the curvature of the earth is taken into account is called

a)Geodetic surveying

b)Plane surveying

c)Preliminary surveying

d)Topographical surveying

Que 58. If his the difference in height between end points of a chain of length *l*, the required slope correction is _______.

a) $\frac{h^2}{2l}$

b) $\frac{h}{2l}$

c) $\frac{h^2}{l}$

d) $\frac{h^2}{4l}$

Que 58. If h is the difference in height between end points of a chain of length *l*, the required slope correction is _______.

a) $\frac{h^2}{2l}$

b) $\frac{h}{2l}$

c) $\frac{h^2}{l}$

d) $\frac{h^2}{4l}$

Que 59. Check lines (or proof lines) in Chain Surveying are essentially required __________.

a)To plot the chain lines

b)To plot the offsets

c)To indicate the accuracy of the survey work

d)To increase the out-turn

Que 59. Check lines (or proof lines) in Chain Surveying are essentially required ___________.

a)To plot the chain lines

b)To plot the offsets

c)To indicate the accuracy of the survey work

d)To increase the out-turn

Que 60. For which of the following, will the chain surveying be well adopted one?

a)Large areas with difficult details

b)Small surveys in open ground

c)Small surveys with crowded details

d)Large areas with simple details

Que 60. For which of the following, will the chain surveying be well adopted one?

a)Large areas with difficult details

b)Small surveys in open ground

c)Small surveys with crowded details

d)Large areas with simple details

Que 61. Which of the following would represent the surface of the water level of a still lake?

a)Level surface

b)Contour surface

c)Horizontal surface

d)None of these

Que 61. Which of the following would represent the surface of the water level of a still lake?

a)Level surface

b)Contour surface

c)Horizontal surface

d)None of these

Que 62. The sag correction in surveys in always _________.

a)Positive

b)negative

c)zero

d)None of these

Que 62. The sag correction in surveys in always __________.

a)Positive

b)negative

c)zero

d)None of these

Que 63. What is the true area (in acres), if the area calculated by a chain which is found to be 0.8 link too long is 100 acres?

a)100.8

b)99.2

c)98.4

d)101.6

Que 63. What is the true area (in acres), if the area calculated by a chain which is found to be 0.8 link too long is 100 acres?

a)100.8

b)99.2

c)98.4

d)101.6

Que 64. The correction to be applied to each 30 meter chain length along $\theta°$ slope is ________.

a) $30(\sec\theta - 1)$ m

b) $30(\sin\theta - 1)$ m

c) $30(\cos\theta - 1)$ m

d) $30(\tan\theta - 1)$ m

Que 64. The correction to be applied to each 30 meter chain length along $\theta°$ slope is ________.

a) $30(\sec\theta - 1)$ m

b) $30(\sin\theta - 1)$ m

c) $30(\cos\theta - 1)$ m

d) $30(\tan\theta - 1)$ m

Que 65. An angle 45° with a chain line may be set our with _________.

a)Optical square

b)Open cross staff

c)French cross staff

d)Prismatic square

Que 66. An angle 45° with a chain line may be set our with ________.

a)Optical square

b)Open cross staff

c)French cross staff

d)Prismatic square

Que 67. The surface of zero elevation around the earth, which is slightly irregular and curved is known as ________.

a)Mean sea level

b)Geoid surface

c)Level surface

d)Horizontal surface

Que 67. The surface of zero elevation around the earth, which is slightly irregular and curved is known as ________.

a)Mean sea level

b)Geoid surface

c)Level surface

d)Horizontal surface

Que 68. The main principle of surveying is to work

a)From part to the whole

b)From whole to the part

c)From higher level to the lower level

d)From lower level to higher level

Que 68. The main principle of surveying is to work

a)From part to the whole

b)From whole to the part

c)From higher level to the lower level

d)From lower level to higher level

Chapter 4: Traversing

- Traverse is a framework consisting of series of straight lines connected together forming an open or closed traverse

Types of Traverse

- Open Traverse
- Closed Traverse

Measurement in Traversing

- In traversing, Linear measurement equipment should be selected such that degree of accuracy is of some order of angle measuring equipment
- If very precise equipment are used for angular measurement, then equally precise equipment shall be used for distance measurement.
- If θ is the least count of angle measuring equipment then permissible error in Linear measurement equipment should be of the order of

$$tan\theta = \frac{\delta L}{L}$$

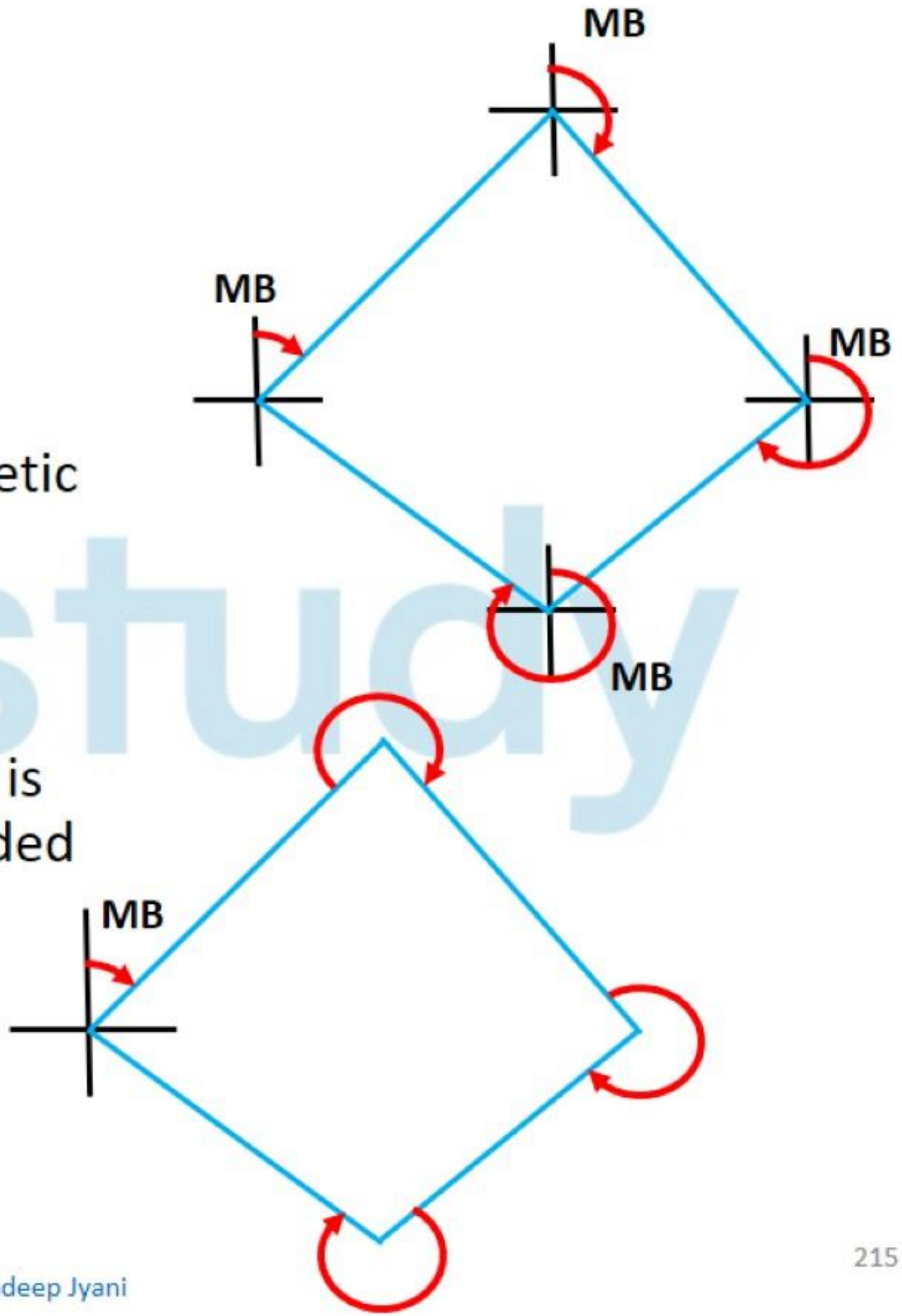
Que: If LC of compass is 30′, then determine order of error for linear measurement equipment in compass survey for 1m.

$$tan\theta = \frac{\delta L}{L} \Rightarrow \tan(30') = \frac{\delta L}{L} \Rightarrow 0.00873 = \frac{\delta L}{L}$$

If we take L=1m=1000mm, δL = 8.73 mm

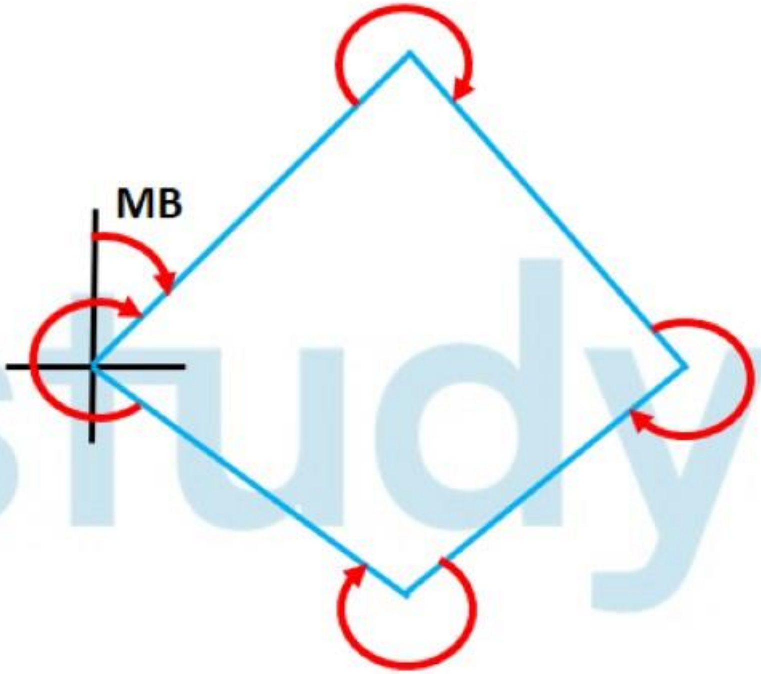
Angular Measurements

1. Loose Needle Method/Free needle method
   - In this method we try to measure magnetic bearing (MB) of each traverse line
2. Fast Needle method
   - In this method we measure magnetic bearing of any one line (and generally it is first traverse line and we measure included angle at all the other stations)
   - This method is more accurate than previous method



Angular Measurements

3. Included angle Method
   - In this method we measure MB of any one line generally
   - It is the first traverse line and we measure included angles at ***all*** the stations.
   - This method is more accurate than previous two methods



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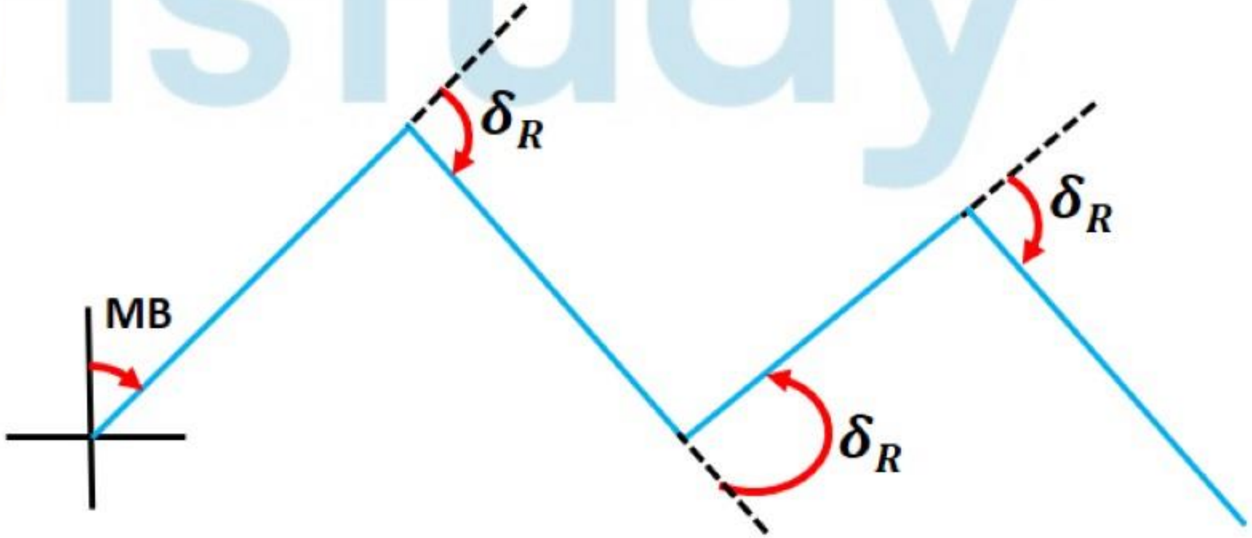
Angular Measurements

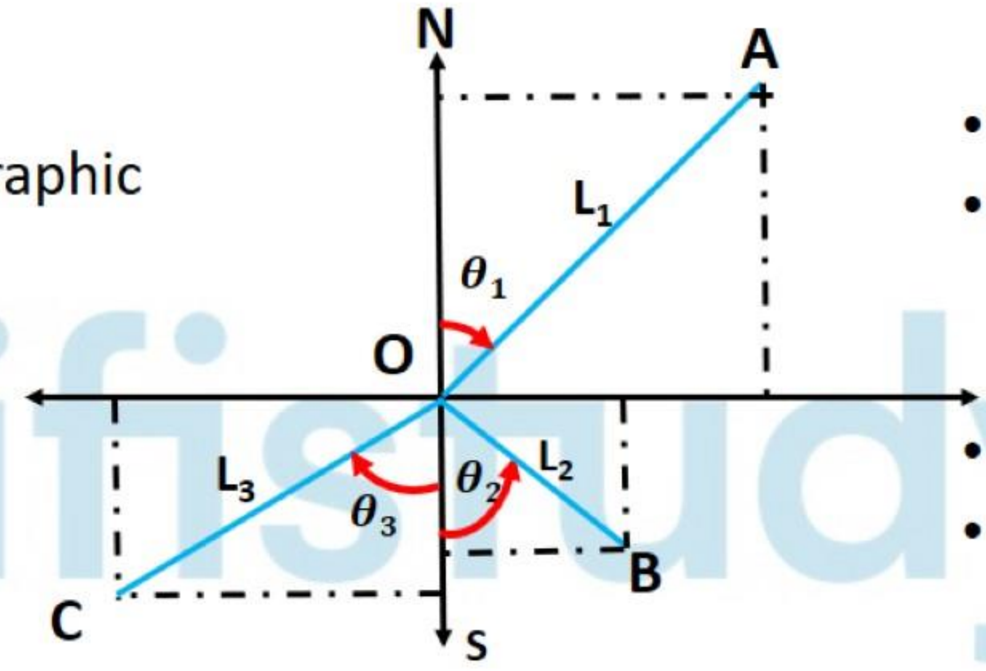
4. Direct Angle Method
    - It is used for open traverse
    - In this method direct angles, i.e. angles towards right direction are measured

5. Deflection Angle Method
    - Deflection angle method is used for open traverse in which traverse line makes small deflection angle like in railways, canals, sewers, etc



Latitude and Departure

1. Latitude
   - Latitude of a line is orthographic projection on North-South Meridian
   - +ve → Northing
   - -ve → Southing
2. Departure
   - Departure is orthographic projection of a line on East West Meridian
   - +ve → Easting
   - -ve → Westing

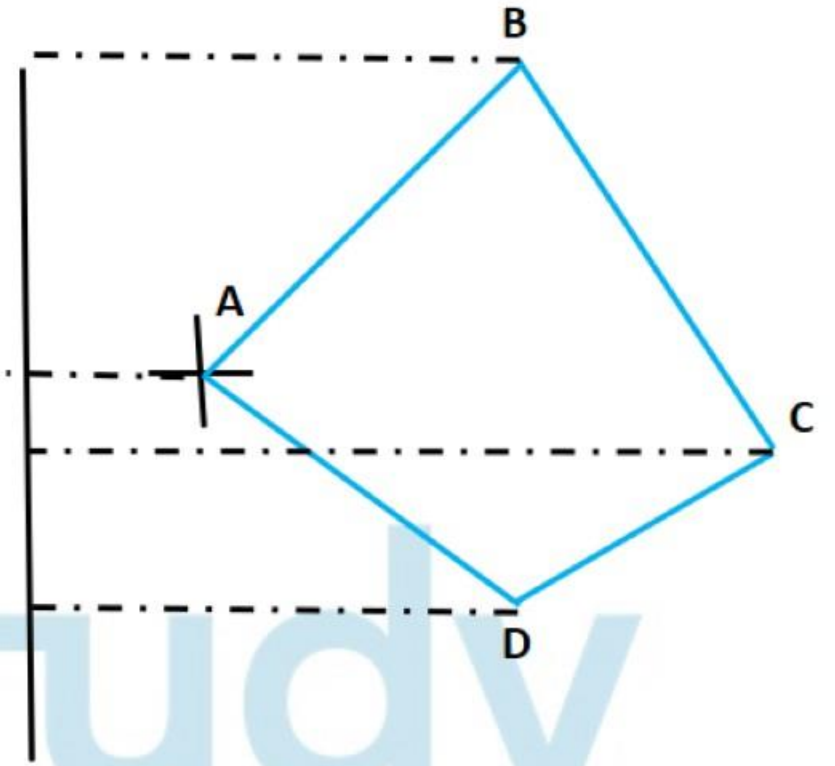


- $L_{OA} = L_1 cos\theta_1$
- $D_{OA} = L_1 sin\theta_1$

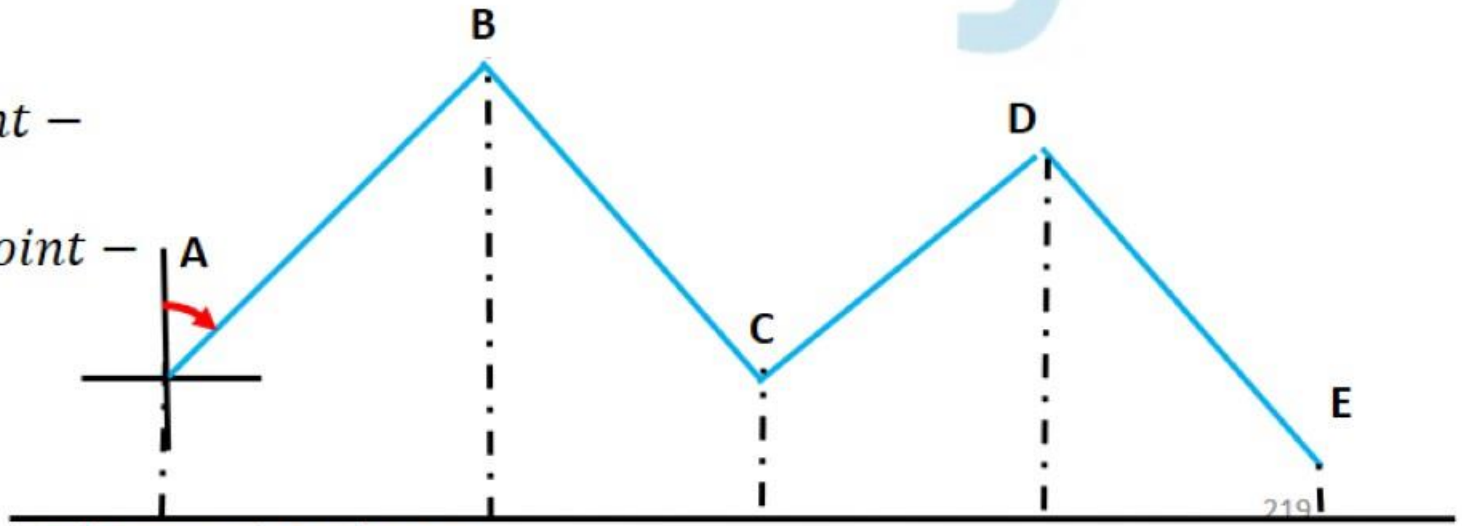
- $L_{OB} = -L_2 cos\theta_2$
- $D_{OB} = L_2 sin\theta_2$

- $L_{OC} = -L_3 cos\theta_3$
- $D_{OC} == L_3 sin\theta_3$

Check in Closed Traverse

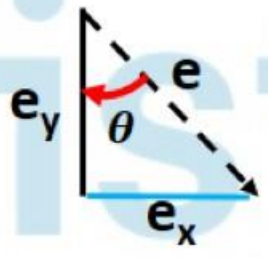


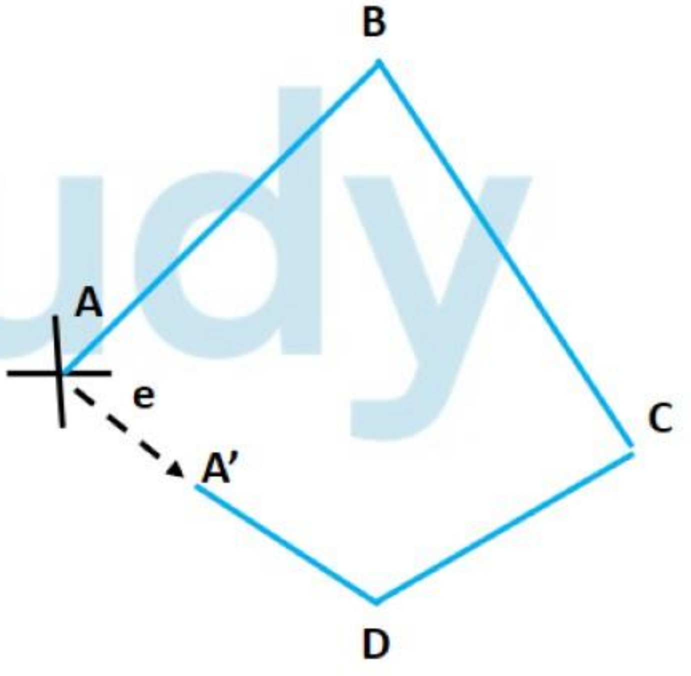
1. Loop Traverse
   - In any closed loop traverse, if a survey work is error free, then
     - $\Sigma L = 0$
     - $\Sigma D = 0$
     - Sum of Northings = Sum of Southings
2. Link Traverse
     - $\Sigma L = Latitude\ of\ last\ point - Latitude\ of\ first\ point$
     - $\Sigma D = Departure\ of\ last\ point - Departure\ of\ first\ point$



Closing Error / Error of closure

- If a traverse has an error, it will not close on a piece of paper
  - Closing error = AA'
  - $e_x = \Sigma D$
  - $e_y = \Sigma L$
  - $e = \sqrt{{e_x}^2 + {e_y}^2}$
  - $\boldsymbol{\theta = tan^{-1}(\frac{e_x}{e_y})}$





Que. If coordinates of E (25,5), E'(20,1), then determine magnitude and direction of closing error

Given that E (25,5), E'(20,1),

$$e_x = x' - x = 1 - 5 = -4$$

$$e_y = y' - y = 20 - 25 = -5$$

$$\Rightarrow e = \sqrt{e_x{}^2 + ey^2} = \sqrt{(-4)^2 + (-5)^2} = 6.403$$

$$\boldsymbol{\theta = tan^{-1}(\frac{e_x}{e_y}) = tan^{-1}(\frac{-4}{-5})} = \mathbf{38.65°}$$

Adjustment of Traverse

If there is error of Closure, it is to be adjusted such that traverse is closed geometrically

There are various methods of adjusting a traverse:

1. Arbitrary Method:
    - In this method, closing error is distributed arbitrarily according to the experience of Surveyor based on field condition
2. Bowditch Rule:
    - It is also called as compass rule
    - It is generally used for adjusting traverse in which angles and distances are measured with same precision
    - Bowditch rule assumes that closing error is due to random error
    - Therefore error in traverse line will be directly proportional to root of length of the line
    - $error \propto \sqrt{Length\ of\ Line}$

Chapter 5: Plane Table Surveying

- **It is a graphical method of surveying in which field work and plotting are done simultaneously**
- **It is mainly used for small and medium scale mapping (1:10 000 to 1: 25 00 000)**
- **Before starting plane table surveying, at first control stations are established to cover entire area, then a suitable scale is decided**
- **After that surveyor starts collecting details from either of the point and traverses all the stations**
- **Elevation of points of observation are determined with the help of levelling, Indian Clinometer and telescopic alidade**

Advantages of Plane Table Surveying

- **It is suitable for location of details as well as contouring for large scale maps directly in the field.**
- **As surveying and plotting are done simultaneously in the field, chances of getting omission of any detail get less.**
- **The plotting details can immediately get compared with the actual objects present in the field. Thus errors as well as accuracy of the plot can be ascertained as the work progresses in the field.**
- **Contours and specific features can be represented and checked conveniently as the whole area is in view at the time of plotting.**
- **Only relevant details are located because the map is drawn as the survey progresses. Irrelevant details get omitted in the field itself.**
- **The plane table survey is generally more rapid and less costly than most other types of survey.**
- **As the instruments used are simple, not much skill for operation of instruments is required. This method of survey requires no field book.**

Disadvantages of Plane Table Surveying

- **The plane table survey is not possible in unfavorable climates such as rain, fog etc.**
- **This method of survey is not very accurate and thus unsuitable for large scale or precise work.**
- **As no field book is maintained, plotting at different scale require full exercise.**
- **The method requires large amount of time to be spent in the field.**
- **Quality of the final map depends largely on the drafting capability of the surveyor.**
- **This method is effective in relatively open country where stations can be sighted easily .**

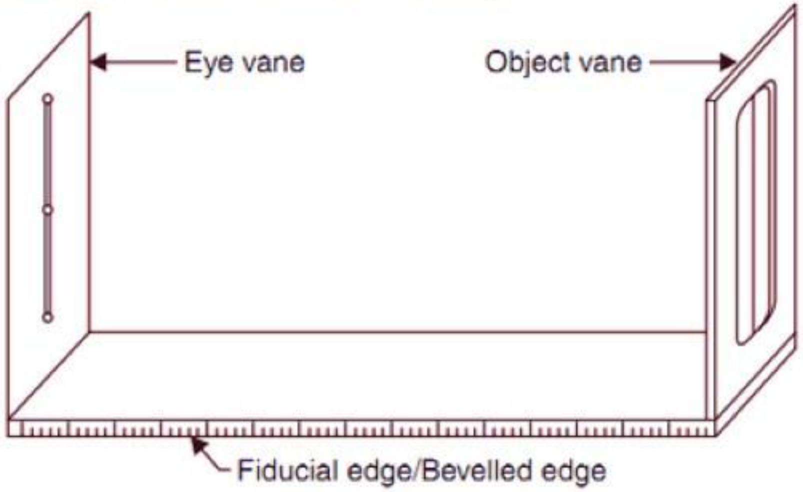
Instruments

- **A plane table mounted on a tripod stand and a number of accessories are used during plane table survey. The accessories consist of alidade, spirit level, trough compass, plumbing fork, plumb bob, drawing sheet**

1. **The plane table consists of a drawing board with arrangement for fixing on a tripod stand.**

A plane table

2. An **alidade is a straight edge ruler used for sighting the object and drawing lines with object vane and sight vane,** with one of the edges is beveled and graduated known as fiducial edge
   - **The line passing through the slit of the eye vane joining the thin wire of the object vane and passing beyond is known as the line of sight of a plane alidade**

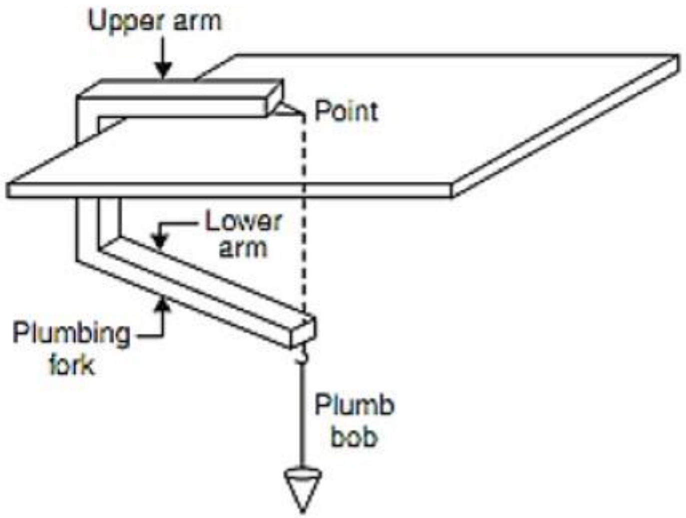


Alidade

Instruments

3. Plumbing Fork

- A plumbing fork is a U-shaped piece of metal or wooded frame
- The end of one of its arm is pointed and the other arm is having an arrangement for hanging a plumb bob
- The frame is constructed in such away that the tip of the pointed arm and the plumb line lie in the same vertical line. At the time of use, the pointed arm is placed on the table and the other arm, with a plumb bob attached, is kept below the table. Plumbing fork with a plumb bob is used in large scale surveying for Centering of the plane table and for Transferring of ground point.



Instruments

4. Spirit Level

- It consists of flat based tube with a small bubble either circular or tubular in shape .
- It is used to check the level of plane table by placing it on the board in two positions at right angles to each other.
- When the bubble tube remains in the centre at any point on the table is considered to be properly leveled.

Instruments

5. Compass

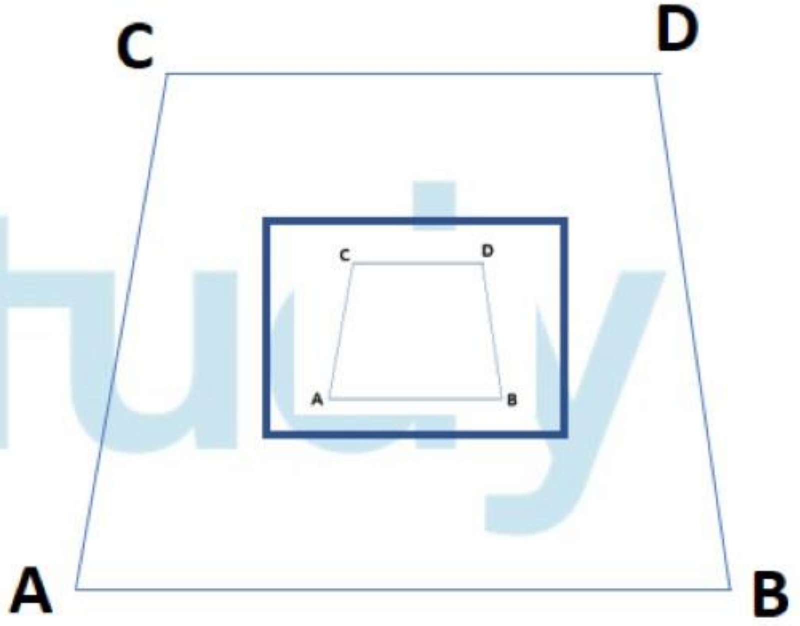
- Type of compass used is trough compass
- It is used for orienting the plane table to magnetic north
- The side of trough compass should be parallel and plane such that they can be used as ruler or for placing the compass such that it coincides with the line already drawn in north south direction

6. Drawing Paper

- A drawing paper of good quality and well-seasoned is to be used for plotting.
- It should be able to withstand the rubbing of the alidade.
- The effect of changes in humidity and temperature of the atmosphere should be minimum thus reduction in the expansion or contraction of the paper, and minimum alteration in the scale of the map and distortion in the plan.

Basic Principle of Plane Table Surveying

- Plane table surveying is based on the principle that lines drawn during plotting always lie parallel to the corresponding lines actually present on the ground.
- For example, let us consider four ground stations A, B, C and D which on joining provides a polygon ABCD. This has been plotted on a sheet of paper at a scale by plane table surveying. Here, the sides AB, BC, CD and DA are plotted in such a way that they are parallel to the sides actually available on the ground.



Setting of Instruments

- At each station, the plane table is required to get set up before carrying out any plotting work.
- It basically consists of the four operations:
  1. **Fixing**
     - In this operation, first the top of the tripod stand is fixed in level by eye estimation at convenient height with its legs uniformly spread and shoes fixed firmly into the ground. The board is fixed to the tripod head by tightening the clamping screw.
  2. **Leveling**
     - The top of the table is leveled by moving the legs of the tripod. The level of plane table is first judged by eye estimation. Further, it is checked by keeping spirit level at different positions on the table and if required, legs are further adjusted.
  3. **Centering**
     - The table should be so placed over the station on the ground that the point plotted on the sheet corresponding to the station occupied should be exactly over the station on the ground
  4. **Orientation**
     - It is a process of putting the plane table into same fixed direction so that the line representing a certain direction on the plan is parallel to the direction on the ground
  5. **Sighting the points**

Methods of Orientation:

a) By Trough compass

- A trough compass is placed on the top right side corner of the drawing sheet an draw line on north south direction
- To orient the plane table, on the top right hand side corner of the drawing sheet and rotate the table till magnetic needle coincides with the line drawn in north south direction

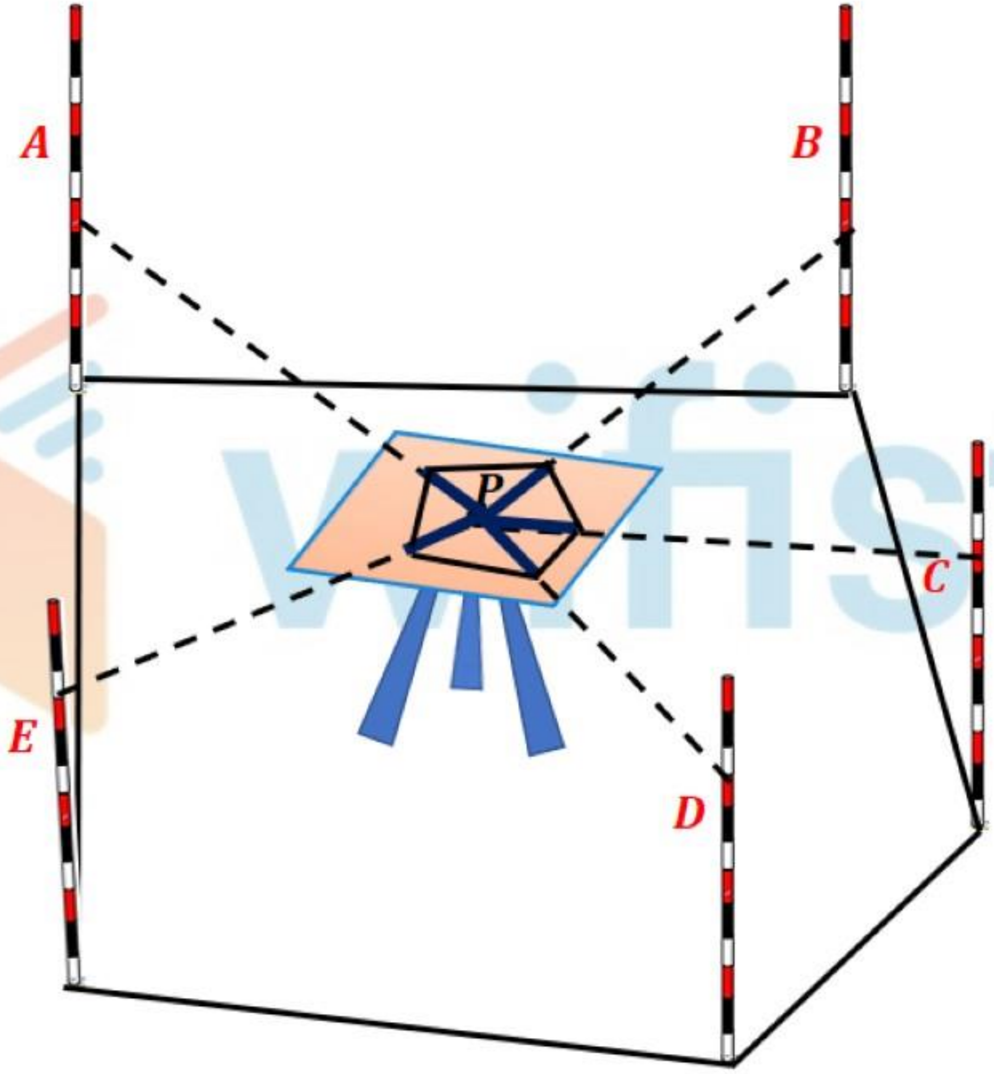
b) By back sighting

- In this method, plane table is oriented by Backsighting on previous station

METHODS OF PLANE TABLE SURVEY

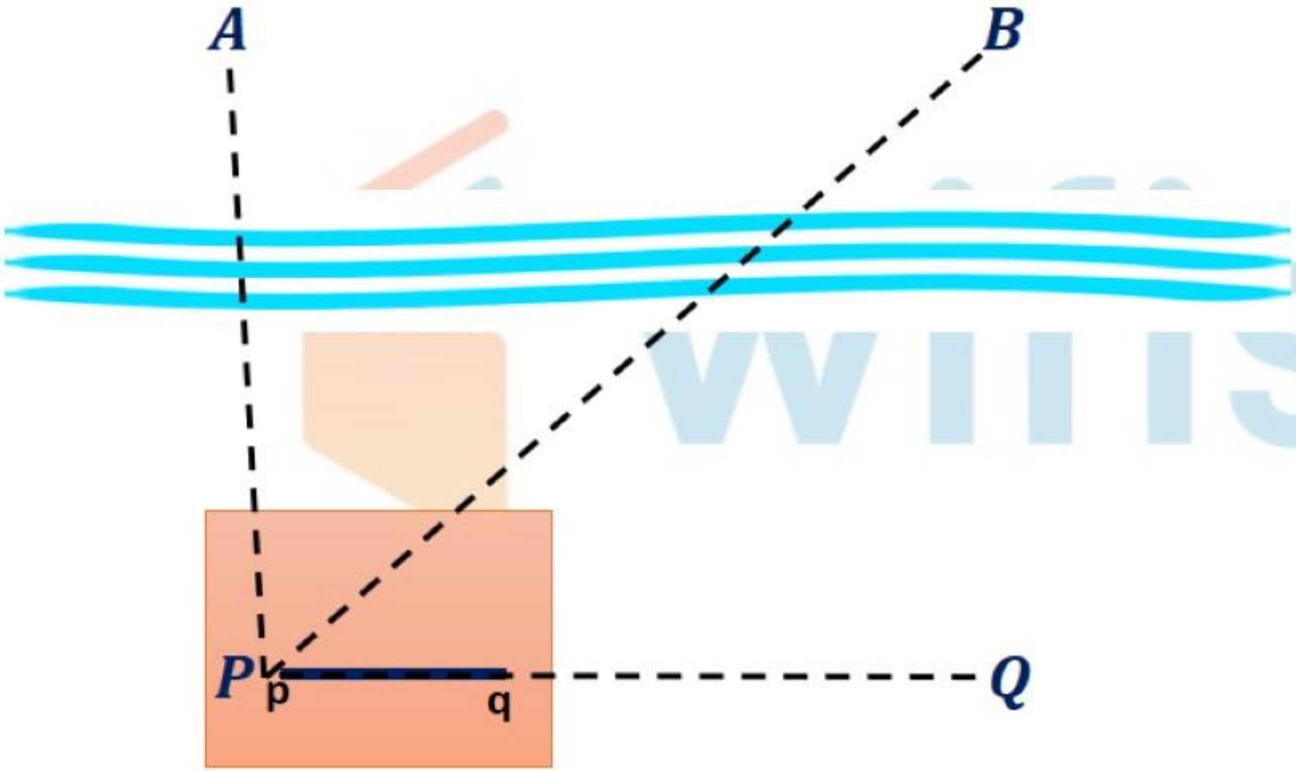
- Different operations are involved during the location of details through plane table surveying.
- To carry out the operations under different field conditions, different methods of plane table surveying have been evolved –
  1. **Method of Radiation**
  2. **Method of Intersection**
  3. **Method of Traversing**
  4. **Method of Resection.**
- The method of radiation and the method of intersection are employed to locate objects and features present in the area of survey.
- The method of traversing is used to plot the network of stations and the method of resection is employed to determine and to plot the location of the plane table as well as to orient the table simultaneously.

