ARYAN SCHOOL OF ENGINEERING & ECHNOLOGY

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LECTURE NOTE

SUBJECT NAME- LAND SURVEYING-I

BRANCH-CIVIL ENGG.

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Chapter-1 :- Linear Measurement and chain survey:-

Objective of Surveying:-

→ The aim of surveying is to prepare a map to show the relative positions of the objects on the surface of the earth. The map is drawn to some suitable scale.

→ It also shows the natural features of the country such as towns, villages, roads, railways etc.

→ Maps may also include details of different engineering works such as roads, railways, irrigation canals etc.

What is the need for society:-

→ You should be able to understand the concepts of basic surveying, linear measurement and chain survey.

→ You should be able to apply the techniques of measurement and its application in daily life.

→ You should be able to understand how should you use the tools in a optimal way.

→ You should be able to understand the drawbacks and errors of the tools to overcome it.

Uses of surveying:-

Surveying may be used for the following applications are:-

i) To prepare a topographical map

ii) To prepare cadastral map

iii) To prepare a engineering map

iv) To prepare a millitary map

v) To prepare a contour map

vi) To prepare a geological map

vii) To prepare archeological map

Classification of surveying

Surveying can be classified into two types

i> Primary classification

ii> Secondary classification

Surveying is primarily classified as under

1> Plane surveying

2> Geodetic surveying

1> **Plane Surveying:-** As we know that the shape of earth is spheroidal. Thus, the surface is obviously curved. In plane surveying the curvature of the earth is not taken into consideration, because plane surveying is carried out over a small area. So, the surface of the earth is considered plane.

→ plane surveying is done on an area of less than 250 km^2.

2> **Geodetic Surveying:-**

→ In Geodetic surveying, the curvature of the earth is taken into consideration. It is extended over a large area.

→ Geodetic surveying is conducted by the survey of India department and is carried out over an area exceeding 250 km^2.

Surveying is secondarily classified as under:-

1> Based on Instruments

2> Based on methods

3> Based on objects

4> Based on nature of field.

Sb.

General Principle of Surveying :-

The general principles of surveying are given below :-
i) To work from the whole to the part and
ii) To locate a new station by atleast two measurements (linear or angular) from fixed reference points.

1) According to the first principle, the whole area is first enclosed by main stations and main survey lines. The area is then divided into a no. of parts by forming well-conditioned triangles. A nearly equilateral triangle is considered the best well-conditioned triangle. The main survey lines are measured very accurately with a standard chain. Then the sides of the triangles are measured.
→ The purpose of this process of working is to prevent accumulation of error.
→ During this procedure, if there is any error in the measurement of any side of a triangle then it willn't affect the whole work. The error can always be detected and eliminated.

2) According to the second principle, the new stations should always be fixed by atleast two measurements from fixed reference points. Linear measurement refer to horizontal distance measured by chain or tape.
→ Angular measurement refer to the magnetic bearing or horizontal angle taken by a prismatic compass or theodolite.
→ In chain surveying, the positions of main stations are directions of main survey lines are fixed by tie-lines and check lines.

Methods of Linear Measurements :-

The following methods are generally employed for linear measurements :-

1) By pairing or stepping :-

For rough and speedy work, distances are measured by pairing i.e., by counting the no. of walking steps of a man. The walking step of a man is considered 2.5 ft or 80 cm. This method is generally employed reconnaissance survey of any project.

2) By pascometer :-

A small instrument, just like a stopwatch, the passometer is used for counting the number of steps automatically by some mechanical device

3) By perambulator :-

It is a wheel fitted with a fork & handle. The wheel is graduated and shows a distance per revolution. There is a dial which records the no. of revolution. Thus, the distance can be ascertained.

4) By speedometer :-

This is used in automobiles for recording distances.

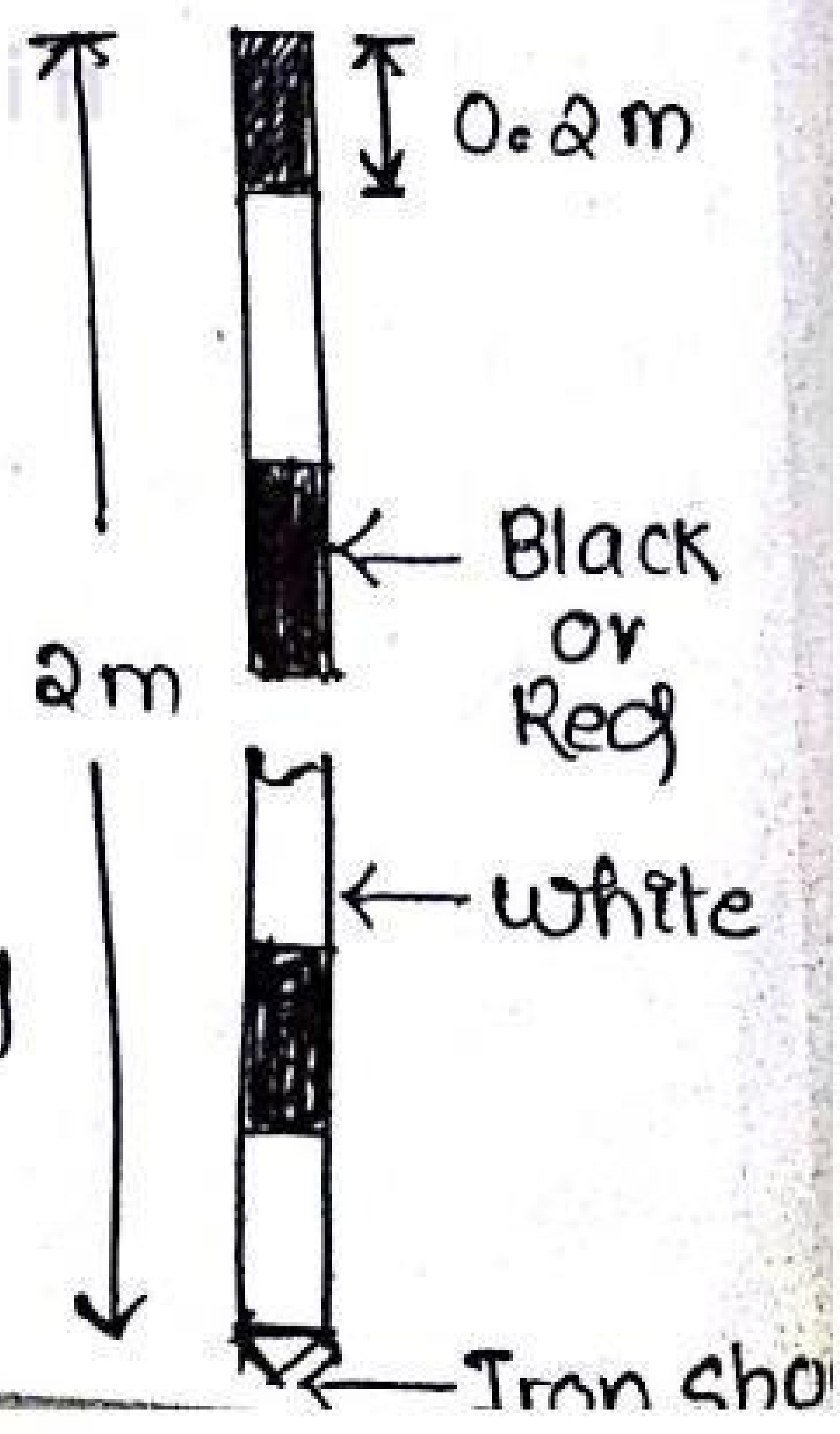
5) By chaining :-

This is an accurate and common method of measuring distance. In this method, the distances are directly measured in the field by chain or tape

Accessories for linear measurements :-

1) Ranging Rods :-

Rods which are used for ranging a line are known as ranging rods. Such rods are made of seasoned timber or seasoned bamboo. Sometimes G.I pipes of 23 mm dia are also used as ranging rods. They are generally circulated in section, of 23 mm dia and 2 m length.



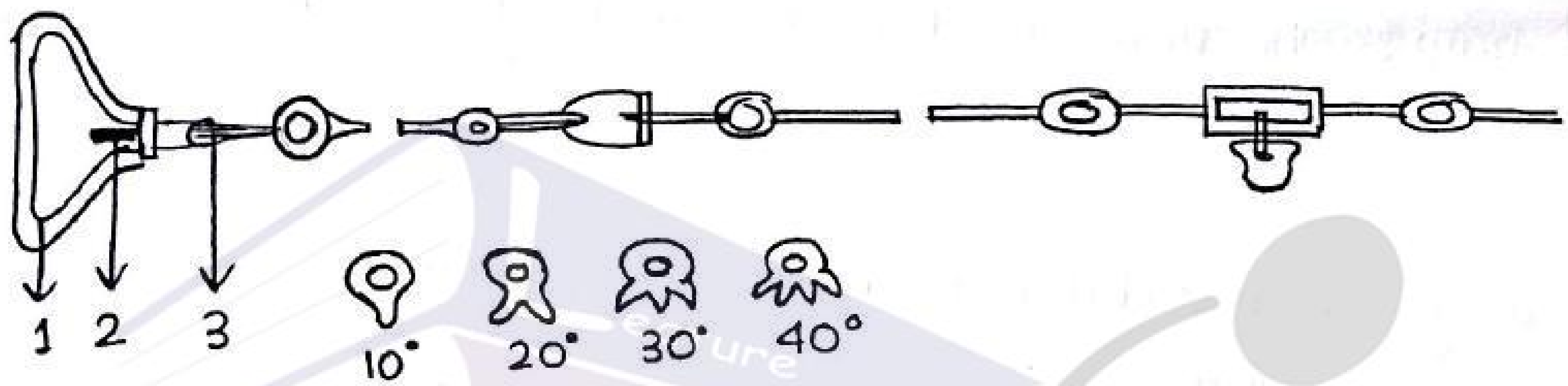
(5) The rod is divided into equal parts of 20cm each and the divisions are painted black and white or red and white alternately so that the rod is visible from a long distance.

2) Chains:-

→ A chain is prepared with 100 or 150 pieces of galvanished mild steel wire of 4mm diameter. The end of the pieces are bent to form loops.

→ Tallies are provided at every 10 or 25 links for facility of counting.

→ 'One link' means the distance between the centres of adjacent middle rings.



1. Brass handle
2. Collor
3. Eye bolt
4. Circular ring
5. End link

The following are the different types of chains:-

a) Metric chain
b) Steel band
c) Engineer's chain
d) Gunter's chain
e) Revenue chain

(a) Metric chain:- These are available in lengths of 20m and 30m.

→ The 20m chain is divided into 100 links, each of 0.2m. Tallies are provided at every 10 links (2m).

→ The 30m chain is divided into 150 links. So, each link is of 0.2m. The tallies are provided after every 25 links (5m).

b) Steel Band:- It consists of a ribbon of steel of 16 mm width and of 20 or 30 m length. It has a brass handle at each end. It is graduated in metres, decametres and centimeters on one side and has 0.2 m links on the other.

c) Engineer's chain:- The engineer's chain is 100ft long and is divided into 100 links. So, each link is of 1ft.
Tallies are provided at every 10 links, the central tally being round.

d) Gunter's chain:- It is 66ft long and divided into 100 links. So, each link is of 0.66 ft. It was previously used for measuring distances in miles and furlongs.

e) Revenue chain:- The revenue chain is 33ft long and divided into 16 links.

3) Tapes:-
The following are the different types of tapes:-
a) Cloth or linen tape
b) Metalic tape
c) Steel tape and
d) Invar tape

a) Cloth or Linen tape:- Such a tape is made of closely woven linen and is varnished to resist moisture. It is 15mm wide and available in lengths of 10 and 15m.

b) Metallic tape:- When linen tape is reinforced with brass or copper wires to make it durable then it is called a metalic tape. This tape is available in lengths of 15, 20 and 30 m.

c) Steel tape:- The steel tape is made of steel ribbon of width varying from 6 to 16mm. The commonly available lengths are 10, 15, 20, 30 and 50m. It is graduated is metres, decimeters and centimetres

d) Invar tape:- It is made of an alloy of steel (64%) and nickel (36%). Its thermal coefficient is very low. Therefore, it is not affected by change of temperature.

⇒ This instrument measure distances by determining the no. of full and partial wavelengths between the object and the instrument. This results in a two way distance.

⇒ A partial wavelength is determined by the phase shift of the returning wave, compared to the emitted one. If the phase shift is 135° then the partial wavelength is $(135/360)\lambda = 0.375\lambda$

⇒ If there are 'n' full wavelengths and partial wavelengths then the distance $l = (n+p)\lambda/2$. The factor '2' is required for dividing the whole value to obtain one-way distance

Measurement of Distances:-

An EDM can be used to plane objects or points in 3-dimensional relation to the unit.

The EDM emits a beam of infrared light that can be modulated at a controlled rate.

⇒ During use, the light beam is emitted from the EDM reflected off a prism or target held at a point to be mapped, and bounced back to the EDM.

⇒ The phase of the returning beam is shifted from that of the emitted beam.

⇒ This phase shifting is the func of travel time of the light beam.

⇒ The shifting of light wave is to determine the distance travelled by the light.

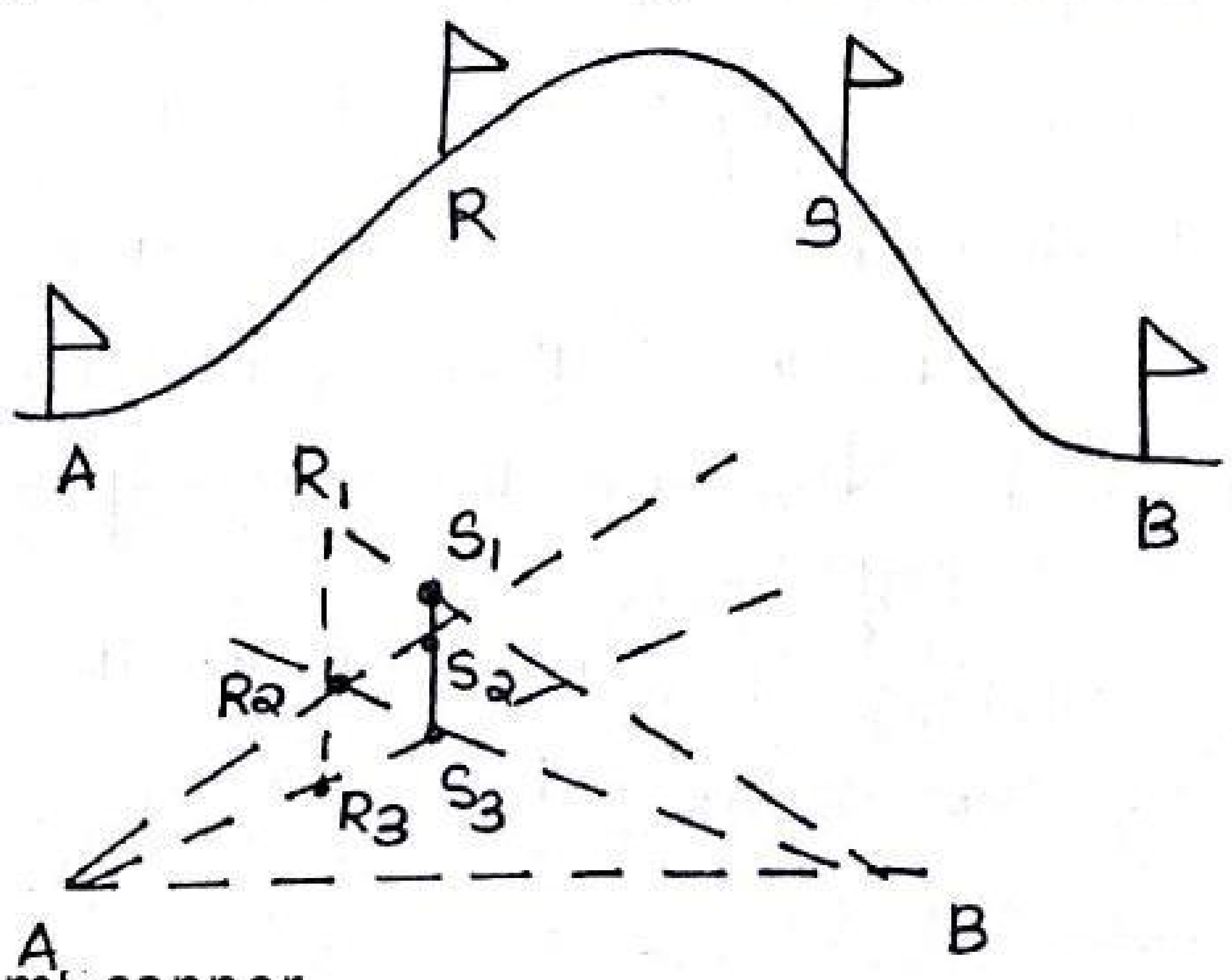
⇒ The comparison of returning and emitted signal gives the distance between the unit and target with an accuracy of approximately 1/8 inch in 1/4 mile.

fig: Direct Ranging

2) Indirect ranging:-

when the end stations are not intervisible due to there being high ground between them, intermediate ranging rods are fixed on the line in a indirect way. This method is known as indirect ranging or reciprocal ranging.

Suppose A and B are two end stations which are not intervisible due to high ground existing between them. Suppose it is required to fix intermediate points between A to B. Two chain men takeup positions at R_1 and S_1 with ranging rods in their hands. The chainman at R_1 stands with his face towards B So that he can see the ranging rods at S1 and B. Again, the chainman at S_1 stands with his face towards A, So that he can see the ranging rods at R_1 and A. Then the chainmen proceed to range the line by directing each other alternatively. The chainman at R_1 directs the chainman at S_1 to come to the position S_2. So that R_1, S_2 and B are in a same straigth line. By directly each other alternatively in this manner, they change their positions everytime untill they finally comes to the position R and S, which are in straight line



Method of chaining on sloping ground

→ Horizontal distances are required in surveying so, in chaining along adoping ground, the horizontal distances between two stations are measured carefully by applying some convenient methods.

→ The following methods are employed :-

i> Direct method

ii> Indirect method

A. Direct method :- This method is applied when the slope of the ground is very steep. In this method, the sloping ground is divided into a number of horizontal and vertical strips, like steps. So, this method is also known as the stepping method.

Procedure :-

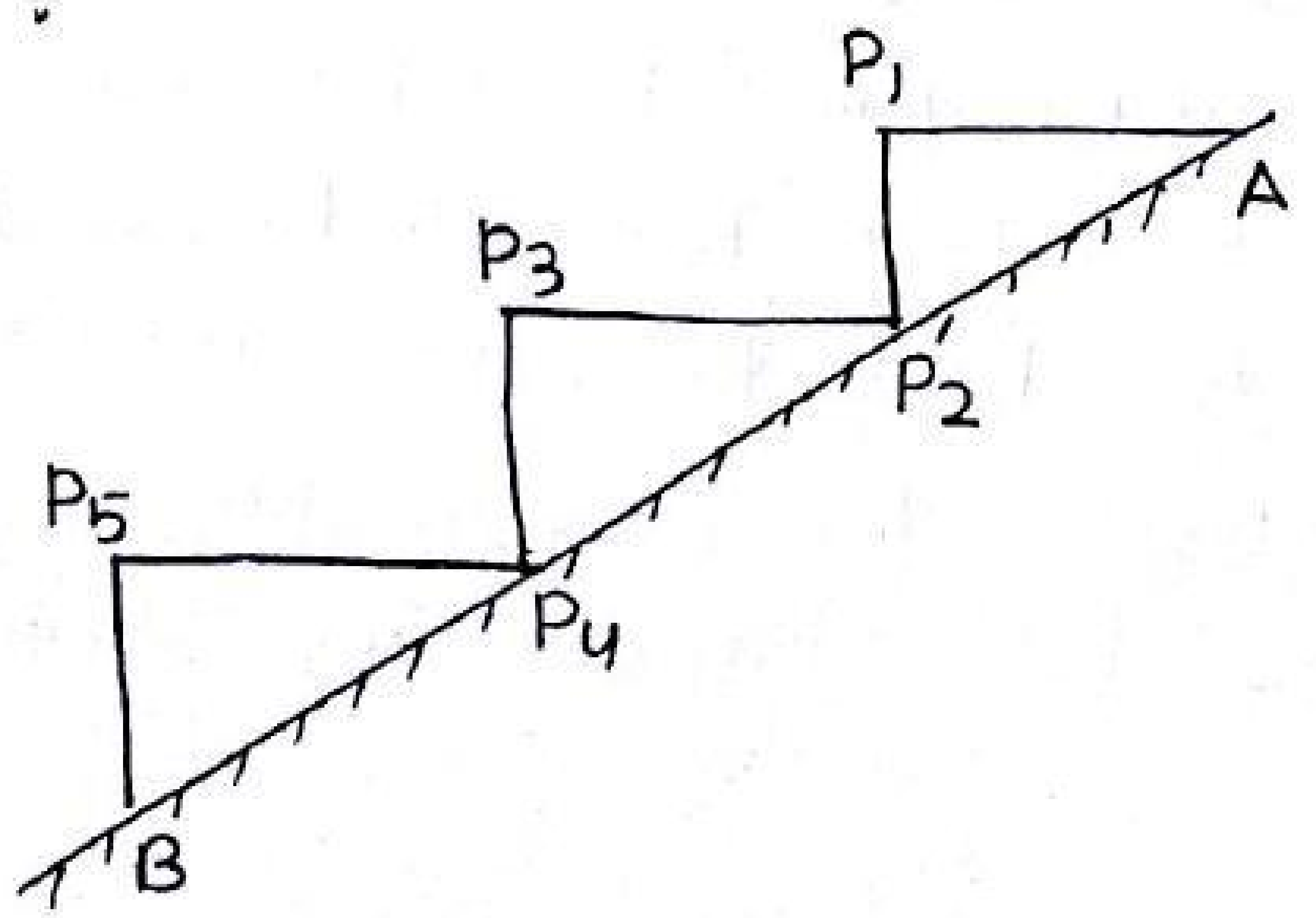
→ Suppose the horizontal distance betn points A and B is to be measured. The line AB is first ranged properly. Then, the follower holds the zero end of the tape at A. The leader selects a suitable length AP_1 so that P_1 is at chest height at AP_1 is just horizontal.

→ The horizontality is maintained by eye estimation, by tri-square or by wooden set-square.

→ The point P_2 is marked on the ground by plumb-bob so that P_1 is just over P_2.

→ The horizontal length AP_1 is noted. Then the follower moves to the position P_2 and holds the zero end of the tape at that point.

→ Again the leader selects a suitable length P_2P_3 in such a way that P_2P_3 is horizontal and P_4P_5 vertical. Then the horizontal length P_2P_3 and P_4P_5 are measured.



So, the total horizontal length $AB = AP_1 + P_2P_3 + P_4P_5$

3. Indirect method:-
when the slope of the ground surface is long and gentle, the stepping method is not suitable. In such a case, the horizontal distance may be obtained by the following processes:-
1. By measuring the slope with the clinometer.
2. By appling hypotenusal allowance and
3. By knowing the difference of level between the points.

Obstacle In chaining:-

A chain line may be interrupted in the following situations:-
1) when chaining is free, but vision is obstructed
2) when chaining is obstructed, but vision is free and
3) when charming and vision are both obstructed

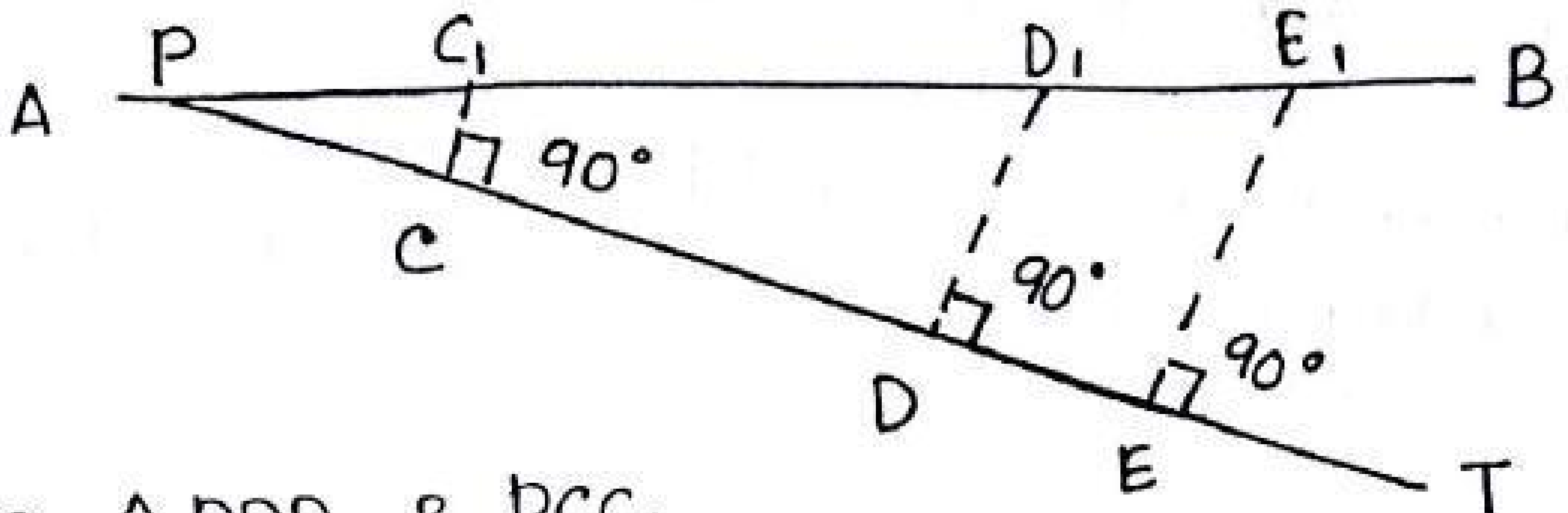
1. Chaining free but vision obstructed:-
such a problem arises when a rising ground or a jungle area interupts the chain line. Here, the end stations are not intervisible. There may be two cases.

case I:- The end stations may be visible from some intermediate points on the rising ground. In this case, reciprocal ranging is resorted to and the chaining is done by the stepping method.

case II:- The end stations are not visible from intermediate points when a jungle are comes across the chain line. In this case the obstacle may be crossed over using a random line as explained below.

Let AB be the actual chain line which cannot be ranged and extended because of interruption by a jungle. Let the chain line be extended upto R. A point R is selected on the chain line and a random line PT is taken in a suitable dirn, points C, D and E are selected on the random line & ⊥ar are projected from them. The ⊥ar at meets the chain line at C1.

∴ The ⊥ars at D and E, will meet the chain line at D_1 & E_1. Now the distance PC, PD, PE and CC_1 are measured.



from ΔPDD_1 & PCC_1

$$\frac{DD_1}{DD} = \frac{CC_1}{DC}$$

$$\Rightarrow DD1 = \frac{CC_1}{DC} \times DD \quad \text{—— (1)}$$

Again from ΔPEE_1 & PCC_1

$$\frac{EE_1}{PE} = \frac{CC_1}{PC}$$

$$\Rightarrow EE_1 = \frac{CC_1}{PC} \times PE \quad \text{—— (2)}$$

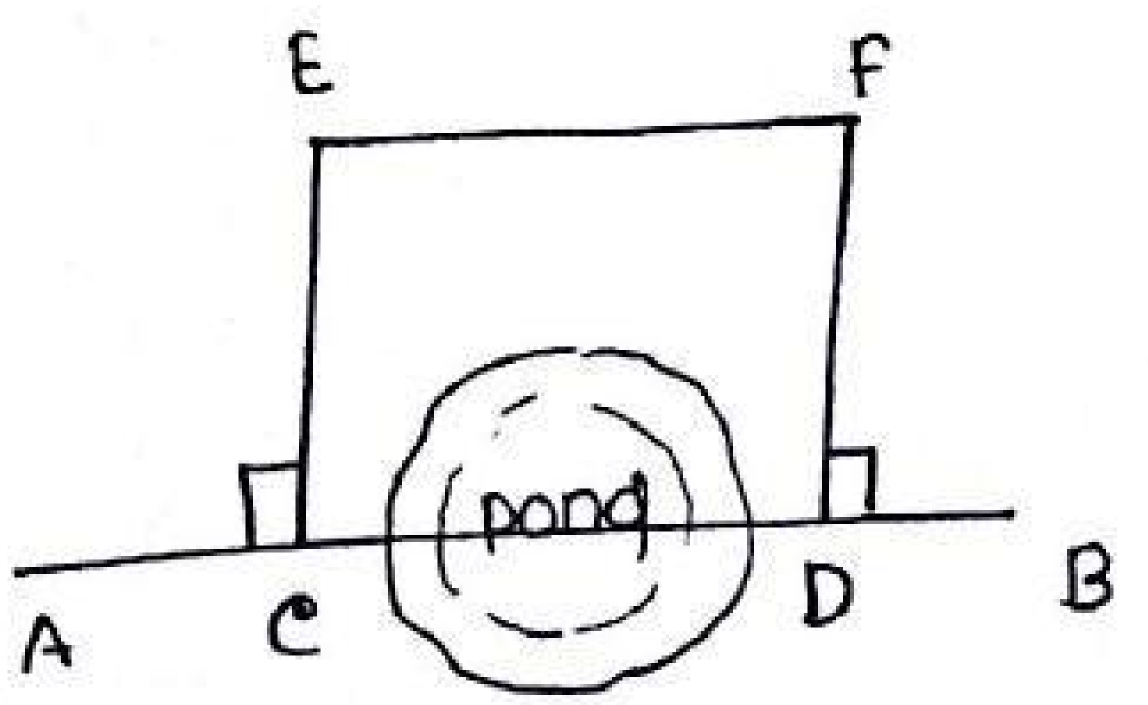
from eqn (1) & (2) the lengths DD_1 & EE_1 are calculated. These calculated distance are measured along the ⊥ars at D & E. Point D_1 & E_1 should lie on the chain line AB.