1. METHOD OF RADIATION

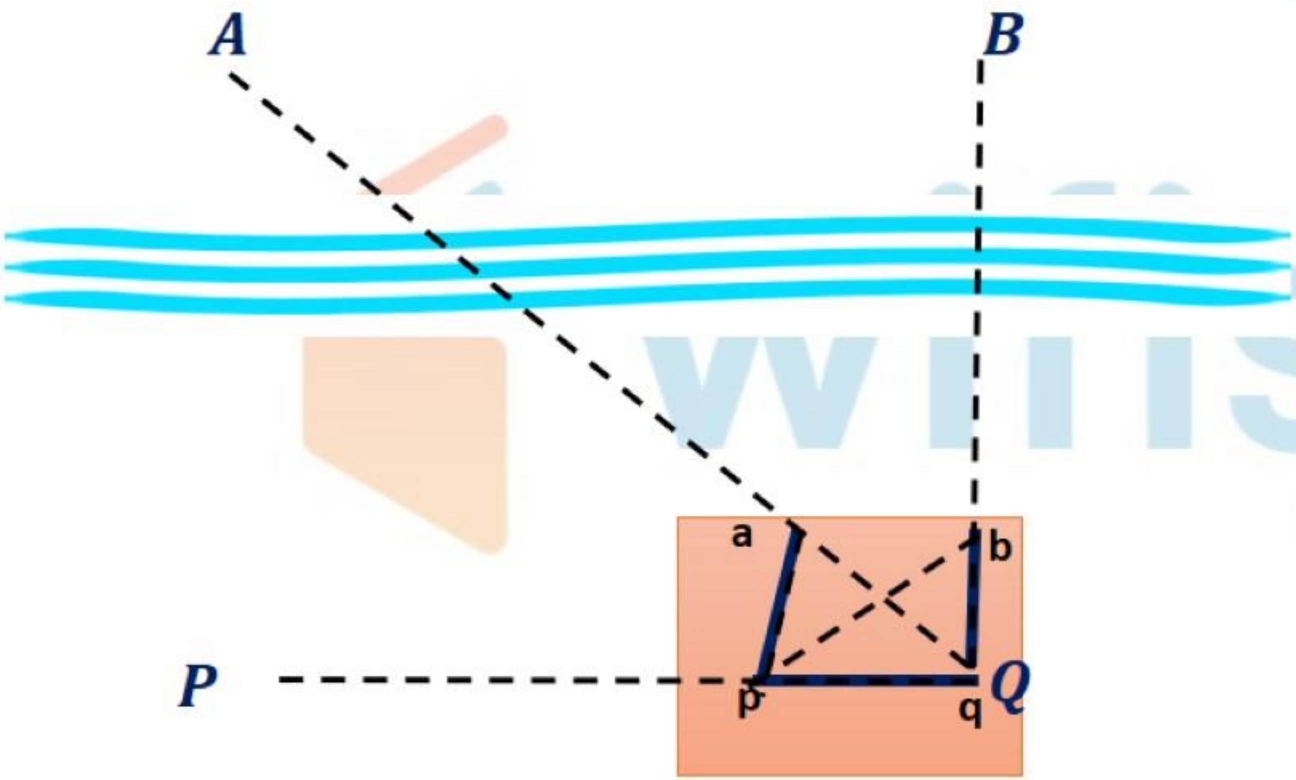


- In this method, instrument is set up at a station and rays are drawn to various stations which are to be plotted.
- Then distances are cut on a suitable scale after actual measurement.
- It is suitable for small area where all the points are visible and accessible from the station.
- The method is convenient if telescopic or digital alidade is used. Otherwise, it is effective when associated with tacheometer or EDM for measurement of horizontal distance.

2. METHOD OF INTERSECTION



2. METHOD OF INTERSECTION

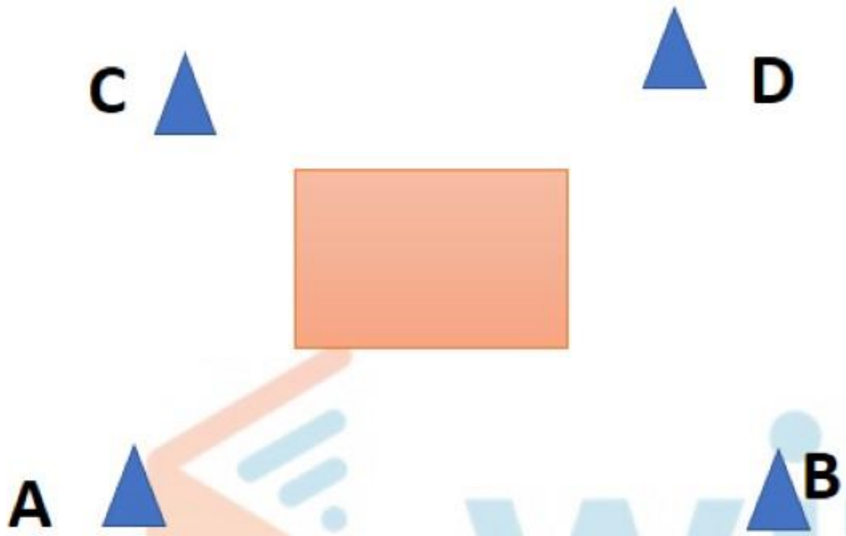


- In this method, locating of a point on the drawing sheet is done by intersecting two rays drawn from two different stations.
- Also called as GRAPHICAL TRIANGULATION.
- It is preferred when distance between stations is very large and stations are inaccessible and ground is undulating.

3. METHOD OF TRAVERSING

- This method of plane table surveying is used to plot a traverse in cases stations have not been previously plotted by some other methods.
- In this method, traverse stations are first selected. The stations are plotted by method of radiation by taking back sight on the preceding station and a fore sight to the following station.
- Here distances are generally measured by tachometric method and surveying work has to be performed with great care.

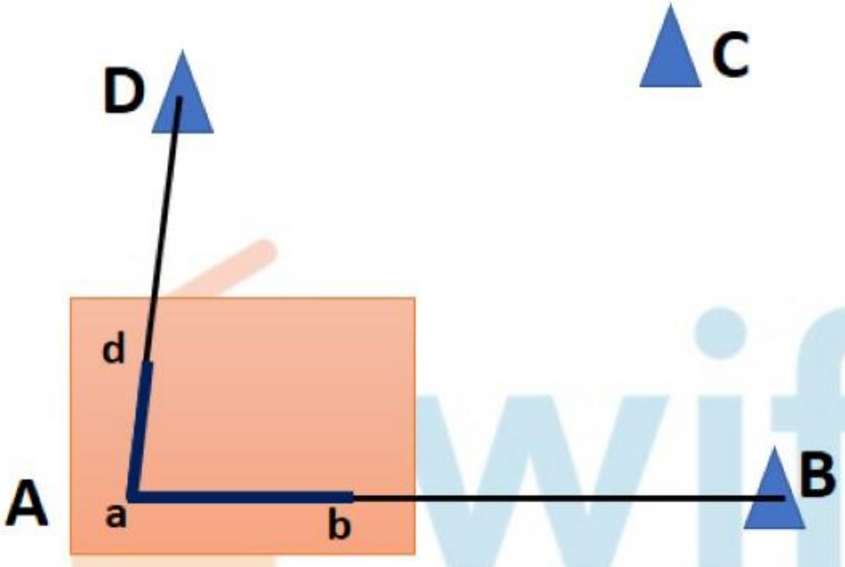
3. METHOD OF TRAVERSING



Let us consider the stations A, B, C and D

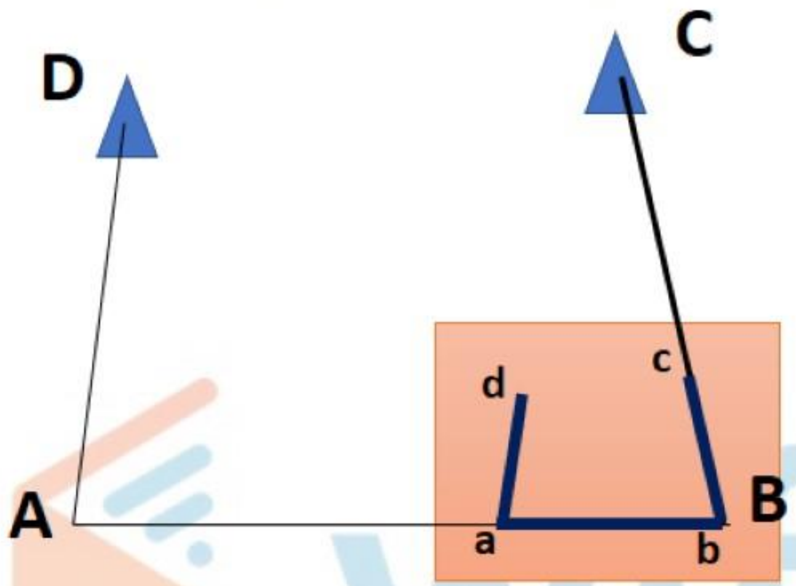
Stations are to be chosen in such a way that adjoining stations are visible

3. METHOD OF TRAVERSING



With the alidade pivoted at a, draw the rays to B and D. Distances AB and AD are measured and plotted on the respective rays, ab and ad respectively.

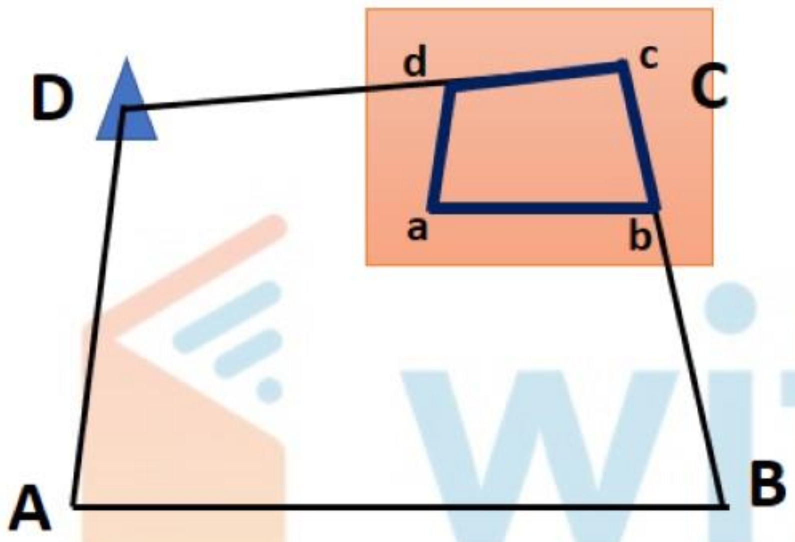
3. METHOD OF TRAVERSING



The plane table is then shifted to station B, get it set and then oriented by back sighting to station A.

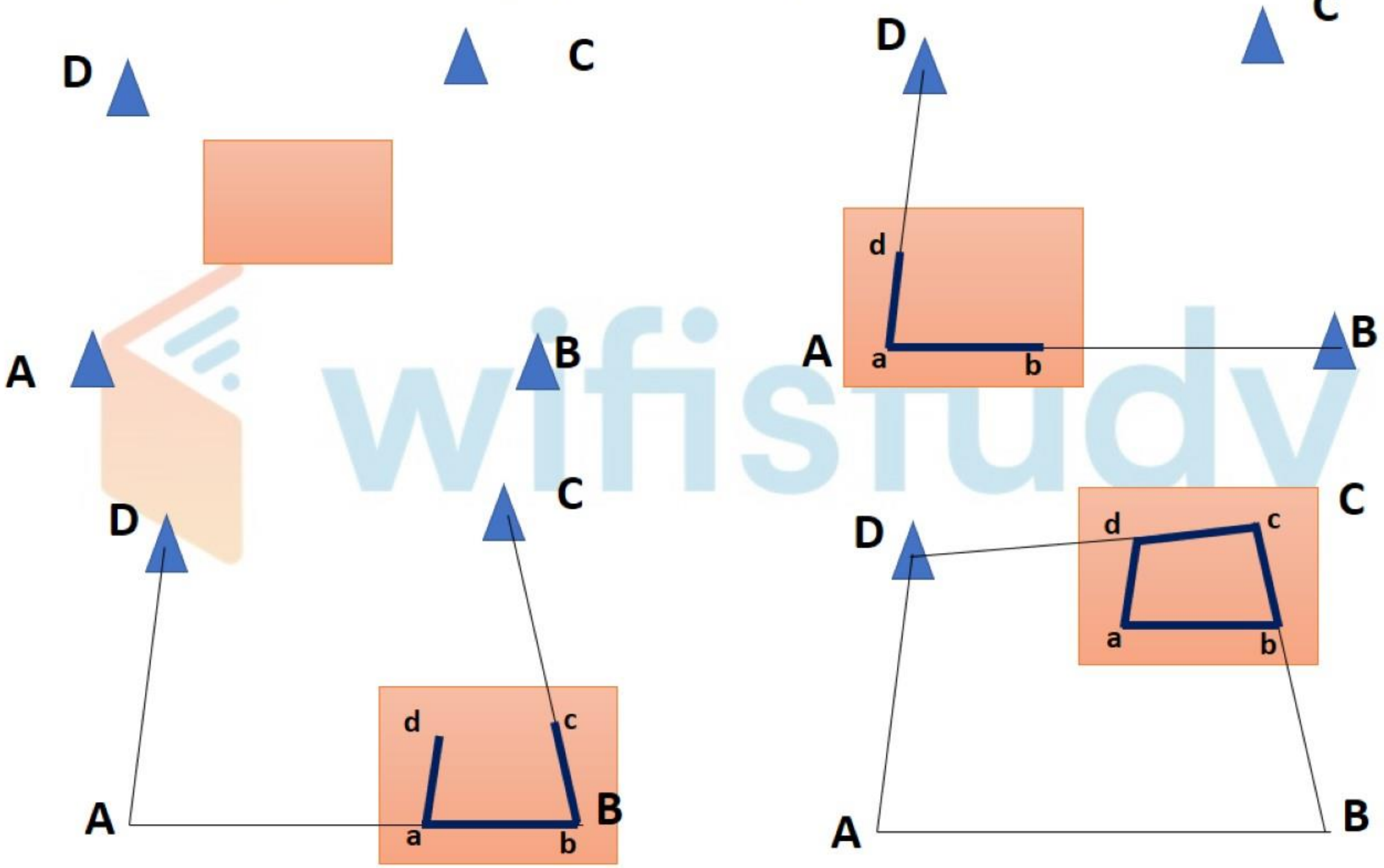
With the alidade pivoted at b, draw a ray to C. Distance BC is measured and plotted on the ray as bc.

3. METHOD OF TRAVERSING



In this way, plane table is shifted to stations C and D and corresponding rays are drawn to obtain the plotting of the traverse abcd.

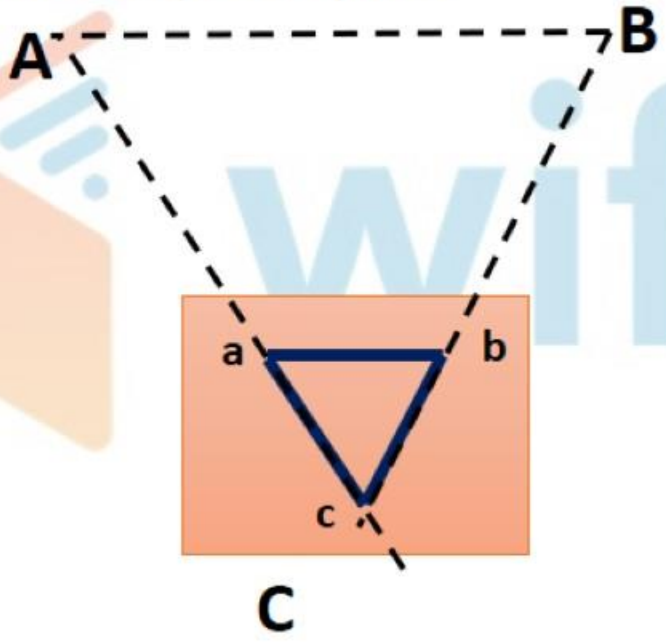
3. METHOD OF TRAVERSING



4. Method of Resection

- It is the process of determining location of station occupied by the plane table with reference to stations which are already plotted on the drawing sheet

a) Resection by Compass



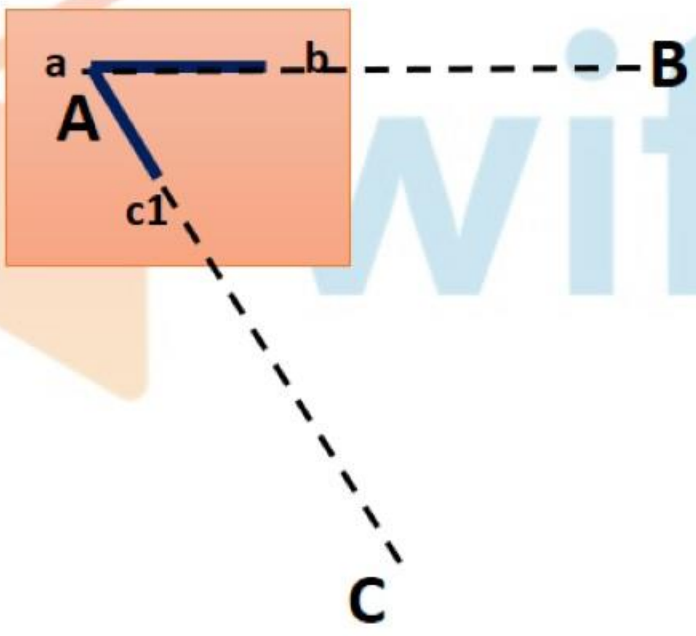
C is the instrument station to be located
A and B are visible stations *already plotted on sheet as a and b*

Set the table at C, orient it with compass and clamp
Draw a resector towards A from a
Similarly sight B from b and draw a resector

Intersection of the resectors will give c (the required point)

4. Method of Resection

b) Resection by Backsighting

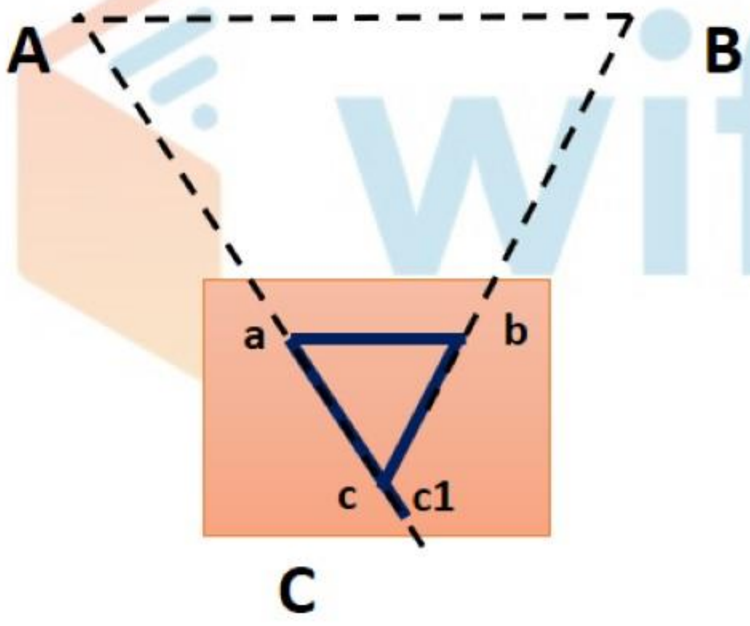


C is the instrument station to be located
A and B are visible stations *already plotted on sheet as a and b*

Set the table at A, orient it by backsighting B along AB
From a, sight C and draw a ray and estimate point C roughly as c_1

4. Method of Resection

b) Resection by Backsighting



C is the instrument station to be located
A and B are visible stations *already plotted on sheet as a and b*

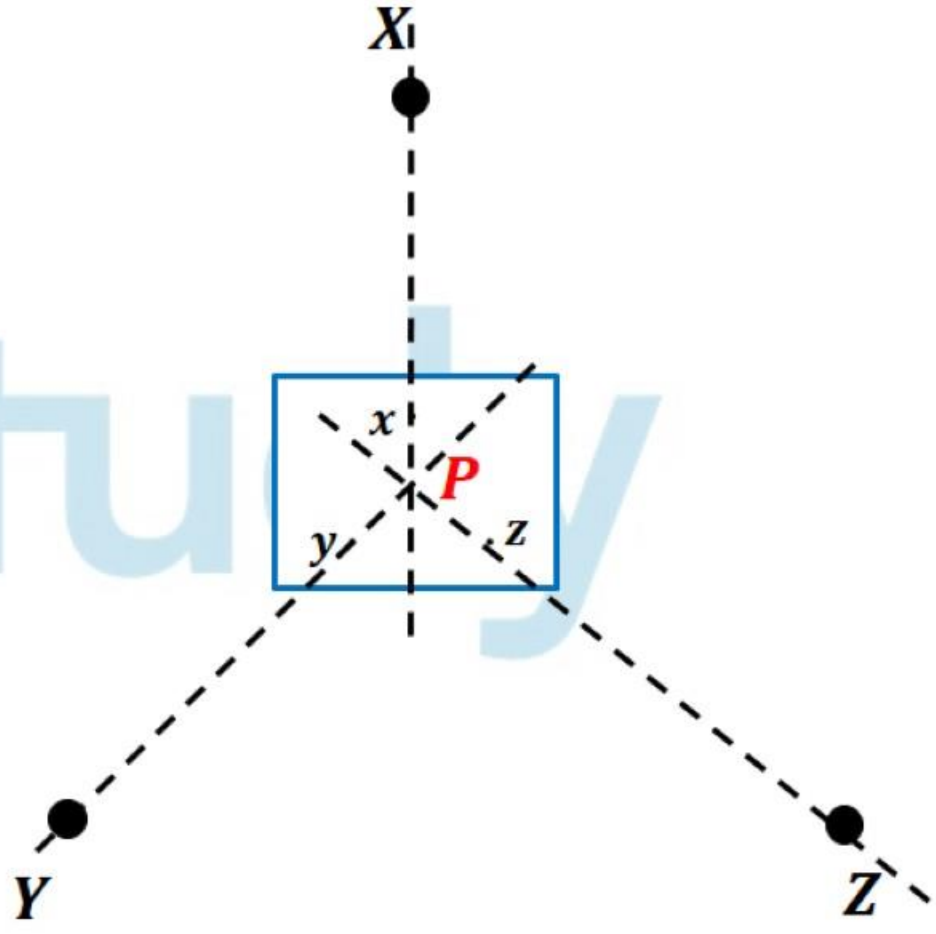
Set the table at A, orient it by backsighting B along AB
From a, sight C and draw a ray and estimate point C roughly as c_1

Shift the table to C and centre it with respect to c_1
From c_1a , orient the table and backsight to A
From b, sight B and draw a ray bB to intersect c_1a on c

4. Method of Resection

c) Resection by 3 point problem

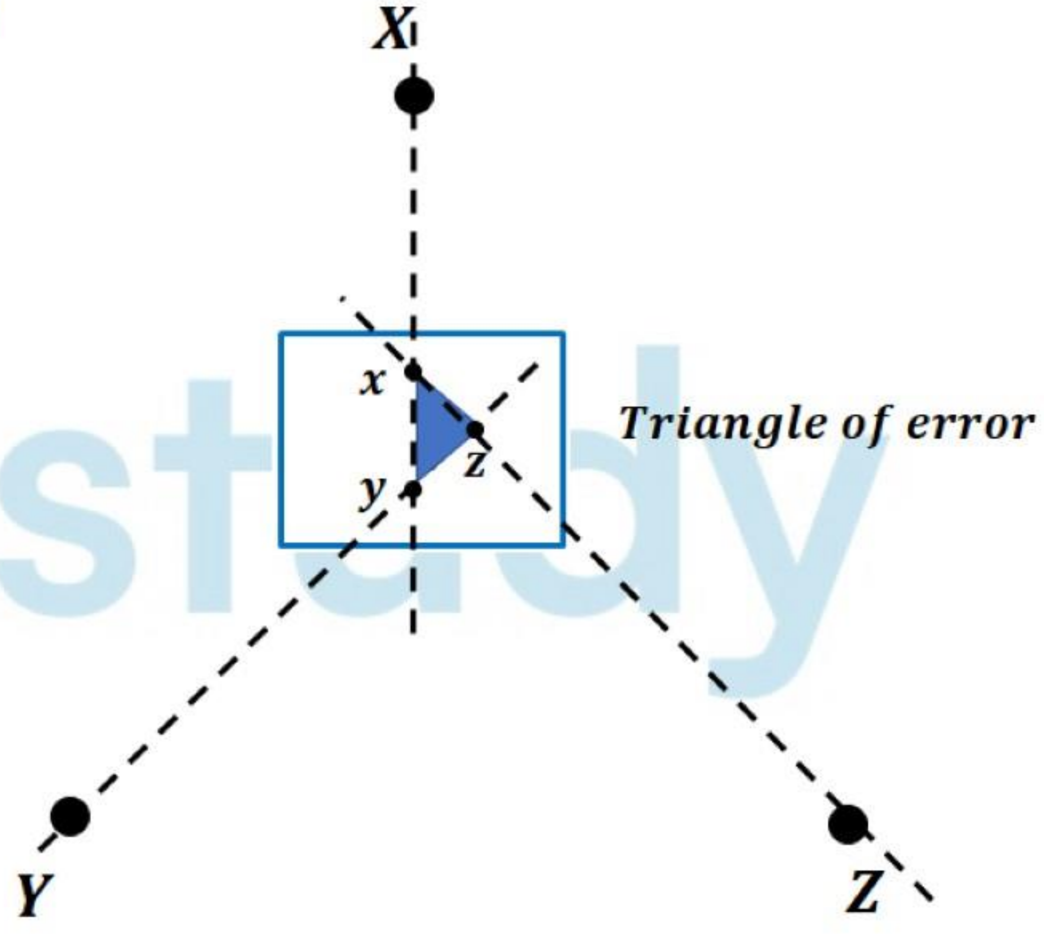
- In this method, three well defined points, having locations already being plotted on the drawing are involved. These are used to find and subsequently plot the location of the plane table station.
- if X, Y and Z are well defined objects present in the field whose plotted positions are x, y and z. Now, if the plane table is oriented correctly, the three resectors X_x, Y_y and Z_z get intersected at p which represents the location of the plane table station, P on the drawing sheet.
X



4. Method of Resection

c) Resection by 3 point problem

- in three point problem, if the orientation of the plane table is not proper, the intersection of the resectors through the three points will not meet at a point but will form a triangle, known as triangle of error
- The size of the triangle of error depends upon the amount of angular error in the orientation.
- In three point problem, orientation and resection are accomplished in the same operation.
- The trial and error method of three point problem, also known as Lehman's method minimises the triangle of error to a point iteratively.
- The iterative operation consist of drawing of resectors from known points through their plotted position and the adjustment of orientation of the plane table.

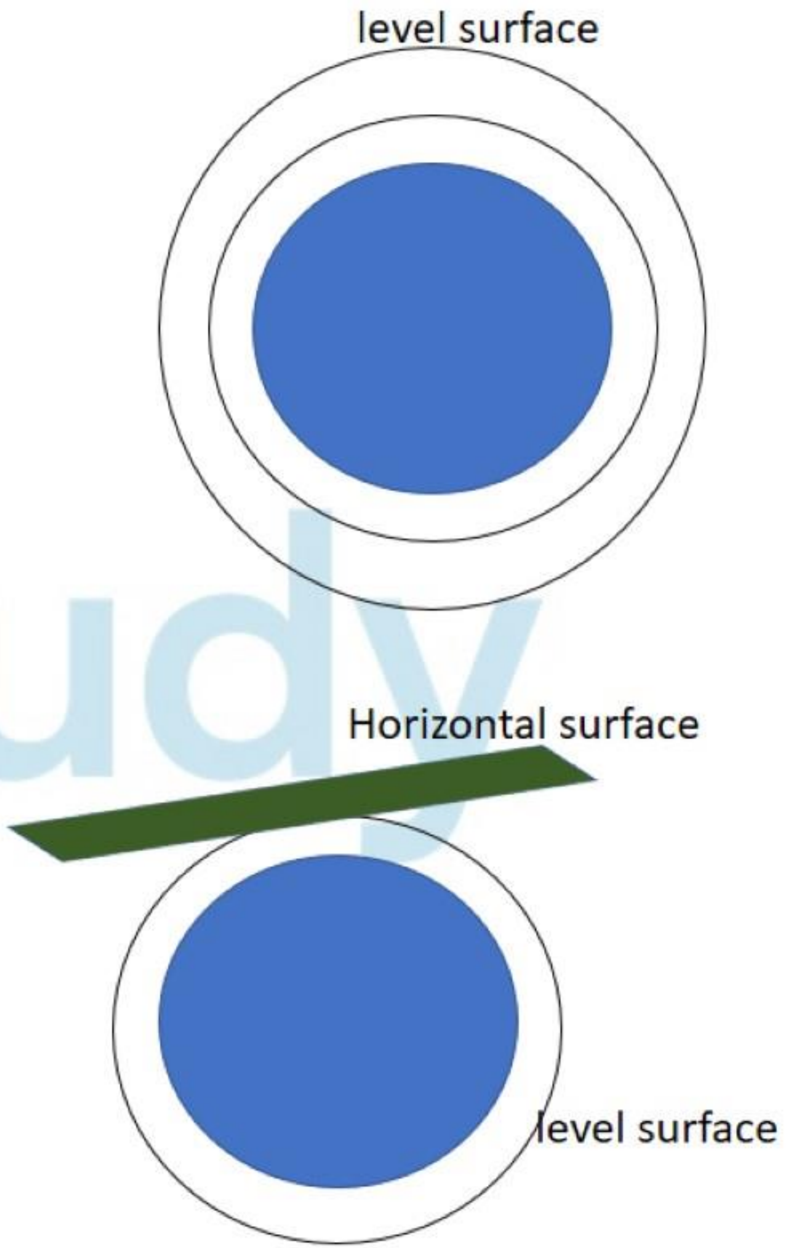


Chapter 6 :LEVELLING

- **Levelling is the operation of determining elevation of various points.**
- **Elevation is the height of a point above (or) below a reference level called 'Datum'.**
- **In topographical work most commonly used datum is Mean Level of Sea (or) Mean Sea Level (MSL).**
- **MSL is mean level of sea obtained by averaging elevation of high and low tides at several points for a long period of time. i.e, 19 years.**

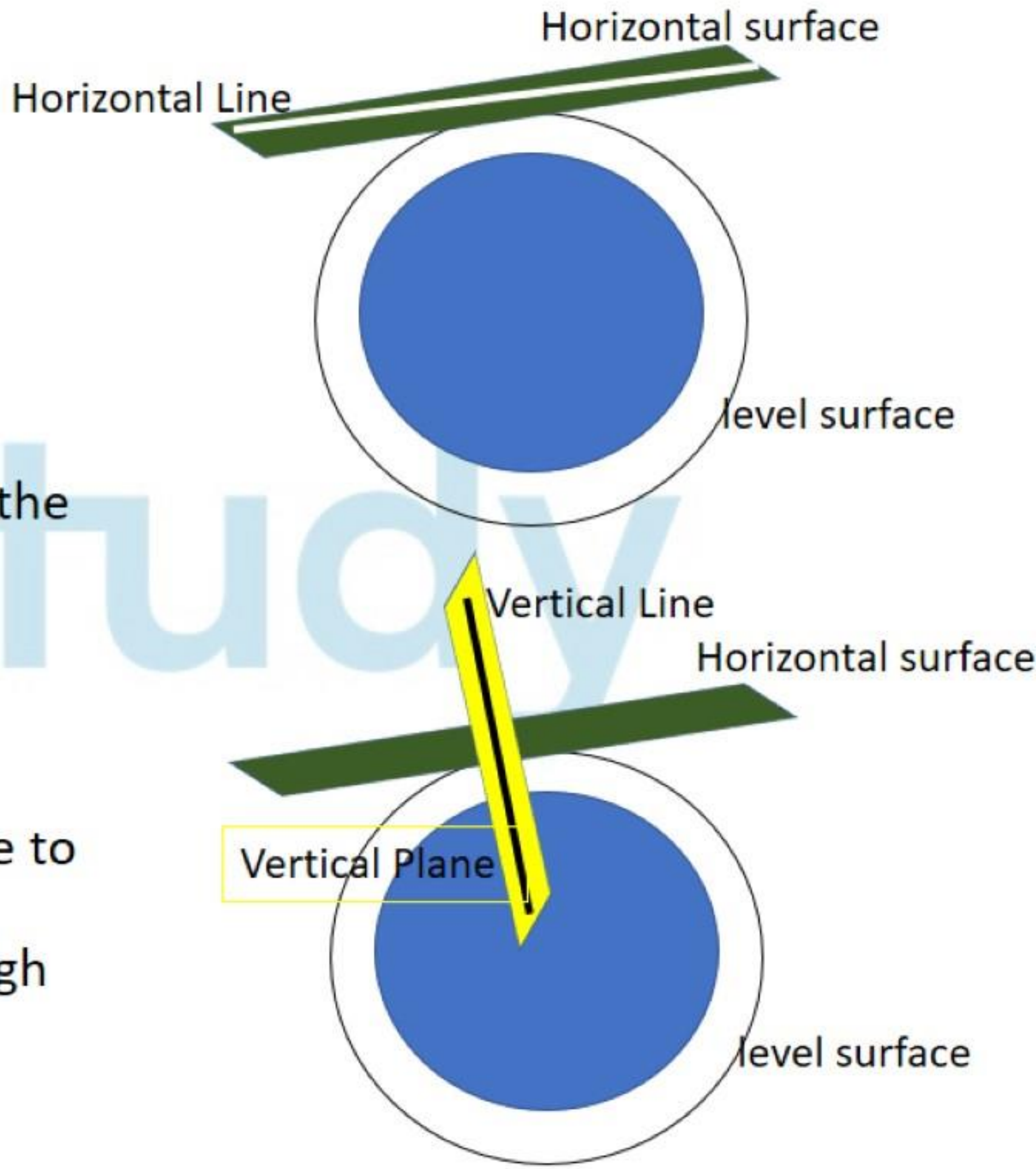
Levelling

- Level Surface:
  - It is curved surface which is parallel to the mean surface of the Earth (ignoring undulations)
  - Exp: surface of water in a still lake or pond
- Level Line:
  - It is a curved line on any level surface
- Horizontal Surface
  - Horizontal surface at any point is a plane surface tangential to the level surface at that point
  - It is always perpendicular to the plumb line

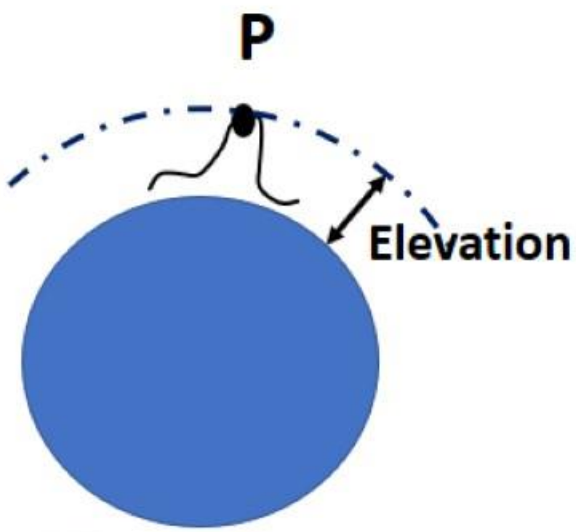


Levelling

- Horizontal Line:
  - Any line lying of on the horizontal surface
- Vertical Surface
  - At any point in a plane surface perpendicular to the horizontal surface at that point
  - Vertical surface contains the plumb line
- Datum
  - Datum is a reference level surface with reference to which elevation are measured/ referred.
  - Datum for India is Mean Sea Level at Bombay High
  - Earlier it was Karachi upto 1962.



BASIC DEFINITIONS



1) ELEVATION

- **Elevation is the vertical distance of a point above (or) below datum.**
- **Elevation are also known as 'Reduced Level Height'.**
- **Vertical distances are determined along line of Gravity.**

2) ALTITUDE

- **It is height of a point above datum.**
- **Above datum, elevation and altitude will be same thing.**

BASIC DEFINITIONS

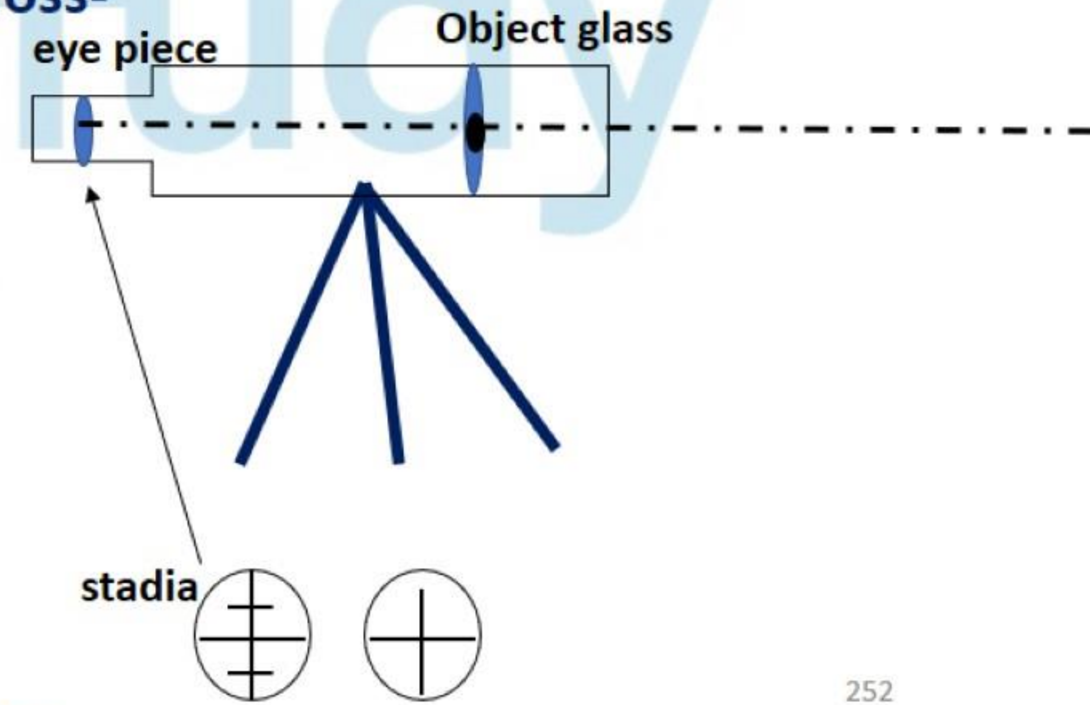
3) AXIS OF TELESCOPE

- **Axis of telescope is the line joining optical centre of objective glass & centre of eye piece.**

In a permanently adjusted instrument, all these lines are same

4) LINE OF SIGHT

- **Line of sight is the line joining intersection of cross-hair to the optical centre of objective.**



5) LINE OF COLLIMATION

- **In levelling line of sight should be horizontal while observing readings.**
- **When line of sight becomes horizontal it is called as *'line of collimation'* (or) it is line joining the intersection of cross-hair, optical centre of objective and in continuation.**

BASIC DEFINITIONS

5) LINE OF COLLIMATION

- **In levelling line of sight should be horizontal while observing readings.**
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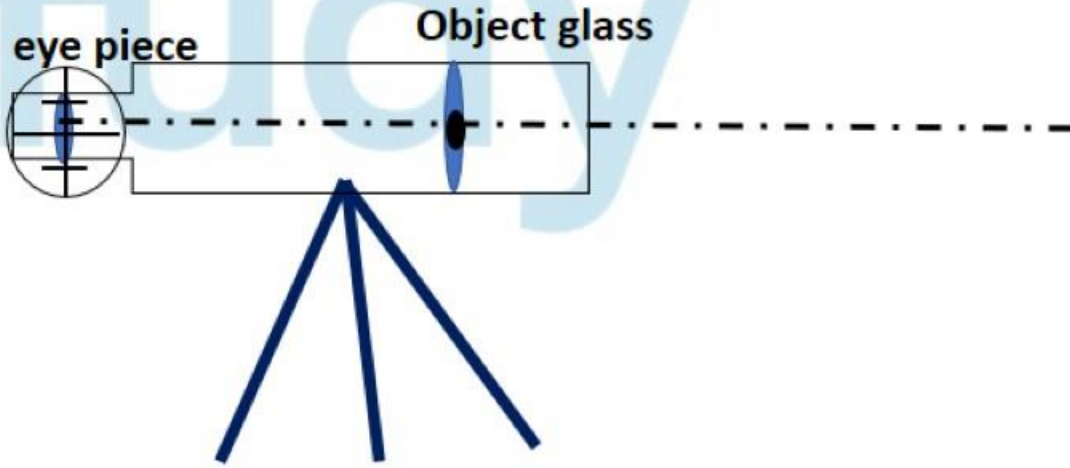


- **Plane of Collimation: Horizontal plane formed by 360° rotation of line of collimation**

BASIC DEFINITIONS

6) HEIGHT OF INSTRUMENT

- **It is RL of plane of collimation.**

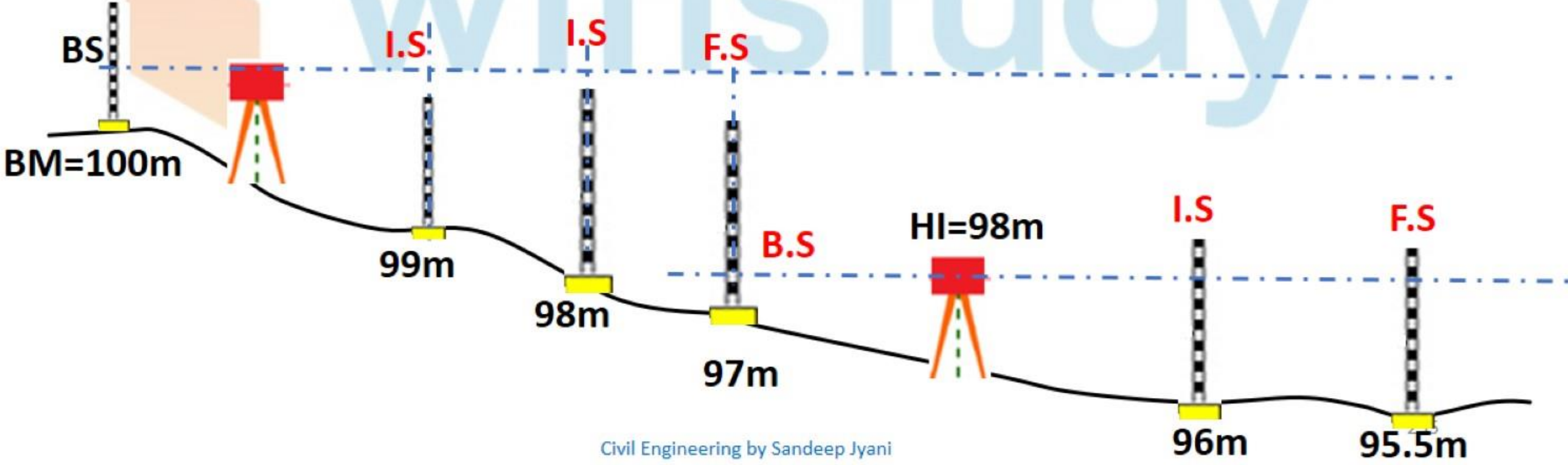
7) STATION

- **Station is a point of unknown elevation where staff is held for observing readings**

BASIC DEFINITIONS

8. Backsight (BS)

- Backsight is the staff reading taken on a point of known elevation
- It is first reading taken from after instrument is set up
- Height of instrument=RL of bench mark +Backsight



BASIC DEFINITIONS

9) FORE SIGHT

- **Fore sight is the reading taken on a last point of survey or on change point i.e, just before shifting of instrument .**

Elevation of staff station = H.I. – Fore Sight.