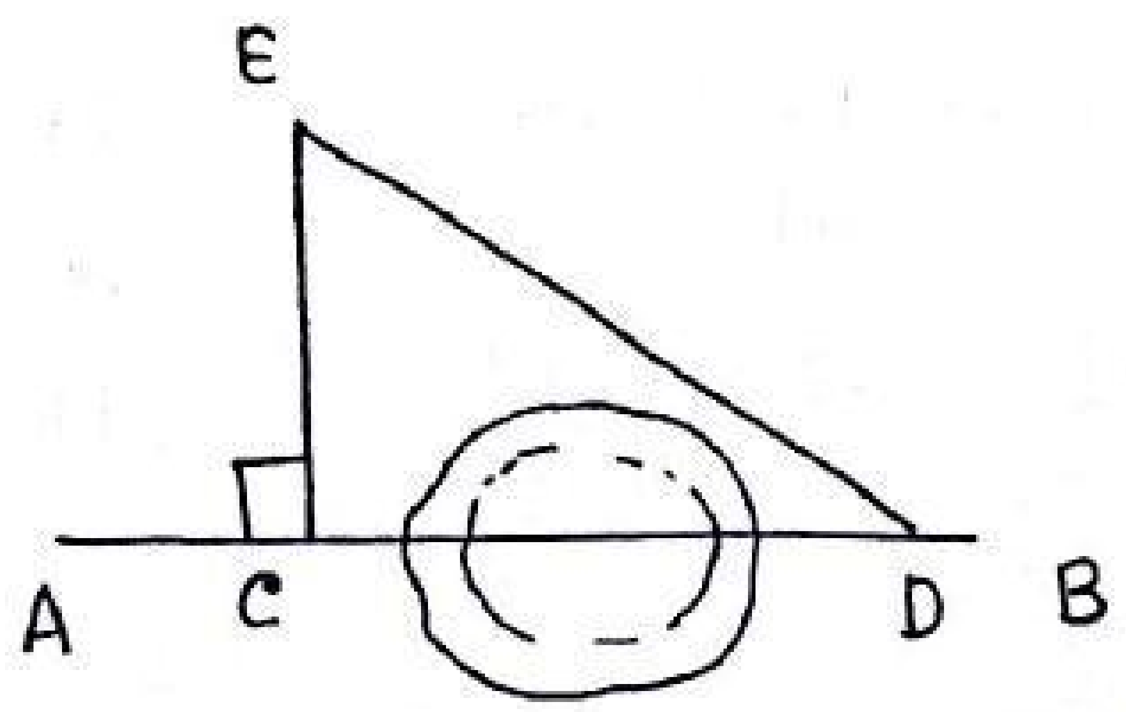
Distance $PE_1 = \sqrt{PE^2 + EE_1^2}$

2) <u>Chaining obstructed but vision free</u> :-

Such a problem arises when a pond or a river comes across the chain lines.

<u>case - I</u> :- when a pond interupts the chain line, it is possible to go around the obstruction.





Suppose AB is the chain line. Two points C & D are selected on it on opposite banks of the pond. Equal perpendicular CE and DF are selected at C & D.

The distance EF is measured.

Here $CD = EF$

The pond may also be crossed by forming a triangle as shown in the figure.

A point C is selected on the chain line. The perpendicular CE is set out at C and a line ED is suitably taken. The distances CE & ED are measured $CD = \sqrt{ED^2 - CE^2}$

Case II :- Sometimes it is not possible to go around the obstruction.

a) Imagine a small river comes across the chain line:- Suppose AB is the chain line. Two points C & D are selected on this line on opposite banks of the rivers At C, a lar CE is erected and bisected at F. A lar is set out at E and a point G is so selected on it that D, F & G are in the same St. line.

From Δs DCF & GEF

$GE = CD$

This distance GE is measured and thus the distance CD is obtained indirectly.

b) Consider the case when a large river interrupts the chain line:-

Let AB be the chain line. Points C, D & E are selected on this line such that D & E are on opposite banks of the river. The lars DF & CG are erected on the chain line in such a way that E, F, G are on the same straight line. The line FH is taken parallel to CD.

Now, from triangles DEF & HFG

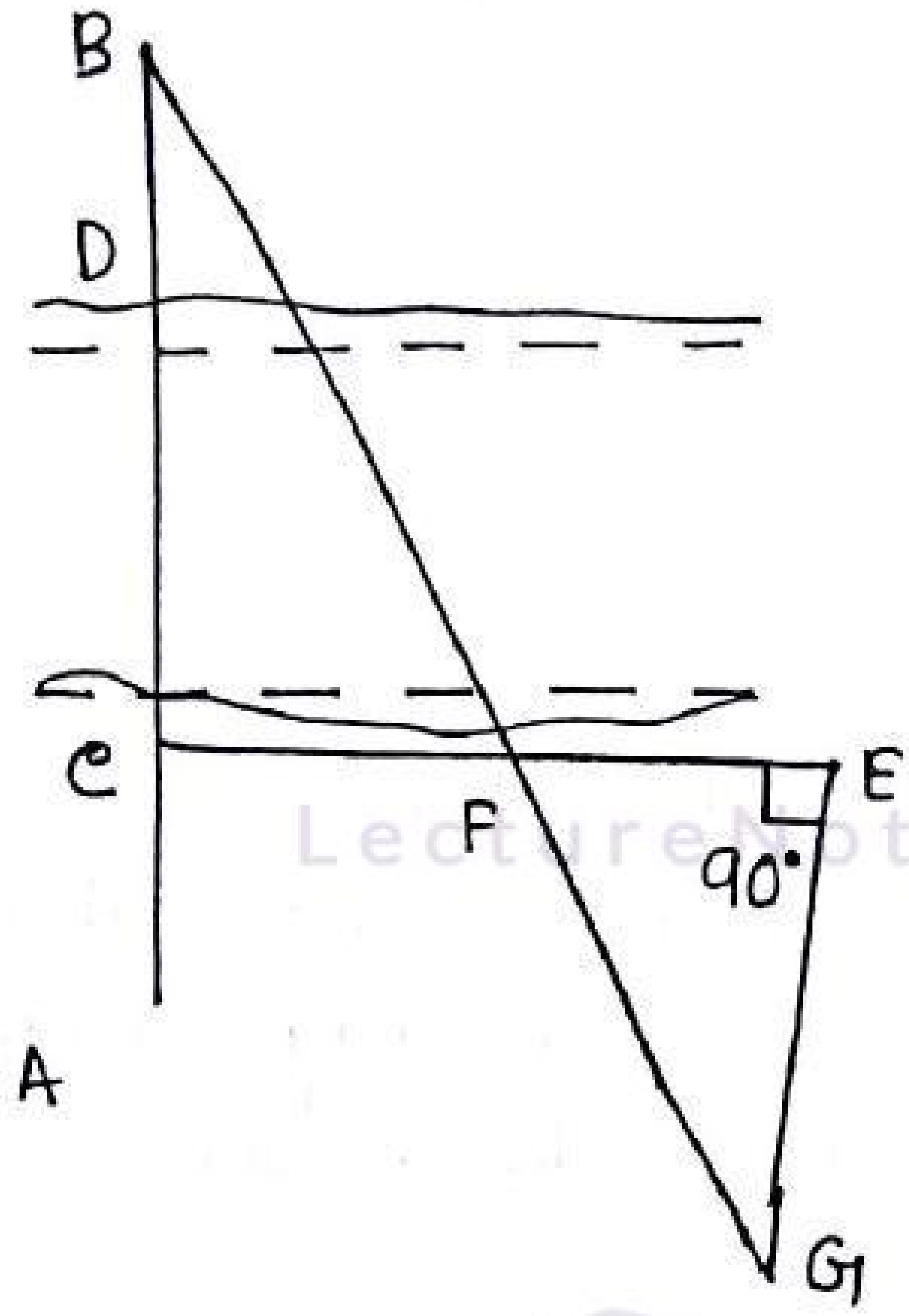
$$\frac{ED}{DF} = \frac{FH}{HG} \quad \text{where } FH = CD$$

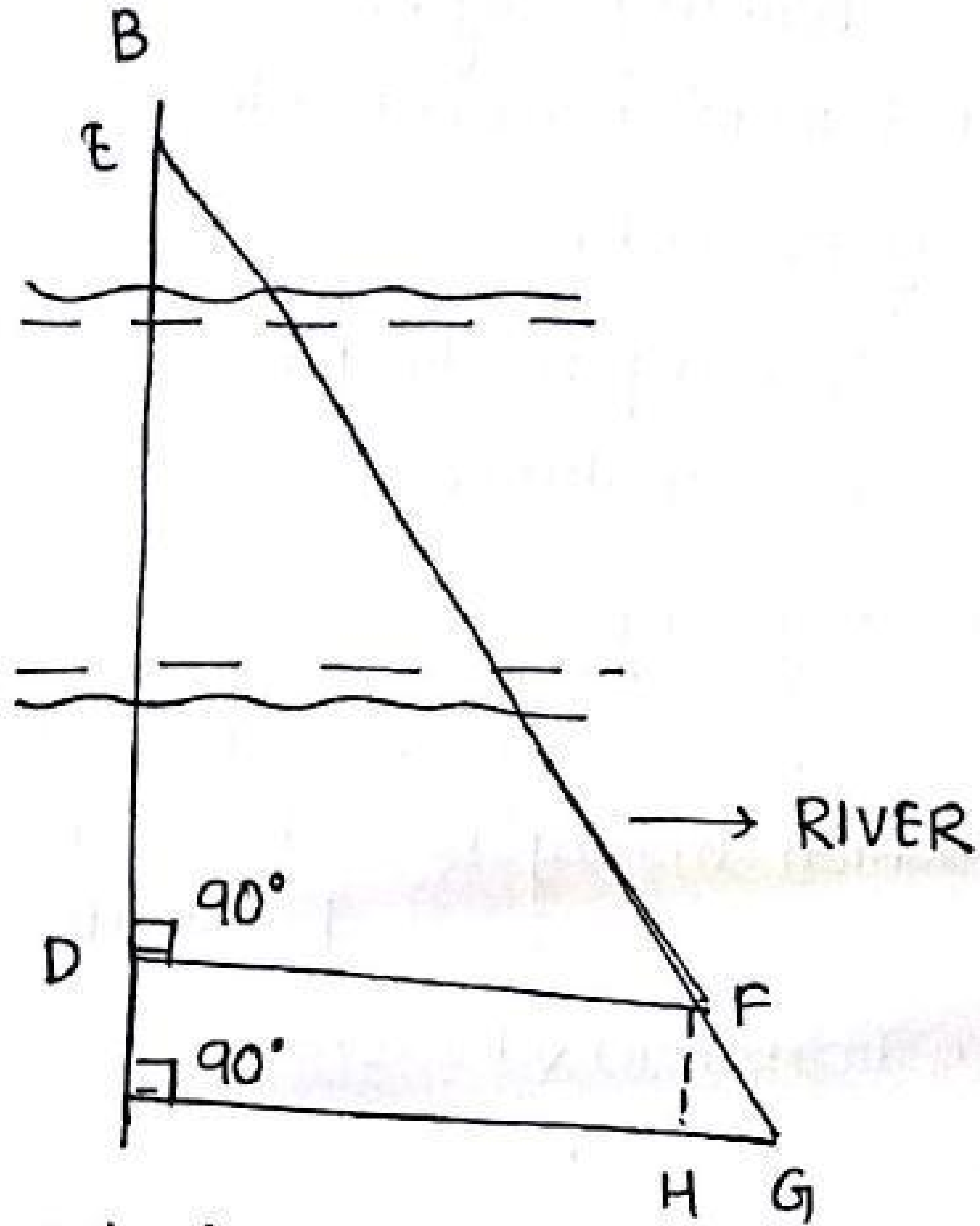
$$ED = \frac{FH}{HG} \times DF \qquad CH = DF$$

$$HG = CG - CH$$

$$= \frac{CD}{CG - DF} \times DF \qquad HG = CG - DF$$

The distances CD, DF and CG are measured. Thus, the required distance ED can be calculated.





3) Chaining and vision both obstructed

Such a problem arises when a building comes across the chain lines. It is solved in the following manner.

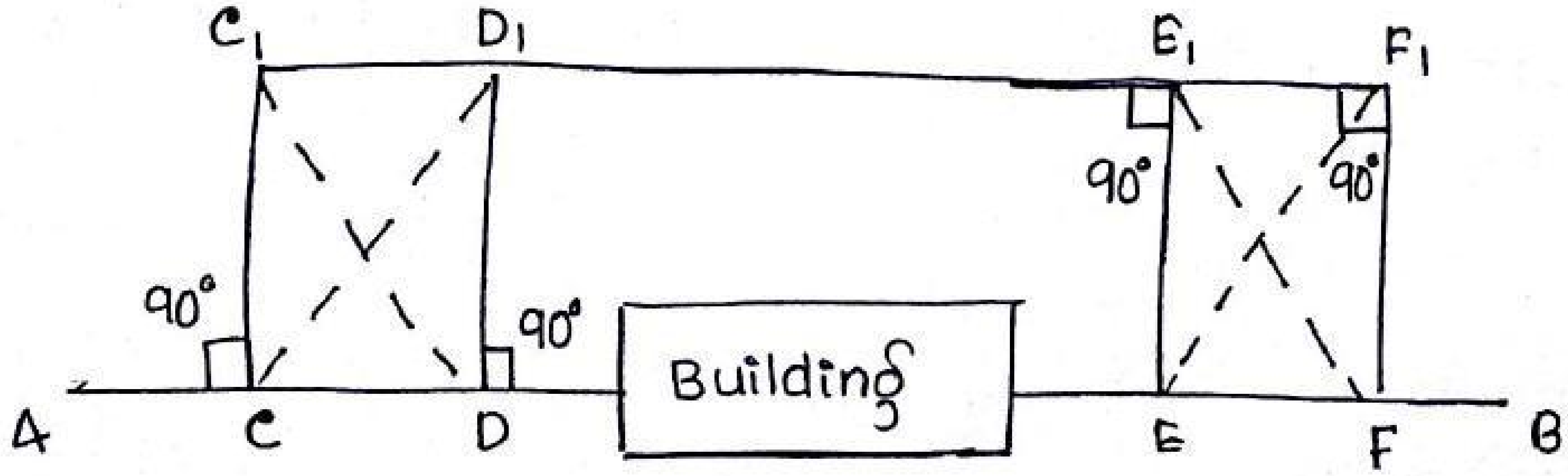
Supposed AB is the chain line. Two points C and D are selected on it at one side of the building. Equal perpendicular CC_1 and DD_1 are erected. The line C_1D_1 is extended until the building is crossed. On the extended line, two points E_1 & F_1 are selected. Then perpendiculars E_1E and F_1F are so erected that.

$$E_1E = F_1F = D_1D = C_1C$$

Thus, the points C, D, E and F will lie on the same straight line AB.

Here $DE = D_1E_1$

The distance D_1E_1 is measured and is equal to the required distance DE.



Errors and mistakes in chaining :-

Error in chaining may be caused due to variation in temperature and pull defect in instruments etc.

They may be either

1. Compensating or
2. Cumulative

Compensating Error :-

1) Error which may occur in both dirn (i.e., both positive and -ve) and which finally tend to compensate are known as compensating errors. These errors donot affect survey work seriously. They are proportional to $\sqrt{L}$, where L is the length of the line. Such errors may be caused by

a) Incorrect holding of the chain.

b) Horizontality are verticality of steps not being properly maintained during the stepping operation.

c) Fractional parts of the chain or tape not being uniform throughout its length &

d) Inaccurate measurement of right angles with chain & tape.

2) Cumulative error

→ Errors which may occur in the same dirn and which finally tend to accumulate are said to be cumulative.

→ They seriously affect the accuracy of the work and are proportional to the length of the line (L). The error may be +ve or -ve.

Positive errors:- when the measured length is more than the actual length (i.e., when the chain is too short) the error is said to be positive.

Negative errors:- when the measured length of the line is less than the actual length.

3) Mistakes

Errors occurring due to the carelessness of the chainman are called mistakes.

Few common mistakes are:-

a) Displacement of arrows

b) Reading may be taken from the wrong end of the chain.

c) Some no. may be called wrongly

d) Interchanging of figures while doing a entry in the databook.

Chain and Tape Correction:-

A. Tape Correction:-

1) Temperature correction (C_t)

This correction is necessary because the length of the tape or chain may increase or decrease due to rise or fall of temp. during measurement.

It can be given by

$$C_t = \alpha (T_m - T_o) L$$

where,

C_t = Correction for temp. in meters

α = Coeff. of thermal expansion

T_m = Temp. during measurement in degree centrigrade or celsius

L = length of tape, in metre

α may be assumed as 11×10^{-6} per degree centrigrade or celsius.

The sign of correction may be +ve or -ve according as T_m is greater or less than T_o.