10) CHANGE POINT

- **Change point is the point denoting shifting of level.**
- **Both B.S & F.S are taken on change point.**

BASIC DEFINITIONS

11) INTERMEDIATE SIGHT

- **Intermediate sight is the reading taken on a point of unknown elevation between B.S & F.S**
- **It should be noted that both intermediate sight and fore sight are taken at point of unknown elevation.**
- **But F.S. is taken either at change point (or) last point of survey, where as intermediate sight (I.S) is taken at any other point.**

BASIC DEFINITIONS

12) BENCH MARK

- **Bench mark is fixed point of known R.L**
- **On the basis of degree of accuracy and permanency bench marks can be classified as below:**

a. ***GTS Bench Mark***

b. ***Temporary Bench Mark***

c. ***Permanent Bench Mark***

d. ***Arbitrary Bench Mark***

BASIC DEFINITIONS

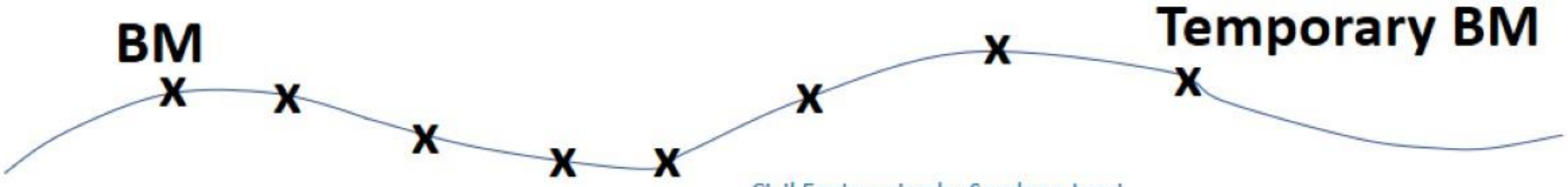
12) BENCH MARK

a. GTS Bench Mark

- **GTS (**Great Trigonometrical Survey**) Bench marks are established by survey of India throughout the country w.r.t. Bombay High.**

b. Temporary Bench Mark

- **These BM are temporarily established whenever required.**
- **Generally these are the points at which work is closed for a day and next day work is started.**



BASIC DEFINITIONS

12) BENCH MARK

c. Permanent Bench Mark

➢ **Permanent Bench Marks are established at closer interval between widely spaced GTS Bench Mark.**

d. Arbitrary Bench Mark

➢ **These are bench marks whose elevation does not referred to MSL, their value is Arbitrarily assumed for small survey.**

13) PARALLAX

- **It is apparent movement of image.**

BASIC DEFINITIONS

14) LEVEL TUBE

- **With the help of level tube, vertical axis of instrument can be made to coincide with the line of gravity or line of sight can be made horizontal.**
- **Level tube is a glass tube sealed at both ends which is partially filled with a liquid such that an air bubble is formed in the level tube.**
- **The type of liquid filled should be less viscous, stable and non freezing at ordinary temperature.**
- **These days synthetic alcohol is used as liquid.**
- **Cross section of level tube is circular.**

Question: The following staff readings were taken successfully with level, the instrument having been moved forward after the second, fourth and eighth reading

0.875, 1.235, 2.310, 1.385, 2.930, 3.125, 4.125, 0.120, 1.875, 2.030, 3.765

The first reading was taken on a benchmark of elevation 132.135. Enter the readings in level book form and reduce levels.

Answer:

Question: The following staff readings were taken successfully with level, the instrument having been moved forward after the second, fourth and eighth reading

0.875, 1.235, 2.310, 1.385, 2.930, 3.125, 4.125, 0.120, 1.875, 2.030, 3.765

The first reading was taken on a benchmark of elevation 132.135. Enter the readings in level book form and reduce levels.

Answer: Given data:

1. 0.875
2. 1.235
3. 2.310
4. 1.385
5. 2.930
6. 3.125
7. 4.125
8. 0.120
9. 1.875
10. 2.030
11. 3.765

Question: The following staff readings were taken successfully with level, the instrument having been moved forward after the second, fourth and eighth reading

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The first reading was taken on a benchmark of elevation 132.135. Enter the readings in level book form and reduce levels.

Answer: Given data:

1.	0.875	BS
2.	1.235	FS
3.	2.310	BS
4.	1.385	FS
5.	2.930	BS
6.	3.125	IS
7.	4.125	IS
8.	0.120	FS
9.	1.875	BS
10.	2.030	IS
11.	3.765	FS

Question: The following staff readings were taken successfully with level, the instrument having been moved forward after the second, fourth and eighth reading

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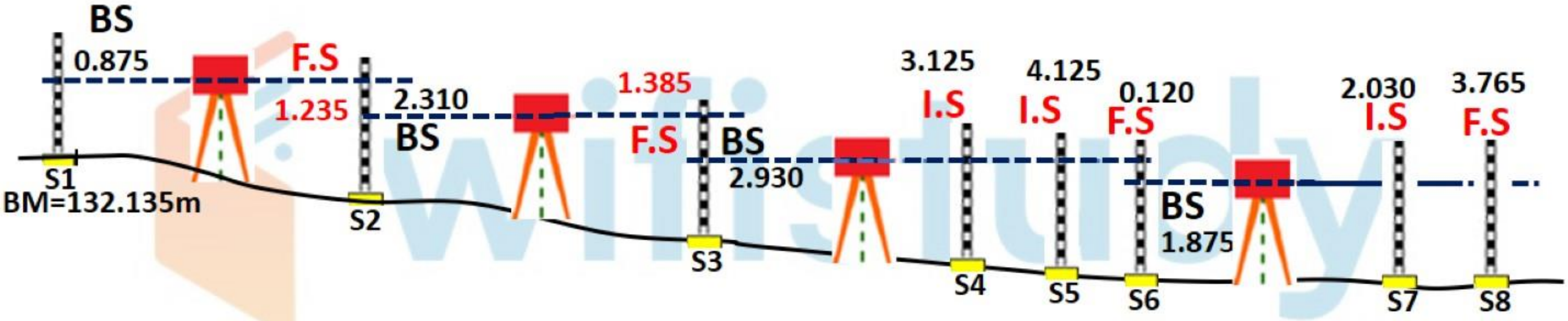

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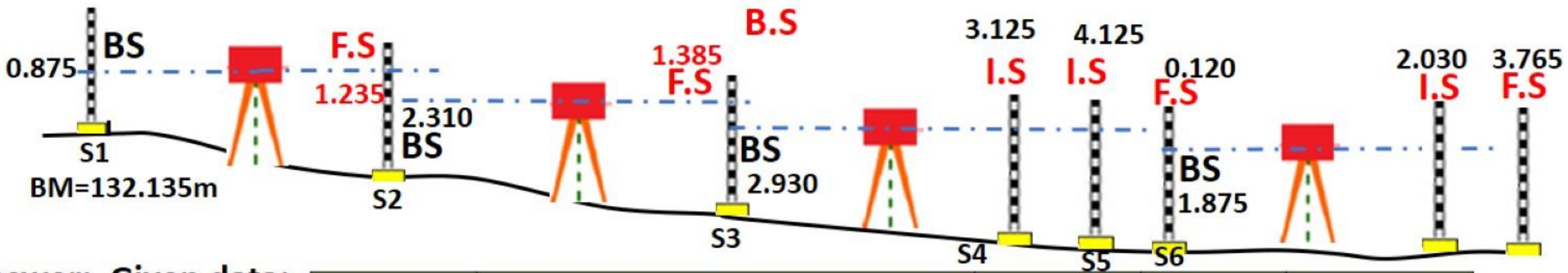
3. 2.310 BS
4. 1.385 FS
5. 2.930 BS
6. 3.125 IS
7. 4.125 IS
8. 0.120 FS
9. 1.875 BS
10. 2.030 IS
11. 3.765 FS



Answer: Given data:

1. 0.875 BS
2. 1.235 FS
3. 2.310 BS
4. 1.385 FS
5. 2.930 BS
6. 3.125 IS
7. 4.125 IS
8. 0.120 FS
9. 1.875 BS
10. 2.030 IS
11. 3.765 FS

Staff Station	Staff Reading			HI	RL	Remarks
	BS	IS	FS			
S1	0.875			133.01	132.135	Bench Mark
S2	2.310		1.235	134.085	131.775	CP1
S3	2.930		1.385	135.63	132.70	CP2
S4		3.125			132.705	
S5		4.125			131.505	
S6	1.875		0.120	137.385	135.510	CP3
S7		2.030			135.355	
S8			3.765		133.620	

HI= RL of BM or CP + SR on BM or CP (BS)

RL of staff station= HI – IS or FS at that staff station

Answer: Given data:

1. 0.875 BS
2. 1.235FS
3. 2.310 BS
4. 1.385 FS
5. 2.930 BS
6. 3.125IS
7. 4.125 IS
8. 0.120 FS
9. 1.875 BS
10. 2.030 IS
11. 3.765 FS

Staff Station	Staff Reading			HI	RL	Remarks
	BS	IS	FS			
S1	0.875			133.01	132.135	Bench Mark
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S4		3.125			132.705	
S5		4.125			131.505	
S6	1.875		0.120	137.385	135.510	CP3
S7		2.030			135.355	
S8			3.765		133.620	

Sum of Backsight = 7.990

Sum of foresight = 6.505

$\Sigma BS - \Sigma FS$ =7.990-6.505=1.485m

Last RL – First RL = 133.620-132.135

= 1.485

Check OK!

Rise and Fall Method

- Rise and fall method is more accurate as there is complete check on calculations of RLs of intermediate sites also

Question: The following staff readings were taken successfully with level, the instrument having been moved forward after the second, fourth and eighth reading

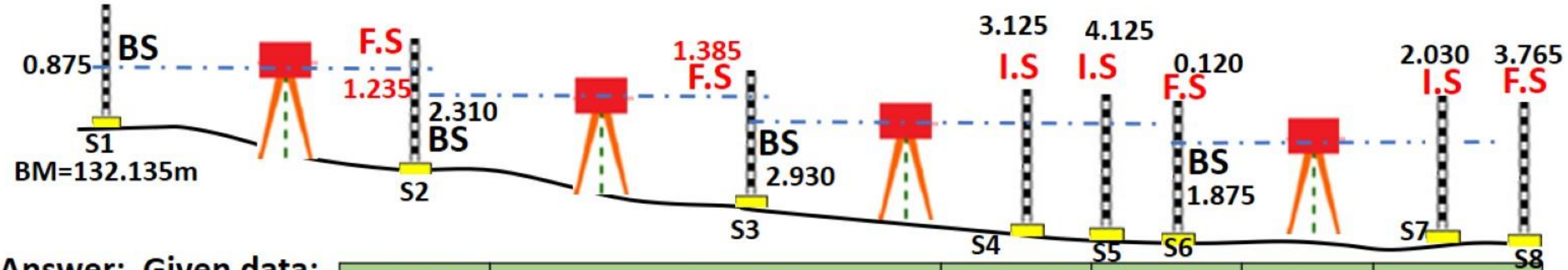
0.875, 1.235, 2.310, 1.385, 2.930, 3.125, 4.125, 0.120, 1.875, 2.030, 3.765

The first reading was taken on a benchmark of elevation 132.135. Enter the readings in level book form and reduce levels.

Answer: Given data:

1.	0.875	BS
2.	1.235	FS
3.	2.310	BS
4.	1.385	FS
5.	2.930	BS
6.	3.125	IS
7.	4.125	IS
8.	0.120	FS
9.	1.875	BS
10.	2.030	IS
11.	3.765	FS

Rise and Fall Method



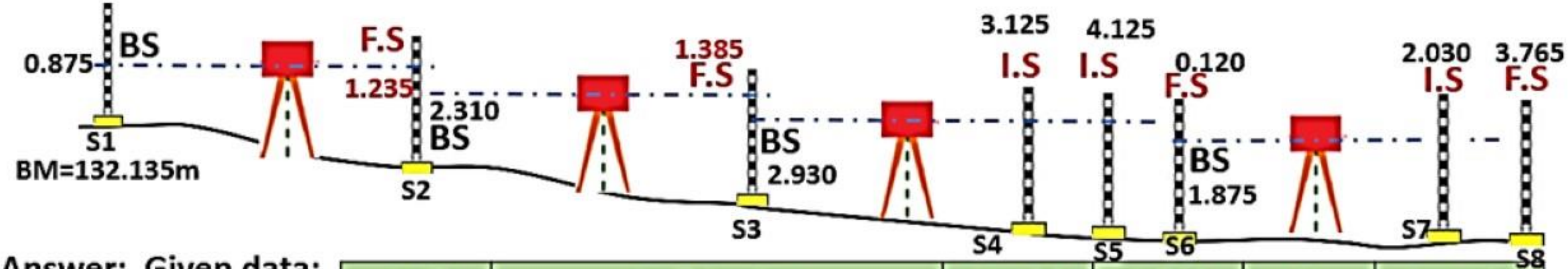
Answer: Given data:

1. 0.875 BS
2. 1.235 FS
3. 2.310 BSx
4. 1.385 FS
5. 2.930 BS
6. 3.125 IS
7. 4.125 IS
8. 0.120 FS
9. 1.875 BS
10. 2.030 IS
11. 3.765 FS

Staff Station	Staff Reading			Rise (+)	Fall (-)	RL	Remarks
	BS	IS	FS				
S1	0.875					132.135	Bench Mark
S2	2.310		1.235		-0.360	131.775	CP1
S3	2.930		1.385	+0.925		132.70	CP2
S4		3.125			-0.195	132.505	
S5		4.125			-1.000	131.505	
S6	1.875		0.120	+4.005		135.510	CP3
S7		2.030			-0.155	135.355	
S8			3.765		-1.735	133.620	

RL of any staff station= *RL* of previous *SS* ± *rise*/*fall*

Rise/*fall* of any staff station= *SR* of previous *SS* −*SR of this station*



Answer: Given data:

1. 0.875 BS
2. 1.235 FS
3. 2.310 BSx
4. 1.385 FS
5. 2.930 BS
6. 3.125 IS
7. 4.125 IS
8. 0.120 FS
9. 1.875 BS
10. 2.030 IS
11. 3.765 FS

Staff Station	Staff Reading			Rise (+)	Fall (-)	RL	Remarks
	BS	IS	FS				
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S6	1.875		0.120	+4.005		135.510	CP3
S7		2.030			-0.155	135.355	
S8			3.765		-1.735	133.620	

RL of any staff station = *RL* of previous *SS* ± *rise*/*fall*

Rise/*fall* of any staff station = *SR* of previous *SS* − *SR of this station*

Answer: Given data:

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2. 1.235 FS
3. 2.310 BS
4. 1.385 FS
5. 2.930 BS
6. 3.125 IS
7. 4.125 IS
8. 0.120 FS
9. 1.875 BS
10. 2.030 IS
11. 3.765 FS

Staff Station	Staff Reading			Rise (+)	Fall (-)	RL	Remarks
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S4		3.125			-0.195	132.505	
S5		4.125			-1.000	131.505	
S6	1.875		0.120	+4.005		135.510	CP3
S7		2.030			-0.155	135.355	
S8			3.765		-1.735	133.620	

Sum of Rise = 4.930

Sum of fall = 3.445

$\Sigma Rise - \Sigma Fall$ =4.930-3.445=1.485m

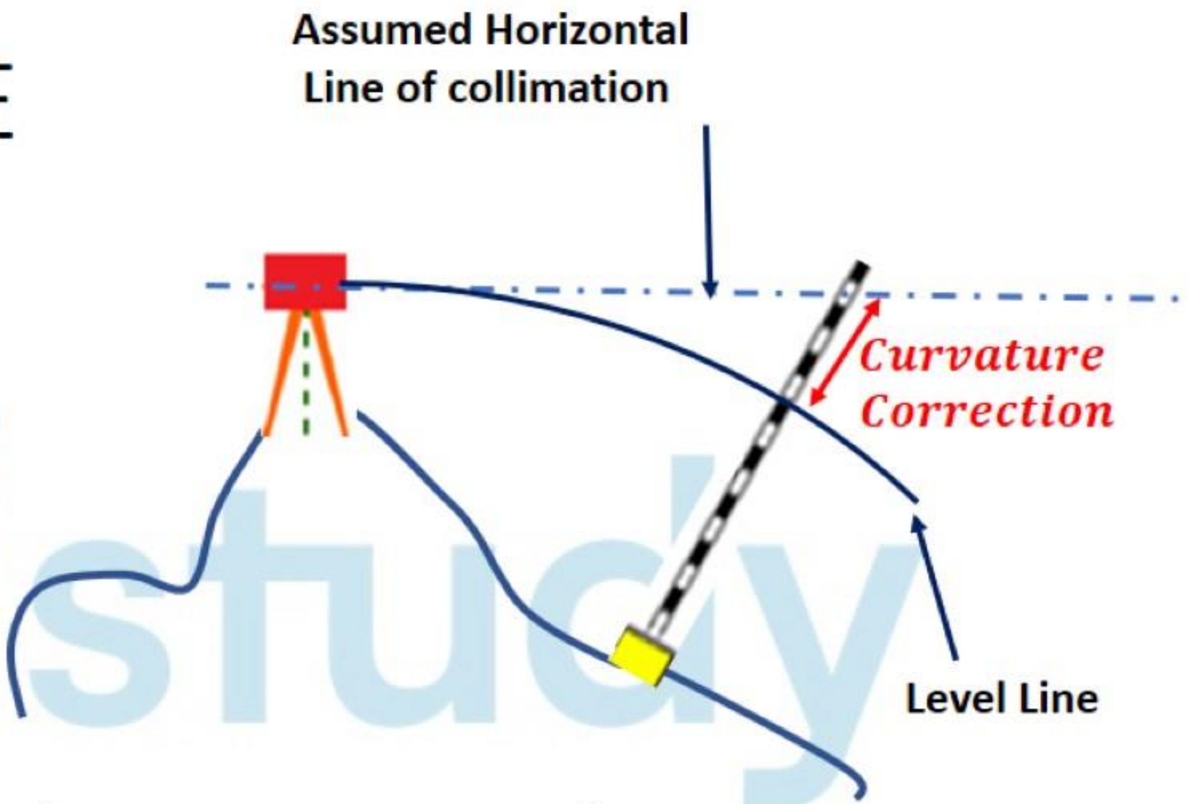
Last RL – First RL = 133.620-132.135 = 1.485m

Check OK!

EFFECT OF CURVATURE

- E = M.V – T.V (M.V > T.V)
- Error due to curvature is always positive.
- So correction will be negative.
- CORRECTION DUE TO CURVATURE is given by

$$C_C = -0.0785d^2$$



d = distance between instrument and staff station (in km)

C_c = in m

- Effect of curvature occurs because the difference between level line and horizontal line increases as the distance of the staff station from the instrument station is increased.
- Level line is a curved line but line of collimation is a horizontal line which is tangential to the level line.
- Due to curvature of Earth points appear to be lower than actually they are.

EFFECT OF REFRACTION

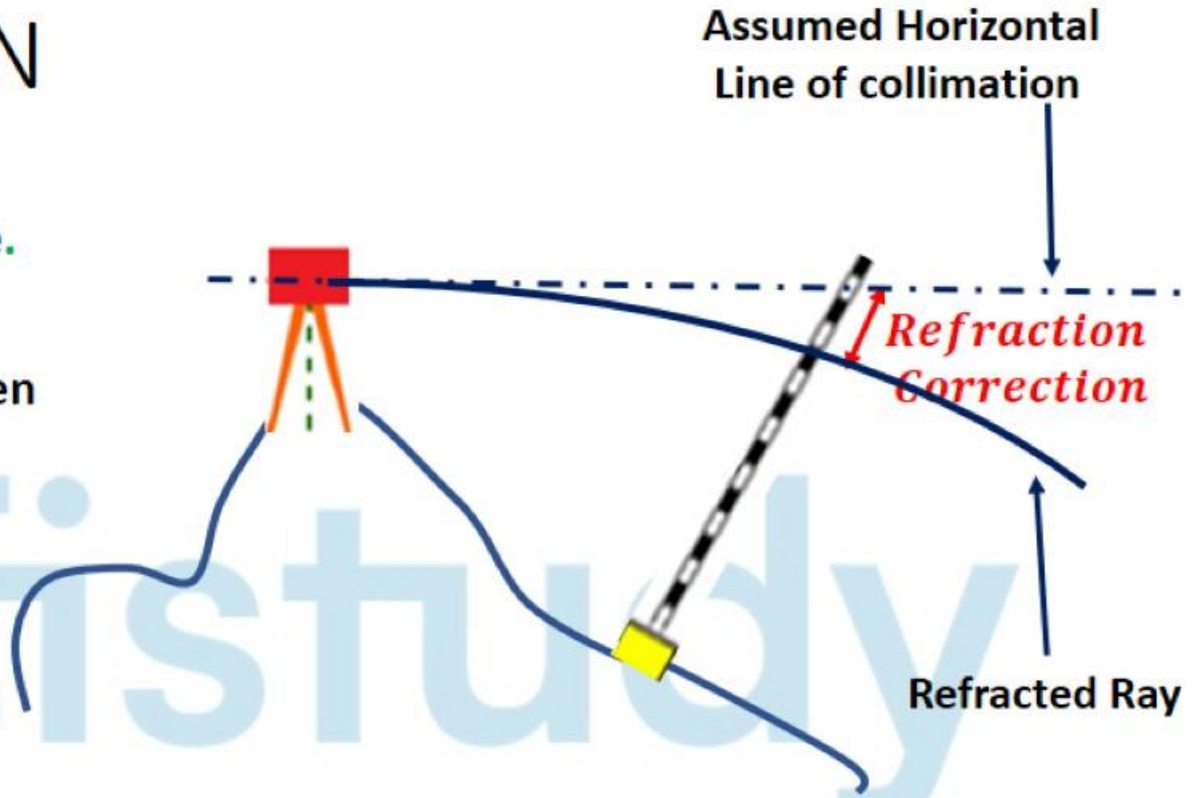
- E = M.V – T.V   (M.V < T.V)
- Error due to refraction is always negative.
- So correction will be positive.
- CORRECTION DUE TO REFRACTION is given by

$$C_r = \frac{1}{7}\,|cc|$$

$$C_r = 0.0112d^2$$

d = distance between instrument and staff station (in km)

C_r = in m



- Density of air in the atmosphere decreases with the increase in altitude as air is denser near the earth surface.
- A ray of light travels from thinner medium to denser medium, therefore it bends towards the normal.
- Hence line of sight does not remains horizontal but it bends towards the centre of the earth, i.e, downwards.

COMBINED CORRECTION

$$C = C_c + C_r$$

$$C = -0.0673d^2$$

where

C is in m

d is in km

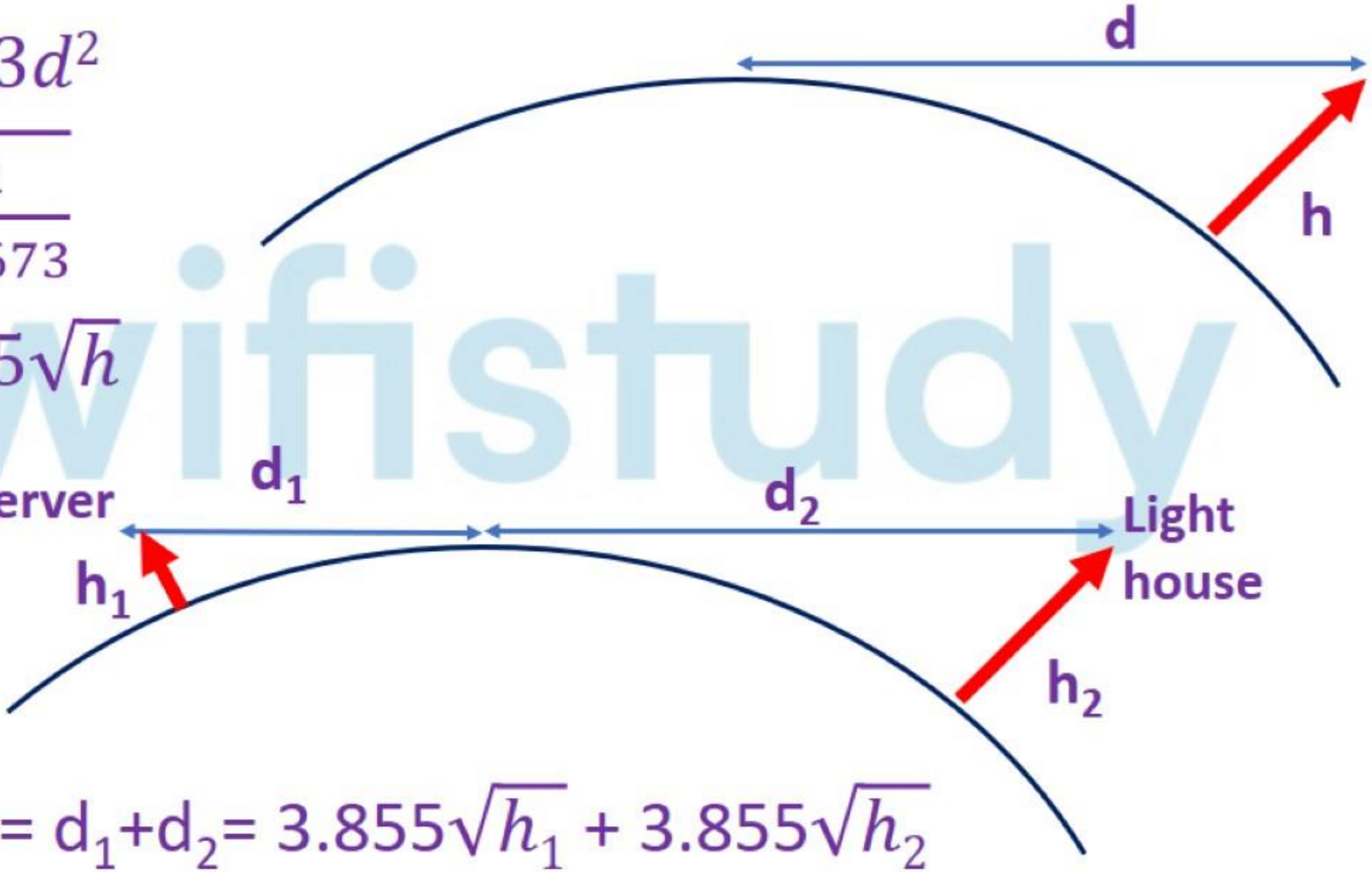
For a distance less than 250m, combined correction is neglected in ordinary levelling.

DISTANCE OF VISIBLE HORIZON

$$h = 0.0673d^2$$

$$d = \sqrt{\frac{h}{0.0673}}$$

$$d = 3.855\sqrt{h}$$



where

h is in m

d is in km

$$d = d_1 + d_2 = 3.855\sqrt{h_1} + 3.855\sqrt{h_2}$$

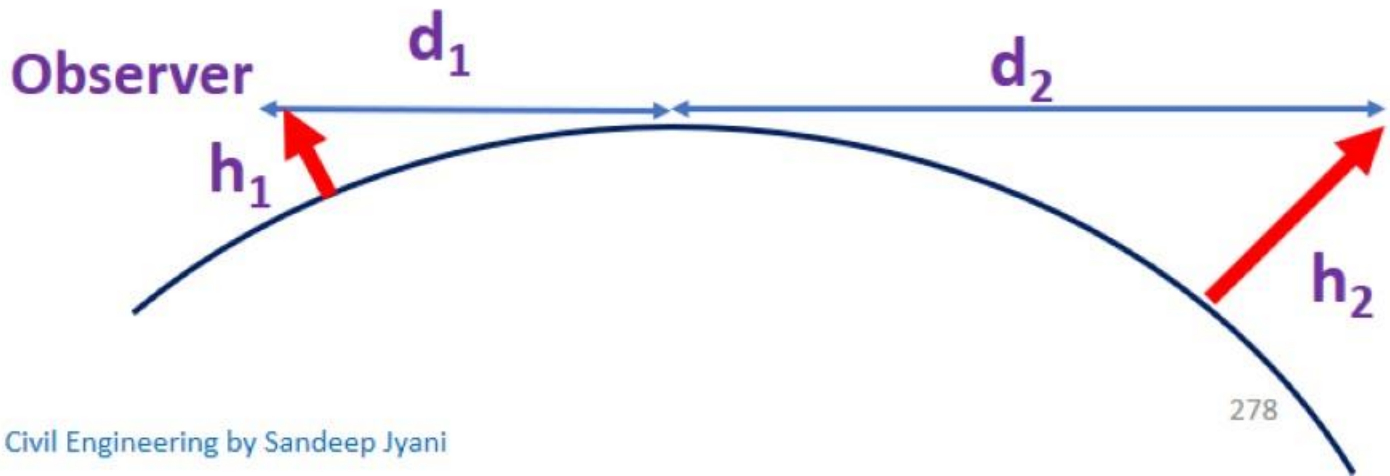
DISTANCE OF VISIBLE HORIZON

Que. An observer standing on the deck of a ship just sees the light house which is 40m above the sea level if the height of observer's eye is 8m above the sea level, determine the distance of the observer from the light house.

DISTANCE OF VISIBLE HORIZON

Que. An observer standing on the deck of a ship just sees the light house which is 40m above the sea level if the height of observer's eye is 8m above the sea level, determine the distance of the observer from the light house.

Sol. $d_1+d_2 = 3.855\,(\sqrt{8} + \sqrt{40}) =$ 35.28km



TYPES OF LEVELLING

Different types of levelling are:

1. **Direct / Spirit Levelling**
2. **Trigonometric Levelling**
3. **Barometric Levelling**
4. **Hypsometric Levelling**

TYPES OF LEVELLING

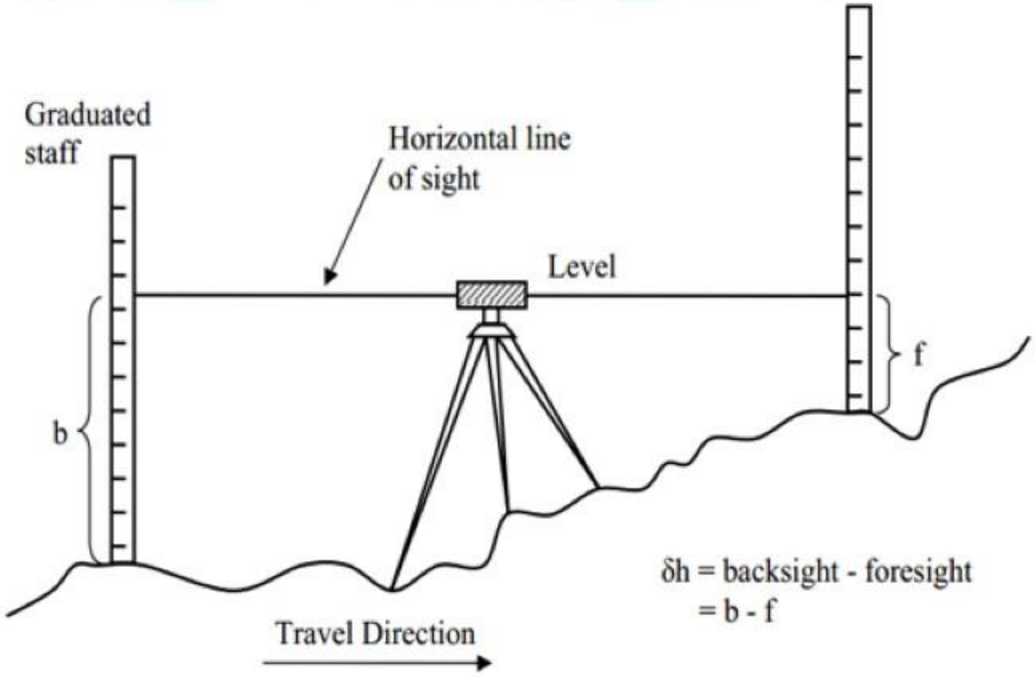
1. DIRECT / SPIRIT LEVELLING

- It is most common method of leveling.
- A spirit level fixed to the telescope of a leveling instrument is used to make line of sight horizontal.
- Vertical distances are measured w.r.t. horizontal line of sight.
- Classification of Direct Levell

a) Simple Levelling

b) Differential Levelling

   i. Check Levelling
   ii. Fly Levelling
   iii. Profile Levelling
   iv. Cross sectional Levelling
   v. Reciprocal Levelling



TYPES OF LEVELLING

1) DIRECT / SPIRIT LEVELLING

a) Simple Levelling

- **In this only one setting of instrument is done to determine the height of instrument.**

b) Differential Levelling

- **It is done to determine elevation between two points by multiple setting of instrument.**
- **It is done when two points are at large distance, difference of elevation between two points is large and some obstacles are there between the two points.**

TYPES OF LEVELLING

1) DIRECT / SPIRIT LEVELLING

b) Differential Levelling

i. <u>Check Levelling</u>

- **It is done for the purpose of checking of elevations which are already obtained.**
- **Generally it is done at the end of each days work from the last point to the starting point of that day.**

TYPES OF LEVELLING

1) ***DIRECT / SPIRIT LEVELLING***

b) ***Differential Levelling***

ii. **Fly Levelling**

- **It is used for determination of approximate elevations of different points.**
- **Line of sight is as long as possible.**
- **Only B.S and F.S are taken.**
- **It is done when time available is less and accuracy desired is low.**

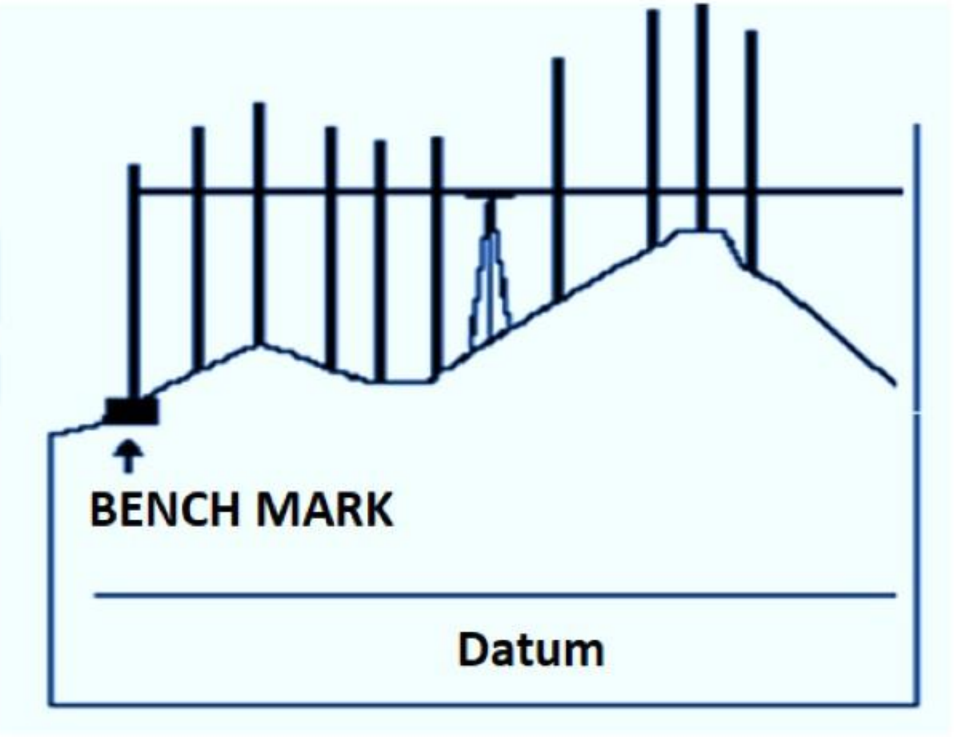
TYPES OF LEVELLING

1) DIRECT / SPIRIT LEVELLING

b) Differential Levelling

iii. <u>Profile Levelling</u>

- **It is done for the purpose of determining elevations of ground surface along a fixed line.**
- **Fixed line is generally centre line of the proposed project.**
- **It is used to establish gradient of the project.**



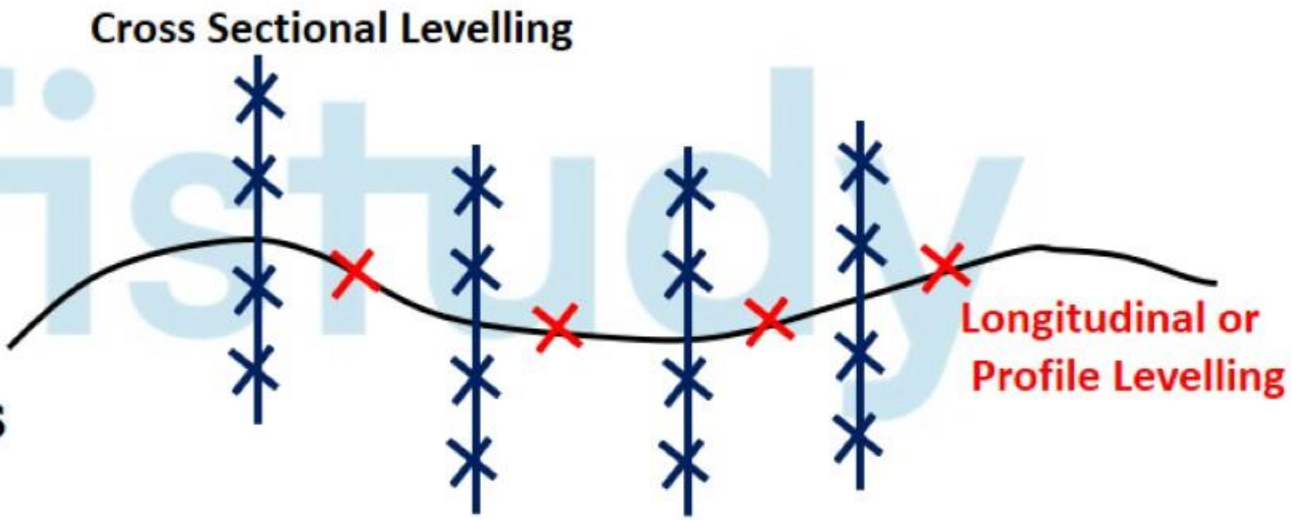
TYPES OF LEVELLING

1) DIRECT / SPIRIT LEVELLING

b) Differential Levelling

iv. Cross Sectional Levelling

- ➢ **It is done to determine difference of elevation of ground surface along the lines perpendicular to the centre line.**
- ➢ **Generally profile levelling and cross sectional levelling are done simultaneously.**



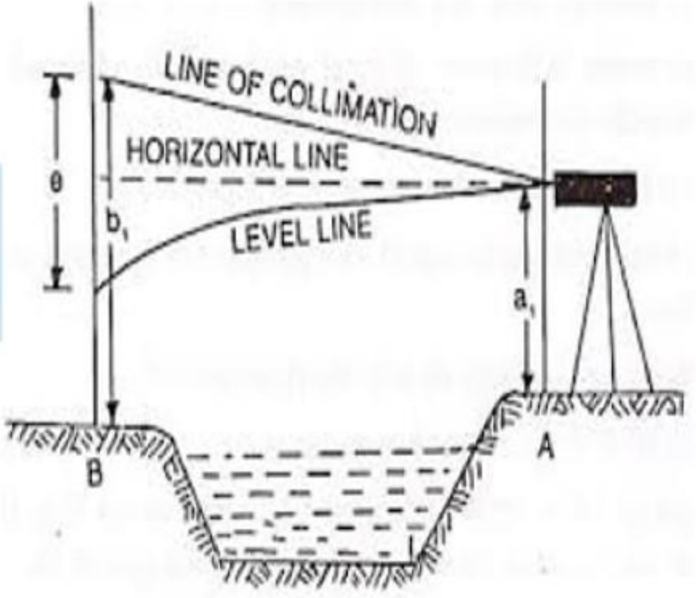
TYPES OF LEVELLING

1) DIRECT / SPIRIT LEVELLING

b) Differential Levelling

v. <u>Reciprocal Levelling</u>

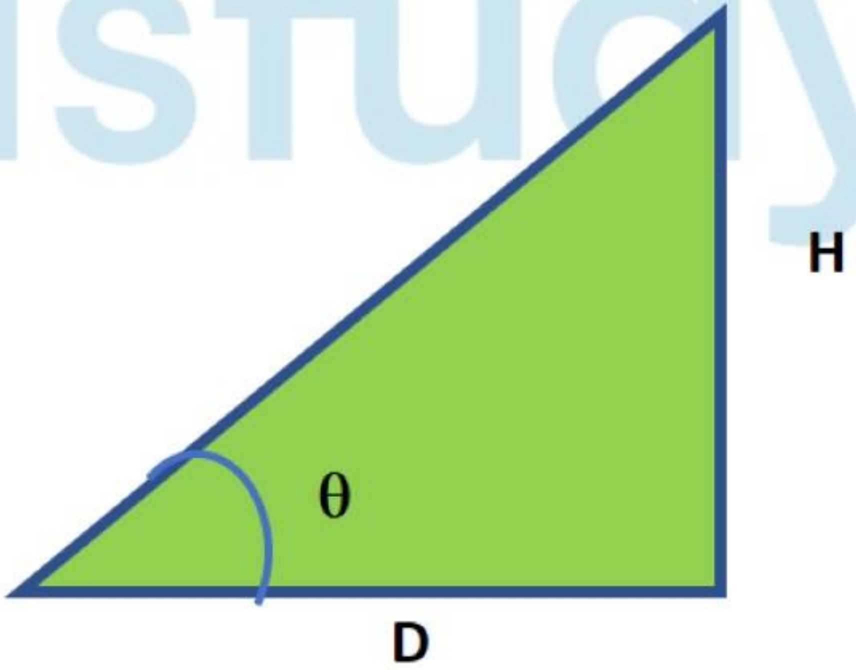
- **It is done to determine height difference between two points which are situated quite a large distance apart and it is not possible to set up the instrument in between these points.**
- **Eg. Opposite banks of river**
- **It helps in eliminating curvature error, refraction error and collimation error.**



TYPES OF LEVELLING

2) TRIGONOMETRIC LEVELLING

- **It is a type of indirect levelling in which difference of elevation is determined indirectly from horizontal distance 'D' and vertical angle 'θ'.**
- **$H = D\tan\theta$**



TYPES OF LEVELLING

3) BAROMETRIC LEVELLING

- **This is an indirect method of levelling in which elevations are determined indirectly from change in atmosphere pressure.**
- **Atmospheric pressure decreases with the increase in elevation.**
- **Altimeter, Aneroid, Barometer are used for determining change in atmospheric pressure.**
- **Altimeters are used for determining altitude of an aeroplane.**
- **Altimetry may be depicted most accurately by 'CONTOUR LINES.'**
- **Barometric levelling is performed by Altimeters.**

TYPES OF LEVELLING

4) HYPSOMETRIC LEVELLING

- **It is a process of determining elevation of various points by observing temperature at which boiling of water takes place.**
- **As altitude increases, boiling point of water decreases.**

SIMPLE LEVELLING

- **Level is set up at a suitable place in between end stations.**
- **Instrument need not to be in line with end station.**
- **R.L of instrument station is never determined.**
- **Line of sight should be horizontal and staff should be vertical.**
- **To ensure the verticality of the staff, staff is slightly waved towards the instrument and then away from the instrument. This process is called as ROCKING OF STAFF.**

SIMPLE LEVELLING

- **SHIMMER**

➢ **Very intense sunshine causes air close to earth to shimmer, hence we avoid staff reading less than 0.5m.**

- **LEVEL FIELD BOOK**

➢ **It is used for recording and reducing staff reading.**

➢ **It is done by two methods:**

a) **Height Of Instrument**

b) **Rise And Fall Method**

SIMPLE LEVELLING

- **USE OF INVERTED STAFF**

➢ **When the point whose elevation is to be determined is much above the line of sight.**

➢ **Such readings are recorded with a negative sign.**

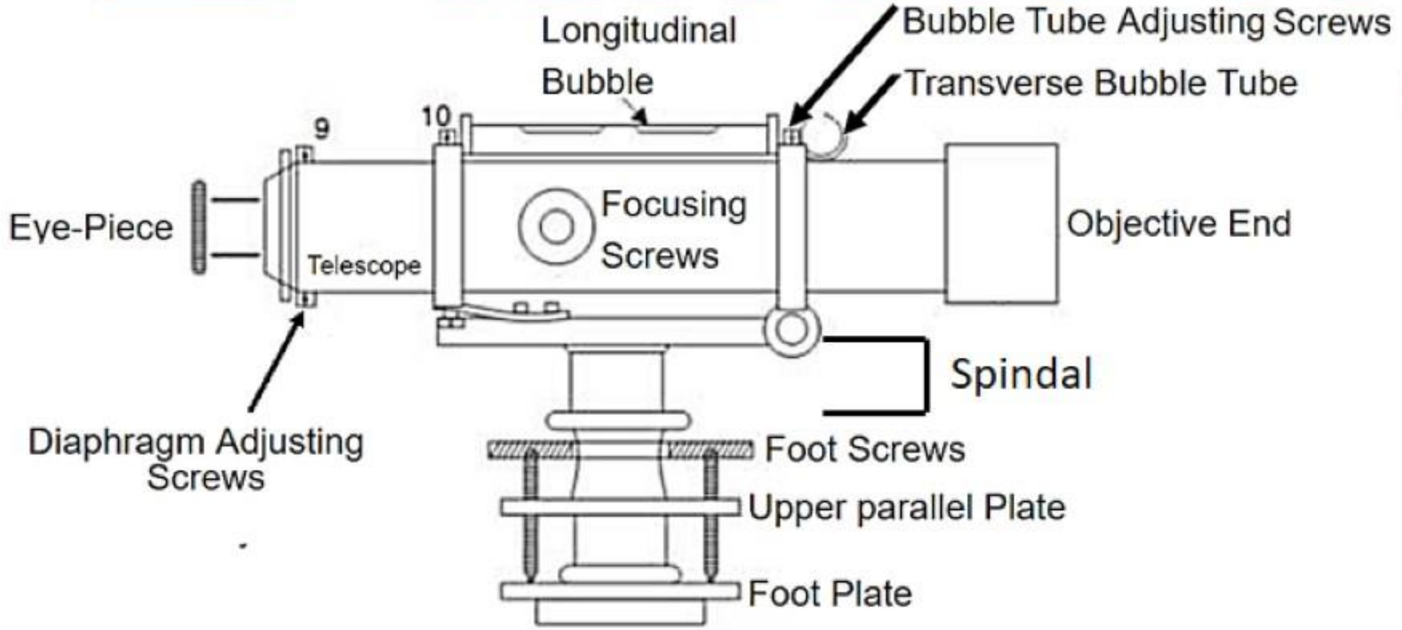
SIMPLE LEVELLING

- **DUMPY LEVEL**

➢ **In dumpy level, telescope and spindal are cast as one piece.**

➢ **Levelling is done with levelling screw.**

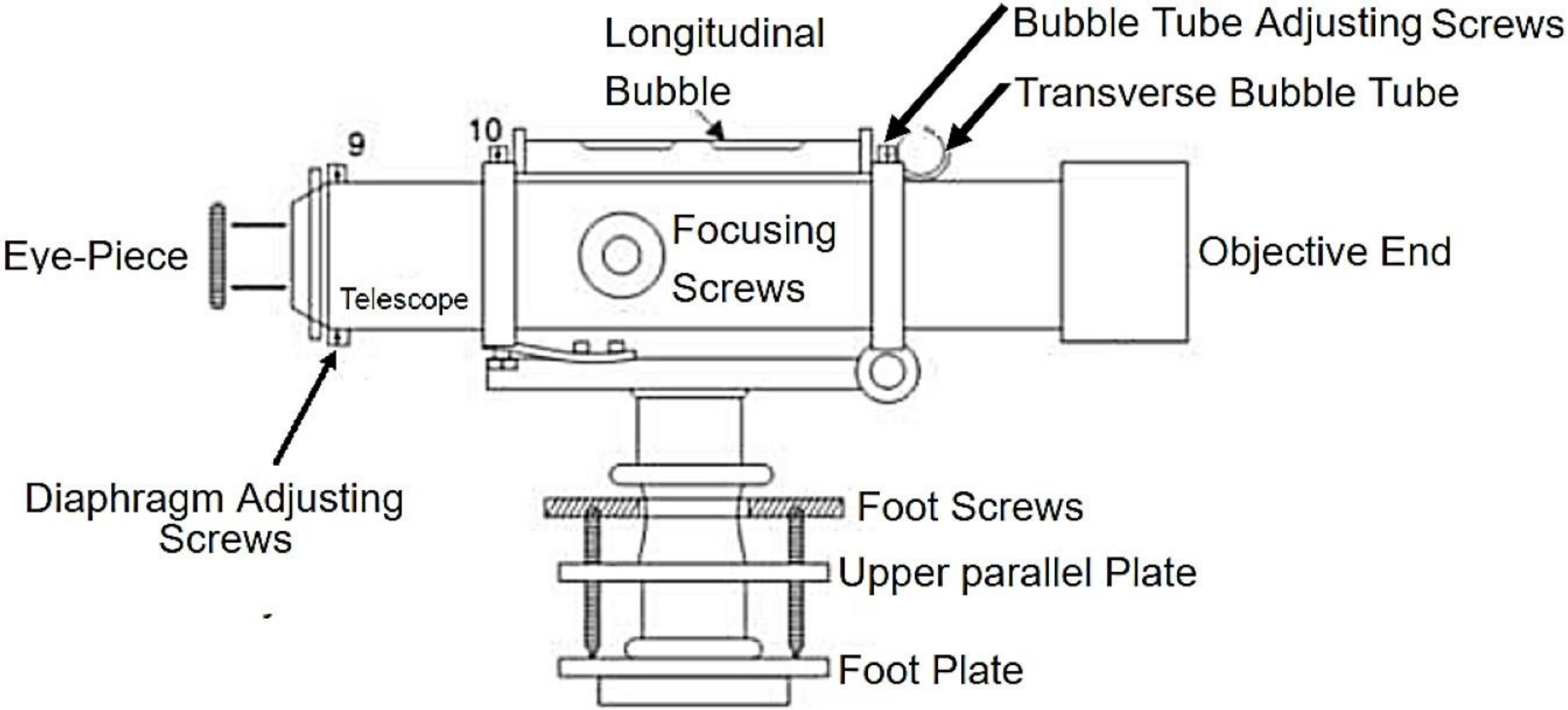
➢ **Under proper adjustment, axis of bubble tube should be perpendicular to vertical axis of instrument.**



SIMPLE LEVELLING

- **TILTING LEVEL**

➢ **Line of sight need not to be perpendicular to vertical axis of instrument.**


Longitudinal
Bubble
Bubble Tube Adjusting Screws
Transverse Bubble Tube
9
10
Eye-Piece
Telescope
Focusing
Screws
Objective End
Diaphragm Adjusting
Screws
Foot Screws
Upper parallel Plate
Foot Plate

SIMPLE LEVELLING

- **PERMANENT ADJUSTMENT OF DUMPY LEVEL**

➢ **Axis of level tube should be perpendicular to vertical axis of instrument.**

➢ **This adjustment is not required in case of tilting level.**

➢ **Axis of level tube should be parallel to line of sight.**

➢ **Horizontal cross hair should lie in a plane perpendicular to vertical axis of instrument.**

➢ **When line of collimation is inclined to the horizontal plane if air bubble is in the centre, this error is called *COLLIMATION ERROR*.**

➢ **To correct this error, we have TWO PEG TEST.**

SENSITIVITY OF LEVEL TUBE

- **Sensitivity of the level tube is expressed in terms of angle in seconds subtended at the centre by an arc equal to 1 division of the level tube.**
- **Radius of upper surface of the tube is a measure of sensitivity of level tube.**
- **If the radius is large, then bubble tube will be more sensitive.**
- **Sensitivity can be increased by changing following parameters:**

1. **Increasing the radius**
2. **Decreasing the viscosity of liquid**
3. **Decreasing roughness of inner walls of the tube**

SENSITIVITY OF LEVEL TUBE

- **Sensitivity expressed as *seconds per division* is not a definite quantity unless length of 1 division is also specified, if not provided length of one division can be assumed as *2mm*.**
- **Length of air bubble can vary under the action of gravity or change in temperature.**
- **Determination of sensitivity**

$$\alpha = \frac{nd}{R} = \frac{S}{D}$$

$$\alpha' = \frac{d}{R} = \frac{S}{nD}$$

S – Staff intercept

n – no. of division moved by air bubble

D – horizontal distance between vertical axis of instrument and staff station

TACHEOMETRY SURVEY

- Tacheometry is a branch of angular surveying in which the horizontal and vertical distances of points are obtained by optical means as opposed to the ordinary slower process of measurements by tape or chain.
- The method is very rapid and convenient.
- It is best adapted in obstacles such as steep and broken ground, deep revines, stretches of water or swamp and so on, which make chaining difficult or impossible.
- The primary object of tacheometry is the preparation of contoured maps or plans requiring both the horizontal as well as vertical control.
- Also, on surveys of higher accuracy, it provides a check on distances measured with the tape.

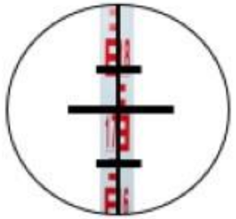
TACHEOMETRY SURVEY

The tacheometric methods of surveying are used with advantage over the direct methods of measurement of horizontal distances and differences in elevations.

Some of the uses are:

I. **Preparation of topographic maps which require both elevations and horizontal distances.**
II. **Survey work in difficult terrain where direct methods are inconvenient.**
III. **Detail filling.**
IV. **Reconnaissance surveys for highways, railways, etc.**
V. **Checking of already measured distances**
VI. **Hydrographic surveys.**
VII. **Establishing secondary control.**

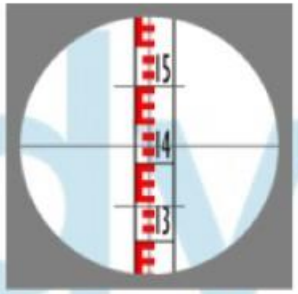
TACHEOMETER



- A tacheometer is essentially a transit theododilte, diaphragm of which is equipped with stadia wires in addition to cross wires

stadia

- Multiplying constant, k = 100
- Additive constant, c = 0
- Telescope is fitted with anallatic lens, purpose of annalatic lens is to make staff intercept proportional to its distance from the tacheometer.



- Magnifying power of eye piece is kept high
- An ordinary transit theodolite fitted with a stadia diaphragm is generally used for tacheometric survey.
- Two stadia hairs are equidistant from central cross hair.
- Stadia rod is a vertical staff which is used when distance between telescope and the staff is so large that graduations become indistinct in ordinary staff
- Subtense bar is a horizontal staff used for distance measurements.

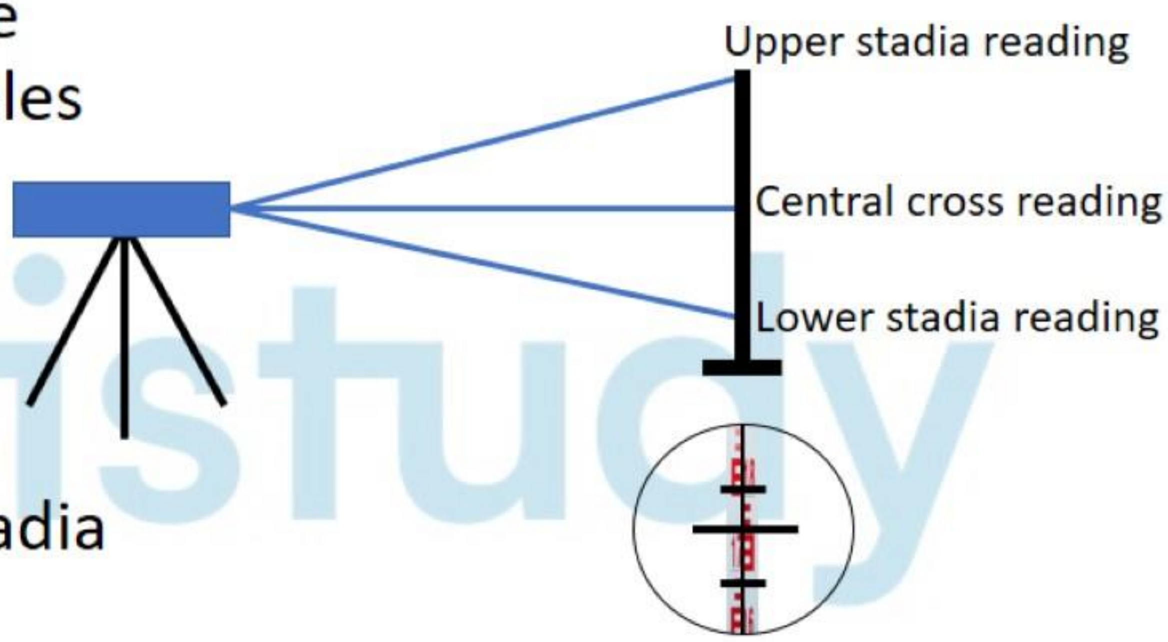
METHODS OF TACHEOMETRY

- The various methods of the tacheometric survey may be classified as follows:

1. The Stadia System
   - Fixed Hair Method
   - Movable Hair Method, or Subtense Bar Method
2. The Tangential System

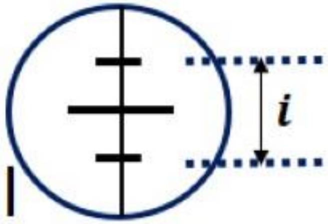
STADIA METHOD

- The stadia method follows the principle that in similar isosceles triangles the ratio of the perpendicular to the base is constant.
- In this method staff intercept (between upper and lower stadia hair) is measured.
- This method is used to determine horizontal and vertical distances.

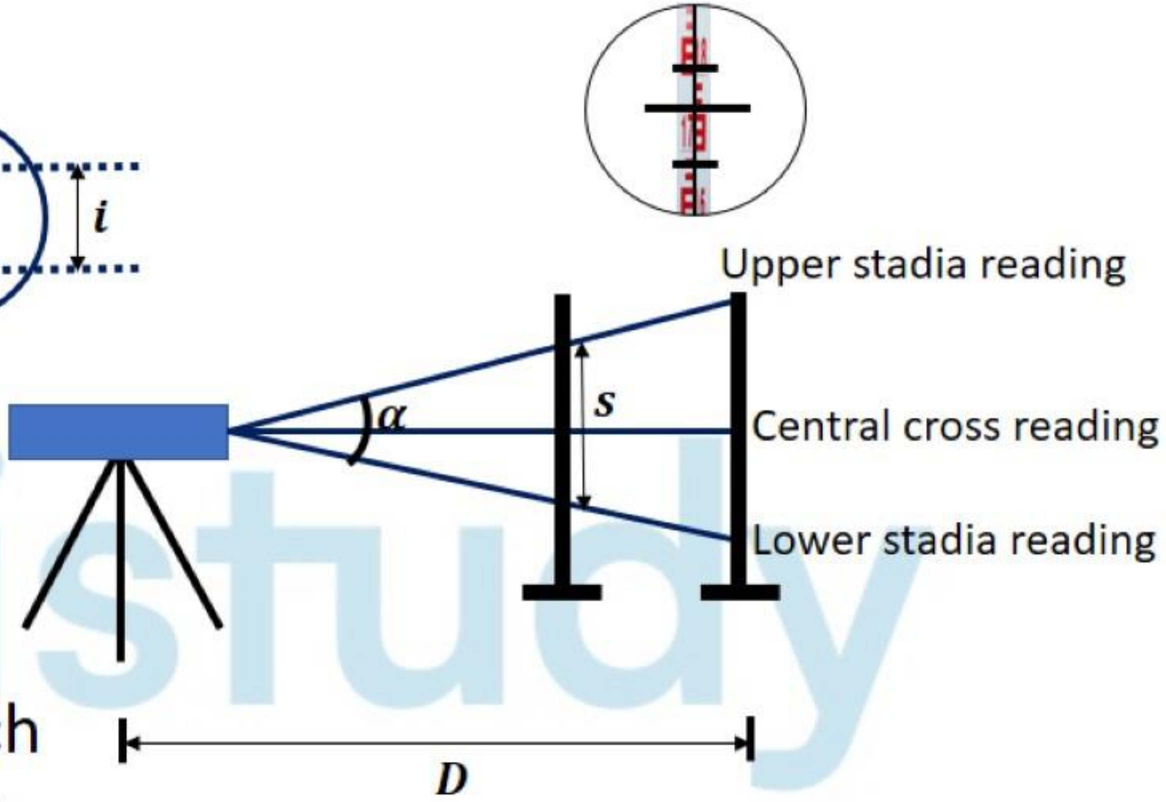


STADIA METHOD

1. <u>FIXED HAIR METHOD</u>



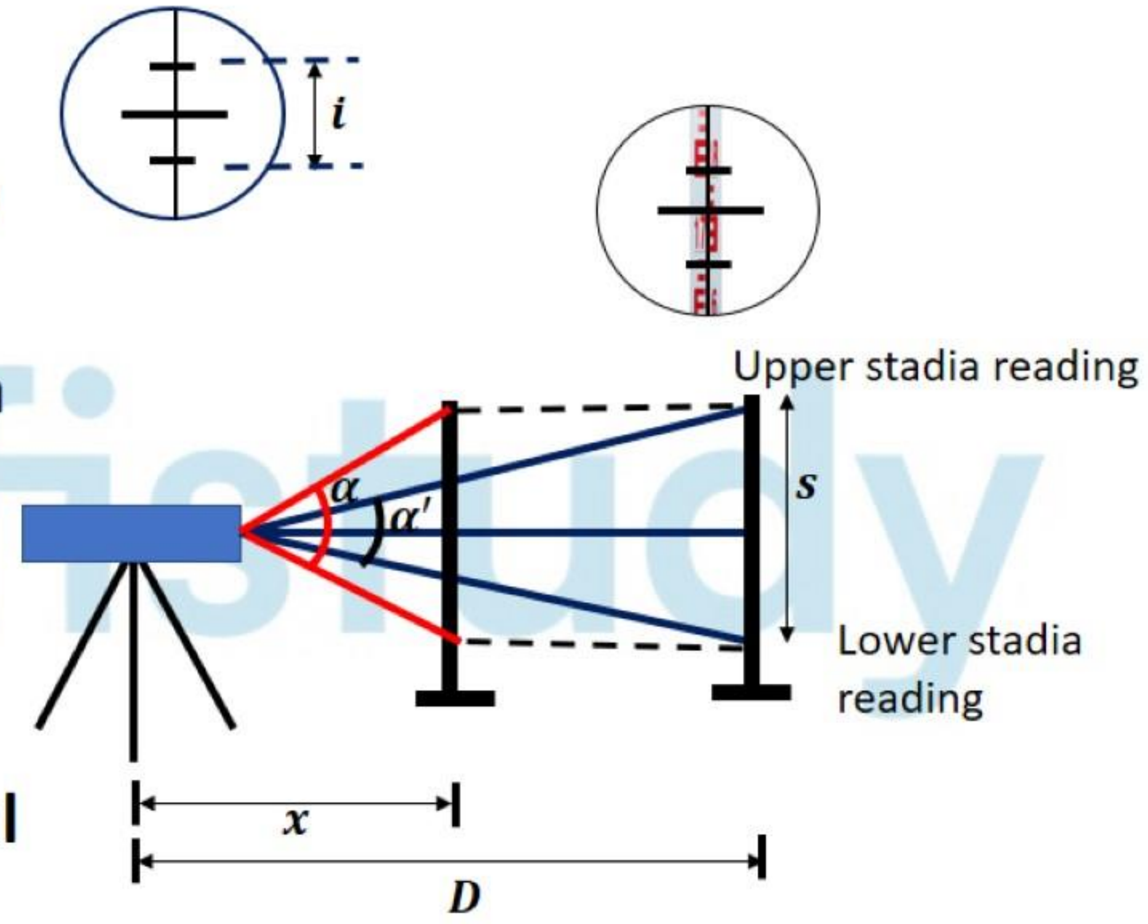
- In this method, the vertical spacing between upper stadia hair and lower stadia hair called 'stadia interval' is kept fixed.'
- Parallatic angle(α) is defined, with the help of stadia hair, which is kept fixed while staff intercept (s) is varied



STADIA METHOD

2. MOVABLE HAIR METHOD

- **In this method, staff intercept is fixed and stadia interval is varying using micrometer screws.**
- **This method is rarely used since it is inconvenient to measure stadia hair interval accurately.**



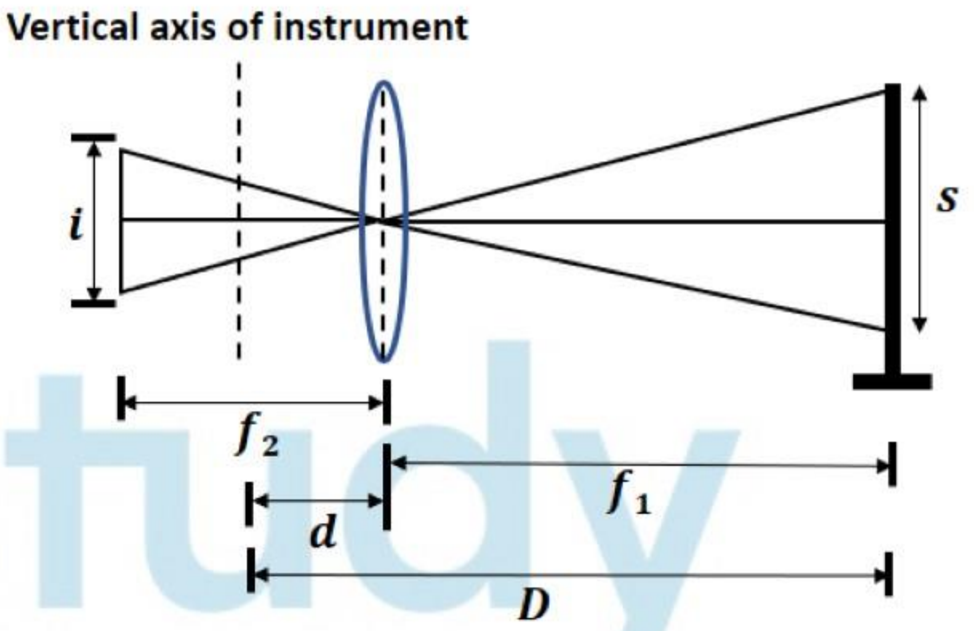
PRINCIPLE OF STADIA METHOD

- $\Rightarrow D = \frac{f}{i}(s) + (f + d)$
- $\Rightarrow D = ks + c$
- *Multiplying constant* $k = \frac{f}{i}$ (k=100)
- *Additive constant* $c = f + d$ (c=0)

This equation is TACHEOMETRIC DISTANCE EQUATION

$$D \propto s$$

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



Where f – focal length

d – distance from object glass to trunnion axis

k – multiplying constant (k=100)

i=stadia interval

c – additive constant (lies between 0.25m to 0.35m)

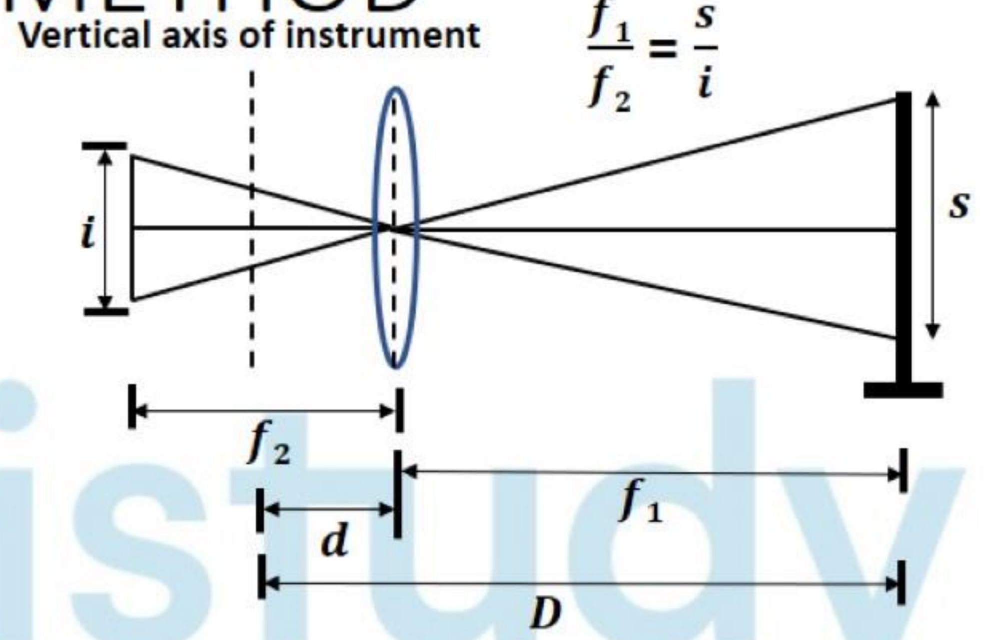
Value of 'c' becomes '0' if an anallatic lens is used in telescope

Intercept 's' is minimum if the staff is held truly normal to line of sight

Trunnion axis: The horizontal axis about which the telescope can be rotated.

PRINCIPLE OF STADIA METHOD

- $D = f_1 + d$
- $\Rightarrow \frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$
- *Multiply by* ff_1
- $f_1 = f + \frac{f_1}{f_2} f$
- *Put values of* $\frac{f_1}{f_2}$ *in* $\frac{f_1}{f_2} = \frac{s}{i}$
- $f_1 = f + \frac{s}{i} f$
- $=> D = d + f_1$
- $\Rightarrow D = \frac{f}{i}(s) + (f + d)$



$$\Rightarrow D = ks + c$$

Multiplying constant $k = \frac{f}{i}$ (k=100)

Additive constant $c = f + d$ (c=0)

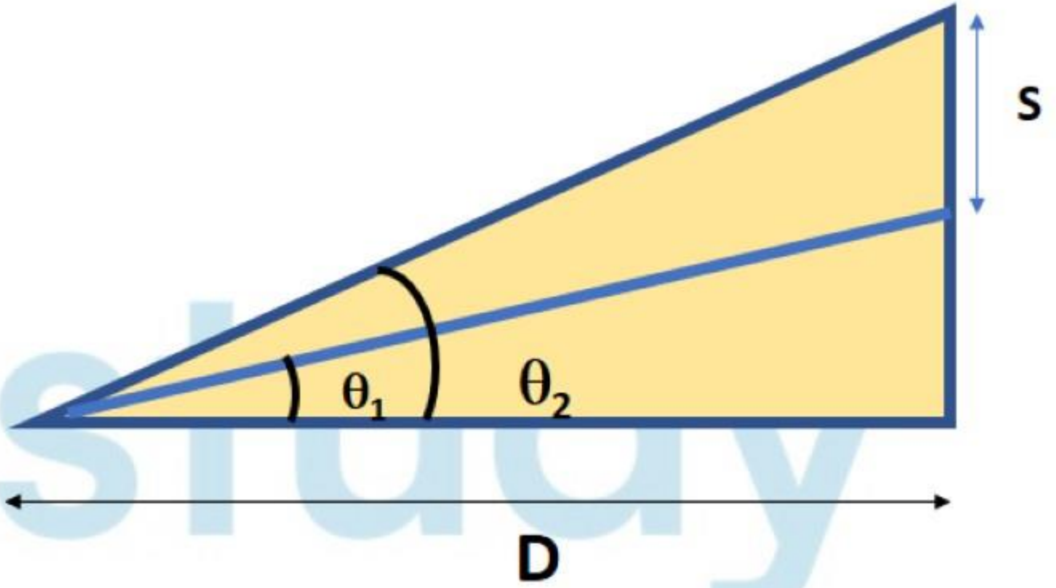
This equation is TACHEOMETRIC DISTANCE EQUATION

$$D \propto s$$

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

TANGENTIAL METHOD

- In this method, stadia hairs are not required hence the method cannot be used when stadia diaphragm is not provided.
- In this system of tachometric surveying, two observations will be necessary from the instrument station to the staff station to determine the horizontal distance and the difference in the elevation between the line of collimation and the staff station.
- The only advantage of this method is that this survey can be conducted with ordinary transit theodolite.

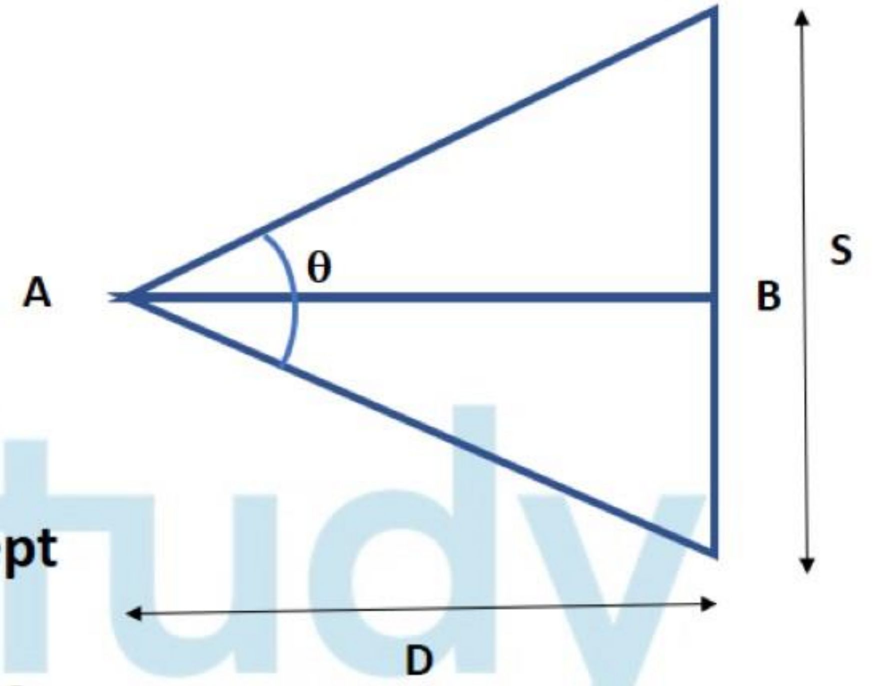


$$s = D\tan\theta_2 - D\tan\theta_1$$

$$s = D(\tan\theta_2 - \tan\theta_1)$$

SUBTENSE BAR METHOD

- This method is almost same as the stadia method except that **the stadia interval is variable.**
- A suitable arrangement is made to vary the distance between the stadia hair as to set them against the two targets on the staff kept at the point under observation.
- Thus, in this case, the staff intercept, i.e., the distance between the two targets is kept fixed while the stadia interval, i.e., the distance between the stadia hair is variable.
- As in the case of fixed hair method, inclined sights may also be taken



Que. 69 Subtense bar is an instrument used for

a) Levelling

b) Measurement of horizontal distances in plane areas

c) Measurement of horizontal distances in undulated areas

d) Measurement of angles

Que. 69 Subtense bar is an instrument used for

a) Levelling

b) Measurement of horizontal distances in plane areas

c) Measurement of horizontal distances in undulated areas

d) Measurement of angles

Que. 70 Horizontal distances obtained by tacheometer observations

a) Require slope correction

b) Require tension correction

c) Require slope and tension correction

d) Do not require slope and tension corrections

Que. 70 Horizontal distances obtained by tacheometer observations

a) Require slope correction

b) Require tension correction

c) Require slope and tension correction

d) Do not require slope and tension corrections

Que. 71 The number of horizontal cross wires in a stadia diaphragm is

a) 1

b) 2

c) 3

d) 4

Que. 71 The number of horizontal cross wires in a stadia diaphragm is

a) 1

b) 2

c) 3

d) 4

Que. 72 If the intercept on a vertical staff is observed as 0.75m from a tacheometer, the horizontal distance between tacheometer and staff station is

a) 7.5m

b) 25m

c) 50m

d) 75m

Que. 72 If the intercept on a vertical staff is observed as 0.75m from a tacheometer, the horizontal distance between tacheometer and staff station is

a) 7.5m

b) 25m

c) 50m

d) 75m

$D = KS + C$ $(C=0)$

$\Rightarrow D = 0.75 \times 100 = 75m$

Que. 73 For a tacheometer, additive and multiplying constants are respectively

a) 0 and 100

b) 100 and 0

c) 0 and 0

d) 100 and 100

Que. 73 For a tacheometer, additive and multiplying constants are respectively

a) <u>0 and 100</u>

b) 100 and 0

c) 0 and 0

d) 100 and 100

Multiplying constant $k = \frac{f}{i}$ (k=100)

Additive constant $c = f + d$ (c=0)

Que. 74 Cross hair in surveying telescope are fitted

a) In the objective glass

b) At the centre of telescope

c) At the optical centre of the eye piece

d) In front of eye piece

Que. 74 Cross hair in surveying telescope are fitted

a) In the objective glass

b) At the centre of telescope

c) At the optical centre of the eye piece

d) In front of eye piece

Que. 75 An annalatic lens is provided in a

a) Theodolite
b) Tacheometer
c) Dumpy level
d) Prismatic compass

Que. 75 An annalatic lens is provided in a

a) Theodolite
b) Tacheometer
c) Dumpy level
d) Prismatic compass

Que. 76 Multiplying constant is

a) f+d

b) f/d + i

c) f/i + d

d) f/i

Que. 76 Multiplying constant is

a) f+d

b) f/d + i

c) f/i + d

d) f/i

Multiplying constant $k = \frac{f}{i}$ (k=100)

Additive constant $c = f + d$ (c=0)

Que. 77 The diaphragm of a stadia theodolite is fitted with two additional

a) Horizontal hairs

b) Vertical hairs

c) Horizontal and vertical hairs

d) None of these

Que. 77 The diaphragm of a stadia theodolite is fitted with two additional

a) Horizontal hairs

b) Vertical hairs

c) Horizontal and vertical hairs

d) None of these

Que. 78 Horizontal distances obtained by tacheometerically are corrected for

a) Slope correction

b) Temperature correction

c) Curvature and refraction correction

d) All of these

Que. 78 Horizontal distances obtained by tacheometerically are corrected for

a) Slope correction

b) Temperature correction

c) Curvature and refraction correction

d) All of these

Que. 79 In tacheometrical observations, vertical staff holding is generally preferred to normal staffing due to

a) Ease of reduction of observations

b) Facility of holding

c) Minimum effect of careless holding on the result

d) None of these

Que. 79 In tacheometrical observations, vertical staff holding is generally preferred to normal staffing due to

a) Ease of reduction of observations

b) Facility of holding

c) <u>Minimum effect of careless holding on the result</u>

d) None of these

Q. 80 Plumb bob lines at two different places in geodetic surveying will

a) Intersect at the surface of the earth

b) Intersect at the center of the earth

c) Parallel to each other

d) Perpendicular to each other

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a) Intersect at the surface of the earth

b) Intersect at the center of the earth

c) Parallel to each other

d) Perpendicular to each other

Q. 81 Which of the following is correct

a) Length of engineering chain is 100ft
b) Length of Gunter's chain is 66ft
c) Length of revenue chain is 33ft
d) All of the above