2) Pull correction (C_p)

During measurement, the applied pull may be either more or less than the pull at which the chain or tap was standardised. Due to the elastic property the strain may vary, so necessary correction should be applied

$$C_p = \frac{(P_m - P_o) L}{A \times E}$$

where C_p = Pull correction (m)

P_m : Pull applied during measurement, in Kgs

P_0 : Pull at which the tape was standardised in kgs

L : Length of tape, in metre

A : Cross-sectional area of tape, in cm^2

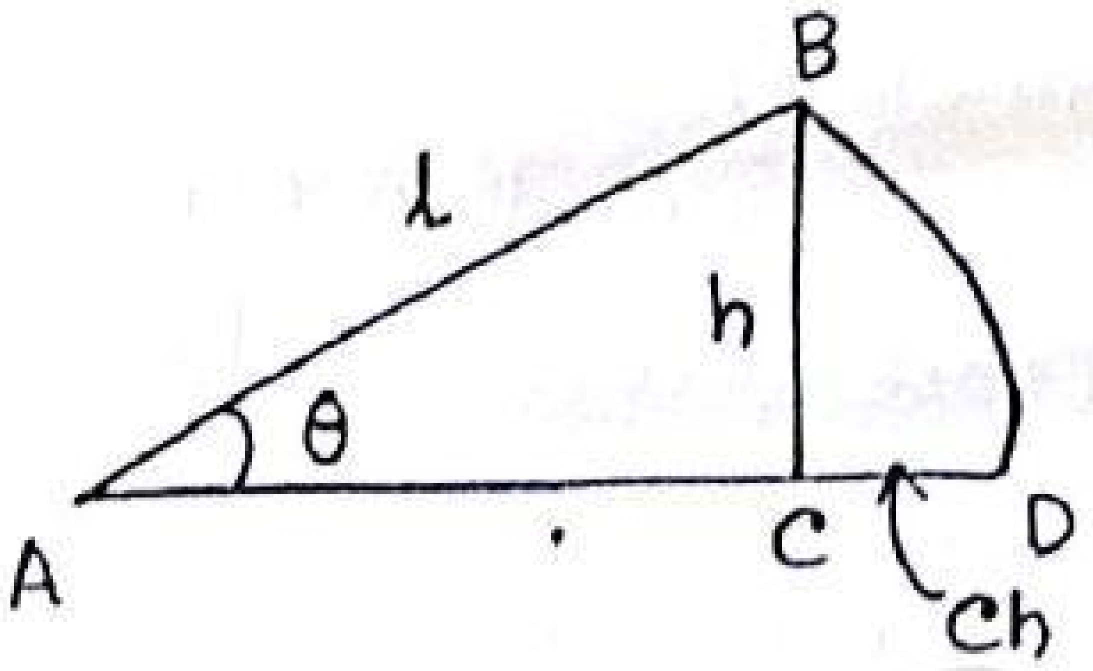
E : modulus of elasticity (Young's modulus) when E is not given, assume it as 2.1×10^6 kg/cm^2. The sign of correction will be +ve or -ve. according as P_m is greater or less than P_0.

3> Slope Correction (C_h)

$C_h = l - \sqrt{l^2 - h^2}$

$= l(1-\cos\theta)$

$= \dfrac{h^2}{2l}$



4> Sag correction (C_s):-

This correction is necessary when the measurement is taken with the tape in suspension

$$C_s = \frac{L(wL)^2}{24n^2 P_m^2}$$

$$C_s = \frac{LW^2}{24n^2 P_m^2}$$

where total wt. is given

where, C_s = sag correction (meter)

L = length of tape or chain in meters)

w = weight of tape per unit length, in kgs/m.

W : total wt. of tape, in kgs

n : no of spans

P_m : pull applied during measurement in kgs.

The sign is always -ve.

5) Normal Tension (P_n):-

The tension at which the effect of pull is neutralised by effect of sag is known as normal tension.

$$\frac{(P_n - P_0)L}{AE} = \frac{L(wL)^2}{24P_n^2} \quad \text{(considering } n=1)$$

where P_n = normal pull or tension.

Here, the value of P_n may be determined by trial.

$$\frac{(P_n - P_0)L}{AE} = \frac{L(wL)^2}{24P_n^2} \quad \text{(considering } n=1)$$

$$\Rightarrow \frac{(P_n - P_0)}{AE} = \frac{w^2}{24P_n^2}$$

$$\Rightarrow (P_n - P_0)P_n^2 = \frac{w^2 AE}{24}$$

By substituting the values of P_0, w, A and E an eqn will be obtained by $xP_n^3 \pm xP_n^3 \pm C = 0$

B. Chain correction.

1) Correction Applied to Incorrected length.

True length of line (TL) = $\left(\frac{L'}{L}\right)$ x measured length (ML)

where, L = true length of line

L' = true length ± error

= $L \pm e$

use +ve sign when the chain or tape is too long and -ve sign when it is too short.

2) Correction of Incorrect area

True area = $\left(\frac{L'}{L}\right)^2$ x measured area

3) Hypotenusal Allowance

Hypotenusal allowance per tape = $L(\sec\theta - 1)$

where L = length of tape

θ = Slope of ground

This allowance is always added to the tape length

Principle of chain surveying:-

The principle of chain surveying is triangulation. This means that the area to be surveyed is divided into no. of small triangle which should be well conditioned.

Chain surveying is recommended when

1> The ground surface is more or less level.

2> A small area is to be surveyed

3> A small- scape map is to be prepared and

4> A formation of well conditioned triangles is easy.

Chain surveying is unsuitable when

1> The area is crowded with many details

2> The area consists of too many undulations.

3> The area is very large and

4> The formation of well conditioned triangles becomes difficult due to obstacles

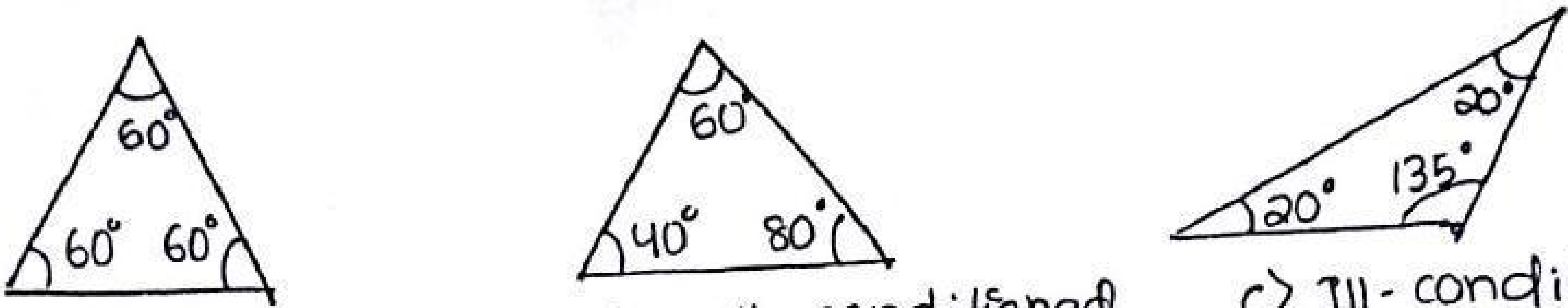
Well-conditioned and ill-conditioned triangles:-

A triangle is said to be well-conditioned when no angle in it is less than 30° or greater than 120°.

→ An equilateral triangle is considered to be the best-condition or ideal triangle.

→ well-conditioned triangles are preferred because their apex points are very sharp and can be located by a single 'dot'. In such a case, there is no possibility of relative displacement of the plotted point.

→ A triangle in which an angle is less than 30° or more than 120° is said to be ill conditioned.



a) Ideal triangle   b) well-conditioned triangle   c) Ill-conditioned triangle

SUMMARY:-

In this section, we disscussed about uses of surveying, methods of linear measurement. Different types of chains & tapes and its testing was also mentioned and also discussed about various methods of chaining on level ground & sloping ground and also got to know about various obstacles in chaining and how to check that lastly discussed about its various errors which occured during work and how to overcome that was discussed.

Chapter - 2 :- COMPASS SURVEYING

Introduction and purpose :-

Chain surveying can be used when the area to be surveyed is divided into a no. of triangles. This method is suitable for fairly level ground covering small areas.

But when the area is large, undulating and crowded with many details, triangulation is not possible. In such area method of traversing is adopted.

In traversing, the framework consist of connected lines. The lengths are measured by chain or tape and the directions are identified by angle measurement by an instrument called 'prismatic compass'. Hence, the total process can be termed as compass surveying.

True meridian :-

The line or plane passing through the geographical north pole, geographical south pole and any point on the surface of the earth, is known as the 'true meridian' or geographical meridian'. The true meridian at a station is constant.

The angle betn the true meridian and a line is known as 'true bearing' of the line. It is also known as the 'azimuth'.

Magnetic meridian :-

When a magnetic needle is suspended freely and balanced properly, unaffected by magnetic substance it indicates a dirn. This dirn is known as the 'magnetic meridian'.

The angle betn the magnetic meridian and a line is known as the 'magnetic bearing' or simply the 'bearing of the line.

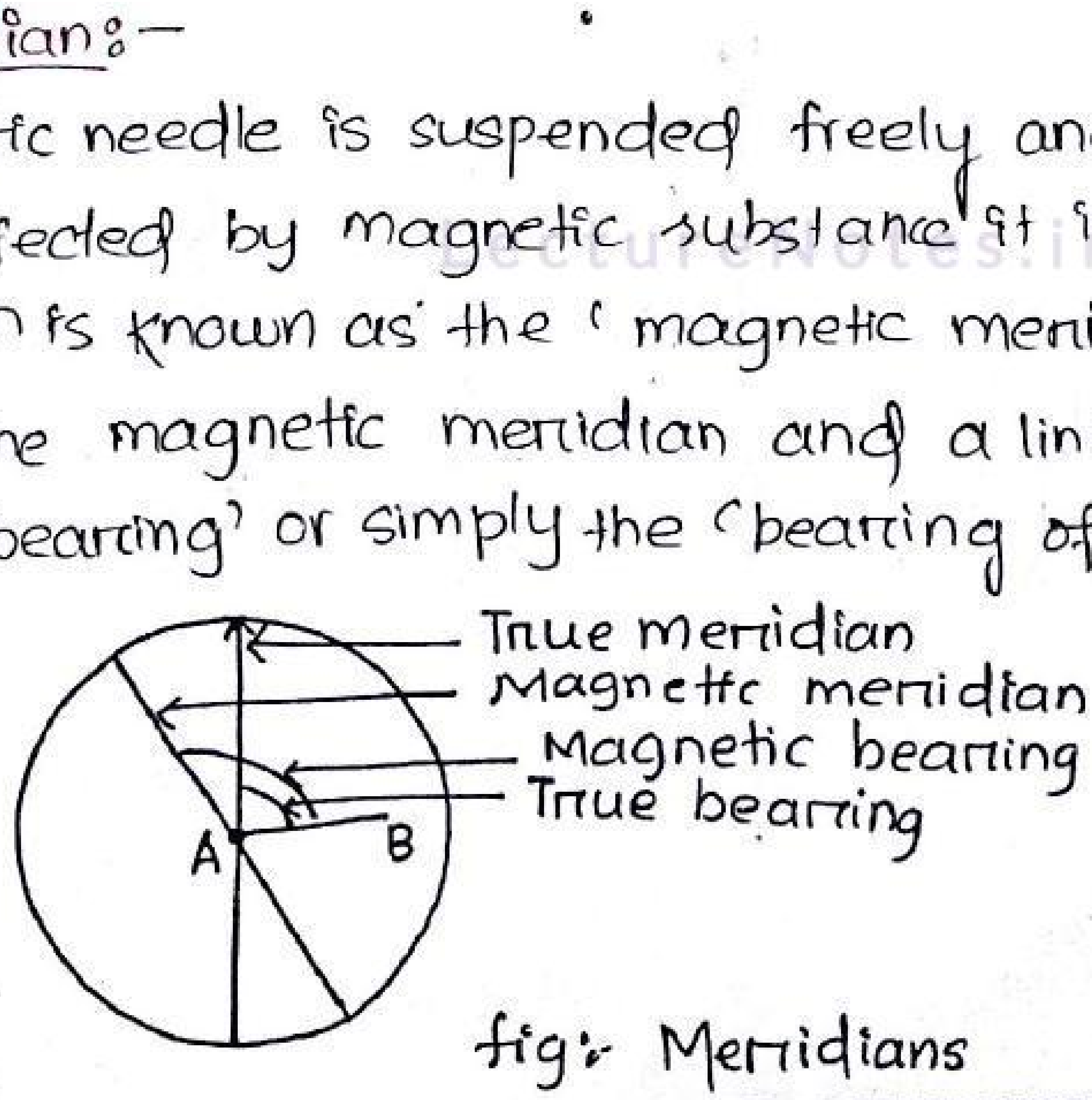


fig:- Meridians

Arbitary meridian

Sometimes for the survey of a small area, a convenient dirn is assumed as a meridian known as the 'arbitary meridian'. The angle between the arbitary meridian and a line is known as the 'arbitary bearing' of the line.

Grid meridian

Sometimes, for preparing a map, some state agencies assume several lines parallel to the true meridian for a particular zone. These lines are termed grid lines and the central line the 'grid meridian'. The bearing of a line w.r.t the grid meridian is known as the grid bearing of the line.

Designation of magnetic bearing

Magnetic bearing are designated by two systems:-

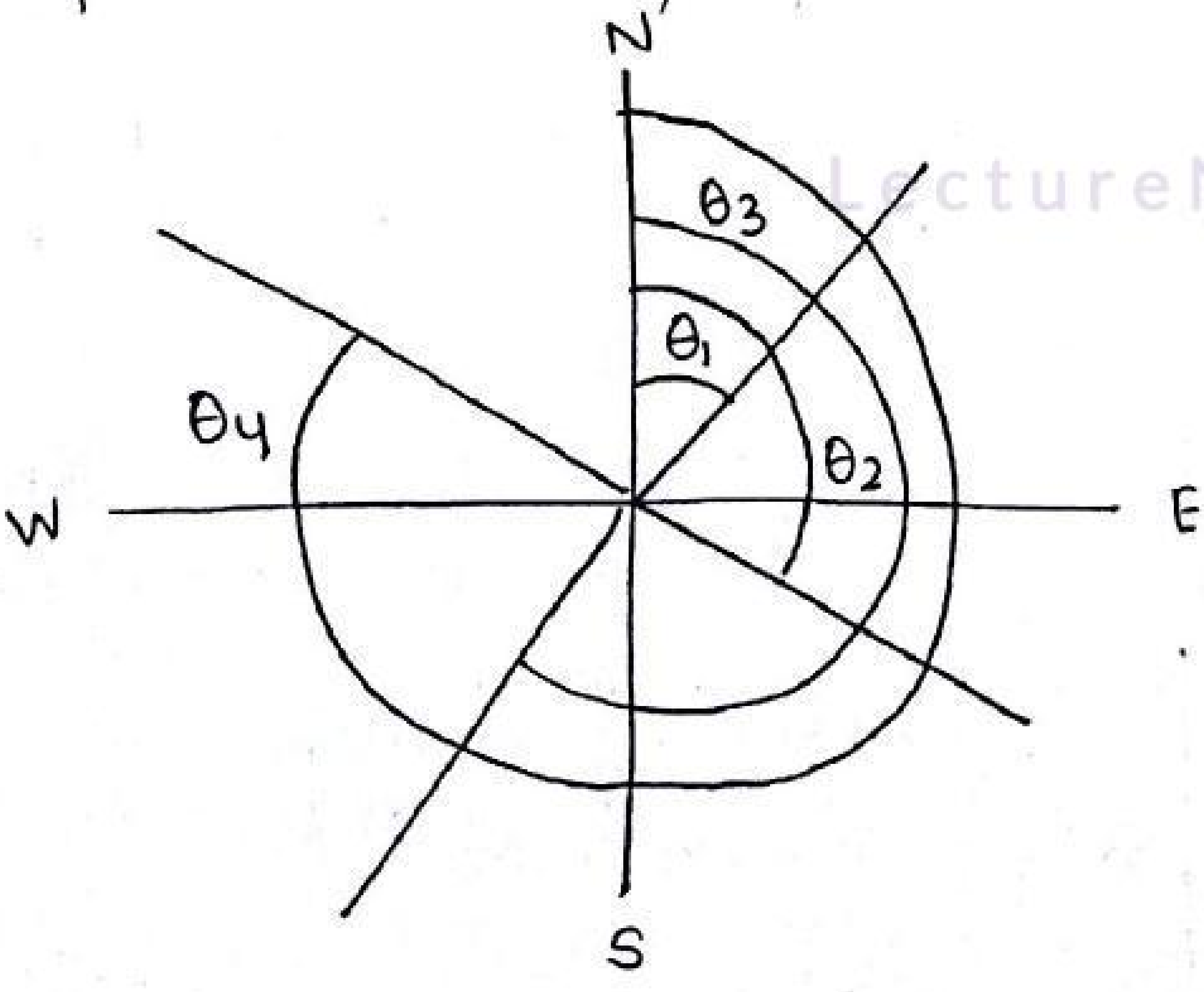
a) whole circle bearing (WCB)
b) Quadrantal bearing (QB)

a) whole circle bearing (WCB)

The magnetic bearing of line measured clockwise from the north pole towards the line, is known as the 'whole circle bearing' of that line.