Q. 81 Which of the following is correct

a) Length of engineering chain is 100ft

b) Length of Gunter's chain is 66ft

c) Length of revenue chain is 33ft

d) <u>All of the above</u>

Q. 82 Which one of the following statements includes the principle of surveying

a) Working from higher to lower level

b) Working from lower to higher level

c) Working from part to whole

d) Working from whole to part

Q. 82 Which one of the following statements includes the principle of surveying

a) Working from higher to lower level

b) Working from lower to higher level

c) Working from part to whole

d) Working from whole to part

Q. 83 Number of links in 20m metric chain is

a) 80

b) 100

c) 120

d) 150

Q. 83 Number of links in 20m metric chain is

a) 80

b) 100 (20m-100, 30m-150)

c) 120

d) 150

Q. 84 In geodetic surveying, sum of all the internal angles of a spherical triangle should be

a) $= 180^\circ$

b) $= 360^\circ$

c) $> 180^\circ$

d) $< 180^\circ$

Q. 84 In geodetic surveying, sum of all the internal angles of a spherical triangle should be

a) = 180°

b) = 360°

c) > 180°

d) <180°

Q. 85 A well conditioned triangle does not have any angle less than

a) 20^o

b) 30^o

c) 45^o

d) 60^o

Q. 85 A well conditioned triangle does not have any angle less than

a) 20^o

b) <u>30^o</u>

c) 45^o

d) 60^o

Q. 86 In a traverse survey, closing error means

a) The error in closing of the traversing operations

b) The actual distance by which the traverse fails to close

c) The distance between the starting and end point of an open traverse

d) None of the above

Q. 86 In a traverse survey, closing error means

a) The error in closing of the traversing operations

b) The actual distance by which the traverse fails to close

c) The distance between the starting and end point of an open traverse

d) None of the above

Q. 87 Point of inaccessible points on a plane table is done by

a) Intersection

b) Traversing

c) Radiation

d) None of these

Q. 87 Point of inaccessible points on a plane table is done by

a) Intersection

b) Traversing

c) Radiation

d) None of these

Q. 88 In surveyor compass the bearings are observed in

a) Whole circle bearing

b) Reduced bearing

c) Both a and b

d) None of these

Q. 88 In surveyor compass the bearings are observed in

a) Whole circle bearing

b) Reduced bearing

c) Both a and b

d) None of these

Q. 89 The two and three point problems are methods of

a) Radiation

b) Intersection

c) Traversing

d) Resection

Q. 89 The two and three point problems are methods of

a) Radiation

b) Intersection

c) Traversing

d) <u>Resection</u>

Que 90. Detailed plotting in plane table surveying is generally done by

a) Resection

b) Traversing

c) Both a and b

d) Radiation

Que 90. Detailed plotting in plane table surveying is generally done by

a) Resection

b) Traversing

c) Both a and b

d) Radiation

Que. 91 If the magnetic bearing of the sun at a place at noon in southern hemisphere is 167^{o}, the magnetic declination is

a) 13^{o} W

b) 13^{o} E

c) 77^{o} N

d) 23^{o} S

Que. 91 If the magnetic bearing of the sun at a place at noon in southern hemisphere is 167^{o}, the magnetic declination is

a) 13^{o} W

b) 13^{o} E

c) 77^{o} N

d) 23^{o} S

Q. 92 The angle between the prolongation of the preceding line and the forward line of a traverse is

a) **Direct angle**

b) **Excluded angle**

c) **Deflection angle**

d) **Included angle**

Q. 92 The angle between the prolongation of the preceding line and the forward line of a traverse is

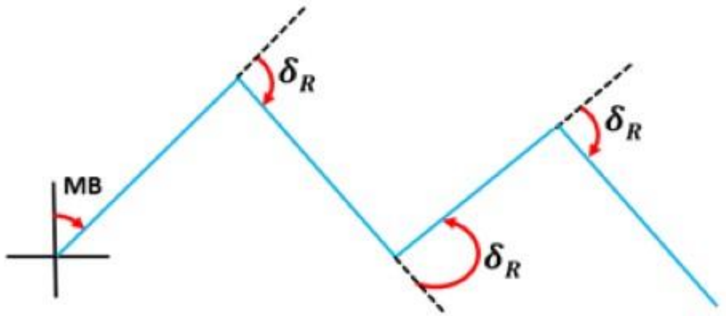
a) **Direct angle**

b) **Excluded angle**

c) **Deflection angle**

d) **Included angle**

5. Deflection Angle Method
   - Deflection angle method is used for open traverse in which traverse line makes small deflection angle like in railways, canals, sewers, etc



Q. 93 If the end points of a line are free from local attraction, the difference between fore bearing and back bearing of that line should be

a) 180^{o}

b) 120^{o}

c) 360^{o}

d) 90^{o}

Q. 93 If the end points of a line are free from local attraction, the difference between fore bearing and back bearing of that line should be

a) 180^o

b) 120^o

c) 360^o

d) 90^o

Q. 94 The fore bearing of the line CD is $324^{o}45'$, the back bearing of the line is

a) $144^{o}45'$

b) $54^{o}45'$

c) $234^{o}45'$

d) $35^{o}45'$

Q. 94 The fore bearing of the line CD is $324^{o}45'$, the back bearing of the line is

a) $144^{o}45'$

b) $54^{o}45'$

c) $234^{o}45'$

d) $35^{o}45'$

Q. 95 The principle of working of optical square is based on

a) Double reflection

b) Double refraction

c) Reflection

d) Refraction

Q. 95 The principle of working of optical square is based on

a) **Double reflection**

b) **Double refraction**

c) **Reflection**

d) **Refraction**

Optical square:

- It is used to setout right angles
- It uses the principle of Double reflection.
- Index mirror fully silvered , Horizon Mirror l half silvered and Top half

Que. 96 Compute the acute angle between the line AB and AC, if their respective bearings are $52^{o}30'$ and $328^{o}45'$

a) $276^{o}15'$

b) $6^{o}15'$

c) $111^{o}15'$

d) $83^{o}45'$

Que. 96 Compute the acute angle between the line AB and AC, if their respective bearings are $52^{o}30'$ and $328^{o}45'$

a) $276^{o}15'$

b) $6^{o}15'$

c) $111^{o}15'$

d) $83^{o}45'$

Q. 97 The whole circle bearing of a line is $287^{o}15'$ then the reduced bearing of that line is

a) S $107^{o}15'$W

b) S $17^{o}15'$W

c) N $72^{o}45'$W

d) S $107^{o}15'$E

Q. 97 The whole circle bearing of a line is $287^{o}15'$ then the reduced bearing of that line is

a) S $107^{o}15'$W

b) S $17^{o}15'$W

c) N $72^{o}45'$W

d) S $107^{o}15'$E

Q. 98 The fore bearing of the lines AB and BC are 40^o and 120^o respectively. The included angle between AB and BC is

a) 40^o

b) 60^o

c) 80^o

d) 260^o

Q. 98 The fore bearing of the lines AB and BC are 40^{o} and 120^{o} respectively. The included angle between AB and BC is

a) 40^{o}

b) 60^{o}

c) 80^{o}

d) 260^{o}

Q. 99 Which of the following is correct

a) Length of engineering chain is 33ft
b) Length of engineering chain is 66ft
c) Length of Gunter's chain is 66ft
d) Length of revenue chain is 100ft

Q. 99 Which of the following is correct

a) Length of engineering chain is 33ft
b) Length of engineering chain is 66ft
c) <u>Length of Gunter's chain is 66ft</u>
d) Length of revenue chain is 100ft

Contours

- **Contours are defined as an imaginary line passing through points of equal elevation on Earth surface**
- **Contour line: is defined as intersection of a level surface with the surface of earth**
- **Note: Contour lines on a plan illustrate topography of the ground**
- **When the contours are drawn under water, they are termed as Submarine contours/fathoms curves/Bathymetric curves**
- **Generally, the contours are not visible on the grounds except in case of shore lines**

Chapter 7: Contours

- **Contour Interval:**
  - It is vertical distance between consecutive contours
  - Generally constant contour interval is preferred throughout the map
  - Generally contour interval is taken as 1 to 15m
  - Smaller the contour interval, more precisely the terrain relief is predicted on the plan
  - The contour interval depends on
    a) Scale of the map
    b) Purpose of map
    c) Nature of ground
    d) Time
    e) Funds

Contours

- **Contour Interval:**
  - **The contour interval depends on**
    a) Scale of the map
      - If scale is small, the contour interval is kept large so that there is no over crowding of the contours
      - If the scale is large the contour interval can be kept small

    b) Purpose of map
      - The contour interval selected should be small so that the map serves the intended purpose, but at the same time it should not be too small otherwise the cost of the work would be more

    c) Nature of ground
      - For a flat ground, contour interval is small, for a steep slope, contour interval is large and if the ground is broken, the contour interval is kept large so that the contours do not come too close to each other

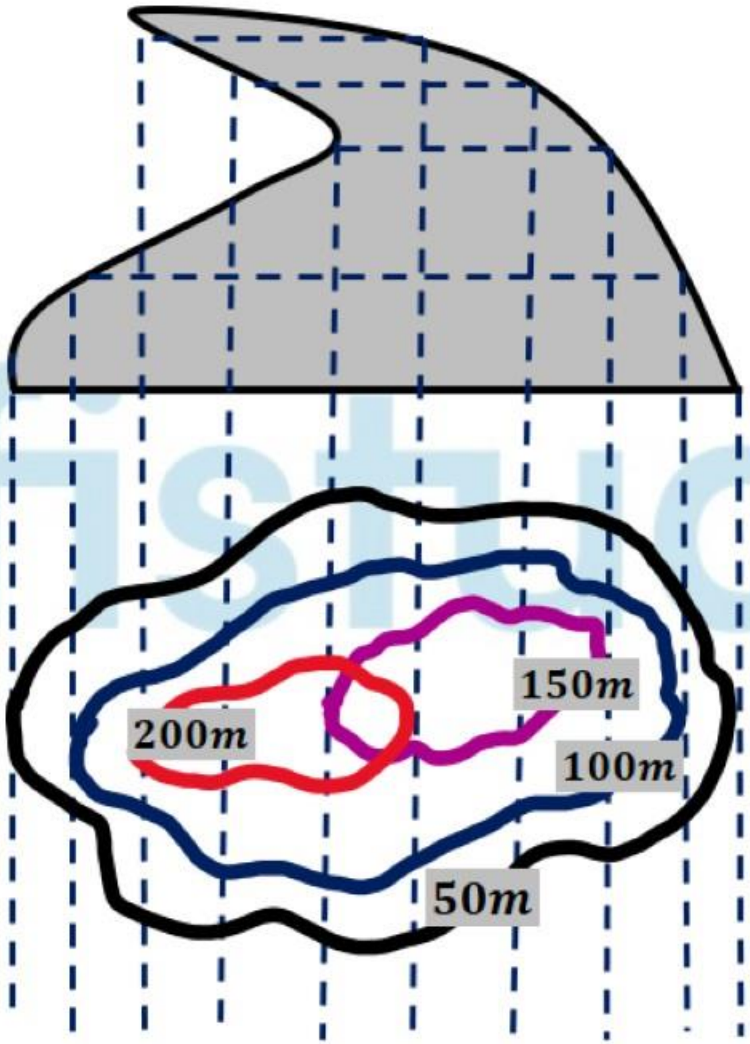
    d) Time
      - Contour interval is kept large when time is less

    e) Funds
      - Contour interval is kept large when funds are less

Characteristics of Contour lines

- **When no value is represented, it indicates a *flat terrain*.**
- **A zero meter contour line, represents the *coast line*.**
- **A contour line is a closed curve. They may close either on the map or outside the map, it depends on topography.**
- **Two contour lines never intersect each other except in the cases of overhanging cliff or a cave penetrating a hill side.**

Characteristics of Contour lines



Characteristics of Contour lines

- **Two contour lines never intersect each other except in the cases of overhanging cliff or a cave penetrating a hill side.**
- **Equally spaced contours represent a *uniform slope* and contours that are well apart represents a *gentle slope*.**
- **A set of closed contours with higher figures inside and lower figures outside indicate *hill lock* whereas in case of *depressions and lakes* etc, the lower figures are inside and the higher figures are outside.**

Characteristics of Contour lines

- **A watershed or a ridge line (line joining the highest point of a series of hills) and the valley line(line joining the lowest points of valley cross the contours at right angles)**
- **Irregular contours represent an uneven ground surface.**
- **Two contour lines having same elevations cannot unite and continue as one line.**
- **Similarly a single contour cannot be put into two lines.**

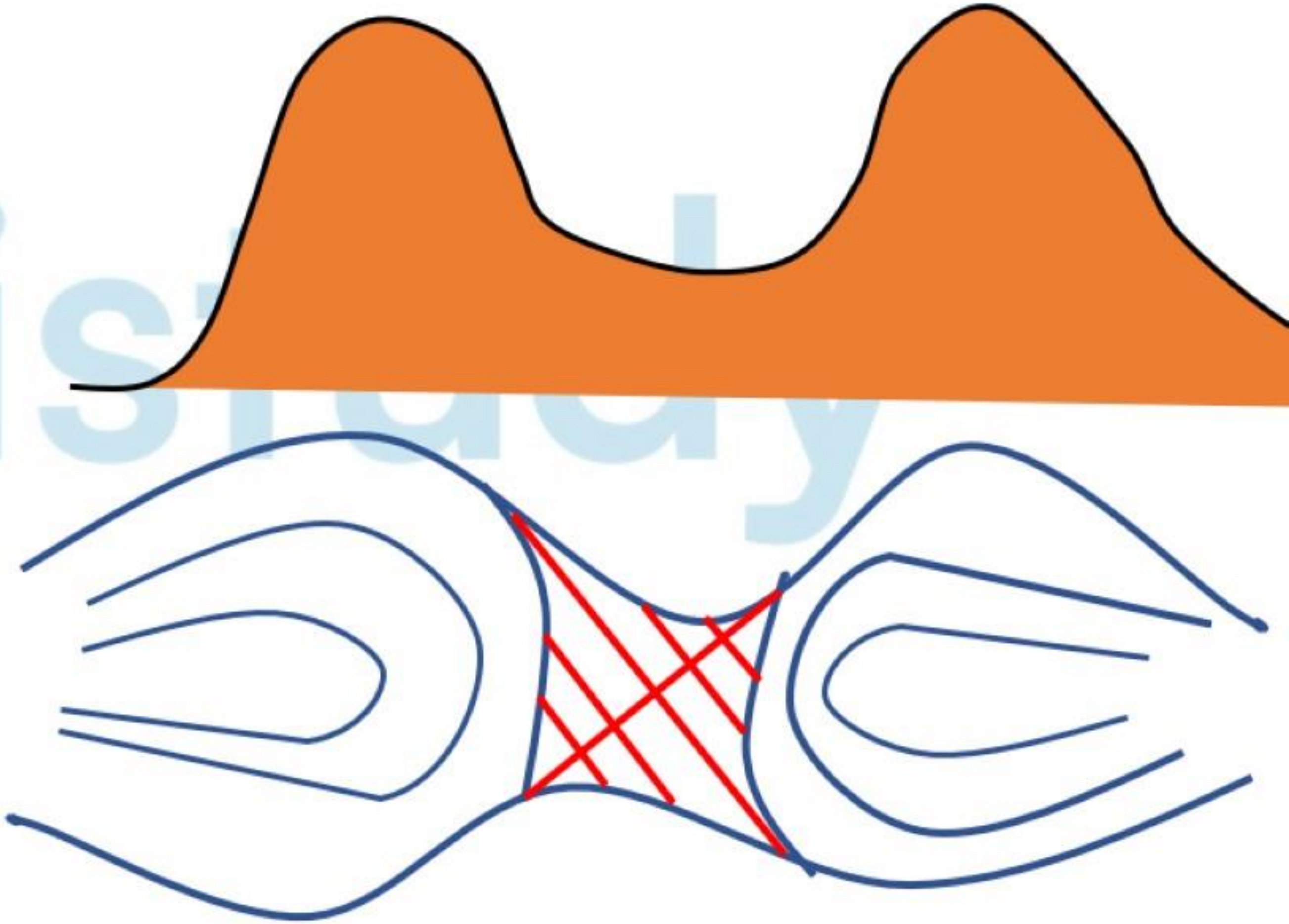
TYPICAL LAND FEATURES AND THEIR CONTOUR FORMS SLOPES

1. **HIGH LYING FORMS**
   - **Hills are elevated ground usually with a pointed peak.**
   - **The contours of hills are bit circular in shape and increasing contour values inwards.**
2. **LOW LYING FORMS**
   - **The most common among low line forms are ravines, valleys etc.**
     - **Ravine is a through like depression of the Earth surface elongated in one direction with the bottom inclined towards one side. A ravine can be imagined as a depression washed out in the ground by flowing water.**
     - **Valley is a broad ravine with a gentle sloping bottom.**

TYPICAL LAND FEATURES AND THEIR CONTOUR FORMS SLOPES

3. SADDLE

- **The lowest points on the watershed are known as passes.**
- **Pass is a narrow low land passing through high mountains on either side. Sometimes this narrow low land is cut back by the streams. This steep sided depression is called *Col*, when this depression is broad and low it is known as *Saddle*.**
- **The contours are similar to that of a valley, the difference is here contour vales decrease towards the vee.**
- **A high land having flat narrow top with steep slope on one side and gentle slope on the other side is called as *Escrapment*.**



TYPICAL LAND FEATURES AND THEIR CONTOUR FORMS SLOPES

4. CLIFF

- **These are the steep rock faces along the sea coast and may be vertical where the contour lines coincide with each other, an overhanging cliff where the contour lines intersect each other.**

Que 100. If the focal length of the object glass is 25cm and the distance from object glass to the trunnion axis is 15cm, the additive constant is

a) 0.1

b) 0.4

c) 0.6

d) 1.33

Que 100. If the focal length of the object glass is 25cm and the distance from object glass to the trunnion axis is 15cm, the additive constant is

a) 0.1

b) <u>0.4</u>

c) 0.6

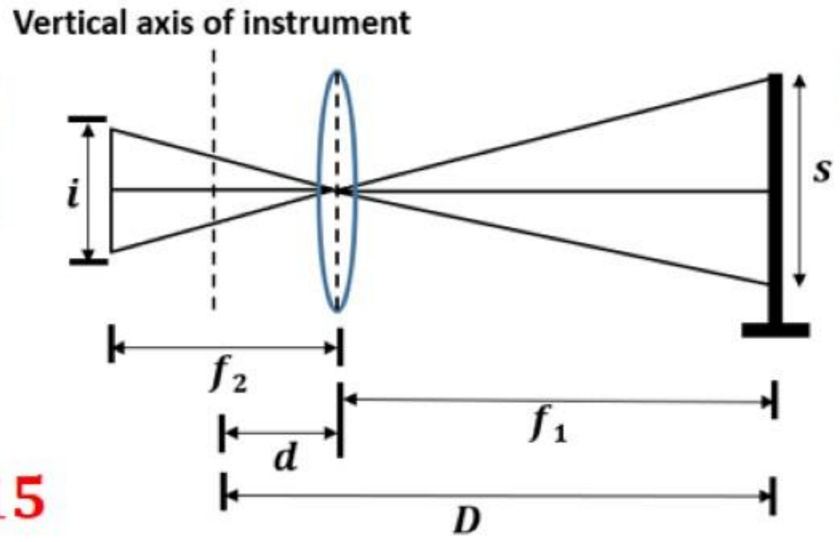
d) 1.33

$$D = ks + c$$

$$c = f + d$$

$$\Rightarrow c = 0.25 + 0.15$$

$$\Rightarrow c = 0.40$$



Que 101. The angle between true meridian and magnetic meridian is called as

a) Orientation

b) Magnetic Declination

c) Magnetic bearing

d) Dip

Que 101. The angle between true meridian and magnetic meridian is called as

a) Orientation

b) <u>Magnetic Declination</u>

c) Magnetic bearing

d) Dip

Que 102. Radiation, Intersection, and resection are

a) Compass surveying techniques

b) Chain surveying techniques

c) Levelling techniques

d) Plane table surveying techniques

Que 102. Radiation, Intersection, and resection are

a) **Compass surveying techniques**

b) **Chain surveying techniques**

c) **Levelling techniques**

d) **Plane table surveying techniques**

Que 103. If the whole circle bearing of a line is 210°0’0”, its value in quadrantal bearing system is

a) S 30°0’0” W

b) N 30°0’0” E

c) S 30°0’0” E

d) N 30°0’0” W

Que 103. If the whole circle bearing of a line is 210°0’0”, its value in quadrantal bearing system is

a) S 30°0’0” W

b) N 30°0’0” E

c) S 30°0’0” E

d) N 30°0’0” W

Que 104. When two points of survey are mutually invisible, the following method is adopted for ranging:

a) **Direct ranging**

b) **Indirect ranging**

c) **Horizontal ranging**

d) **Vertical ranging**

Que 104. When two points of survey are mutually invisible, the following method is adopted for ranging:

a) Direct ranging

b) Indirect ranging

c) Horizontal ranging

d) Vertical ranging

Que 105. The sum of interior angles of a closed traverse is equal to

a) $(2n - 4)90°$

b) $(3n - 4)90°$

c) $(2n - 4)180°$

d) $(3n - 4)180°$

Que 105. The sum of interior angles of a closed traverse is equal to

a) $\underline{(2n-4)90°}$

b) $(3n-4)90°$

c) $(2n-4)180°$

d) $(3n-4)180°$

Que 106. If the fore bearing of the line is observed to be AB 12°24', the back bearing of the line is...

a) 102°24'

b) 73°36'

c) 167°36'

d) 192°24'

Que 106. If the fore bearing of the line is observed to be AB 12°24', the back bearing of the line is...

a) 102°24'

b) 73°36'

c) 167°36'

d) <u>192°24'</u>

Que 107. The direction of a line relative to a given meridian is known as

a) **Angle of line**

b) **Direction of line**

c) **Bearing of line**

d) **Relative meridian**

Que 107. The direction of a line relative to a given meridian is known as

a) Angle of line

b) Direction of line

c) <u>Bearing of line</u>

d) Relative meridian

Que 108. In compass surveying, the

A. The direction and lengths of survey line is measured by compass
B. The direction is measured by compass
C. The lengths of survey line is measured by chain or tape

Which of them are true?

a) Only A
b) Only B
c) Only C
d) Both B and C

Que 108. In compass surveying, the

A. The direction and lengths of survey line is measured by compass
B. The direction is measured by compass
C. The lengths of survey line is measured by chain or tape

Which of them are true?

a) Only A
b) Only B
c) Only C
d) Both B and C

Que 109. In a prismatic compass,

a) The graduated ring attached to the compass moves with sights.

b) Usage is not possible without a tripod

c) The needle remains stationary when box is rotated

d) Whole circle bearings are calculated

Que 109. In a prismatic compass,

a) The graduated ring attached to the compass moves with sights.

b) Usage is not possible without a tripod

c) The needle remains stationary when box is rotated

d) Whole circle bearings are calculated

Que 110. Inclination of the compass needle to the horizontal towards the pole is called

a) Dip
b) Declination
c) Azimuth
d) Bearing

Que 110. Inclination of the compass needle to the horizontal towards the pole is called

a) Dip
b) Declination
c) Azimuth
d) Bearing

Que 111. The dip of the compass needle

a) Remains same at different places
b) Varies from place to place
c) Is zero at equator and 90 degree at poles
d) None of these

Que 111. The dip of the compass needle

a) Remains same at different places
b) Varies from place to place
c) <u>Is zero at equator and 90 degree at poles</u>
d) None of these

Que 112. The imaginary line passing through the intersection of cross hairs and the optical center of the objective is known as

a) Line of Sight
b) Line of collimation
c) Axis of the telescope
d) NOTA

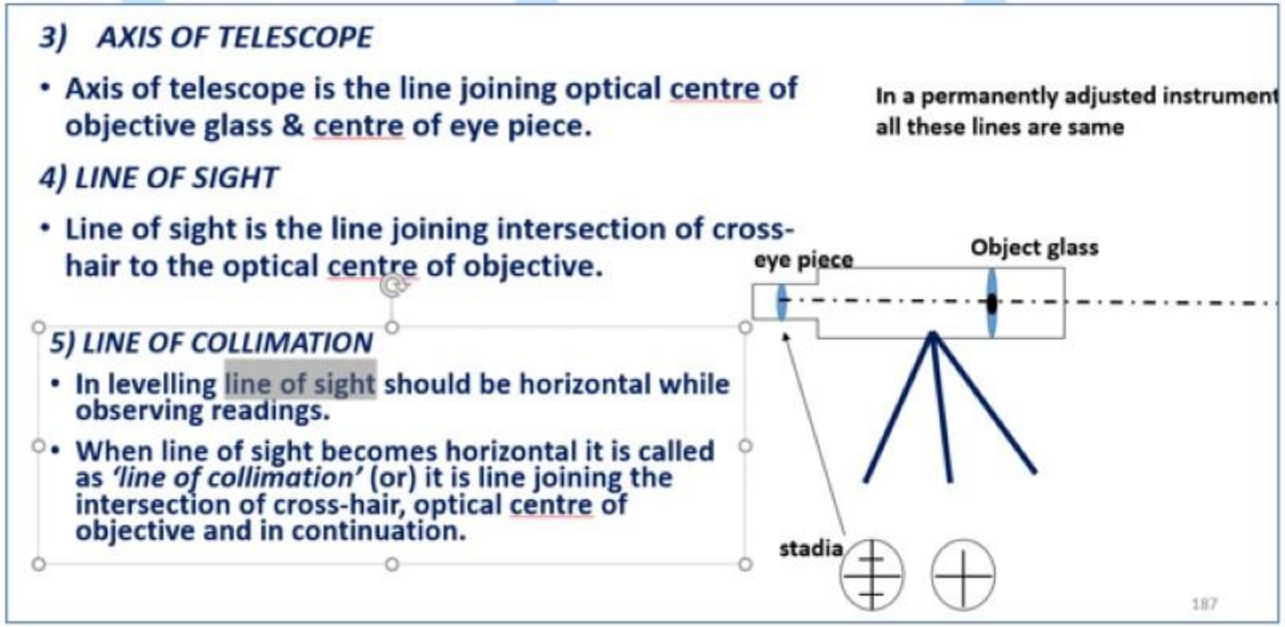
Que 112. The imaginary line passing through the intersection of cross hairs and the optical center of the objective is known as

a) Line of Sight

b) Line of collimation

c) Axis of the telescope

d) NOTA



Que 113. The difference between the fore bearing and back bearing of any station is called as…

a) External angle
b) Either external angle or internal angle
c) Internal angle
d) Right angle

Que 113. The difference between the fore bearing and back bearing of any station is called as…

a) External angle

b) Either external angle or internal angle (included angle)

c) Internal angle

d) Right angle

- Included angle: Angle measured in clockwise direction from previous line to next line
- $Included\ angle = FB\ of\ next\ line - BB\ of\ previous\ line$

Que 114. The value of whole circle bearing system vary from

a) $0° \; to \; 90°$

b) 0 ° to 180°

c) 0 to 270°

d) 0° to 360°

Que 114. The value of whole circle bearing system vary from

a) $0° \; to \; 90°$

b) 0 ° to 180°

c) 0 to 270°

d) <u>0° to 360°</u>

Que 115. Which of the following is correct for sensitivity of bubble tube?

a) Sensitivity decreases with increase in internal radius of tube
b) Sensitivity decreases with increases in diameter of tube
c) Sensitivity increases with decrease in length of the tube
d) Sensitivity increases with decrease in viscosity of fluid

Que 115. Which of the following is correct for sensitivity of bubble tube?

a) Sensitivity decreases with increase in internal radius of tube
b) Sensitivity decreases with increases in diameter of tube
c) Sensitivity increases with decrease in length of the tube
d) Sensitivity increases with decrease in viscosity of fluid

Note: **With increase in temperature, viscocity decreases but volume of fluid also increases for given tube size, hence dia of bubble decreases and we can say that with increase in temperature, sensitivity decreases and vice versa**

Que 116. The line normal to the plumb line is called

a) Horizontal line
b) Level line
c) Datum line
d) Vertical line

Que 116. The line normal to the plumb line is called

a) Horizontal line

b) Level line

c) Datum line

d) Vertical line

Que 117. Levelling deals with measurement in

a) Horizontal plane
b) Vertical plane
c) Both horizontal and vertical plane
d) Inclined plane

Que 117. Levelling deals with measurement in

a) Horizontal plane

b) Vertical plane

c) Both horizontal and vertical plane

d) Inclined plane

Que 118. The following sights are taken on a ‘turning point’.

a) Foresight only

b) Backsight only

c) Foresight and backsight

d) Foresight and intermediate sight

Que 118. The following sights are taken on a 'turning point'.

a) Foresight only

b) Backsight only

c) <u>Foresight and backsight</u>

d) Foresight and intermediate sight

Que 119. If the staff is not held vertical at a levelling station, the reduced level calculated from the observation would be

a) True R.L

b) More than true R.L

c) Less than true R.L

d) None of the above

Que 119. If the staff is not held vertical at a levelling station, the reduced level calculated from the observation would be

a) True R.L

b) More than true R.L

c) <u>Less than true R.L</u>

d) None of the above

RL of staff station= HI – IS or FS at that staff station

Que 120. The R.L. of the point A which is on the floor is 100m and backsight reading on A is 2.455m. If the foresight reading on the point B which is on the ceiling is 2.745m, then the R.L. of point B will be

a) 94.80m

b) 99.71m

c) 100.29m

d) 105.20m

Que 120. The R.L. of the point A which is on the floor is 100m and backsight reading on A is 2.455m. If the foresight reading on the point B which is on the ceiling is 2.745m, then the R.L. of point B will be

a) 94.80m

b) 99.71m

c) 100.29m

d) <u>105.20m</u>

Measurement of Area and Volume

One of the major objective of Surveying is to obtain relative quantities of area and volume.

Chapter 8: Measurement of Area

Measurement of Area:

- **If the shape of Area is enclosed by straight boundaries, it can be divided into simple geometrical shapes such as triangle, trapezoid, rectangle, etc.**
- **Area of these figures can be determined using appropriate formulae.**
- **Areas can also be calculated based on the measurements scaled from the plan or by use of Planimeter/Platometer**

Areas Computed by Sub Division into triangles

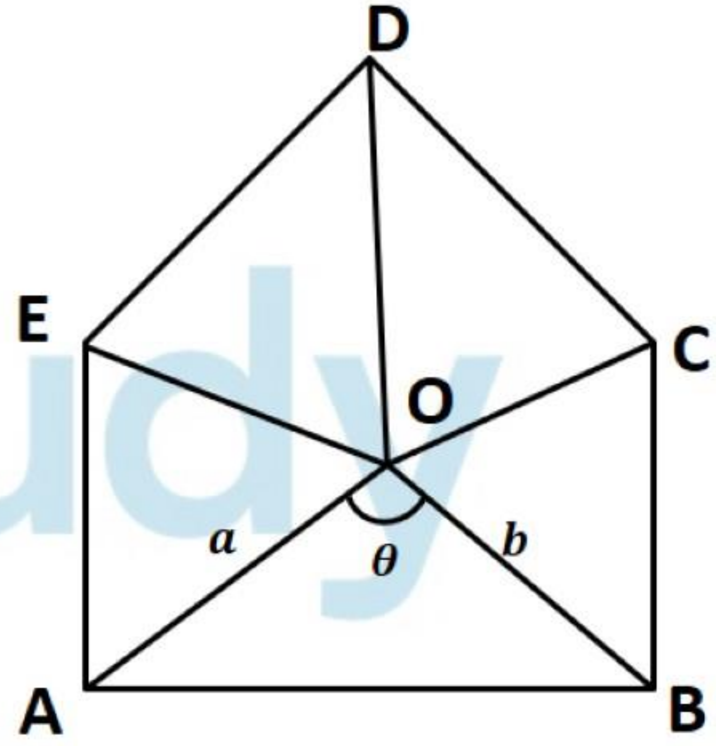
- **Area is divided into a number of triangles and area of each triangle is calculated**
- **If two sides and one included angle between them are given, area may be calculated as**

$$Area = \frac{1}{2} \times ab \sin\theta$$

- **When the lengths of the three sides of triangle are given,**

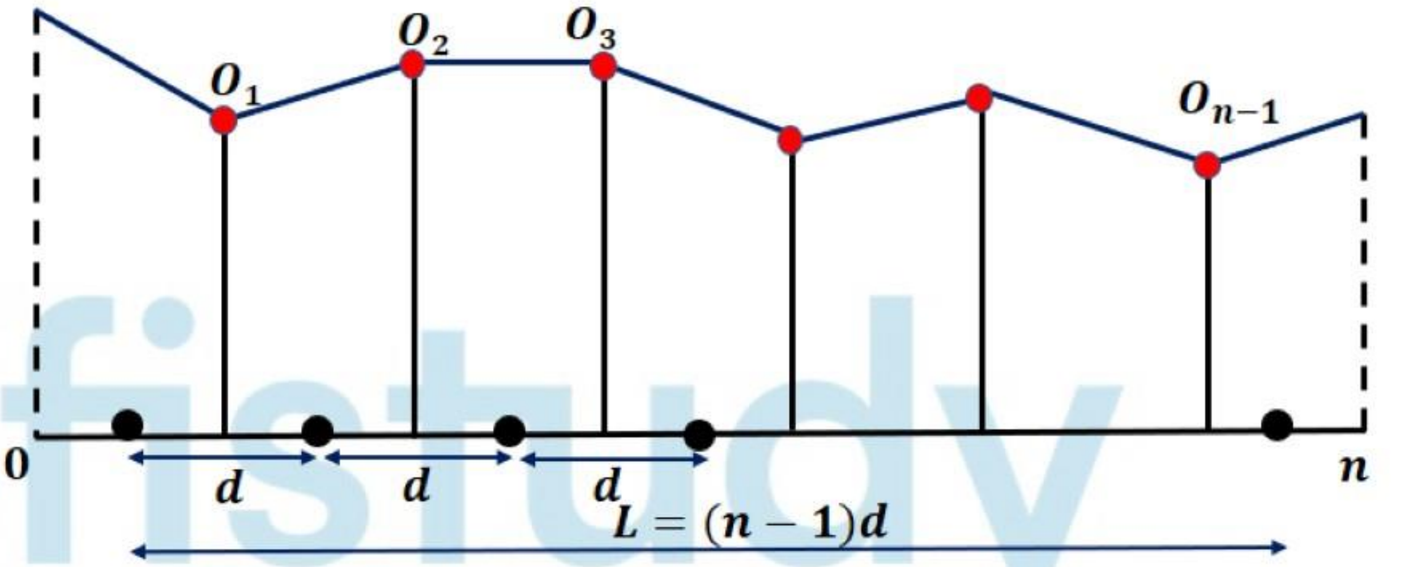
$$Area = \sqrt{s(s-a)(s-b)(s-c)}$$

s=semi perimeter



1. Mid ordinate rule

- This method is used with the assumption that boundaries between the extremities of the ordinates (or offsets) are straight lines.
- The base line is divided into a number of divisions and the ordinates are measured at the mid points of each divisions, so Area....



$$Area = Average\ ordinate \times Length\ of\ base$$

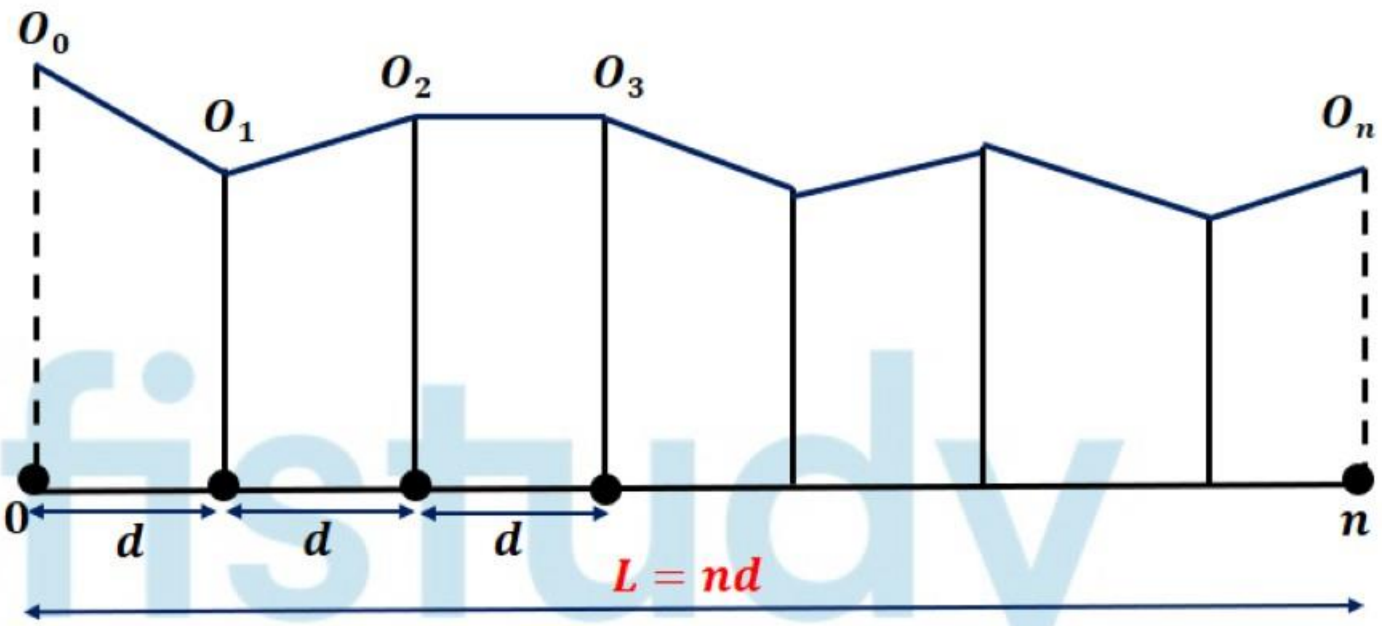
$$\Rightarrow Area = \frac{O_1 + O_2 + O_3 + \cdots + O_{n-1}}{n-1} \times L$$

$$\Rightarrow Area = \frac{O_1 + O_2 + O_3 + \cdots + O_{n-1}}{n-1} \times (n-1)d$$

$$\Rightarrow Area = (O_1 + O_2 + O_3 + \cdots + O_{n-1})d$$

2. Average Ordinate Rule

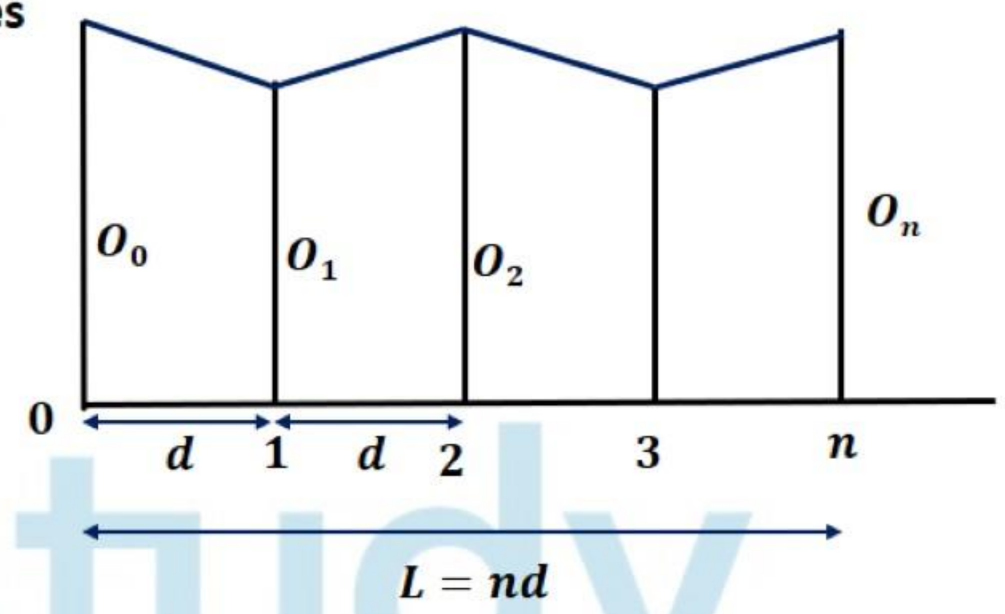
- This rule also assumes that the boundaries between the extremities of the ordinates are straight lines
- The offsets are measured to each of the points of the divisions of the base line



$$\Rightarrow Area = \frac{O_0 + O_1 + O_2 + O_3 + \cdots + On}{n+1} \times L$$

3. Trapezoidal Rule

- This rule is based on the assumption that the figures are trapezoids. The rule is more accurate than the previous two rules which are approximate versions of the trapezoidal rule
- Area of the first trapezoid



$$A_1 = \frac{O_0 + O_1}{2} d$$

$$Similarly\ A_2 = \frac{O_1 + O_2}{2} d\ and\ so\ on..$$

$$\Rightarrow A_n = \frac{O_{n-1} + O_n}{2} d$$

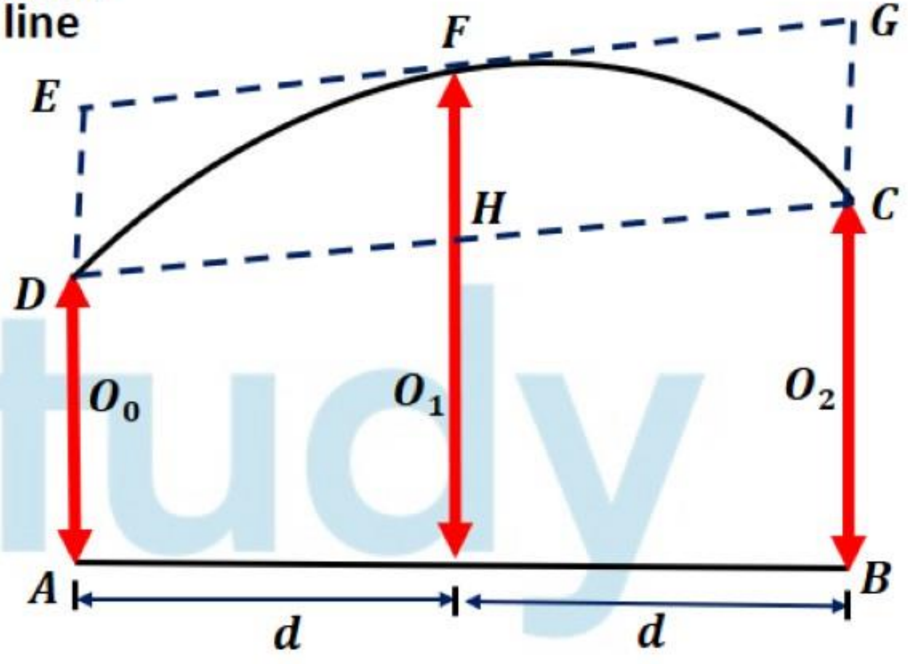
$$Total\ area\ A = A_1 + A_2 + A_3 + \cdots + A_n$$

$$= \frac{O_0 + O_1}{2} d + \frac{O_1 + O_2}{2} d + \cdots + \frac{O_{n-1} + O_n}{2} d$$

$$= \left[\frac{O_0 + On}{2} + O_1 + O_2 + O_3 + \cdots + O_{n-1}\right] d$$

4. Simpson's One Third Rule

- This rule assumes that short lengths of boundary between the ordinates are parabolic arcs. This method is more useful when the boundary line departs considerably from the straight line



- $Area\ of\ ABCD = \frac{O_0+O_2}{2} \times 2d \qquad \dots(1)$
- $Area\ of\ segment\ of\ parabola = \frac{2}{3}\ area\ of\ parallelogram\ enclosing\ it$

$$\Rightarrow Area\ DFC = \frac{2}{3}\ Area\ CDEG$$

$$= \frac{2}{3} \times FH \times AB$$

$$= \frac{2}{3} \times \left\{O_1 - \frac{O_0 + O_2}{2}\right\} \times 2d$$

So area of first two intervals= $\frac{O_0+O_2}{2} \times 2d + \frac{2}{3} \times \left\{O_1 - \frac{O_0+O_2}{2}\right\} \times 2$

$$= \frac{d}{3} \times \{O_0 + 4O_1 + O_2\}$$

Similarly for the next two intervals $= \frac{d}{3} \times \{O_2 + 4O_3 + O_4\}$ *and so on*

$$Total\ area = \frac{d}{3} \times \{(O_0 + On) + 4\underbrace{(O_1 + O_3 + \dots + O_{n-1})}_{\text{Even ordinates}} + 2\underbrace{(O_2 + O_4 + \dots + O_{n-2})}_{\text{odd ordinates}}\}$$

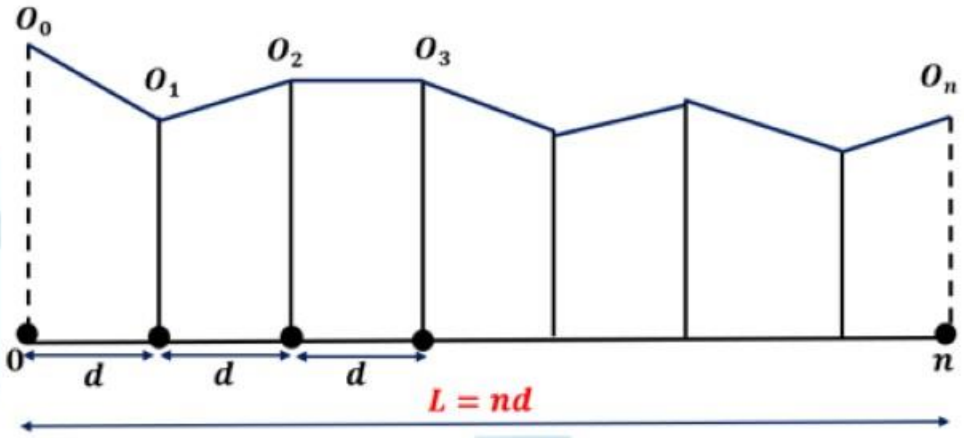
Note:

- **Simpson's one third rule is used when the number of Divisions are even i.e. offsets are odd**
- **If in question it is given to solve by Simpson's rule and number of offsets are even, then**
  Area=A1+A2
  - **A1= area by simpson's one third rule upto second last offset**
  - **A2=Area between last two offsets**

Question: 122 The following perpendicular offsets were taken at 10m interval from a survey line to an irregular boundary line.

3.25, 5.60,4.20,6.65,8.75,6.20,3.25,4.20,5.65

Calculate the area enclosed between the survey line, the irregular boundary line and the first and last offsets.



Solution:

1. By Average Ordinate Rule:

$$Area = \frac{O_0 + O_1 + O_2 + O_3 + \cdots + On}{n+1} \times L$$

$$\Rightarrow Area = \frac{3.25+5.60+4.20+6.65+8.75+6.20+3.25+4.20+5.65}{8+1} \times (10 \times 8)$$

$$\Rightarrow Area = 424.44\ m^2$$

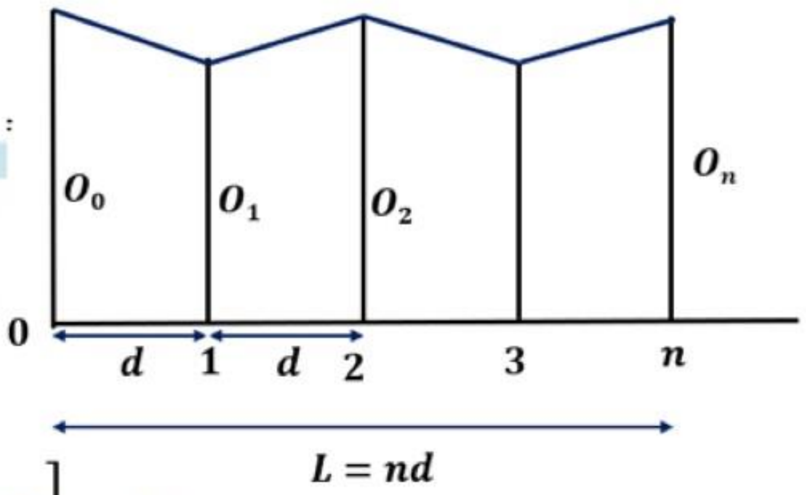
Question: 122 The following perpendicular offsets were taken at 10m interval from a survey line to an irregular boundary line.

3.25, 5.60,4.20,6.65,8.75,6.20,3.25,4.20,5.65

Calculate the area enclosed between the survey line, the irregular boundary line and the first and last offsets.

Solution:

2. By Trapezoidal Rule:



$$Area = \left[\frac{O_0 + On}{2} + O_1 + O_2 + O_3 + \cdots + O_{n-1}\right] d$$

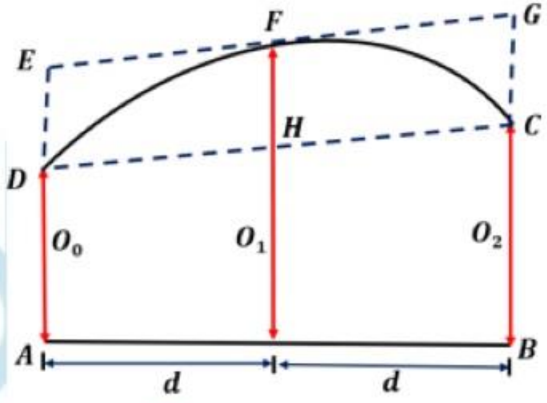
$$\Rightarrow Area = \left[\frac{3.25 + 5.65}{2} + 5.60+4.20+6.65+8.75+6.20+3.25+4.20\right] \times 10$$

$$\Rightarrow \boldsymbol{Area = 433m^2}$$

Question: 122 The following perpendicular offsets were taken at 10m interval from a survey line to an irregular boundary line.

3.25, 5.60,4.20,6.65,8.75,6.20,3.25,4.20,5.65

Calculate the area enclosed between the survey line, the irregular boundary line and the first and last offsets.



Solution:

3. By Simpson's Rule:

$$\boldsymbol{Total\ area} = \frac{\boldsymbol{d}}{\boldsymbol{3}} \times \{(\boldsymbol{O_0} + \boldsymbol{O_n}) + \boldsymbol{4}(\boldsymbol{O_1} + \boldsymbol{O_3} + \cdots + \boldsymbol{O_{n-1}}) + \boldsymbol{2}(\boldsymbol{O_2} + \boldsymbol{O_4} + \cdots + \boldsymbol{O_{n-2}})\}$$

$$\Rightarrow Area = \frac{\mathbf{10}}{\mathbf{3}} \times \left[\frac{3.25 + 5.65}{2} + 4(5.60 + 6.65 + 6.20 + 4.20) + 2(4.20 + 8.75 + 3.25)\right]$$

$$\Rightarrow \boldsymbol{Area} = \mathbf{439.67}\boldsymbol{m^2}$$

Chapter 8: Measurement of Volume

- **Calculation of Volume of various quantities are done for various purposes**
  - **Planning**
  - **Design**

1. **Trapezoidal Formula or Average End Area Rule**
   - $V = d\left[\frac{A_1+A_n}{2} + A_2 + A_3 + \cdots + A_{n-1}\right]$
2. **Prismoidal Rule**
   - $V = \frac{d}{3}\{(A_1 + A_n) + 4(A_2 + A_4 + A_6 + \cdots) + 2(A_3 + A_5 + A_7 \ldots)\}$

Question 123: The cross section area of 3 sections of an embankment at an interval of 40m are 10 m^2, 15 m^2, and 35 m^2. Calculate the quantity of Earth work for the embankment using prismoidal method.

Solution:

$$V = \frac{d}{3}\{(A_1 + A_n) + 4(A_2 + A_4 + A_6 + \cdots) + 2(A_3 + A_5 + A_7 \dots)\}$$

$$\Rightarrow V = \frac{40}{3}\{(10 + 35) + 4(15) + 2(0)\}$$

$$\Rightarrow V = 1400m^3$$

Que. 121 In tacheometrical observations, vertical staff holding is generally preferred to normal staffing due to

a) Ease of reduction of observations

b) Facility of holding

c) Minimum effect of careless holding on the result

d) None of these

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Que. 121 In tacheometrical observations, vertical staff holding is generally preferred to normal staffing due to

a) **Ease of reduction of observations**

b) **Facility of holding**

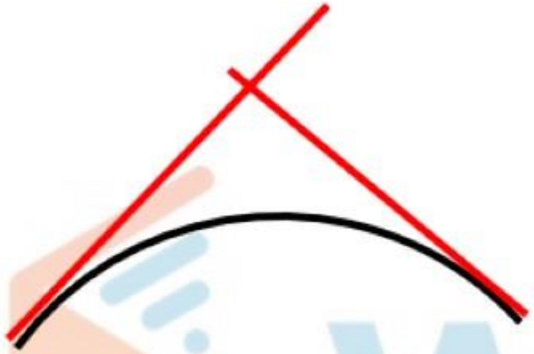
c) **Minimum effect of careless holding on the result**

d) **None of these**

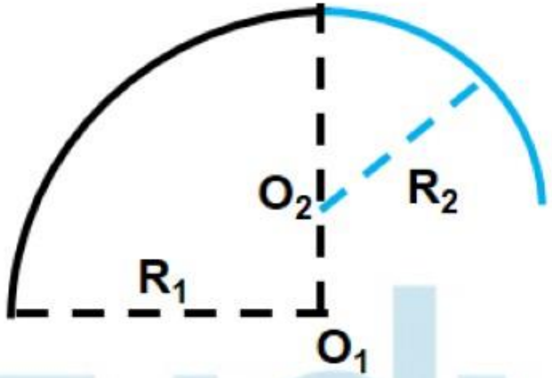
Chapter 9: Curves

- Curve are defined as Arc with some finite radius, provided between intersecting straight lines to gradually negotiate change in direction
- This change in direction of straight line may be in a horizontal plane (or) Vertical plane, resulting in the provision of a horizontal (or) vertical curve respectively.

Horizontal Curves



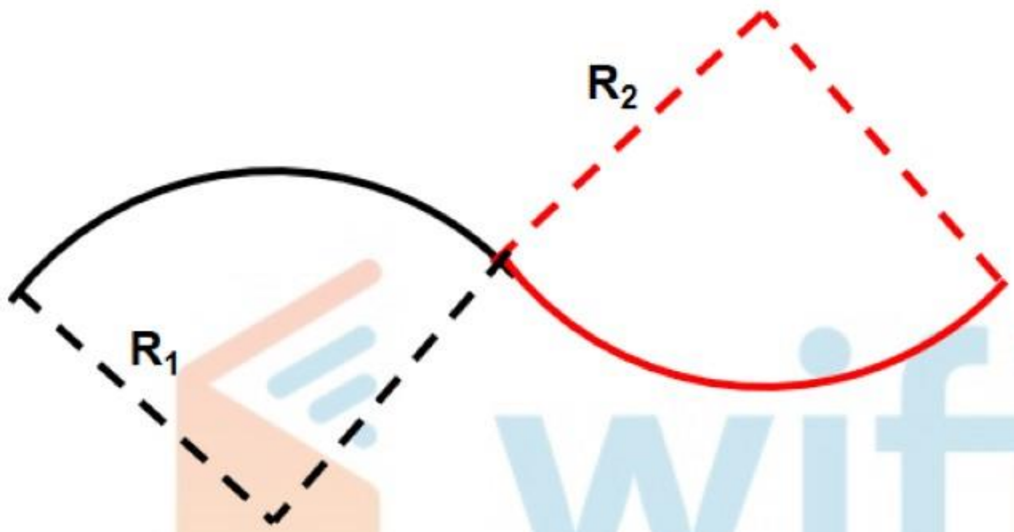
1. Simple Circular Curve



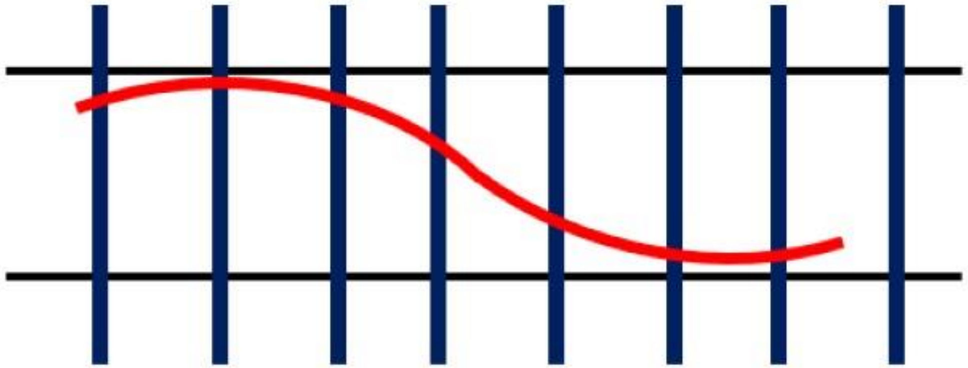
2. Compound Curve

- A simple circular curve consist of an Arc of a circle which is tangential to the straight line at both the ends.
- A compound curve consist of two circular arcs of different radius with their centre of curvature on the same side.

3. Reverse Curve / S- Curve / Serpentine Curve

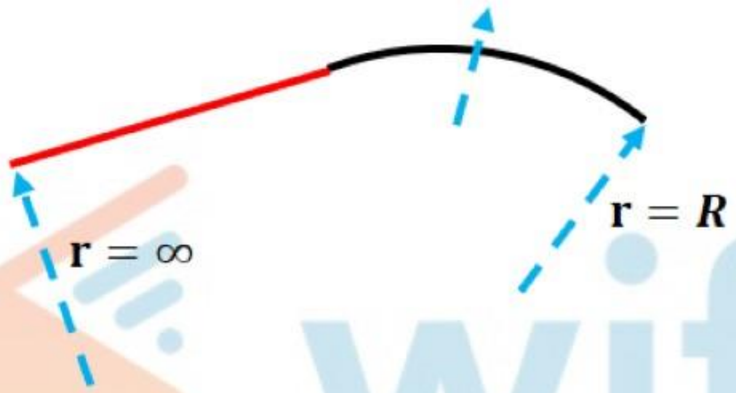


3. Reverse Curve / S- Curve / Serpentine Curve

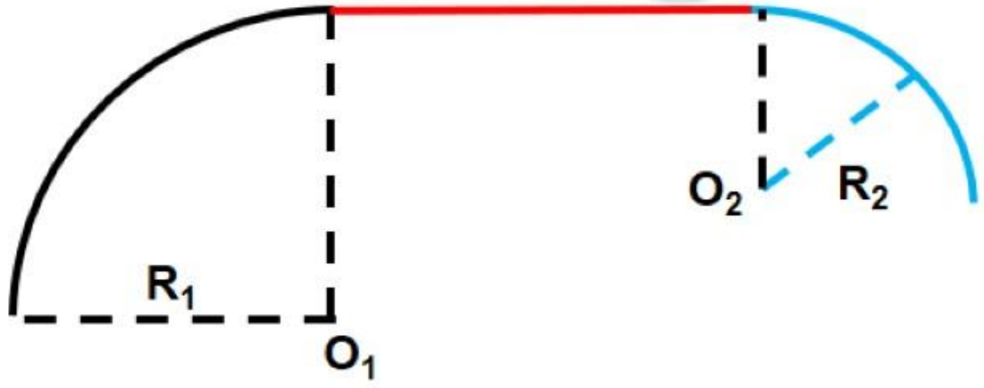


- When two simple circular curves of equal (or) different radius having opposite direction of curvature join together, the resultant curve is called as "Reverse curve"
- Reverse curves are provided between two parallel Lines (or) when angle between them is very small.
- They are commonly used in railway yard but unsuitable for Highways.

4. Transition curve / Easement curve

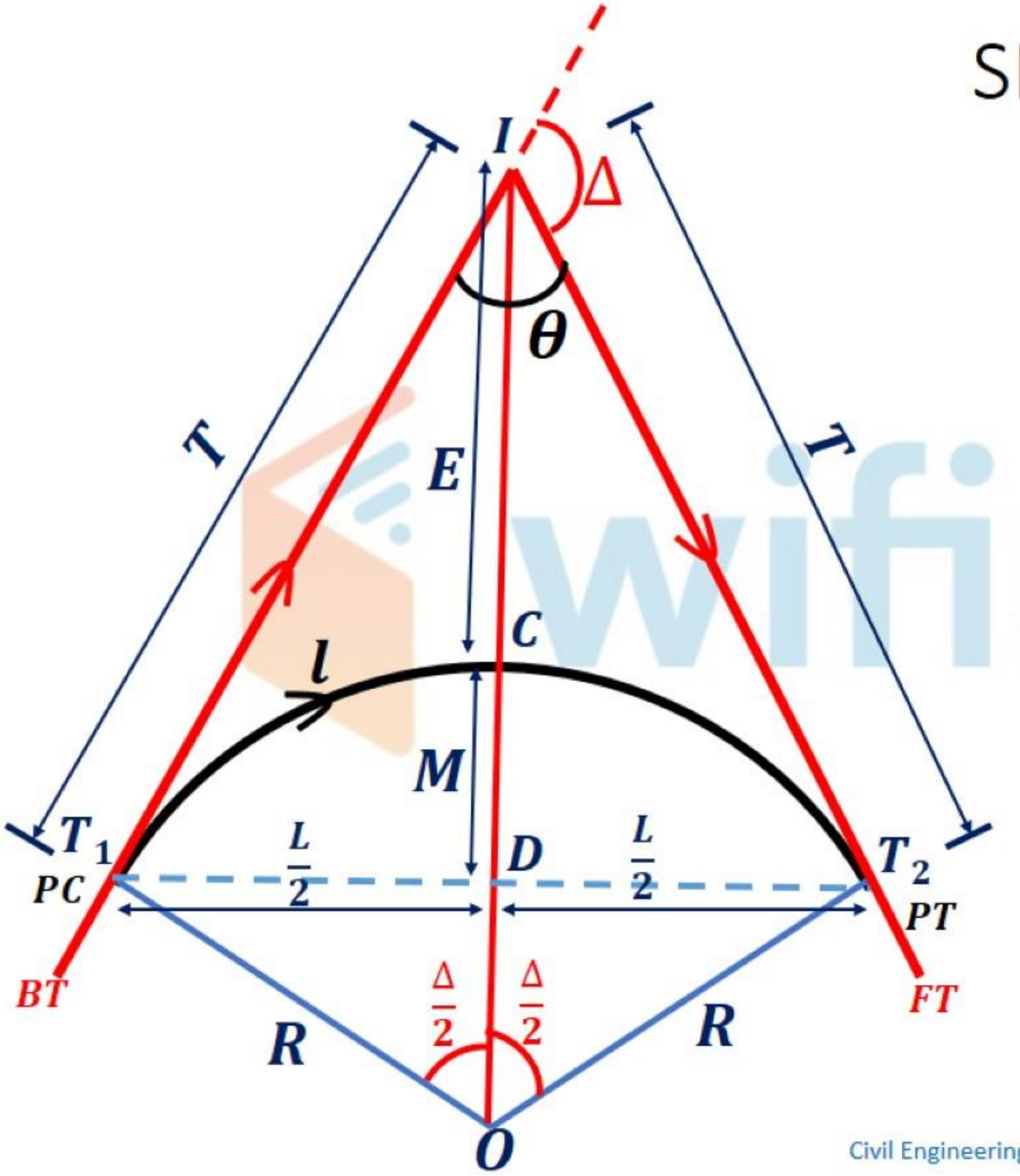


- Transition curve is usually introduced between a simple circular curve and a straight line, vice versa
- Radius of Transition curve gradually varies from finite to infinite value and vice-versa.



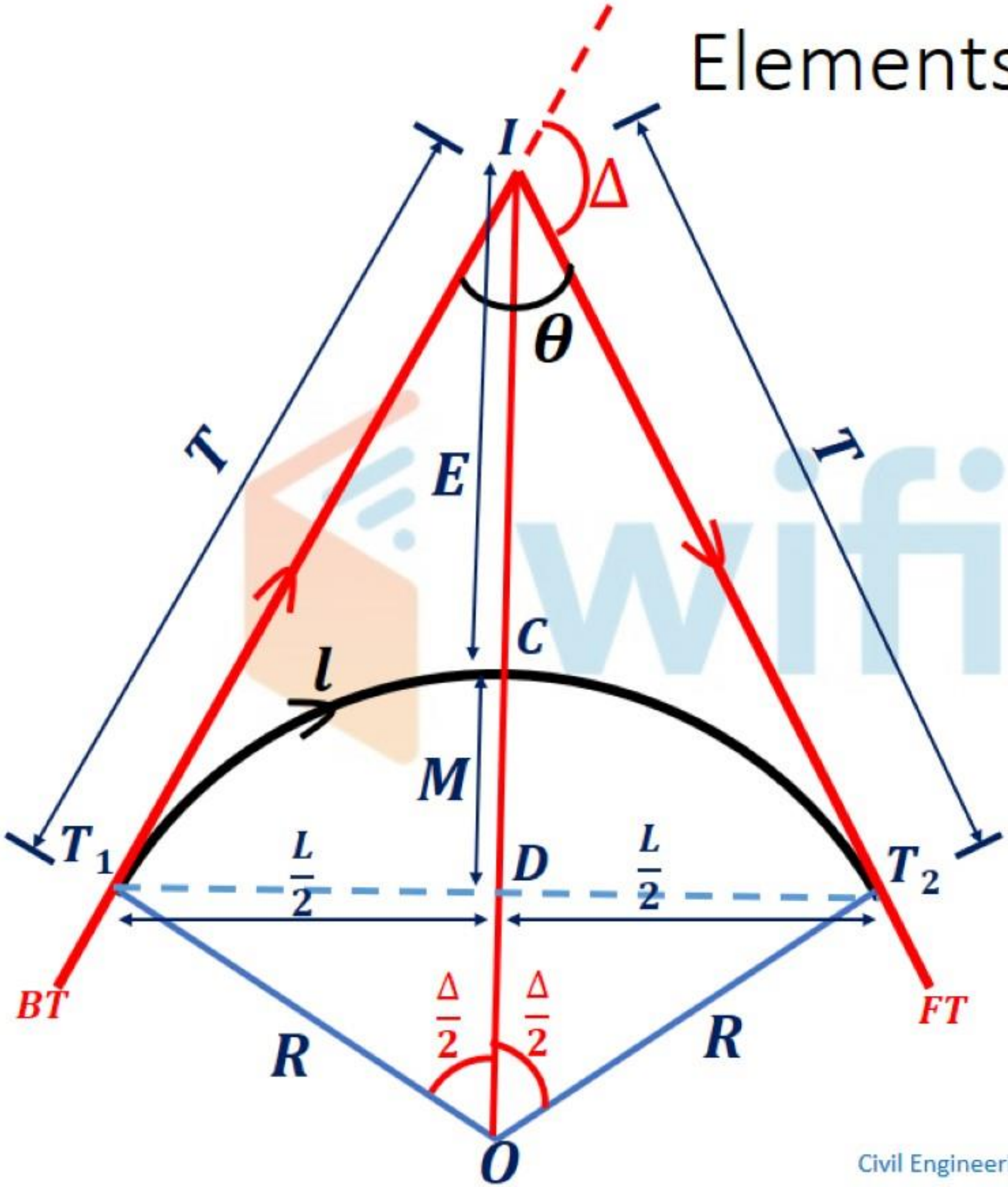
Note:

→ We have to provide a transition curve between two branches of compound Curve and reverse curve



SIMPLE CIRCULAR CURVE

- $BT = Back\ Tangent$
- $FT = Forward\ Tangent$
- $PC\ Point\ of\ curve$ $(beginning\ of\ curve\ from\ where\ alignment\ changes\ from\ tangent\ to\ curve)$
- $\Delta = deflection\ angle$
- $I = point\ of\ intersection$
- $\angle T_1OT_2 = central\ angle = \Delta$
- $T = length\ of\ tangent$
- $L = T_1T_2 = long\ chord$
- $CD = mid\ ordinate = M$
- $E = apex\ distance\ or\ external\ distance$
- $l = length\ of\ curve$



Elements of Simple Circular Curve

1. Length of curve (l):
   - $l = \frac{\pi R \Delta}{180°}$ (in radians)
2. Tangent Length (T)
   - $T = T_1 I = T_2 I = R \tan\frac{\Delta}{2}$
3. Length of long chord (L) :
   - $L = T_1 T_2 = 2\, R.\,sin\left(\frac{\Delta}{2}\right)$
4. Mid ordinate (M):
   - $M = R\left(1 - \cos\frac{\Delta}{2}\right)$
5. External distance (E):
   - $E = R\left(sec\frac{\Delta}{2} - 1\right)$
   - $cos\frac{\Delta}{2} = \frac{R}{E+R}$
6. Chainages of T_1 and T_2
   - $Ch\ of\ T_1 = \ ch\ at\ I - length\ T$
   - $Ch\ of\ T_2 = \ ch\ at\ T_1 + length\ l$

Note:

Relationship between Degrees and Radians

$180° = \pi\ radians$ $\quad 1\ radian = \frac{180°}{\pi}$ $\quad 1° = \frac{\pi}{180}\ radians$

To convert degrees to radians, multiply by $\frac{\pi}{180}$.

To convert radians to degrees, multiply by $\frac{180}{\pi}$.

Designation of Curve

- A curve can be designated by radius R (or) Degree of curve (D).
- Degree of curve is the angle subtended by an Arc (or) a chord of specified length at the centre.

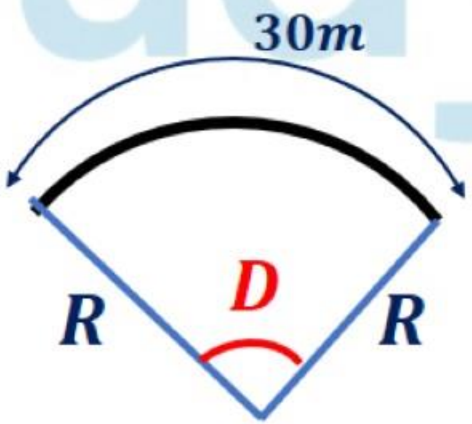
1. <u>Arc Definition</u>:
    - Case 1: Let arc length is 30m and radius of curve is R, the n degree of curve is D

$$\frac{\pi R D}{180^\circ} = 30m$$

$$=> D = \frac{30 \times 180}{\pi R}$$

$$=> D = \frac{1718.87}{R}$$

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



Designation of Curve

1. Arc Definition:

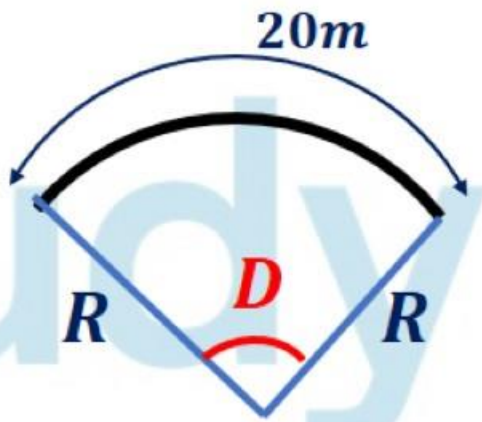
- Case 2: Let arc length is 20 m and radius of curve is R, the n degree of curve is D

$$\frac{\pi R D}{180^\circ} = 20m$$

$$=> D = \frac{20 \times 180}{\pi R}$$

$$=> D = \frac{1145.91}{R}$$

$$\therefore D = \frac{1146}{R}$$ **Remember**



- For 30m $D = \frac{1719}{R}$
- For 20m $D = \frac{1146}{R}$

Designation of Curve

2. Chord Definition:

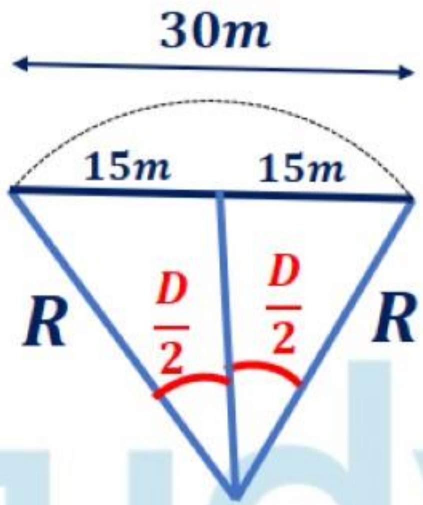
- Case I: for 30m chord

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

Since, $\frac{D}{2}$ will be a small angle, therefore $\sin\theta \rightarrow \theta$

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

$$=>D=\frac{15\times2\times180^\circ}{\pi R}=\frac{1719}{R}$$



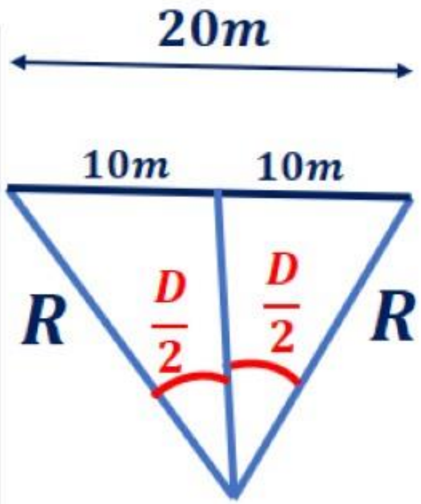
- Case II: for 20m chord

$$\sin\frac{D}{2}=\frac{10}{R}$$

Since, $\frac{D}{2}$ will be a small angle, therefore $\sin\theta \rightarrow \theta$

$$=>\frac{D}{2}\times\frac{\pi}{180^\circ}=\frac{10}{R}$$

$$=>D=\frac{10\times2\times180^\circ}{\pi R}=\frac{1146}{R}$$



- For 30m $\quad D=\frac{1719}{R}$
- For 20m $\quad D=\frac{1146}{R}$

Note:

- Since Degree of curve is inversely proportional to Radius, for sharp circles Degree of curve will be large, whereas for flat curve, Degree of curve will be small.

Que 124: if Radius of curve is 1000 m, Δ = 60°, chainage of P.I = 2000m

Determine

i) length of curve

ii) Tangent Length

iii) Long chord

iv) mid ordinate (M)

v) Apex distance

vi) Chainages of T_1, T_2

vii) Degree of curve for 30 m Arc

i) $l = \frac{\pi R \Delta}{180^\circ} = \frac{\pi\,(1000)\times 60}{180} = 1047.19\ m$

ii) $T = R\tan\left(\frac{\Delta}{2}\right) = 1000\tan(30^\circ) = 577.35m$

iii) $L = 2\,R\sin\left(\frac{\Delta}{2}\right) = 2\times 1000\sin 30^\circ = 1000m$

iv) $M = R\left(1-\cos\frac{\Delta}{2}\right) = 1000\,(1-\cos 30^\circ) = 133.97\ m$

v) $E = R\,\left(Sec\frac{\Delta}{2}-1\right) = 1000\,(sec\,30^\circ - 1) = 154\ 70m$

vi) ch of $T_1 = 2000 - 577.35 = 1422.65\ m$

ch of $T_2 = 1422.65 + 1047.19 = 2469.84\ m$

vii) $D = \frac{1719}{1000} = 1.719$

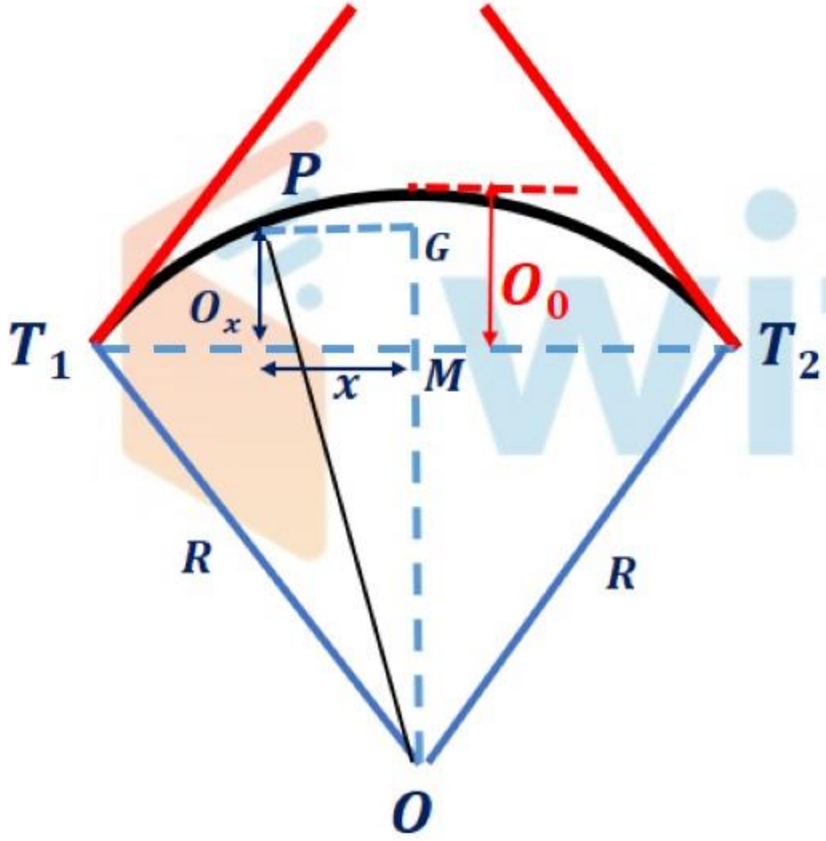
Setting out of Simple Circular Curve

- Setting out of a curve is a process of locating various points along the length of the curve at equal and convenient distances.
- Distance between two successive points is called as "peg interval" Generally peg interval is 20 m (or) 30 m, but for sharp curves it may be further reduced.

Linear Methods (Only chain (or) Tape)	Angular Methods (Theodolite with (or) without chain (or) Tape)
1. Perpendicular offset from long chord	1. Deflection angle method
2. Perpendicular offset from Tangent 3. Radial offset from Tangent	2. Two theodolite method
4. Successive bisection of Arc offset from chord produced	3. Tacheometric distance method.

Linear methods

1. Perpendicular offset from long chord



$$O_x = OG - OM$$

$$\Rightarrow OM = R - O_0$$

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

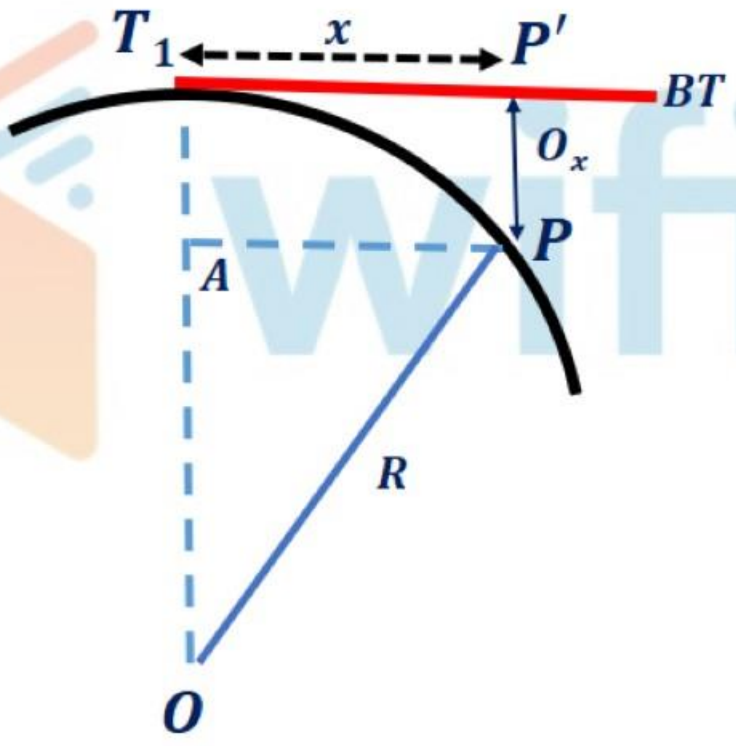
$$\Rightarrow Ox = \sqrt{R^2 - x^2} - (R - O_0)$$

$$\Rightarrow Ox = O_0 - \mathrm{R}\left[\left[1 - \frac{x^2}{R^2}\right]^{1/2} - 1\right]$$

$$\Rightarrow Ox = O_0 - \frac{x^2}{2R}$$

Linear methods

2. Perpendicular offset from Tangent



$$O_x = OT_1 - OA$$

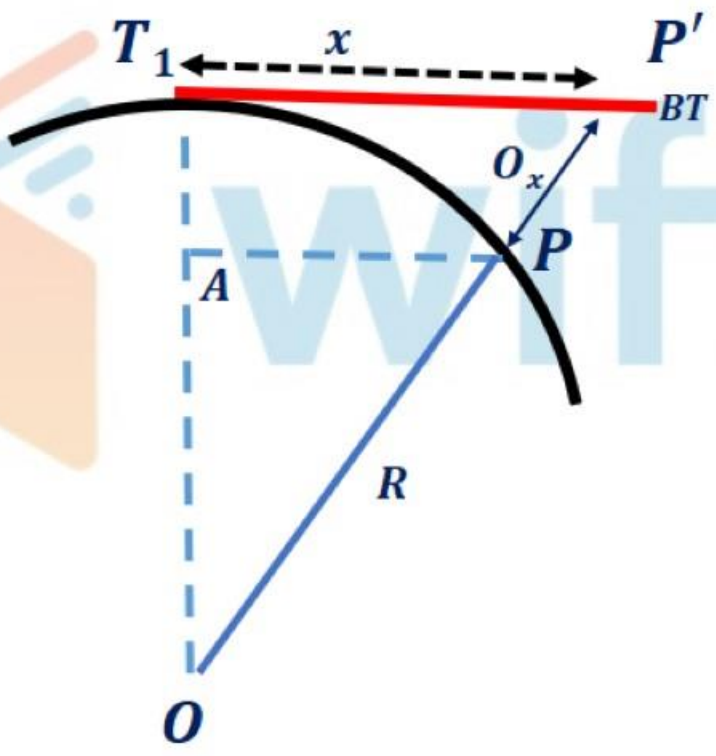
$$\Rightarrow Ox = R - \sqrt{R^2 - x^2}$$

$$\Rightarrow Ox = \mathrm{R}\left[\left[1 - \frac{x^2}{R^2}\right]^{1/2} - 1\right]$$

$$\Rightarrow Ox = \frac{x^2}{2R}$$

Linear methods

3. Radial Offset from Tangent



In this method, centre of curve should be known

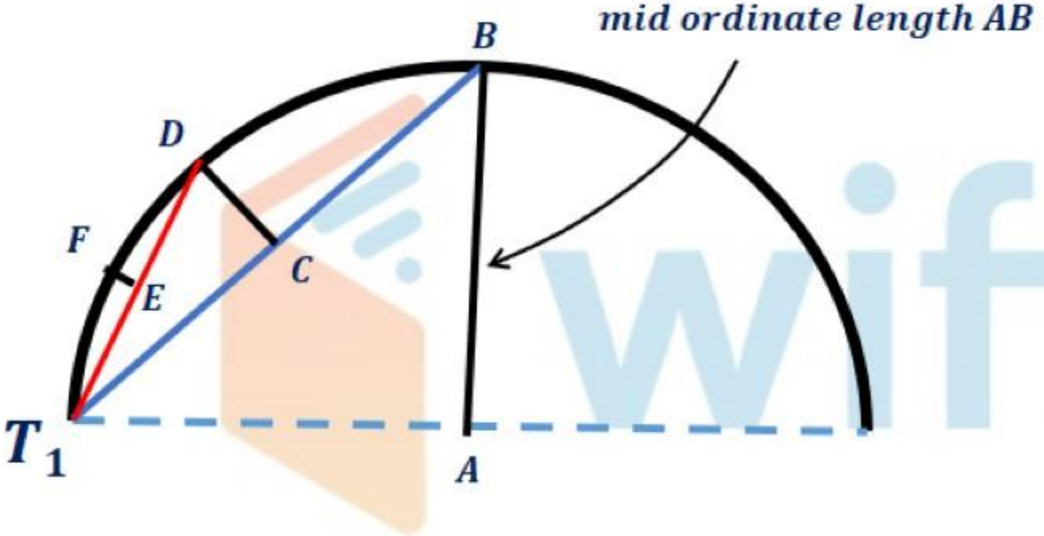
$$O_x = OP' - OP$$

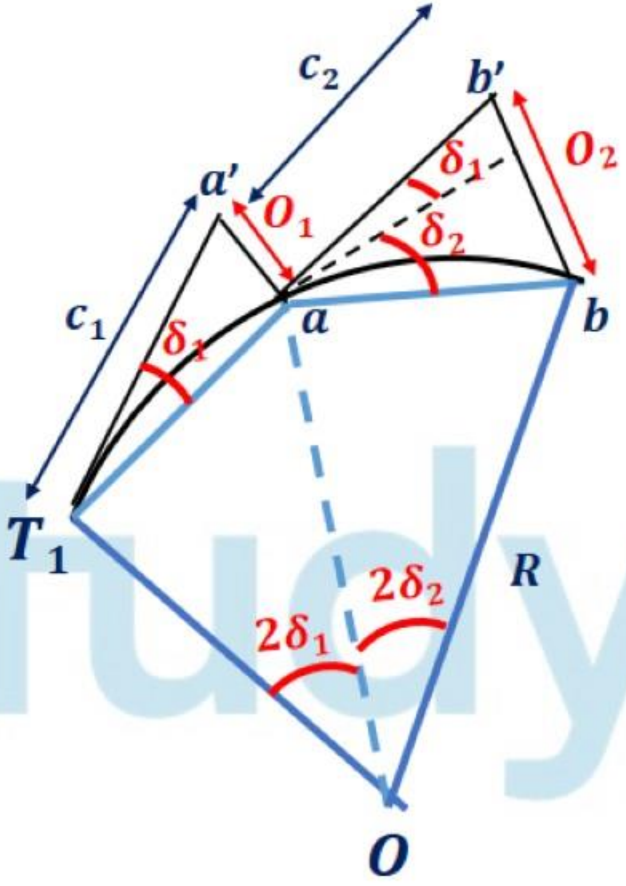
$$\Rightarrow Ox = \sqrt{R^2 + x^2} - \mathrm{R}$$

$$\Rightarrow Ox = \frac{x^2}{2R}$$

Linear methods

4. Successive Bisection of arc





It is the best method when theodolite is not availbale

$$O_1 = c_1\delta_1$$
$$\Rightarrow 2\delta_1 R = c_1$$
$$\Rightarrow \delta_1 = \frac{c_1}{2R}$$

$$O_2 = c_2(\delta_1 + \delta_2)$$
$$\delta_2 = \frac{c_2}{2R}$$
$$O_2 = c_2\left(\frac{c_1}{2R} + \frac{c_2}{2R}\right)$$
$$\Rightarrow O_2 = \frac{c_2}{2R}(c_1 + c_2)$$

$$\Rightarrow On = \frac{c_n}{2R}(c_{n-1} + c_n)$$

Angular Methods

- Angular methods are preferred over linear methods as they are more accurate and less time consuming.