Such a bearing may have any value between 0° & 360°

The WCB of a line obtained by prismatic compass



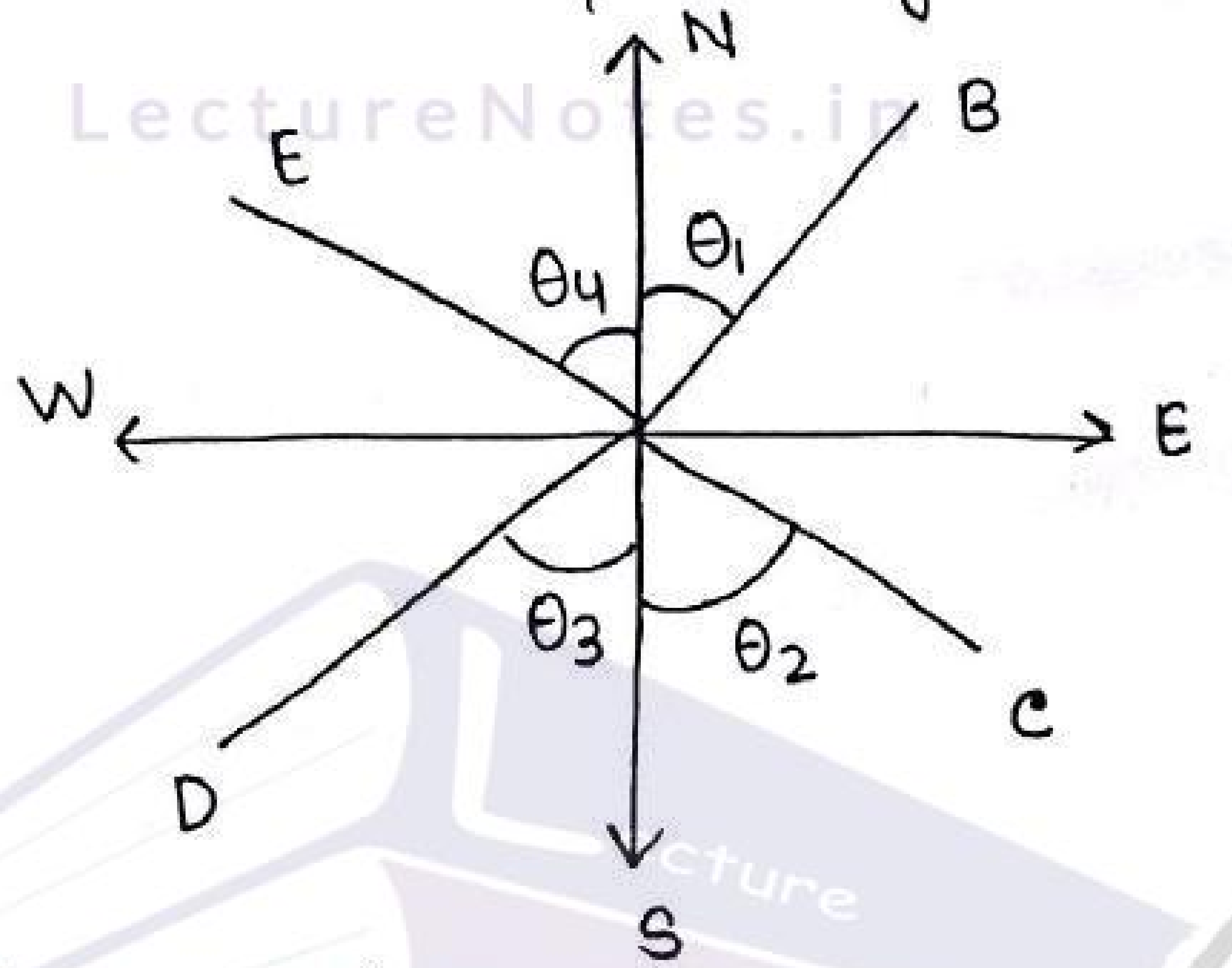
WCB of AB = θ_1
WCB of AC = θ_2
WCB of AD = θ_3
WCB of AE = θ_4

Quadrantal Bearing (QB)

The magnetic bearing of a line measured clockwise or counter clockwise from the north pole (whichever is nearer the line) towards the East or west is known as the 'Quadrantal Bearing of the line.

→ This system consists of 4 quadrants NE, SE, SW and NW. The value of a quadrantral bearing lies betn 0° and 90°. but the quadrant should always be mentioned.

→ They are obtained by surveyor's compass.



Quadrantal Bearing (QB)

QB of AB = $N\theta_1 E$

QB of AC = $S\theta_2 E$

QB of AD = $S\theta_3 W$

QB of AE = $N\theta_4 W$

Reduced Bearing (RB)

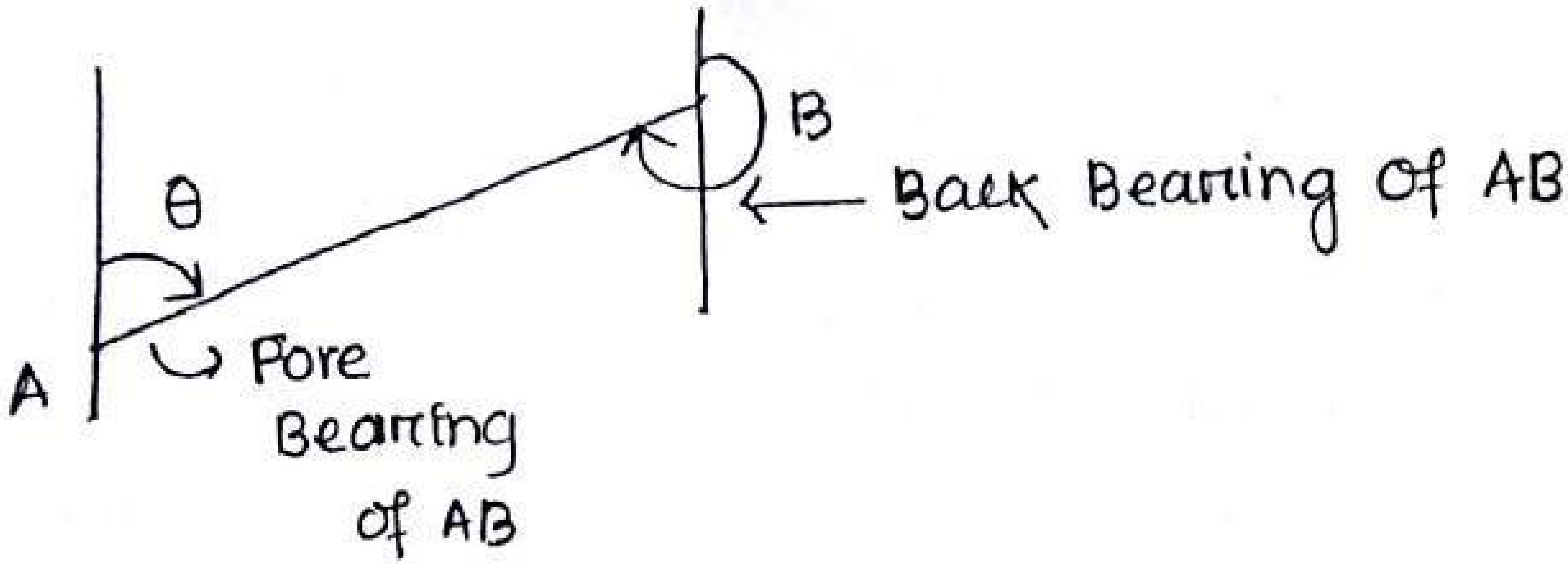
when the WCB of a line is converted to quadrantal bearing, it is termed as the reduced bearing.

→ It lies betn 0° and 90°, but the quadrants should be mentioned for proper designation.

WCB between	Corresponding RB	Quadrant
0° and 90°	RB = WCB	NE
90° and 180°	RB = 180° − WCB	SE
180° and 270°	RB = WCB − 180°	SW
270° and 360°	RB = 360° − WCB	NW

Fore and Back bearing :-

Every line has two bearings :- One is observed along the progress of the survey or forward dirn and is called 'fore bearing' and the second is observed in the reverse or opposite dirn and is called back bearing.



Back bearing = Fore bearing ± 180°

Use +ve sign when fore bearing is less than 180° and use −ve sign when it is more than 180°

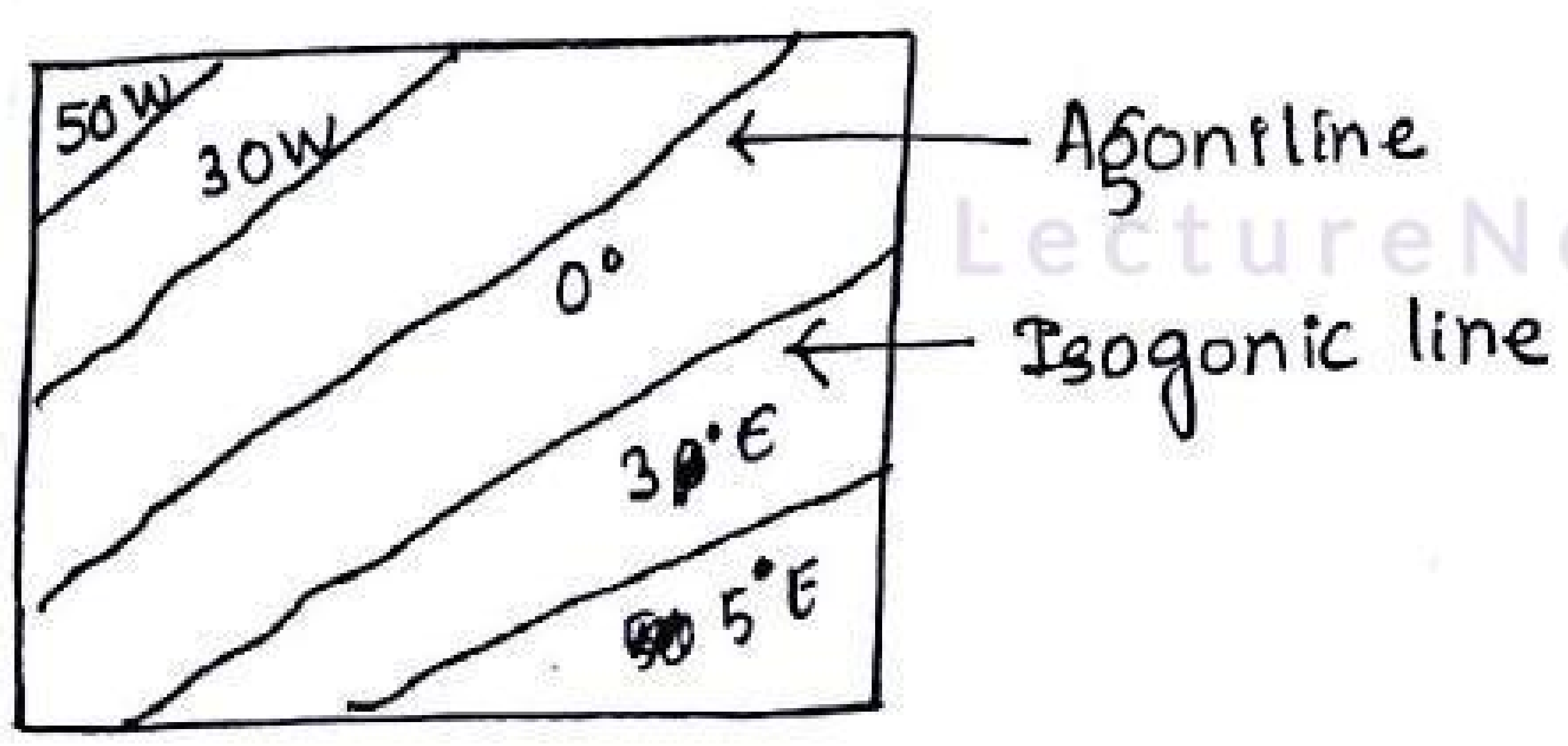
Magnetic Declination :-

The horizontal angle betn the magnetic meridian and true meridian is known as magnetic declination.

Isogonic and Agonic lines

→ Lines passing through points of equal declination are known as isogonic lines.

→ The line passing through points of zero declination is said to be the agonic lines.



Dip of the magnetic needle:-

If a needle is perfectly balanced before magnetisation, it doesn't remain in the balance position after it is magnetised. This is due to the magnetic influence of the earth. The needle is found to be inclined towards the pole. This inclination of the needle with the horizontal is known as the "dip of the magnetic needle".

Local Attraction

A magnetic needle indicates the north-dirn when freely suspended or pivoted. But if the needle comes near some magnetic substance, such as iron ore, steel structures, electric cables conveying current etc, it is found to be deflected from its true dirn and does not show the actual north. This disturbing influence of magnetic substance is known as 'local attraction'.

Principle of compass surveying

The principle of compass surveying is traversing, which involves a series of connected lines. The magnetic bearings of the lines are measured by prismatic compass and the distances of the lines are measured by chain. Such survey doesnot require the formation of a network of triangles.

compass surveying is recommended when

1- A large area to be surveyed.
2- The course of a river or coast line is to be surveyed and
3- The area is crowded with details and triangulation is not possible.

Traversing:-

surveying which involves a series of connected lines is known as 'transversing'. The sides of the traverse are known as "traverse legs".

A traverse may be of two types - closed and open.

Closed traverse

when a serries of a connected lines forms a closed circuit i.e., when the finishing point coincides with the starting point of a survey, it is called a 'closed traverse'.

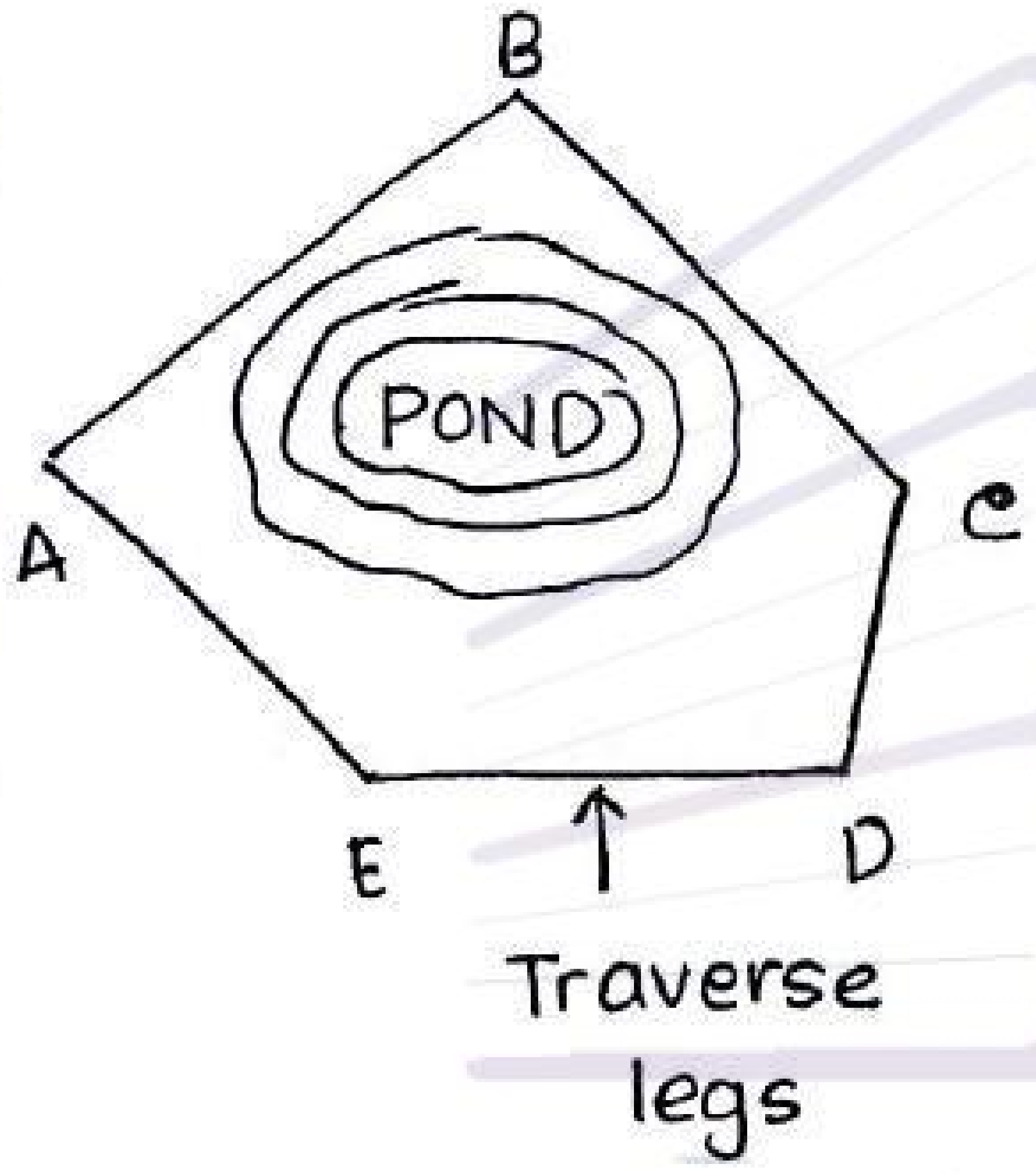
Here ABCDEA represents a closed traverse closed traverse is suitable for the survey of boundaries of ponds, forests, estates etc.

Open traverse

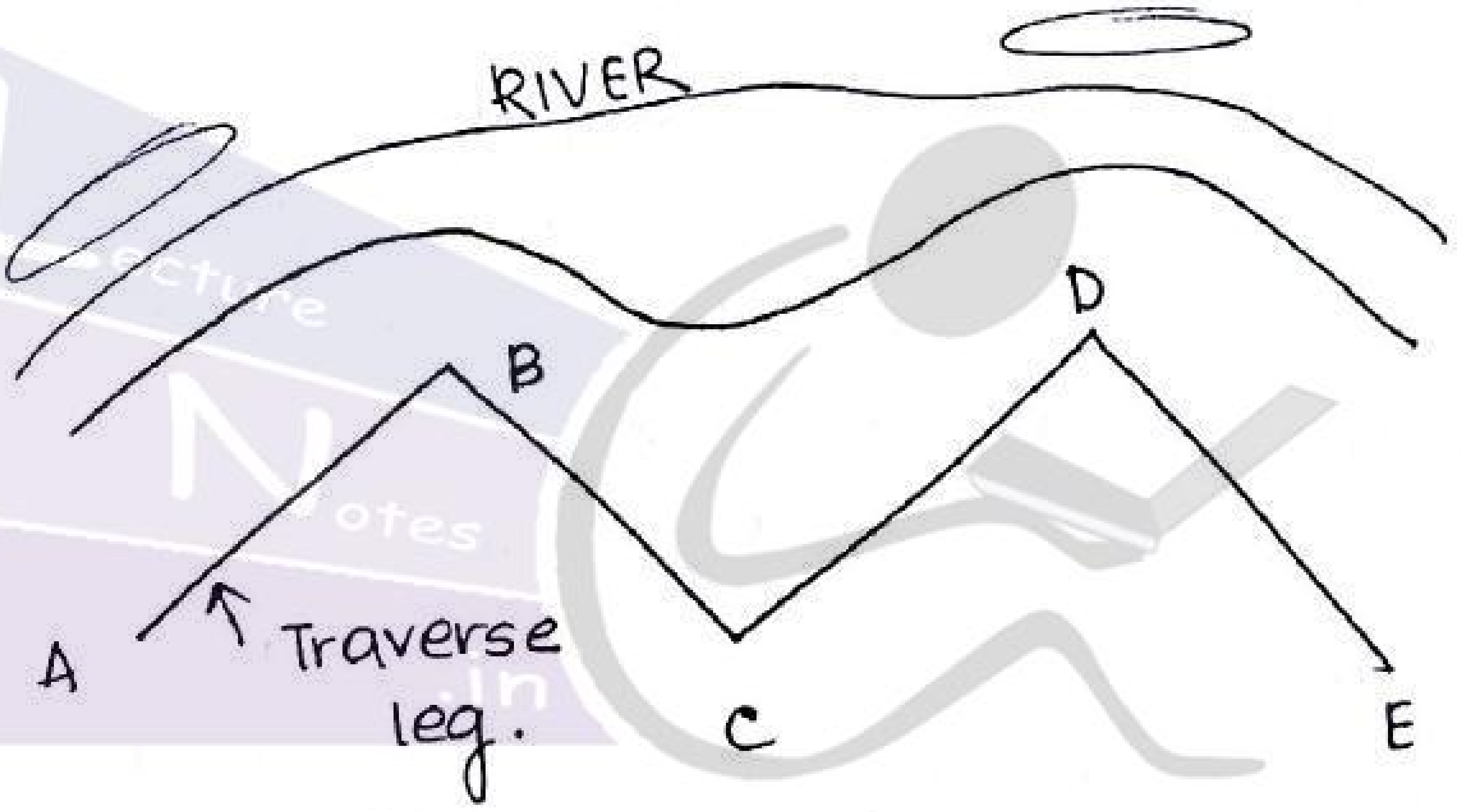
when a sequence of connected lines extends along a general dir^n and doesn't return to the starting point, it is known as 'open traverse'.

Ex:- ABCDE is an open traverse.

- It is suitable for the survey of roads, rivers, coast lines etc.



Closed traverse



Open traverse

CHECK ON CLOSE TRAVERSE

1. Check on Angular measurement

a) The sum of the measured interior angles should be equal to $(2N-4)\times 90^\circ$ where N is the no. of sides of the traverse.

b) The sum of the measured exterior angles should be equal to $(2N+4)\times 90^\circ$

c) The algebraic sum of the deflection angles should be equal to 360°

NOTE:- Right hand deflection is +ve and left hand deflection is -ve.

2) Check on linear measurement:-

a) The lines should be measured once each on two diff. days. Both measurements should tally.

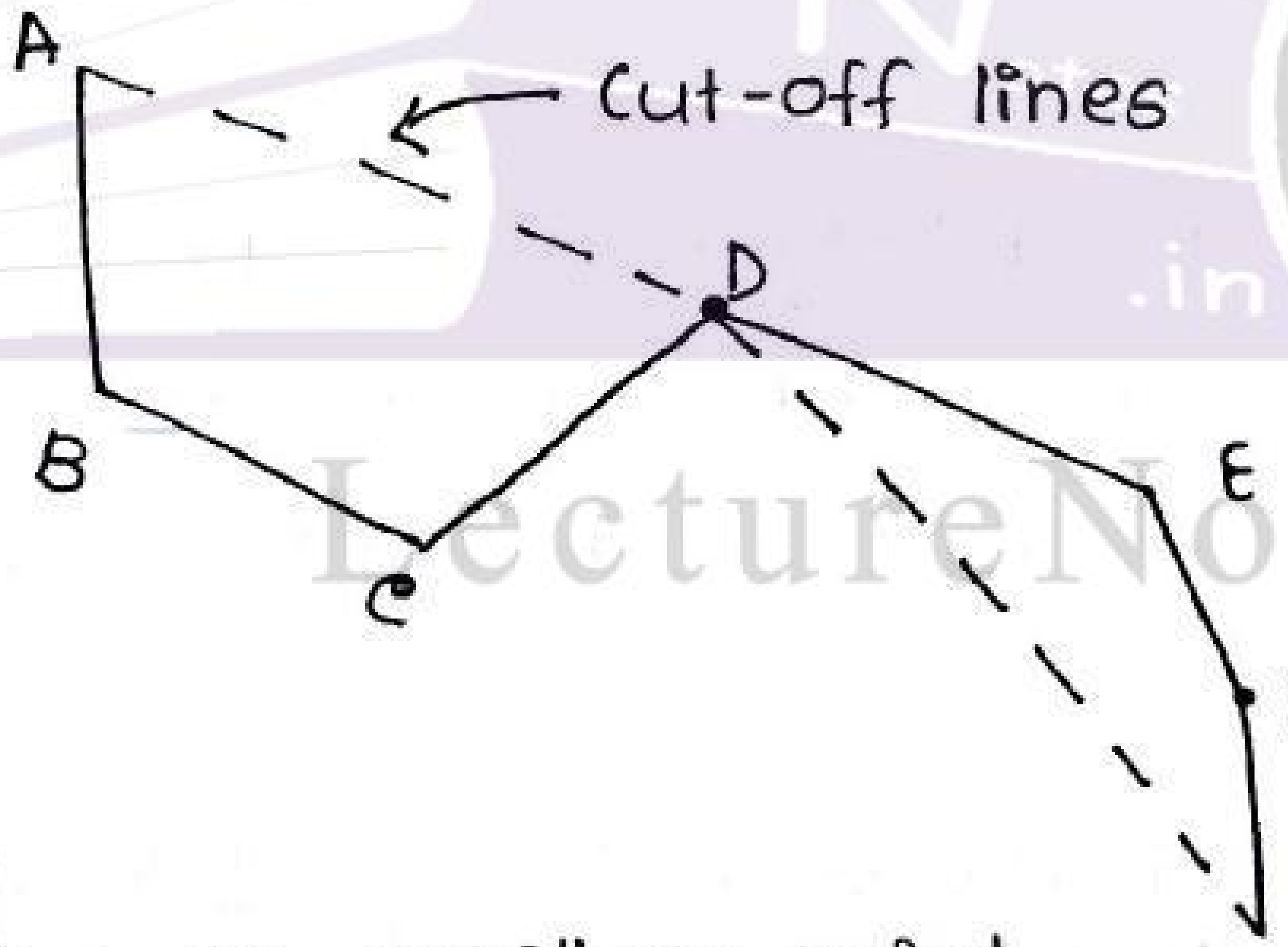
b) Linear measurements should also be taken by the stadia method. The measurements by chaining and by the stadia method should tally.

CHECK ON OPEN TRAVERSE

1. Taking cut-off lines:-

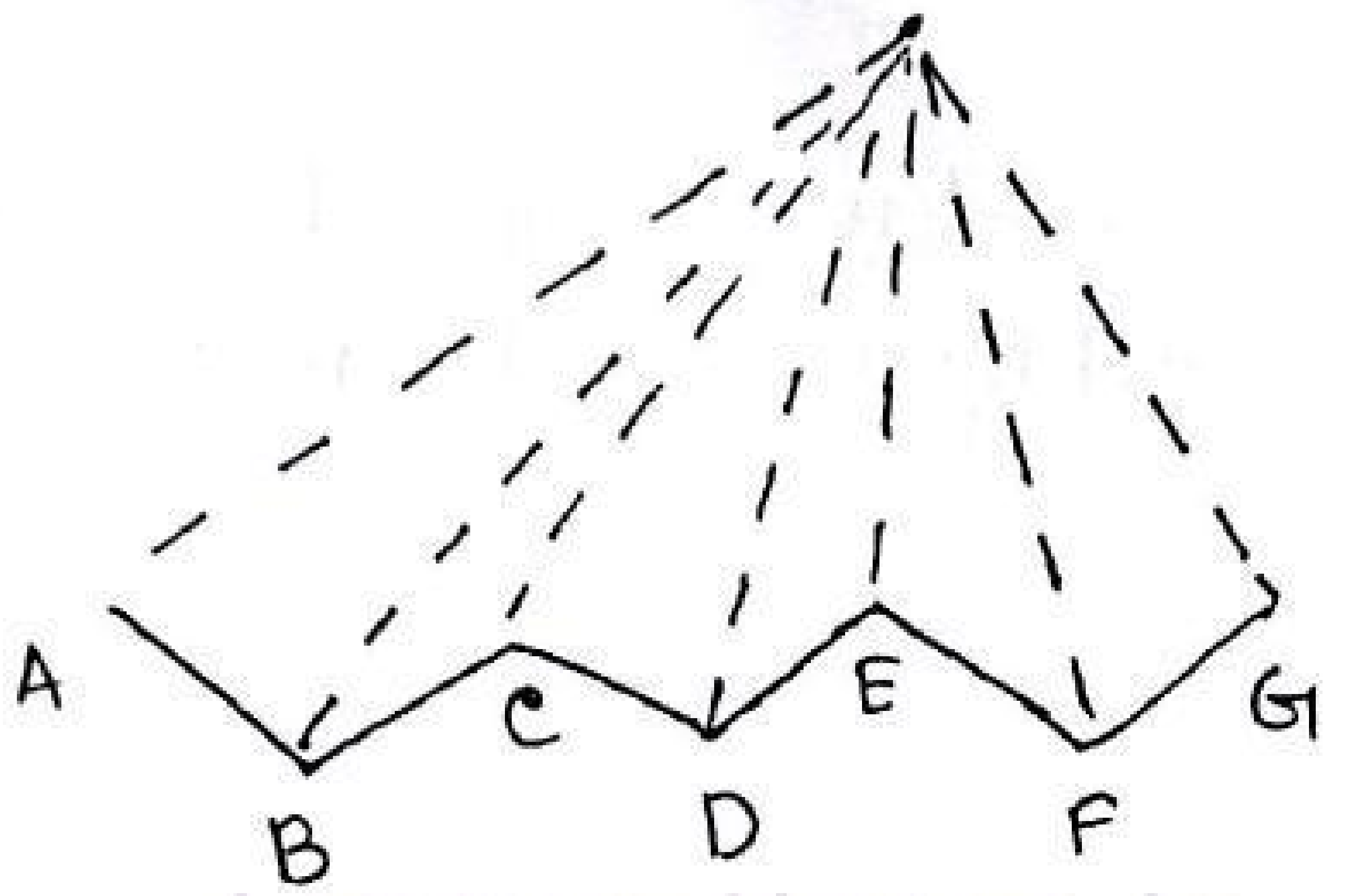
Cut-off are taken between some intermediate stations of the open traverse.