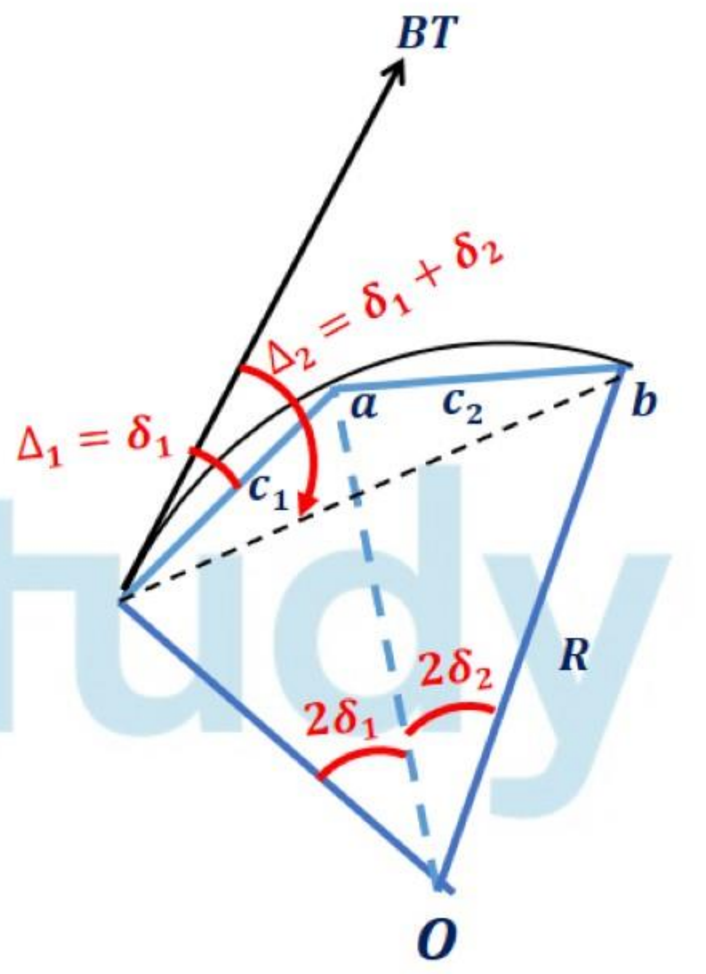
Angular Methods

1. <u>Deflection Angle method / Tangential angle method / One theodolite method / Rankine method</u> :-

$$\delta_1 = \frac{c_1}{2R} \times \frac{180^\circ}{\pi}$$

$$\delta_2 = \frac{c_2}{2R} \times \frac{180^\circ}{\pi}$$

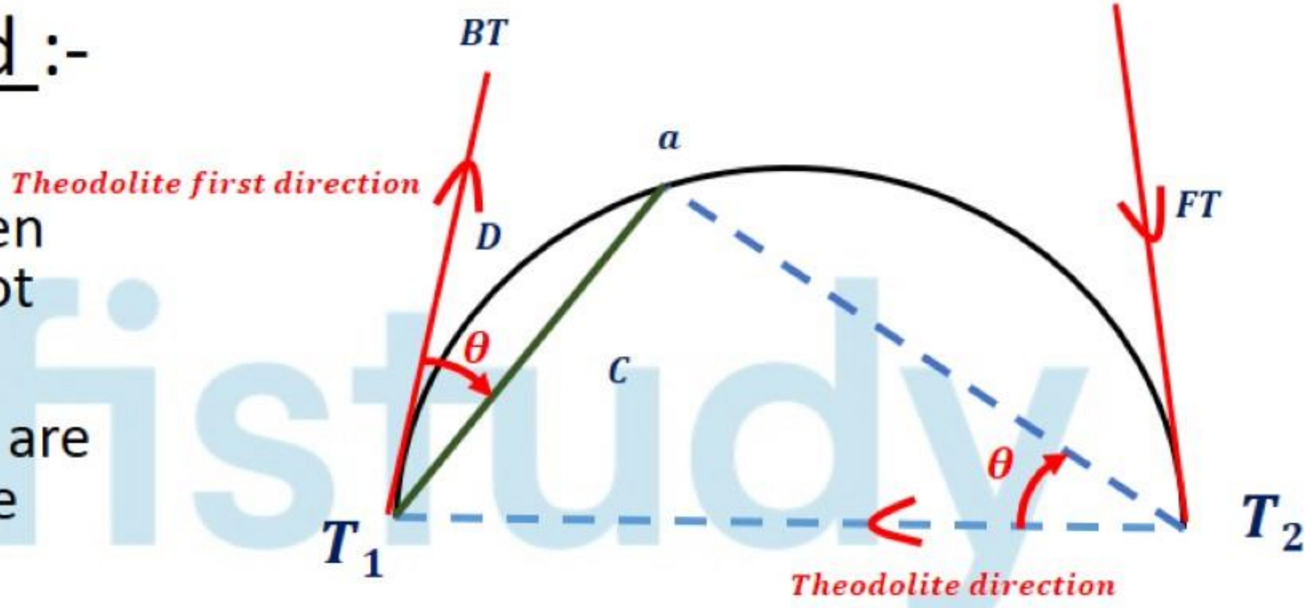
$$\delta_1 = \frac{1719 c_1}{R}$$



Angular Methods

2. Two theodolite method :-

- → This method is most useful when ground is undulating rough and not suitable for linear measurement.
- → In this method two theodolites are used and linear measurements are completely eliminated.
- It is based on "Principle that angle between Tangent and the chord is equal to the angle Subtended by the chord in the opposite segment"

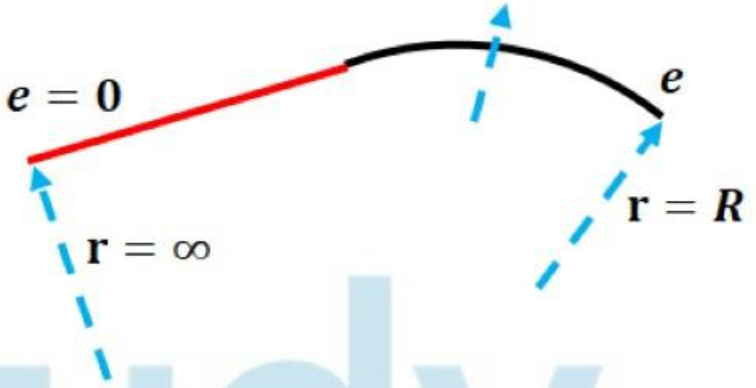


Transition Curves

- Transition curve is a curve of varying radius introduced between a straight line and a circular curve.
- Transition curve provides a gradual change from straight line to the circular curve and from circular curve to the straight line also

Transition Curves

- <u>**Basic criteria for design of Transition Curve:**</u>
  1. **It should be tangential to the straight line and also meet the circular curve tangentially at the junction**
  2. **Its Curvature should be zero $(r = \infty)$ at one end and its curvature should be equal to $\frac{1}{R}$ where it meets the circular curve**
     - $R \rightarrow$ **Radius of circular curve**
  3. **Rate of increase of curvature along the Transition curve should be equal to Rate of increase of Super Elevation.**



Super Elevation:

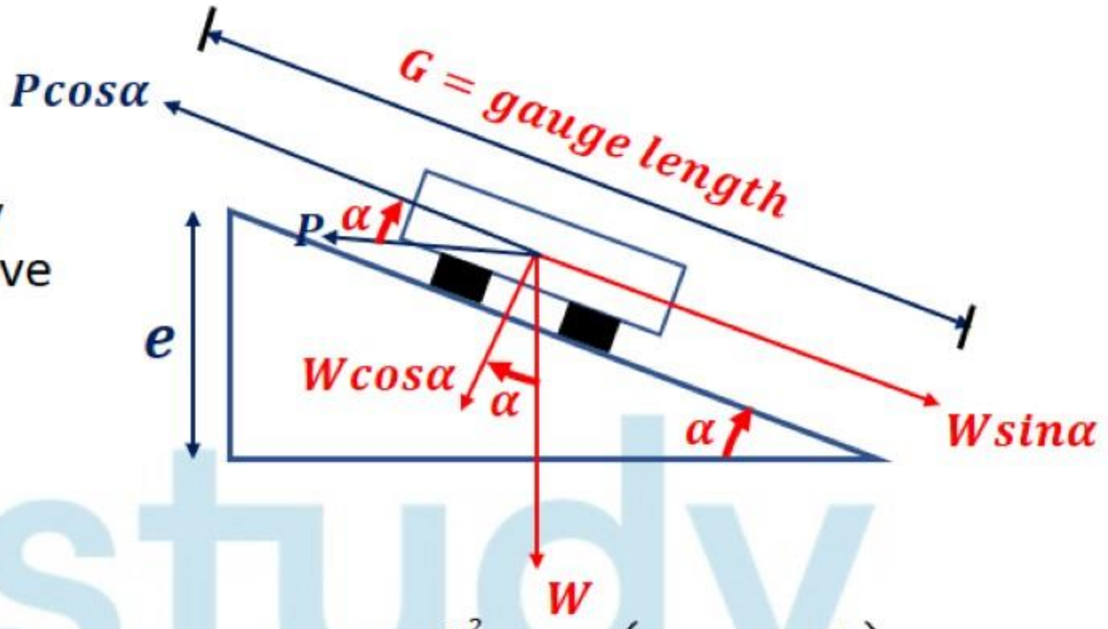
- <u>Super Elevation:</u>
  - Super elevation is the vertical distance by which outer end of the road is raised above the inner one
  - For equilibrium condition:

$$\Rightarrow P\ cos\ \alpha = W\ sin\alpha$$

$$\Rightarrow \tan\alpha = \frac{P}{W} = \frac{mV^2}{mgr} = \frac{V^2}{gr}$$

$$[P = \frac{mv^2}{r}, W = mg]$$

- Since, α will be very small angle therefore, tan α tends to sinα $(i.e, \tan\alpha \rightarrow \sin\alpha\ \ and\ sin\alpha = \frac{V^2}{gr})$



$$i.e,.\ sin\ \alpha = \frac{v^2}{gr} \quad \left(sin\alpha = \frac{e}{G}\right)$$

$$\frac{e}{G} = \frac{V^2}{gr} \quad (e > 7\%\ given\ by\ IRC)$$

$$e = \frac{Gv^2}{gr}$$

The value of super elevation (e) cannot be as high as possible because high super elevation can cause Toppling of vehicle in presence of cross winds. In such case, either large radius is provided or velocity is reduced

- Maximum Centrifugal ratio: $\Rightarrow \frac{P}{W} = \frac{V^2}{gR}$
- To avoid inconvenience to the passengers, the maximum value of centrifugal ratio is generally specified as
  - For highway $\frac{V^2}{gR} = \frac{1}{4} \Rightarrow V = \sqrt{\frac{gr}{4}}$
  - For Railways $\frac{V^2}{gR} = \frac{1}{8} \Rightarrow V = \sqrt{\frac{gr}{8}}$

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Ideal Transition Curve Equation

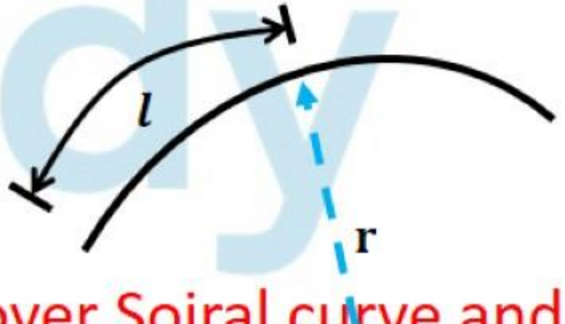
- A curve of variable radius of required length is inserted between straight road and a circular curve such that centrifugal force increases uniformly and gradually along the length of Transition Curve, so that lateral shock and discomfort is minimized

$$P \propto l \quad \text{i.e.}$$

$$P = \frac{mv^2}{r} \text{ and for constant mass and velocity,}$$

$$l \propto \frac{1}{r} \quad or$$

$$lr = constant$$



This equation is called as Euler Spiral, Clothoid Curve, Glover Soiral curve and Ideal Transition Curve

- At the end of transition curve, $l = L \; and \; r = R$
- Therefore at the end of the transition curve $LR = constant$

Length of Transition Curve

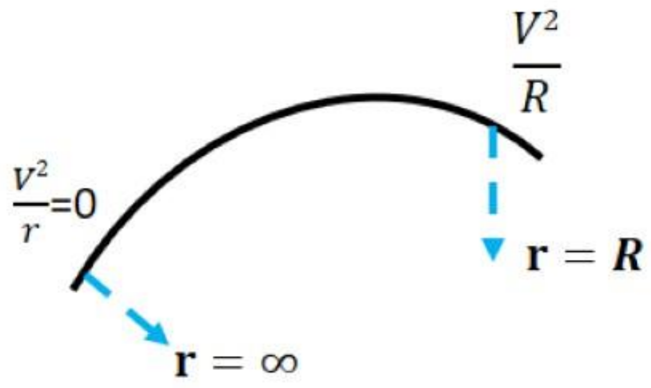
1. Arbitrary value from past experience
2. Such that super elevation is applied at $\frac{1}{n}$ *and* e is the total super elevation to be provided the end of the curve

$$L = \frac{e}{\frac{1}{n}}$$

3. Such that rate of change of radial acceleration is within the desired limit

$$\propto = \frac{\frac{V^2}{R}}{t} \Rightarrow \qquad \propto = \frac{\frac{V^2}{R}}{\frac{L}{V}}$$

$$\Rightarrow \boldsymbol{L = \frac{V^3}{\propto R}}$$



Que: A transition curve is required for a radius of 30m, gauge length is 1m and maximum super elevation is restricted to 100mm. Permissible value of rate of change of radial acceleration = 30cm/sec^2. Determine length of required transition curve.

Solution:

$$L = \frac{V^3}{\propto R}$$

And we know that $e = \frac{Gv^2}{gr}$

$$\Rightarrow 0.1 = \frac{1 \times V^2}{9.81 \times 300} \Rightarrow V = 17.155\ m/sec$$

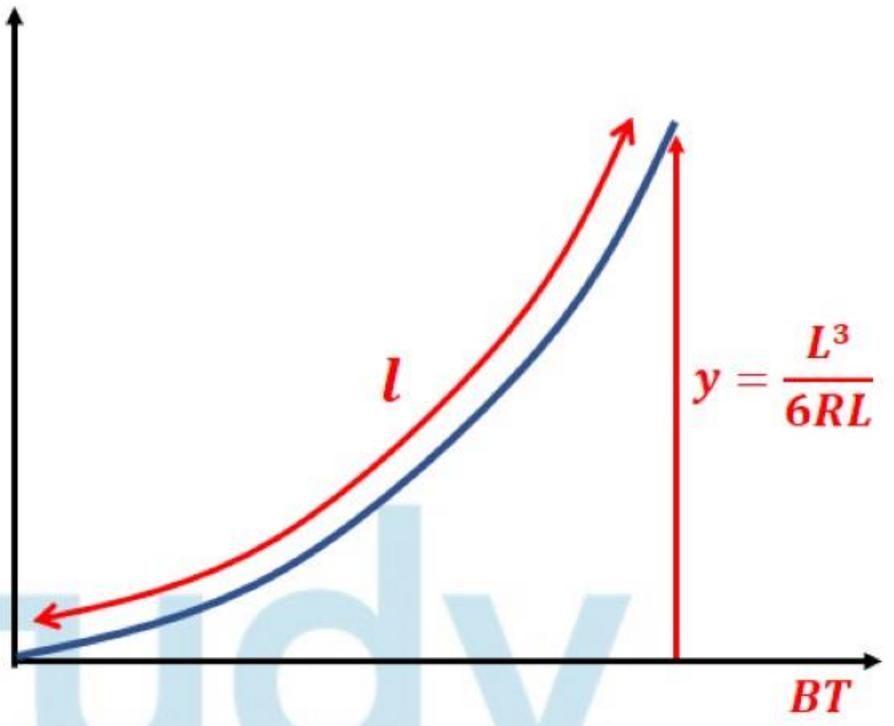
$$L = \frac{V^3}{\propto R}$$

$$\Rightarrow L = \frac{(17.155)^3}{0.3 \times 300} = 56.09m$$

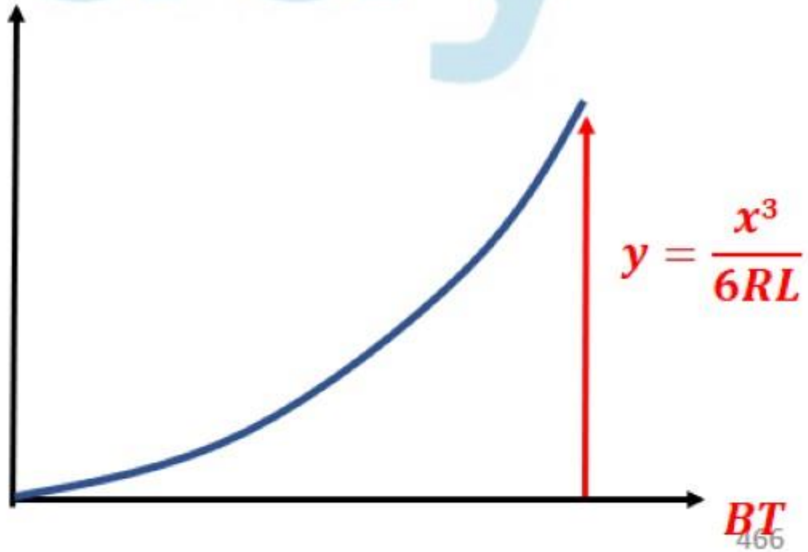
Cubic Spiral Curve

- Ideal transition curve is a cubic Spiral Curve

$$y = \frac{L^3}{6RL}$$



Cubic Parabola



- Also known as “Froude Transition Curve”
- Cubic parabola more resembles Ideal transition curve in comparison to cubic parabola
- Setting out cubic parabola is easy than cubic spiral, so cubic parabola is commonly used
- But after invention of electronic equipment like total station, nowadays any curve can be set out so cubic parabola is obsolete.

Vertical Curve

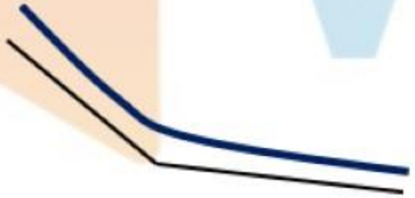
- A vertical curve is used to connect two different gradients of Highway and Railway.
- Vertical curve can be Parabolic (or) circular
- Parabolic curve is preferred over circular curve because.
  - It is flatter at top and provides longer sight distance
  - It is simple to layout
  - Rate of change of gradient is constant.

Vertical Curves

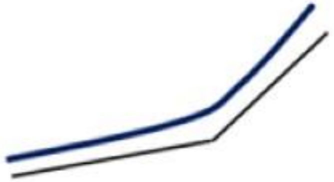
SAG CURVE/Valley Curve

When down gradient is followed by Up gradient

Steep down gradient is followed by mild down gradient



Mild up gradient is followed by steep up gradient



SUMMIT CURVE

When up gradient is followed by down gradient

Mild down gradient is followed by steep down gradient

Steep gradient followed by Mild up gradient

Vertical Curves

- <u>Total change of grade:</u> is the algebraic difference of two gradients

$+g_1 - (-g_2)$

- <u>Length of Vertical Curve:</u>
  - $Length\ of\ vertical\ curve = \dfrac{Total\ change\ in\ gradient}{Permissible\ rate\ of\ change\ of\ gradient}$

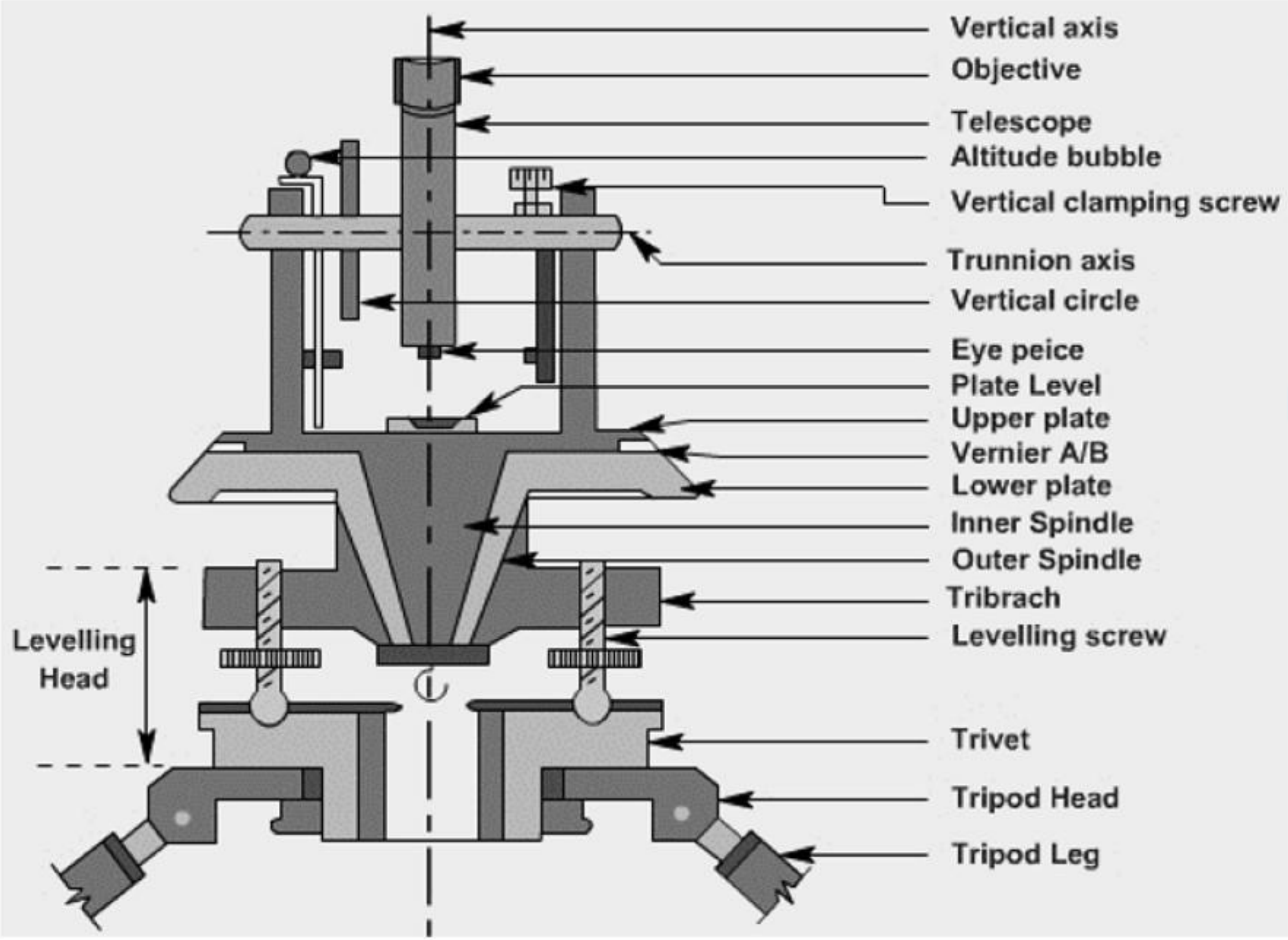
Que: A parabolic curve is to be set out connecting two uniform gradients of +1.6% and +1.0%. The permissible rate of change of gradient is 0.1 % per 30m chain length. Length of vertical curve will be?

Solution: $Length\ of\ vertical\ curve = \dfrac{1.6\% - 1.0\%}{\frac{0.1\%}{30}} = 180m$

Chapter 10 : Theodolite

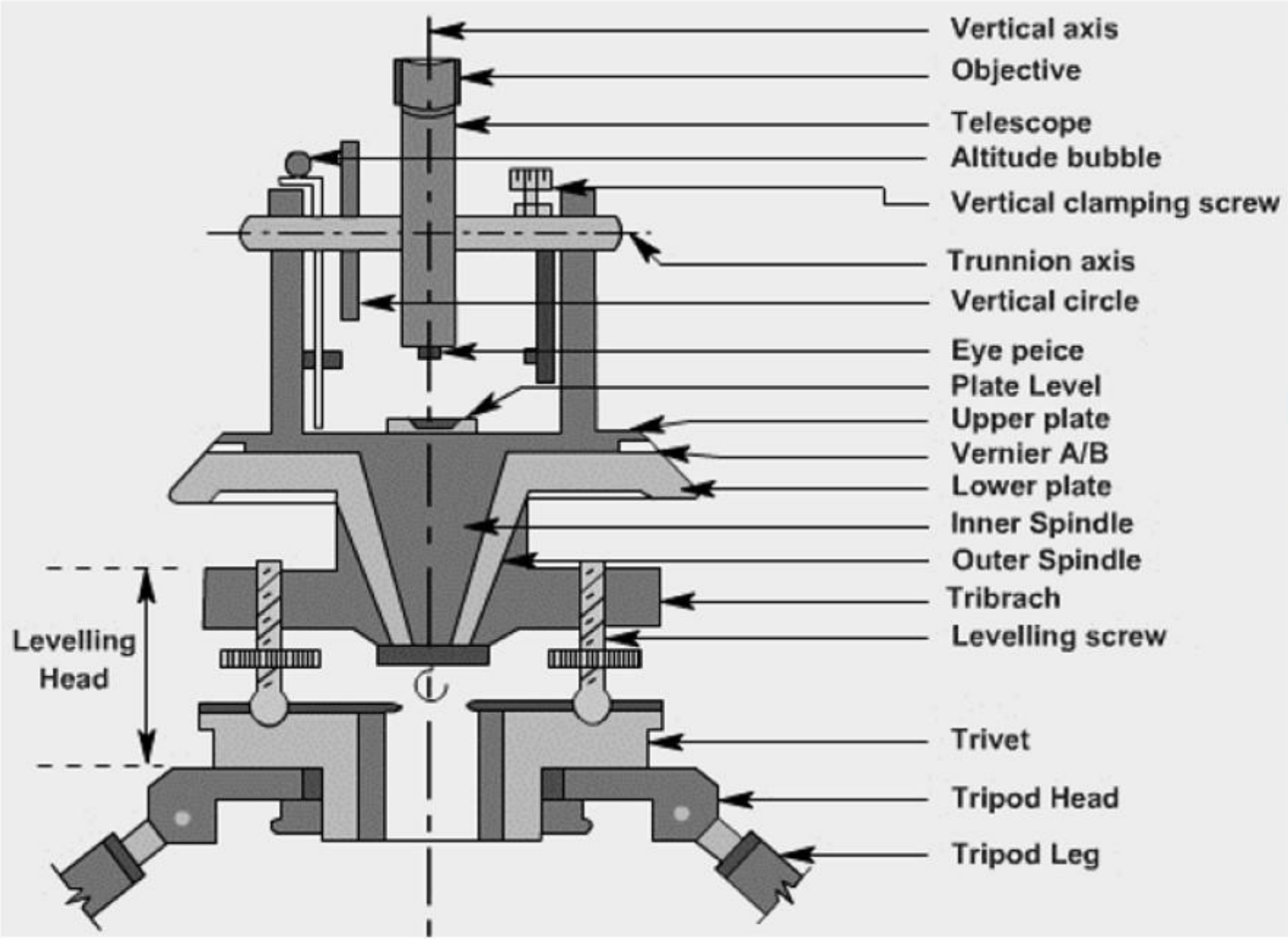
- A theodolite is an instrument which is used primarily to measure angles, both horizontal and vertical.
- It is also used for many other subsidiary work during surveying such as setting up of intermediate points between inter visible points, establishment of inter visible points, prolonging a line, laying out traverse etc.
- Types:
  - Vernier
  - Digital
  - Total Station

Theodolite



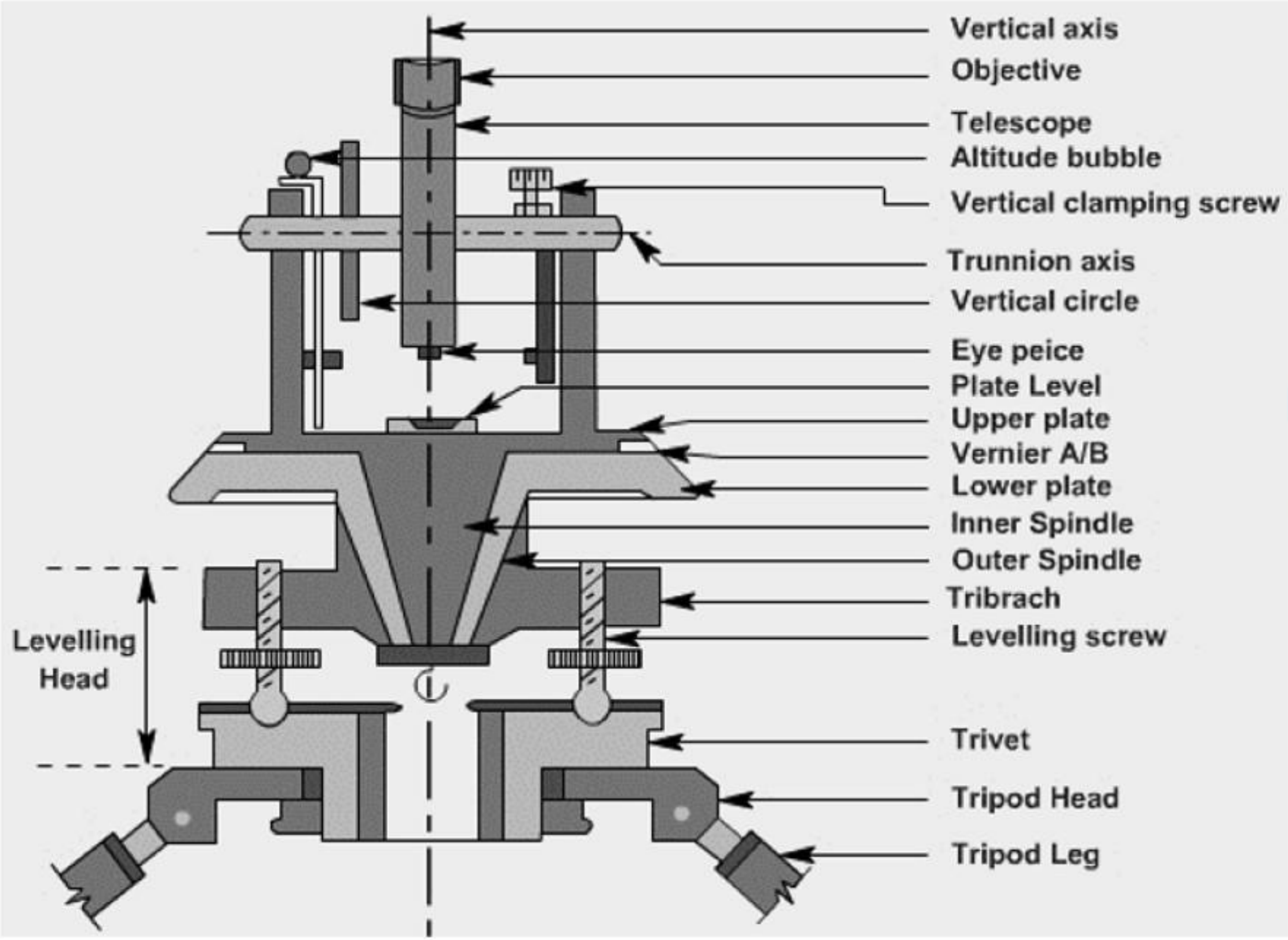
- What are the uses of a theodolite?
  - Theodolite surveying is a branch of surveying, in which the theodolite is accurate instrument used for the measurement of horizontal angles, vertical angles. It can also be used for various purposes such as laying off horizontal angles, locating points on a line, prolonging survey lines, establishing grades, determining differences in elevation, etc,.

Theodolite



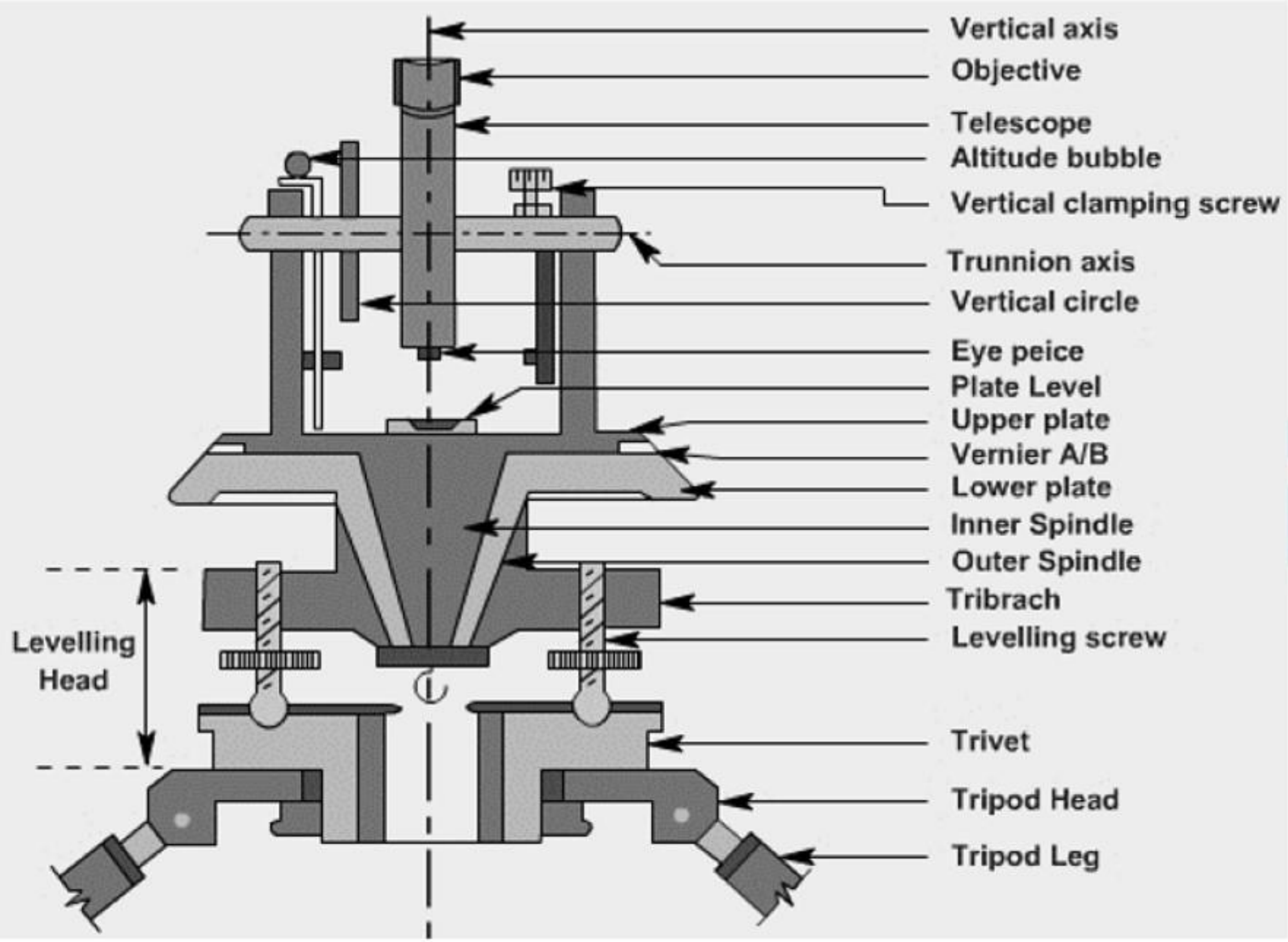
- Why a type of theodolite is called a transit theodolite?
  - A transit theodolite is one is which the line of sight can be reversed by revolving the telescope through 180^0 in the vertical plane.