Lets just say ABCDEFG represents an open traverse. Let AD and DG be the cut-off lines. The lengths and magnetic bearings of the cut-off lines are measured accurately. After plotting the traverse, the distances and bearings are noted from the map. These distances and bearing should tally with the actual records.



2. Taking an auxillary point

Let us assume that ABCDEFG is an open traverse. A permanent point P is selected on one side of it. The magnetic bearing of this point are taken from the traverse station A, B, C, D etc. If the survey is carried out accurately and so is the plotting, all the measured bearings of P when plotted should meet at the point P. The permanent point P is known as the auxillary point.



Types of Compass:-

There are two types of compasses:-

1> The prismatic compass

2> The surveyor's compass

1> Prismatic compass:-

The essential parts of prismatic compass are as follows:-

a> Compass Box:- The compass box is a circular metallic box of 8 to 10 cm diameter.

b> Magnetic Needle and Graduated Ring:- The magnetic needle is made of a board, magnetic iron bar. The bar is pointed at both ends. The magnetic needle is attached to a graduated aluminium ring.

The ring is graduated from 0° to 360° clockwise, and the graduations begin from south end of the needle. Thus, 0° is marked at the south, 90° at the west 180° at the north and 270° at the east.

c> Sight vane and prism:- The prism vane and the reflecting prism are fixed diametrically opposite to the box.

d> Dark Glasses:- Two dark glasses are provided with the prism. The red glass is meant for sighting luminous objects at night and the blue glass for reducing the strain on the observer's eye in bright daylight.

e) Adjustable Mirror:- A mirror is provided with the sight vane. The mirror can be lowered or raised and can be inclined.

f) Brake Pin:- A brake pin is provided just at the base of the sight vane. It pressed gently, it stops the oscillations of the ring.

g) Lifting pin:- A lifting pin is provided just below the sight vane. When the sight vane is folded, it presses the lifting pin.

h) Glass cover:- A glass cover is provided on top of the box to protect the aluminium ring from dust.

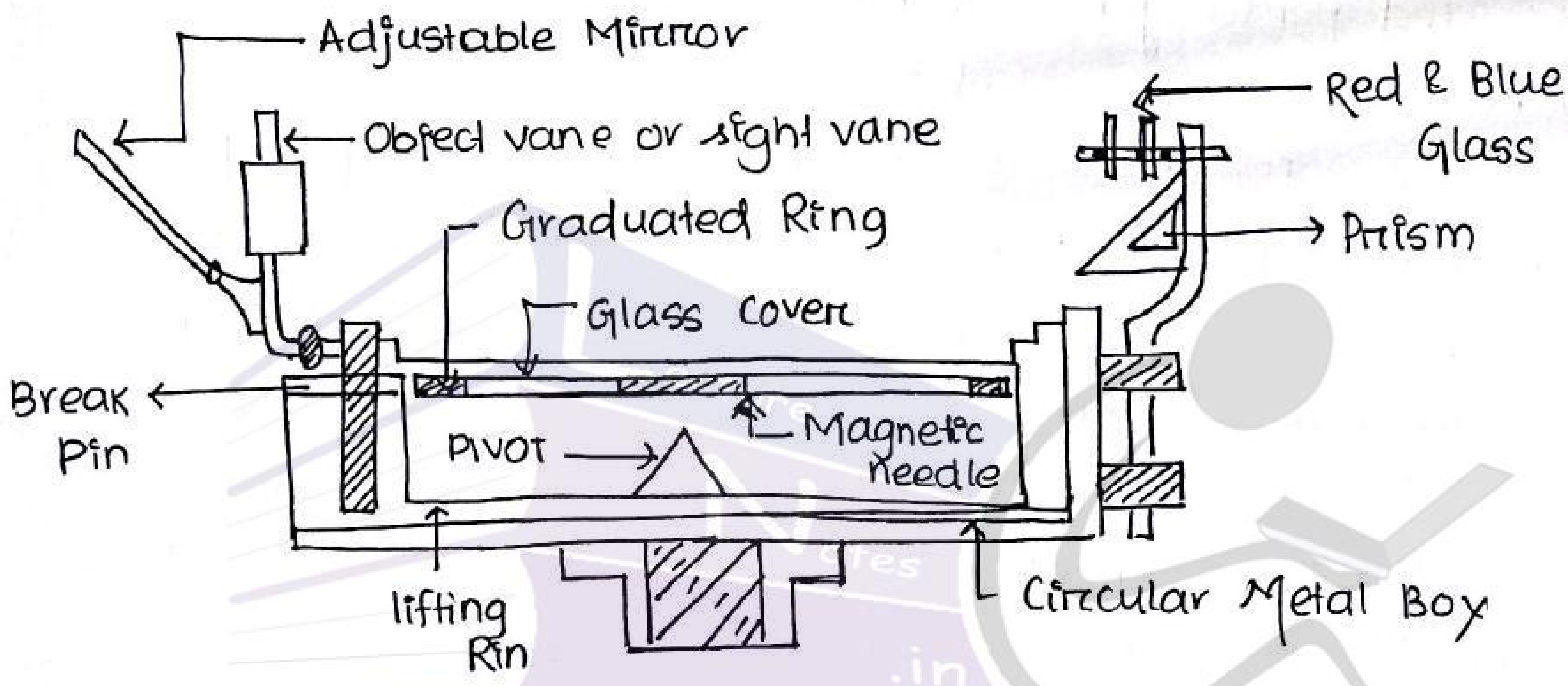


fig:- Prismatic compass

Temporary Adjustment of Prismatic compass

The following procedure should be adopted while measuring the bearing by prismatic compass:-

1. Fixing the compass with Tripod stand:-
The tripod stand is placed at the required station with its legs well apart. Then the prismatic compass is held by the left hand and placed over the threaded top of the stand.

2. Centering:- Normally, the compass is centered by dropping a piece of stone from the bottom of the compass box. Centering may also be done with the aid of a plumb bob held centrally below the compass box.

3> Levelling :- levelling is done with the help of a ball and socket arrangement provided on top of the tripod stand.

4> Adjustment of prism :-

The prism is moved up and down till the figures on the graduated ring are seen sharp and clear.

5> Observation of Bearing

After centering and leveling the compass box over the station, the ranging rod at the required station, ~~the ranging rod~~ is bisected perfectly by sighting through the slit of the prism and horsehair at the sight vane.

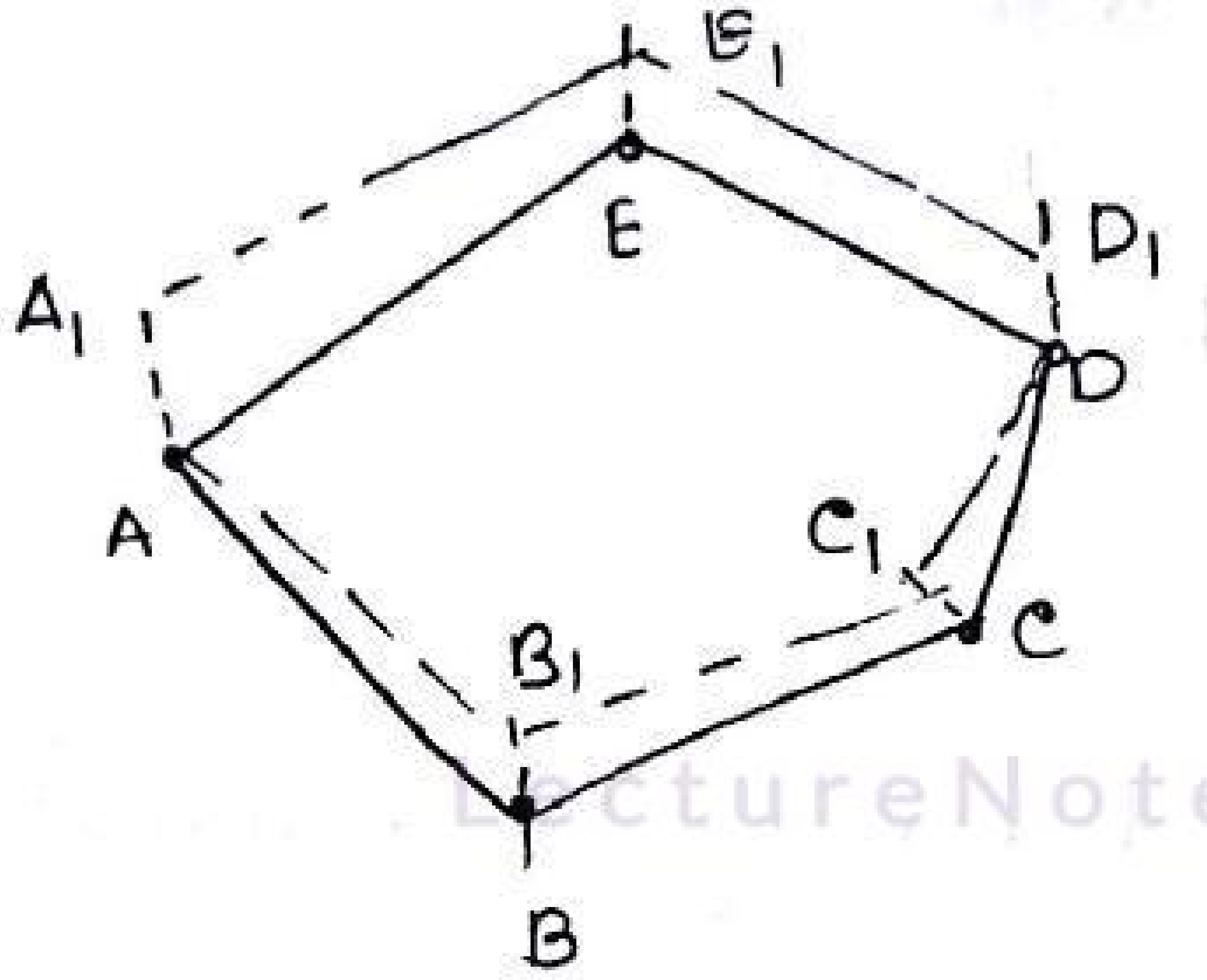
At this time, the graduated ring may rotate rapidly. The brake pin is pressed very gently to stop this rotation. When the ring comes to rest, the box is struck very lightly to verify the horizontality of the ring and the frictional effect on the pivot point. Then the reading is taken from the graduated ring through the hole in the prism. This reading will be the magnetic bearing of the line.

Adjustment of closing error :-

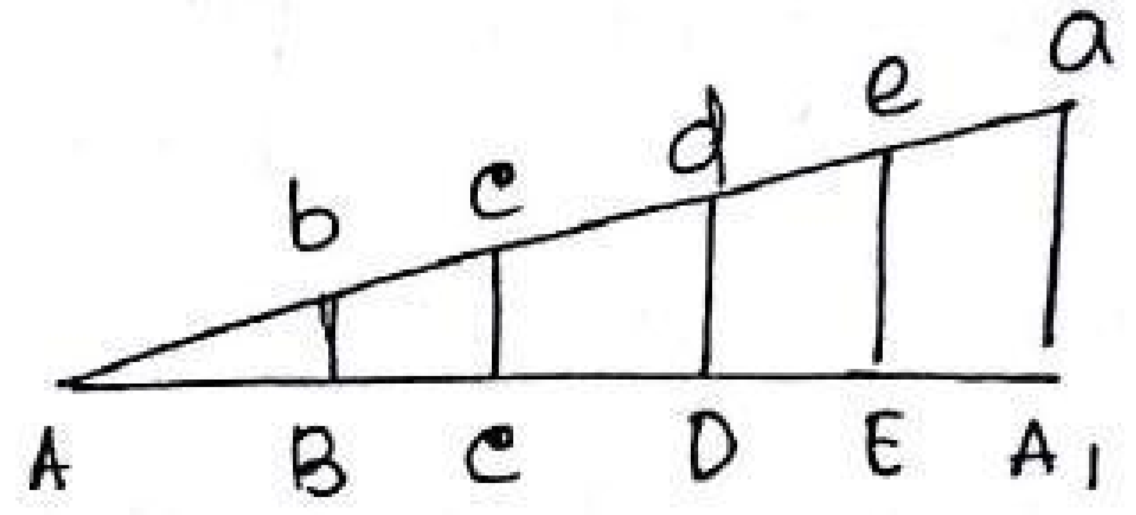
when a closed traverse is plotted, the finishing and starting points may not coincide. The distance by which the traverse fails to close is said to be the closing error. Such an error may occur due to mistakes made the measurement of lengths and bearings of the lines, or because of an error in plotting.

If the closing error exceeds a certain permissible limit, the field work should be repeated. But when the error is within the permissible limit, it is adjusted graphically by Bowditch's rule as explained below.

suppose a traverse $AB_1C_1D_1E_1A_1$ is plotted according to any suitable scale $(RF = 1/400)$



$RF = \frac{1}{400}$ (say)



$RF = \frac{1}{2000}$ (say)

In this case, the traverse fails to close by a distance AA_1 which is the closing error.

To adjust this error, a horizontal AA_1, is drawn to represent the perimeter of the traverse to another scale $(RF = 1/2000)$. On the line, distance AB_1, B_1C_1, C_1D_1, D_1E_1 & E_1A_1 are set off according to the corresponding measured lengths of the traverse legs. A perpendicular A_1a is drawn equal to the amount of closing A_1a is drawn equal to the amount of closing ~~A_1a is drawn~~ error, after which to the line Aa is draw. From the points B_1, C_1, D_1 and E_1 the lines B_1b, C_1c, D_1d and E_1e are drawn parallel A_1a. These intercepts represent the amount by which the respective stations are to be shifted.

Lines are drawn parallel to the closing error through stations B_1, C_1, D_1 and E_1. Then the intercepts B_1b, C_1c, D_1d, and E_1e are set off along the parallel line drawn through the respective stations. In this manner, the adjusted traverse ABCDEA is obtained.

Limits of closing error

The angular error of closure should not exceed $15'\sqrt{N}$ min, where N is the no. of sides of the traverse.

$$\text{Relative closing error} = \frac{\text{amount of closing error}}{\text{Perimeter of traverse}}$$

The value should not exceed 1/600.

Sources of error in a compass

The following are the kinds of error which may occur while taking reading with a compass:-

1) Instrument error
2) Personal error
3) Other sources of error.

SUMMARY:-

In this chapter we discussed about the measure the angle of any line with the help of compass. Discussed about the bearing of line and local attraction. And also about the prismatic which is been used for finding out the bearing and its various parts and also its temporary adjustment of land. Lastly mentioned about various correction of bearing.

Chapter - 3 :- LEVELLING

Objective and use of leveling :-

The main aim of levelling is to determine the relative heights of different objects on or below the surface of the earth and to determine the undulation of the ground surface.

Use of leveling :-

Levelling is done for following purpose :-

1) To prepare a contour map for fixing sites for reservoirs, dams, barrages etc and to fix the alignments of roads, railways, irrigation canals, etc

2) To determine the altitudes of different important points on a hill or to know the RLs of different points.

3) To prepare a longitudinal section and cross-sections of a project.

4) To prepare a layout map for water supply, sanitary or drainage schemes.