Theodolite



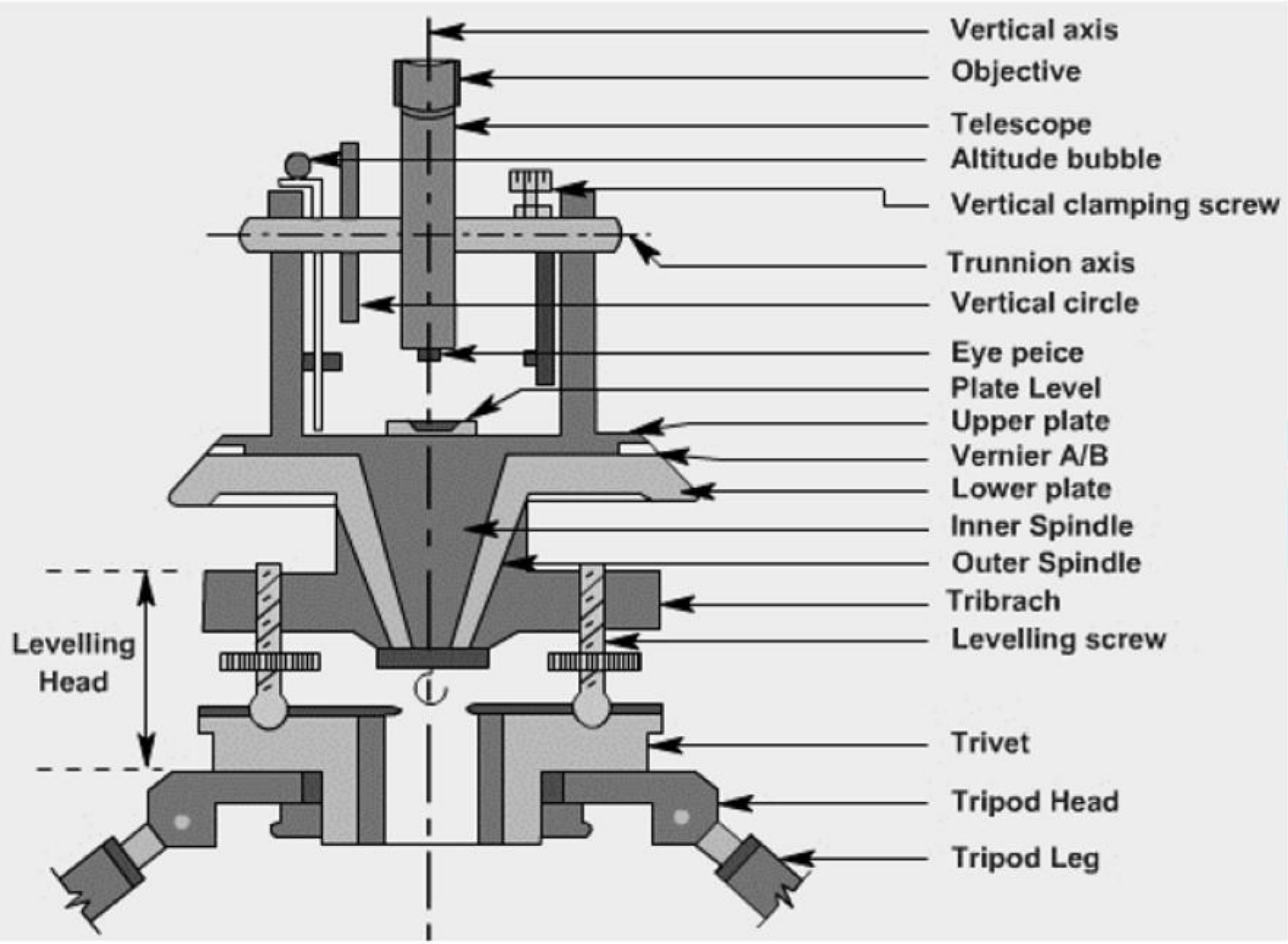
- Vernier theodolite and Micrometer theodolite
  - In Vernier theodolite the verniers are fitted to read the angles upto 20’
  - Micrometer theodolite micrometers are fitted to read the angles.

Theodolite



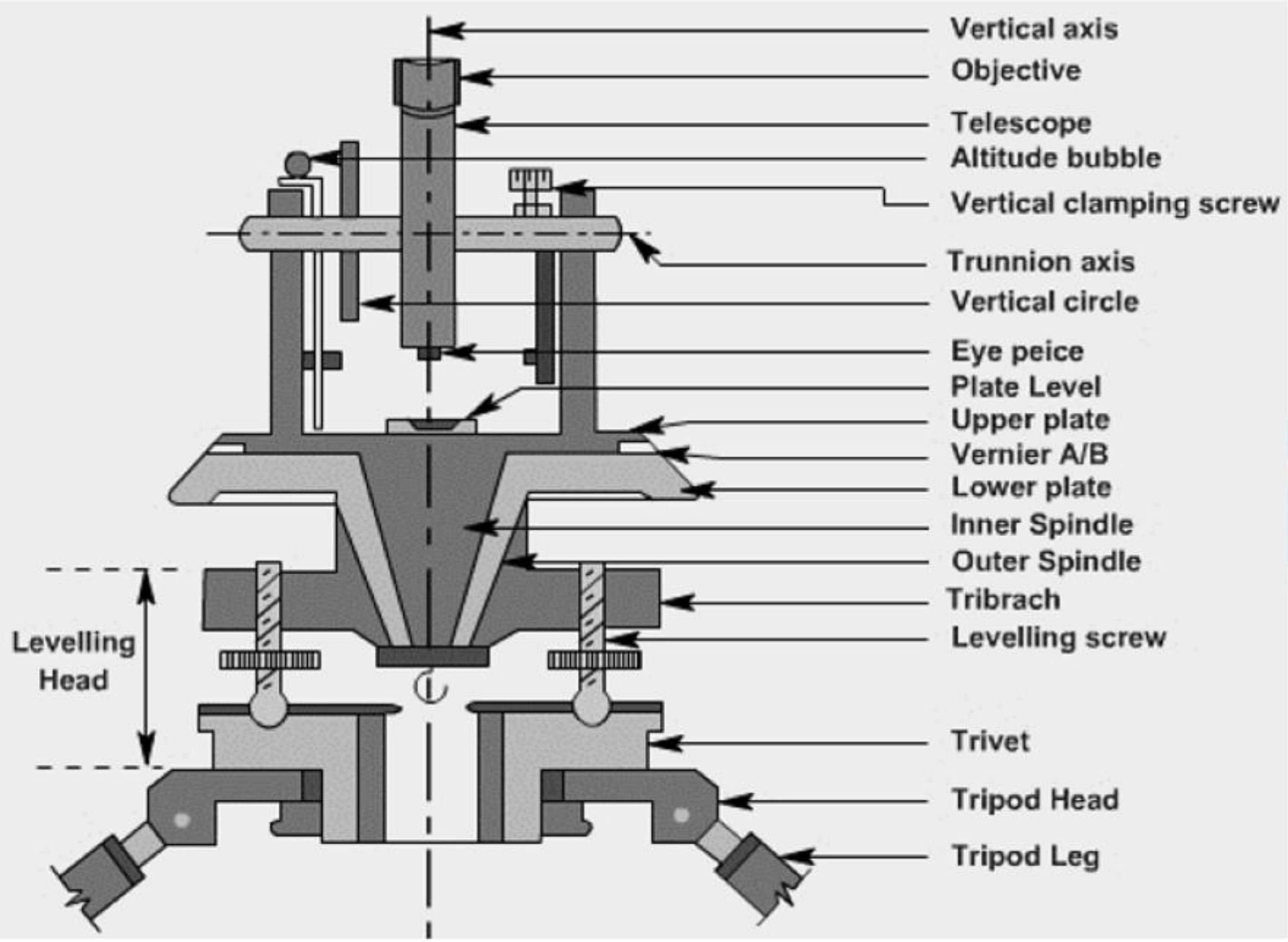
- Features of Theodolite
  - The real image must be formed in front of the eye-piece.
  - The plane of the image must coincide with that of the cross-hairs

Theodolite



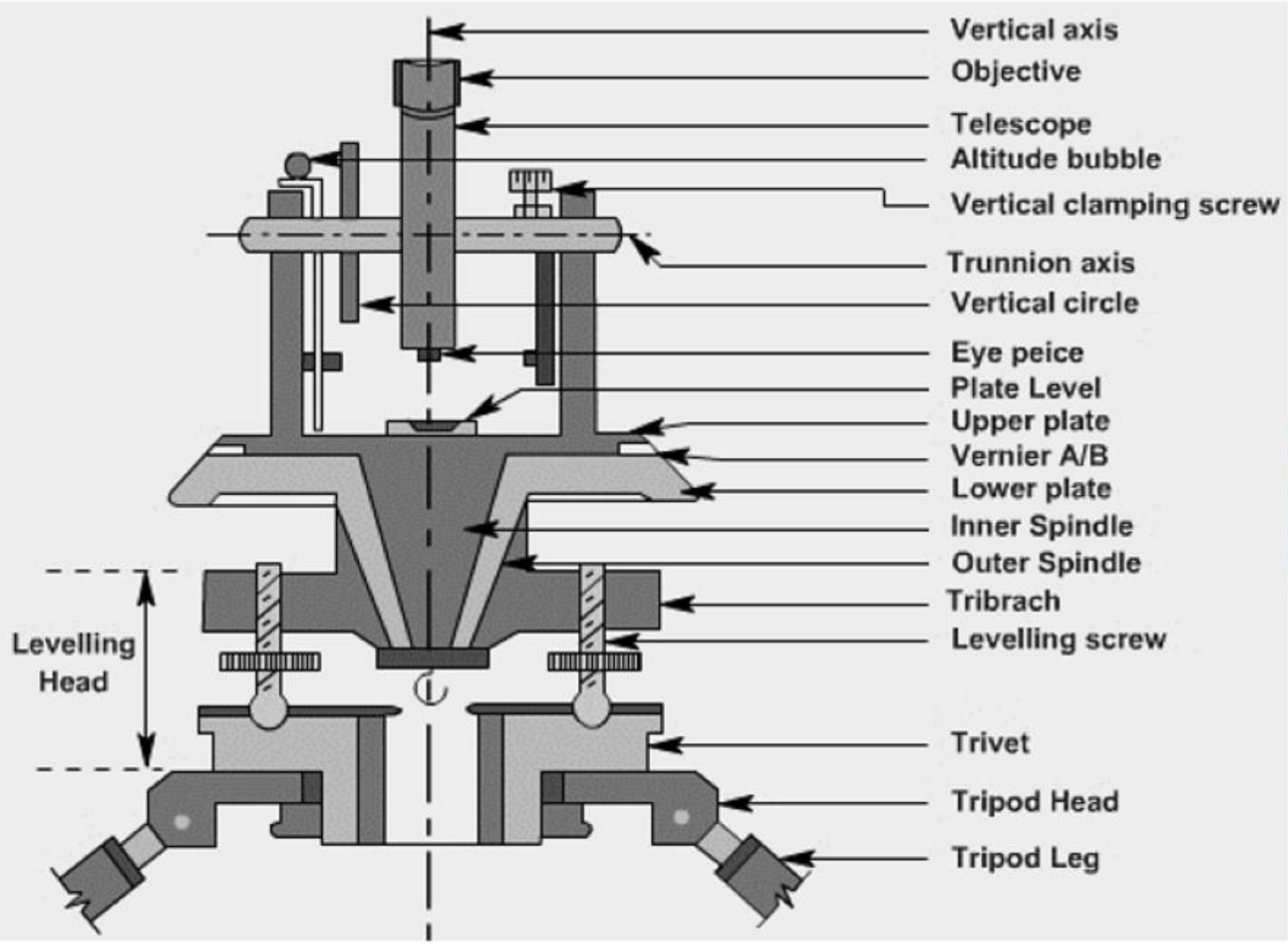
- What are the temporary adjustments of the theodolite?
  - 1. Setting up.
  - 2. Levelling up.
  - 3. Elimination of parallax.

Theodolite



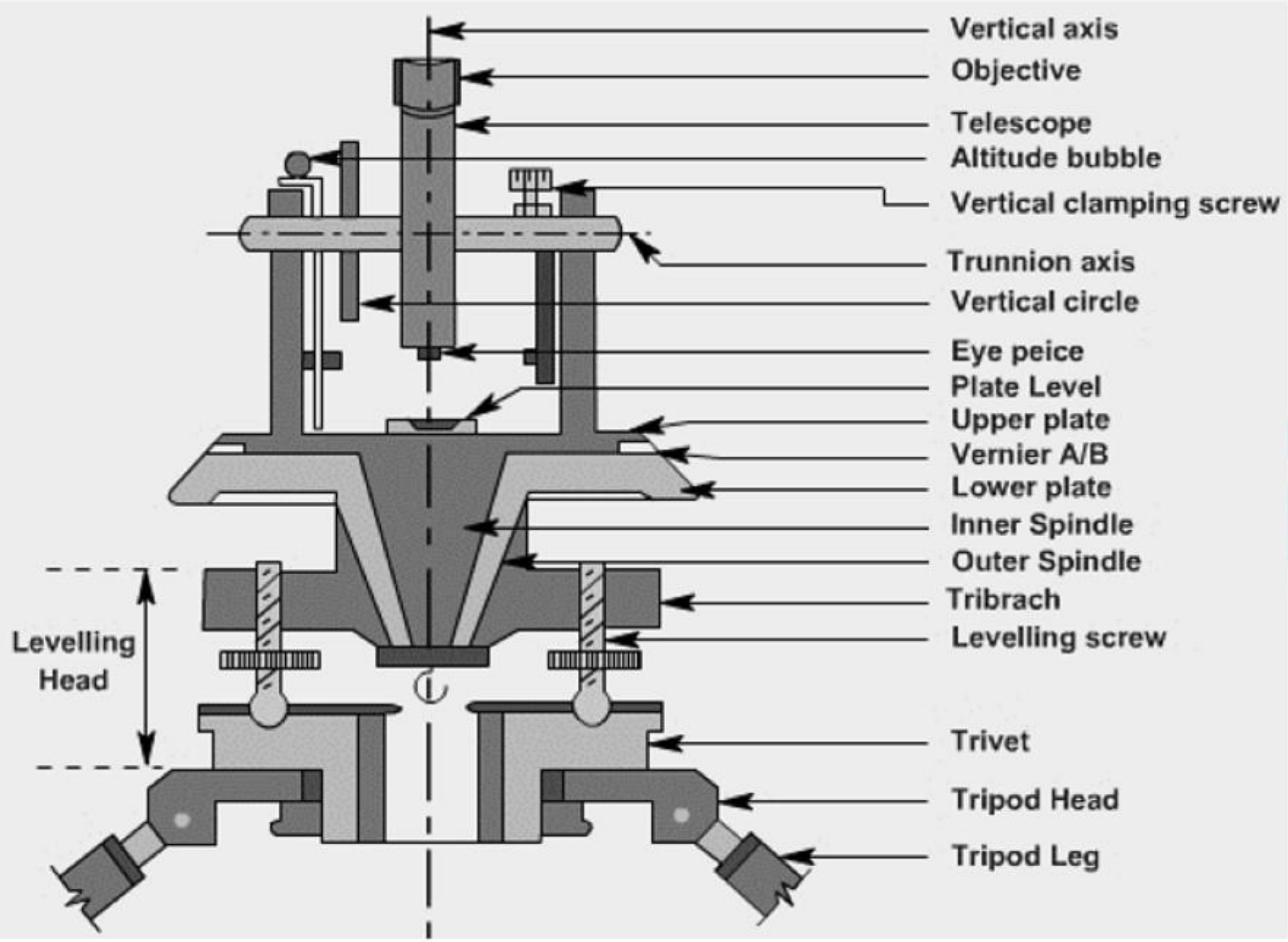
- **<u>Centring :</u>**
  - It is the process of setting up the instrument exactly over the station mark.
  - The plumb bob suspended from a small hook attached to the underside of the inner spindle is used for centring.

Theodolite



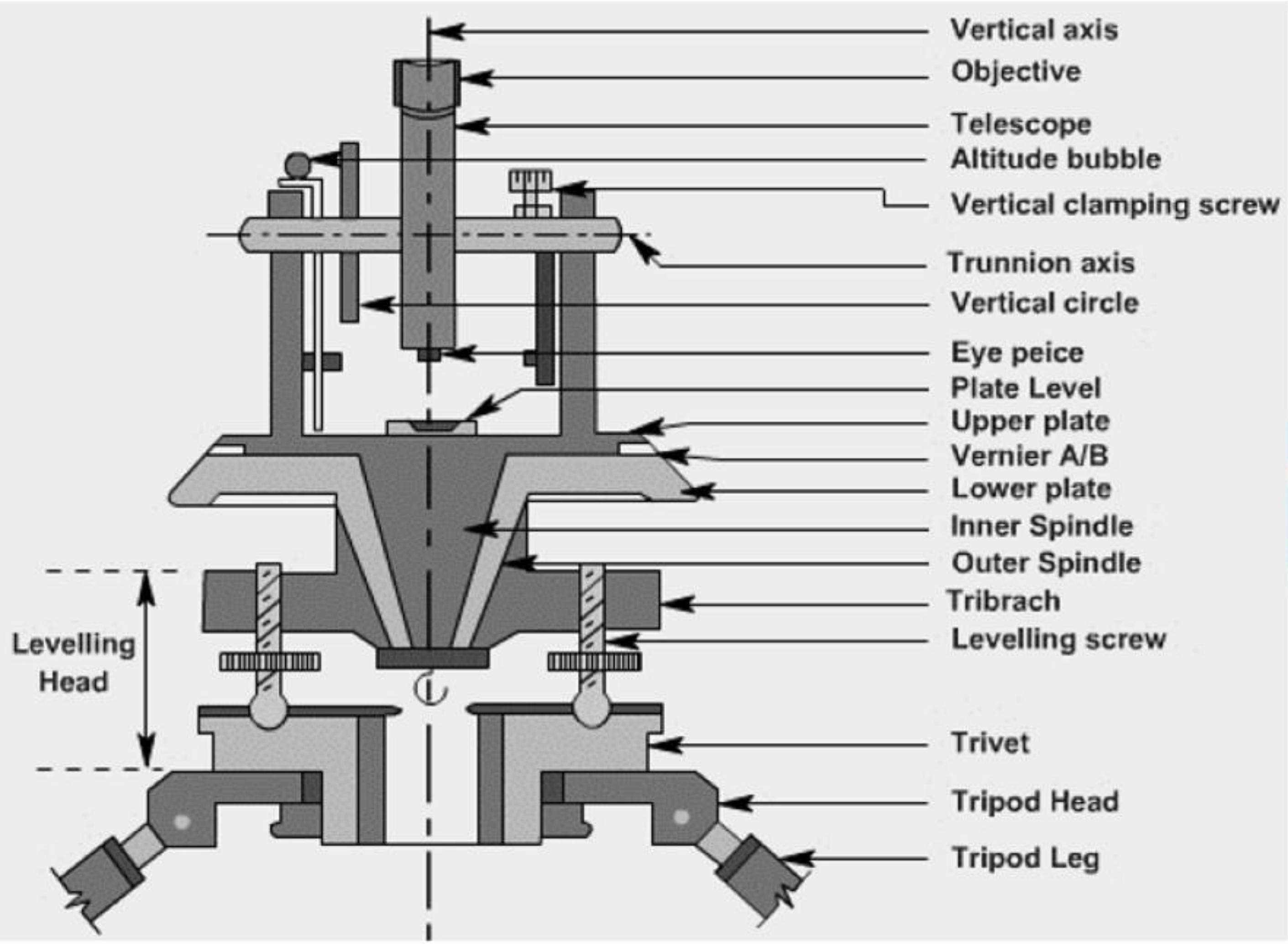
- **Face Left Condition :**
  - If the vertical circle is on the left side of the observer, the theodolite is in the face left condition.
  - Normally, the face left condition is used in practice. The face left condition is, therefore, also known as the normal condition.
  - The telescope is in the normal position. It is also called the direct condition
- **Face Right Condition :**
  - If the vertical circle is on the right side of the observer, the theodolite is in the face right condition.
  - The telescope is in the inverted position. It is also called the reverse condition.

Theodolite



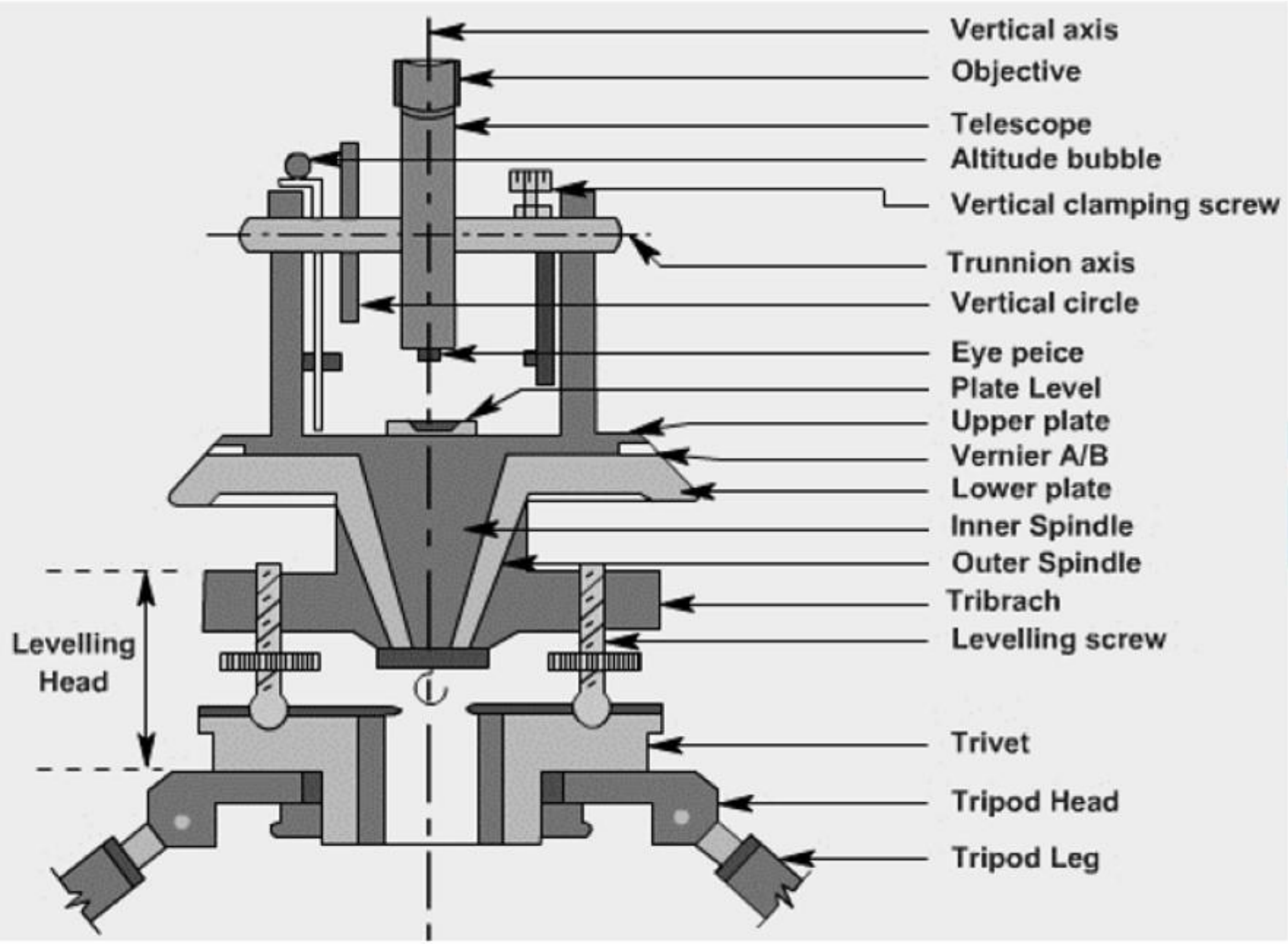
- **<u>Centring :</u>**
  - It is the process of setting up the instrument exactly over the station mark.
  - The plumb bob suspended from a small hook attached to the underside of the inner spindle is used for centring.
- **<u>Changing Face :</u>**
  - It is the operation of bringing the telescope from the face left condition to the face right condition and vice versa.
  - The face is changed by plunging the telescope and swinging it by 180°.

Theodolite



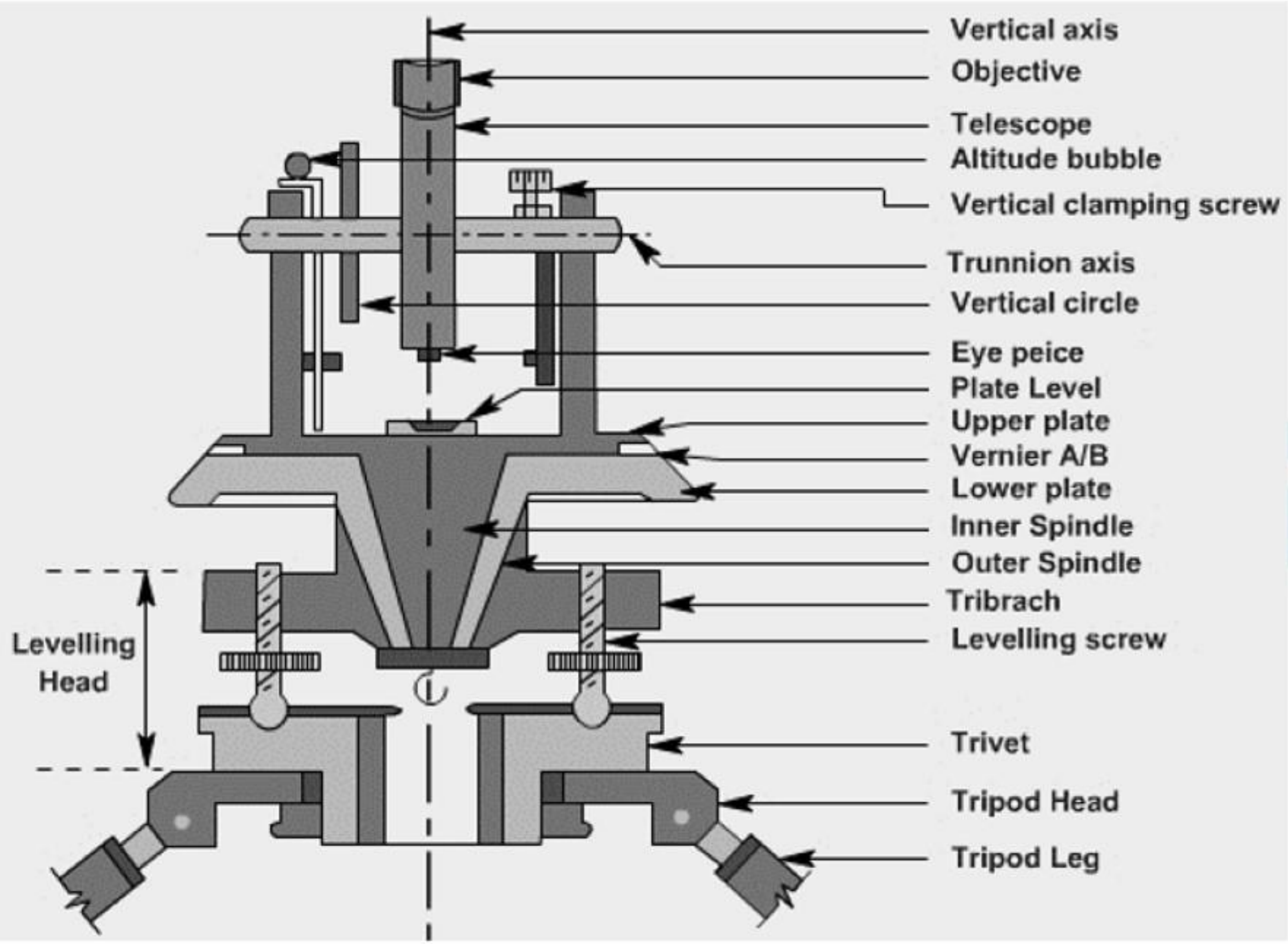
- **<u>Double Sighting :</u>**
  - It is the process of measurement of a horizontal angle or a vertical angle twice; once with the telescope in the normal condition and once with the telescope in the inverted condition.
  - Double sighting is also called double centring

Theodolite



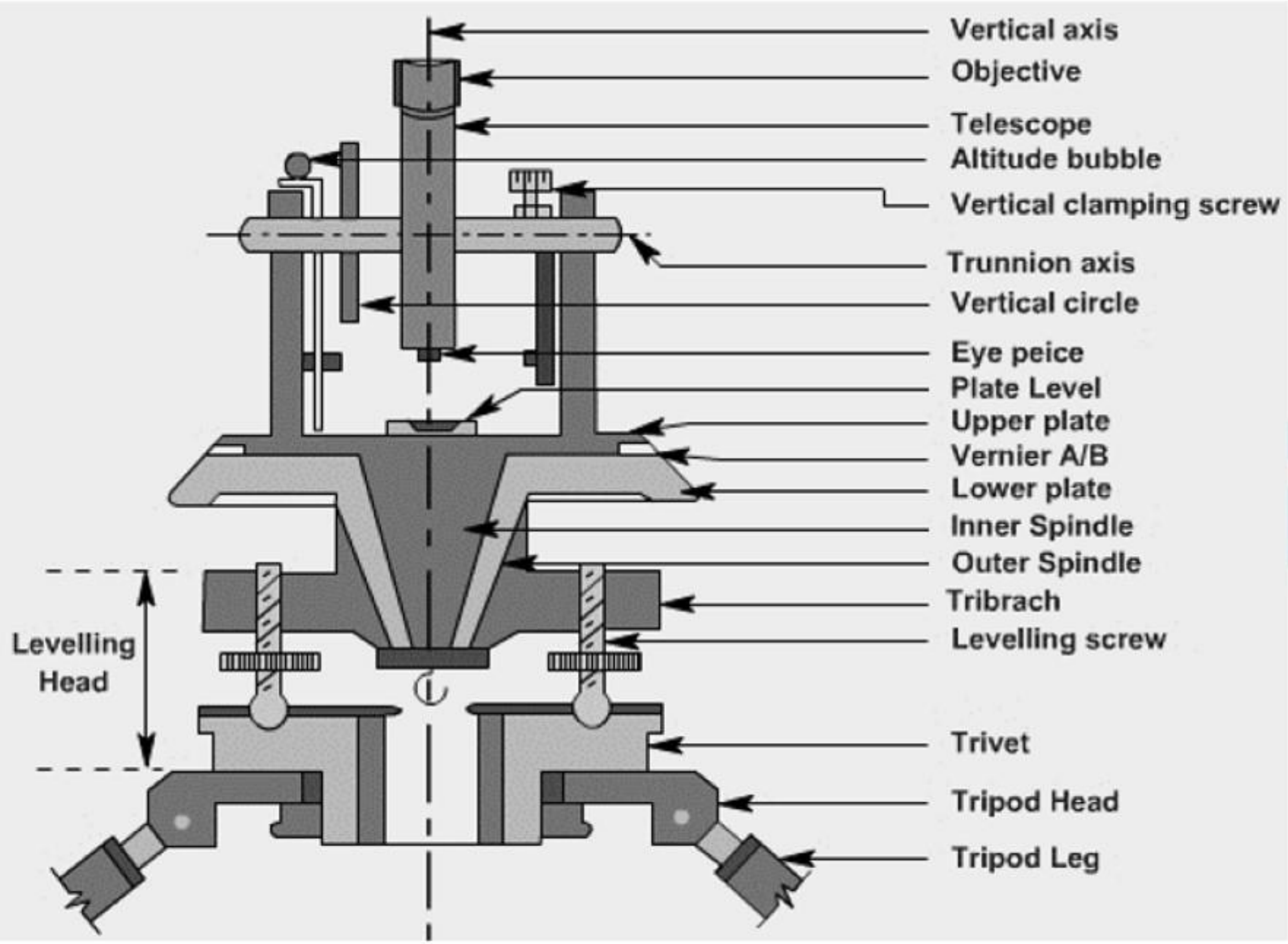
- **<u>Horizontal Axis :</u>**
  - The telescope is turned about the horizontal axis when measuring vertical angles.
  - The horizontal axis is also known as the trunnion axis, elevation axis or transverse axis.
- **<u>Line of collimation :</u>**
  - Imaginary line passing through the intersection of the cross-hairs of the diaphragm and the optical centre of the objective lens.

Theodolite



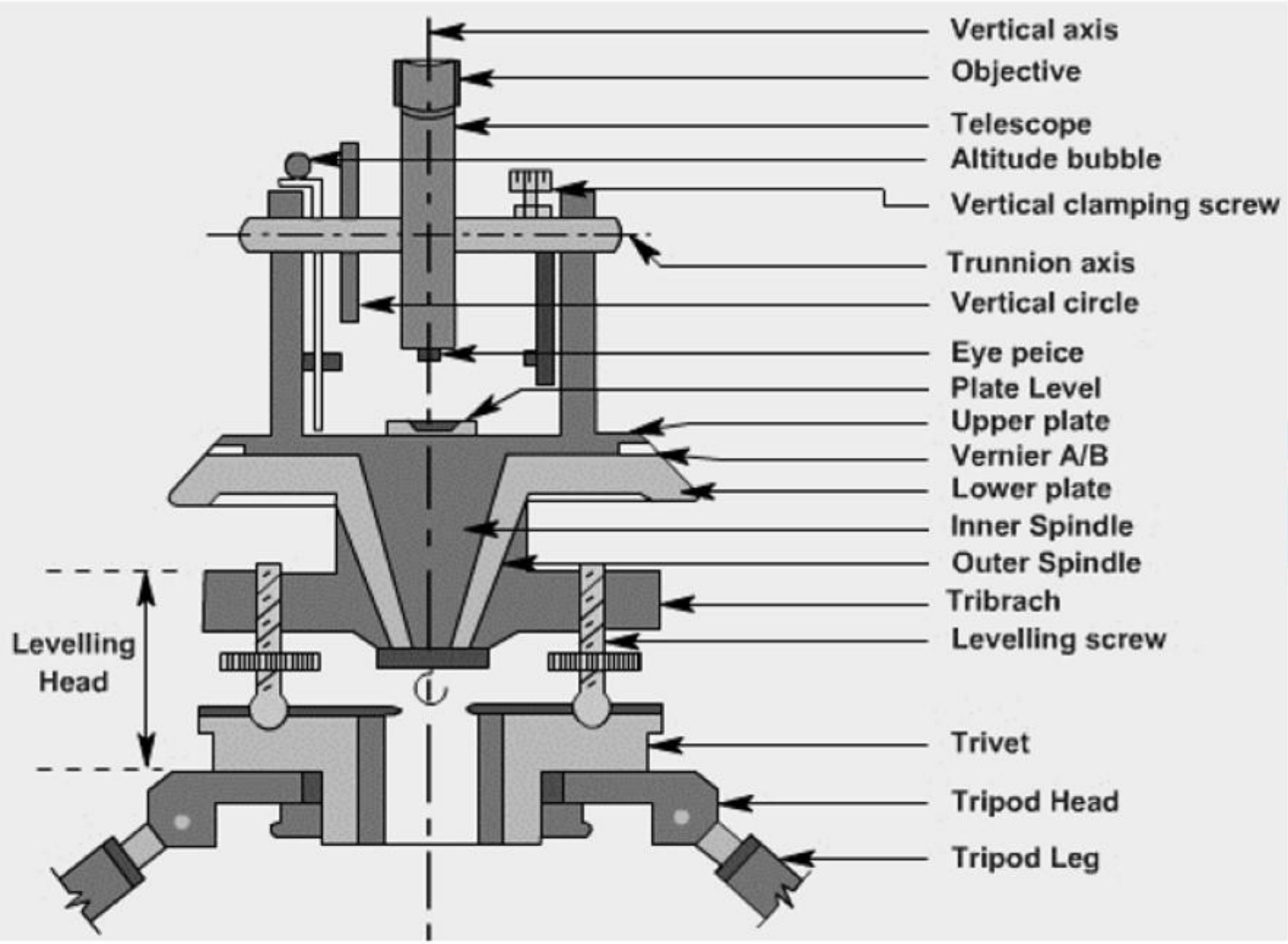
- **<u>Vertical axis :</u>**
  - It is the direction of gravity and is indicated by a freely suspended plumb bob.
  - In case of perfectly adjusted theodolite, it is the line passing through the centre of the inner spindle, outer spindle and the bearing in the tribach.

Theodolite



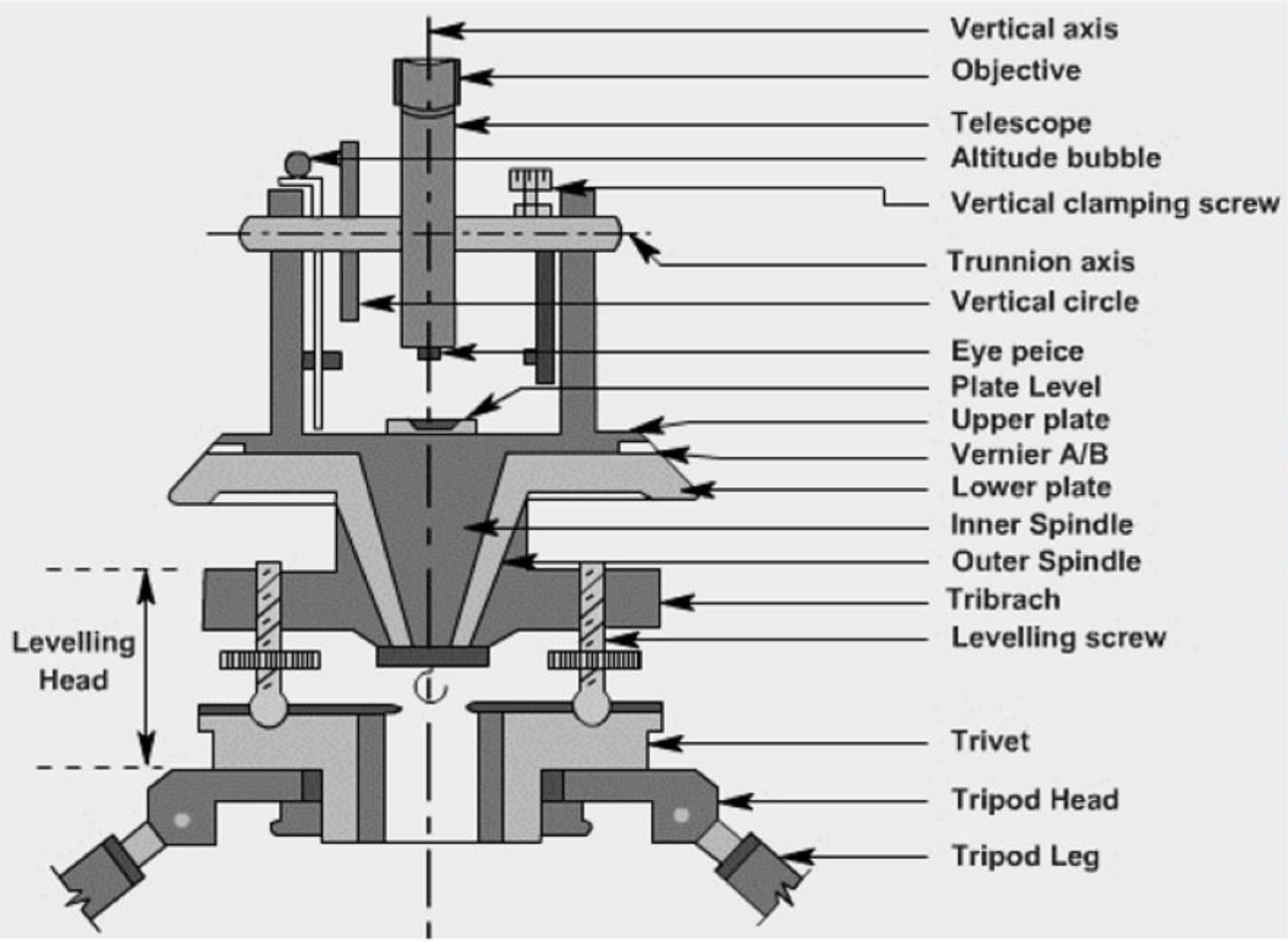
- **Axis of the Altitude Level Tube :**
  - It is the straight line tangential to the longitudinal curve of the altitude level tube at its centre.
  - The axis of the altitude level tube is horizontal when the bubble is centred.
- **Axis of the Plate Level :**
  - It is the straight line tangential to the longitudinal curve of the plate level tube at its centre.
  - The axis of the plate level is horizontal when the bubble is centred.

Theodolite



- **Plunging the Telescope :**
  - It is the process of rotating the telescope over the herizontal axis through 180 in the vertical plane.
  - After plunging the telescope, the directions of the objective end and eyepiece end are reversed, and the telescope points exactly in the opposite direction.
  - Plunging is also known as transiting or reversing.

Theodolite



- **Swinging the Telescope :**
  - It is the process of turning the telescope about the vertical axis in a horizontal plane.
  - The swing is called right swing when the telescope is turned clockwise from the previous position.
  - The swing is called left swing when the telescope is turned anticlockwise from previous position

Theodolite

- What are the permanent adjustments of the theodolite?
  - 1. Adjustment of plate level (Plate level test).
  - 2. Adjustment of line of sight (Cross- hair test).
  - 3. Adjustment of horizontal axis.(Spire test).
  - 4. Adjustment of vertical index frame and altitude bubble.(Vertical arc test)
- What is an anallatic lens? What is the use of an anallatic lens?
  - It is a special convex lens fitted between the object glass and eye piece, at a fixed distance from the object glass, inside the telescope of a tacheometer..
  - The use of an anallatic lens is to reduce the additive constant (C) to zero. Tacheometric equation, D = Ks + C. Where
    - D = horizontal distance between the staff and the instrument station. S = staff intercept
    - K = multiplying constant. C = additive constant.

Thank You Dear All !

If you enjoyed studying these notes, let me know by …

Feedback and Suggestions are always Welcomed !