Definitions to be remembered

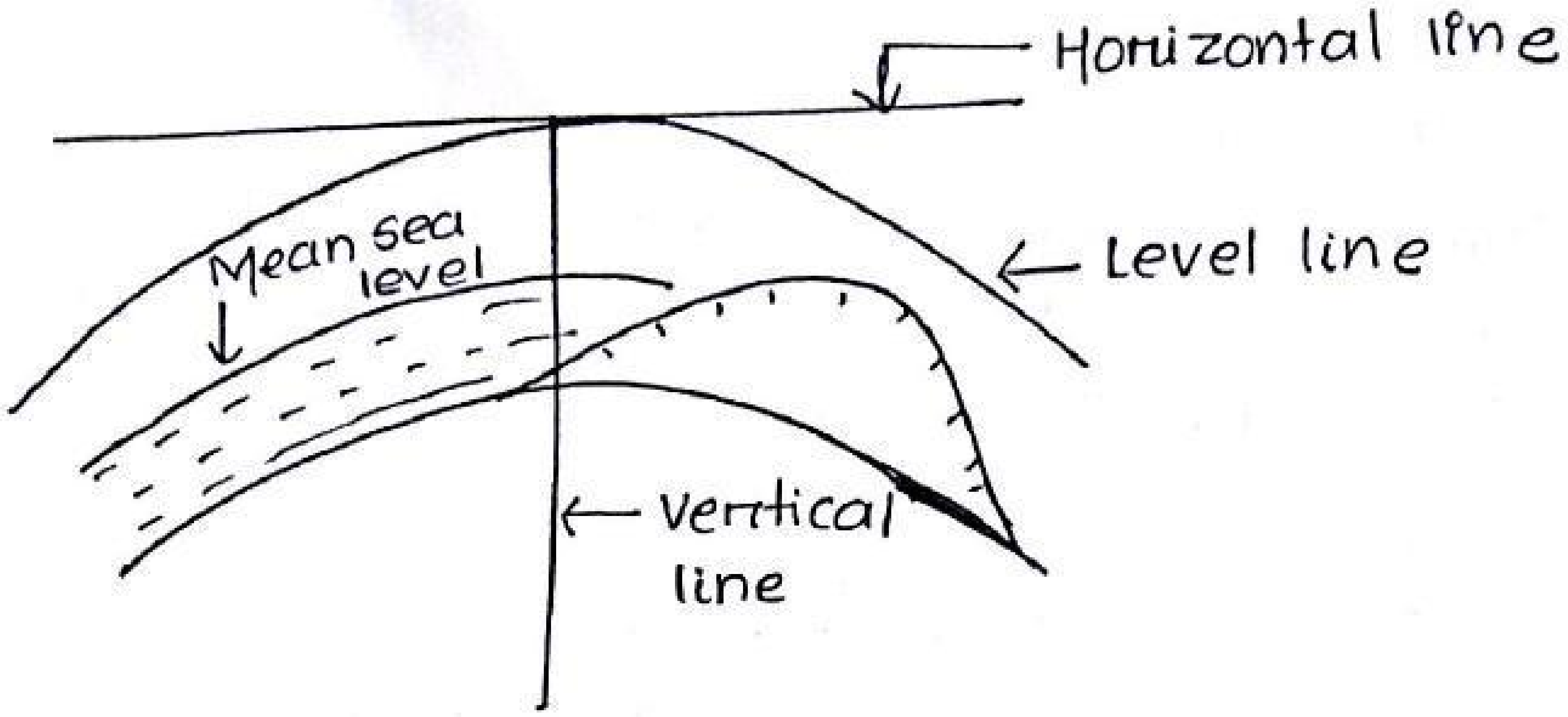
1) Levelling :- The art of determining the relative heights of different points on or below the surface of the earth is known as levelling. Thus, it deals with the measurements in vertical plane

2) Level surface :-

Any surface parallel to the mean spheroidal surface of the earth is said to be a level surface. Such a surface is called as curved and the water surface of a still lake is also considered a level surface.

3) Level line :-

Any line lying on the level surface is called a level line. This is normal to the plumb line at all points.



4) Horizontal plane :-

Any plane tangential to level surface at any point is known as the horizontal plane. It is perpendicular to the plumb line which indicates the direction of gravity.

5) Horizontal line :-

Any line lying on the horizontal plane is said to be horizontal line. It is a straight line tangential to the level line.

6) Vertical plane :-

Any plane passing through the vertical line is known as the vertical plane.

7) Vertical line :-

The dir^n indicates by a plumb line is known as the vertical line. The line is ⊥ar to the horizontal line.

8) Datum surface or line :-

This is an imaginary level surface or level ~~line~~ line from which the vertical distances of diff. point are measured. In India, the datum adopted for the Great trigonometrical Survey (GTS) is the mean sea level (MSL) at Karachi.

9) Reduced level (RL) :-

The vertical distance of a point above or below the datum line is known as the reduced level (RL) of that point. The RL of a point may be +ve or -ve, according as the point is above or below the datum.

11> Axis of the telescope:- This axis is an imaginary line passing through the optical centre of the object glass and the optical centre of the eyepiece.

12> Axis of Bubble tube:- It is an imaginary line tangential to the longitudinal curve of the bubble tube at its middle point.

13> Bench-Marks (BM):-

These are fixed points or marks of known RL determined with reference to the datum line. These are very important marks. They serve as reference points for finding the RL of new points or for conducting levelling operations in projects involving roads railways etc.

Bench-marks are classified into four types:-

a> GTS
b> permanent
c> Temporary
d> arbitary

(a> GTS:- These bench-marks are established by the survey of India Department at large intervals all over the country.

(b> Permanent Bench-marks:-

These are fixed points or marks established by different govt. departments like PWD, railways, Irrigation etc. The RLs of these points are determined with reference to the GTS bench-mark are kept on permanent points like the plinth of a building, parapet of a bridge or culvert etc.

c> Arbitary Bench-marks:-

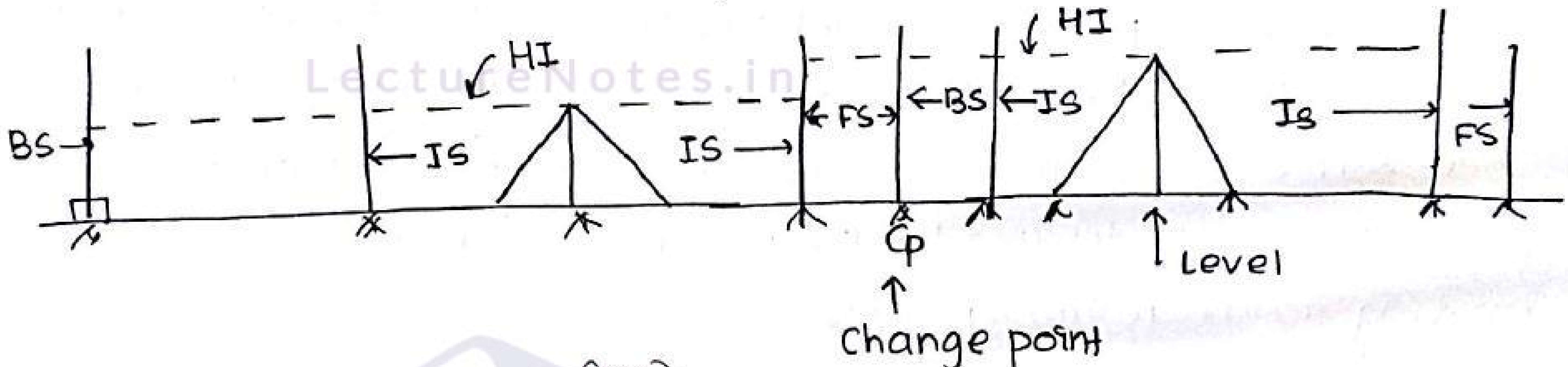
when the RLs of some fixed points are assumed, they are termed arbitary bench-marks. These are adopted in small survey operations when only the undulation of the ground surface is required to be determined.

d) Temporary Bench-marks:-

when the bench-marks are eslabilished temporarily at the end of a day's work, they are said to be temporary BM.

14.) Backsight Reading (BS)

This is the first staff reading taken in any set-up of the instrument after the levelling has been perfectly done.



15) Foresight Reading (FS)

It is the last staff reading in any set-up of the instrument and indicates the shifting of the latter.

16) Intermediate Sight Reading (IS)

It is the intermediate reading between BS and FS.

17) Change point (Cp)

This point indicates the shifting of the instrument. At this point an FS is taken from one setting and a BS from the next setting.

18) Height of Instrument (HI)

when the levelling instrument is properly levelled, the RL of the line of collimation is known as the height of the instrument.

19) Parallax:-

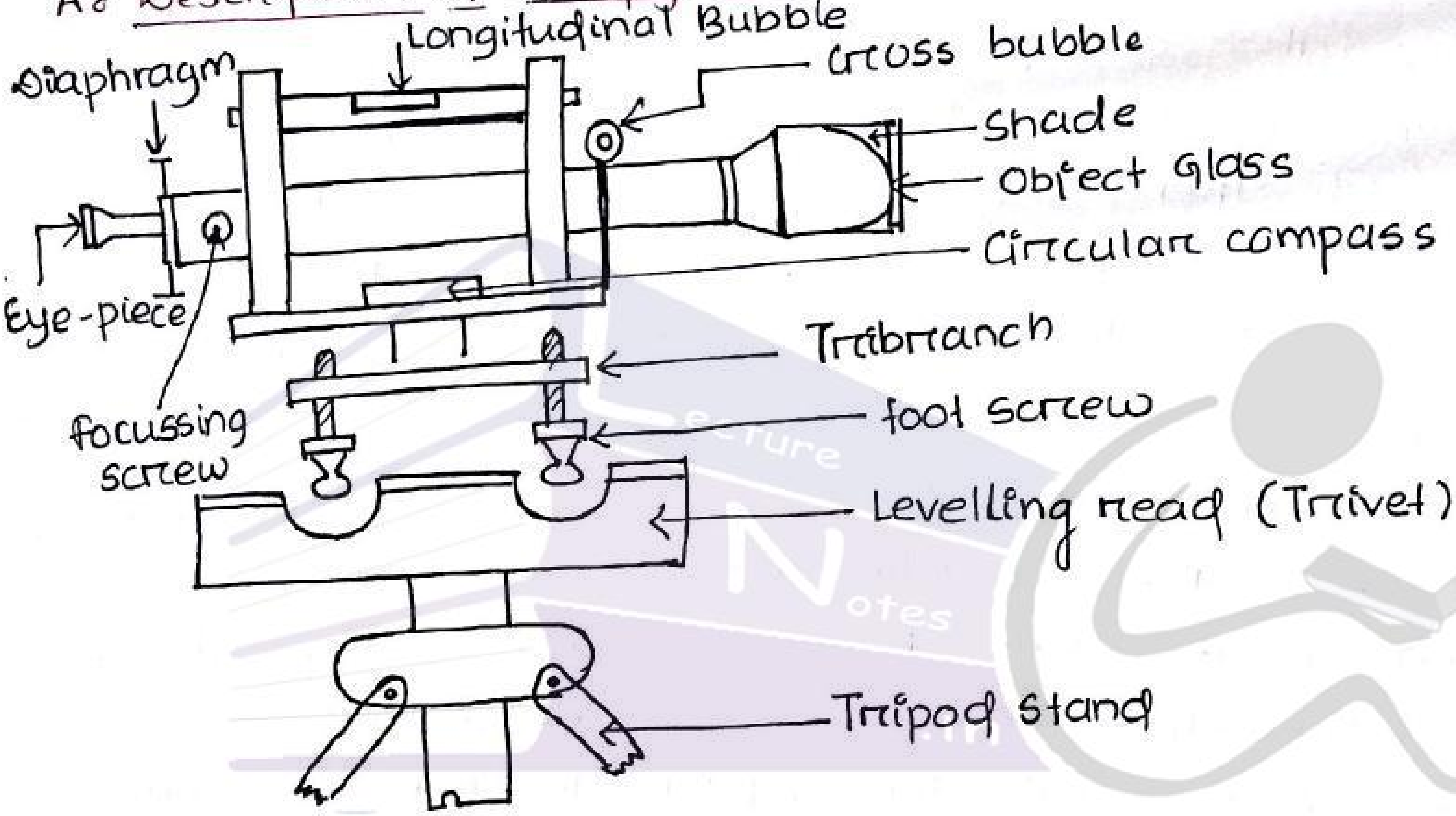
The apparent movement of the image relative to the cross hairs is known as parallax. This occur due to imprefect focussing, when the image doesnot fall in the plane of the diaphragm.

DIFFERENT TYPES OF LEVELS

The following are the different types of levels.

1) Dumpy level
2) Wye level (Y-level)
3) Cooke's Reversible level
4) Cushing's level
5) Modern Tilting level
6) Automatic level.

A. Description of Dumpy level



DUMPY LEVEL

1) Tripod stand :-
It consists of three legs which may be solid or framed. The legs are made of light and hard wood.

2) Levelling Head :-
It consists of two parallel triangular plates having three grooves to support the foot screws.

3) Foot screws :-
Three foot screws are provided between, the trivet and tribranch. By turning the foot screws, the tribranch can be raised or lowered to bring the bubble to the centre of its run.

4) Telescope:-

It consists of two metal tubes, one moving within the other. It also consists of an object glass and an eye-piece on opposite ends. A diaphragm is fixed with the telescope just in front of the eye-piece. The diaphragm carries cross-hairs.

The telescope is focussed by means of the focussing screw and may have either external focussing or internal focussing.

5) Bubble Tubes:-

Two bubble tubes, one called the longitudinal bubble tube and the other the cross-bubble tube are placed at right angles to each other. These tubes contain spirit bubble. The bubble is brought to the centre with the help of foot screws. The bubble tubes are fixed on top of the telescope.

6) Compass:-

A compass is provided just below the telescope for taking the magnetic bearing of a line when required.

The compass is graduated in such a way that a 'pointer', which is fixed to the body of the compass indicates a reading of 0° when the telescope is directed along the north line.

B. Levelling staff:-

The levelling staff is a graduated wooden rod used for measuring the vertical distance between the points on the ground and the line of collimation.

Levelling staves are classified into two groups:-

i> the target staff

ii> the self-reading staff.

1> Target staff :-

The target staff consists of a movable target. The target is provided with a vernier which is adjusted by the staffman, according to directions from the levelman, so that the target coincides with the collimation hair. After this the reading is taken by either the staffman or the levelman. This staff is used for long sightings

2> Self-reading staff :-

The following are diff. types of self-reading staffs:-

a> SOP with telescopic staff

Such a staff is arranged in three lengths placed one into the other. It can be extended to its full length by pulling. The total length of the staff is 4m.

The staff is graduated in such a way that the smallest division is of 5mm. The values in metres are marked in red on the left and those in decimetres are make in black on the right.

b> Folding Metric staff :- This staff is made of well-seasoned timber, and is of 75mm width, 18 mm thickness and 4m length. It is divided into two parts of 2m length having a locking arrangement. It can be folded or detached when required. It is graduated like the telescopic staff.

c> One-length staff :- The one-length staff is solid and made of seasoned timber. It is 3m long and graduated in the same way as the telescopic staff.

d> Invar staff :- It is also 3m long. An invar band is fitted to a wooden staff. The band is graduated in mm. It is used for precise levelling work.

c. Diaphragm:- The diaphragm is a brass ring fitted inside the telescope, just infront of the eye-piece. It can be adjusted by four screws. The ring carries the cross-hairs, which get magnified when viewed through the eye-piece.

Temporary Adjustment of level:-

The adjustments made at every set-up of the level before the staff readings are taken are known as temporary adjustments. The following are the diff. steps to be followed in temporary adjustment:-

1) Selection of suitable position:-

A suitable position is selected for setting the level. From this position, it should be possible to take the greatest number of observations without any difficulty the ground should be level & firm

2) Fixing level with tripod stand

The tripod stand is placed at the required position with its legs were apart and pressed firmly into the ground.
The level is fixed on the top of the tripod stand according to the fixing arrangement provided for that particular level.
It should be remembered that the level is not to be set up at any station or point along the alignment.

3) Approximate levelling by legs of tripod stand. The foot screws are brought to the centre of their run. Two legs of the tripod stand are firmly fixed into the ground. Then the third leg is moved to the left or right, in or out untill the bubble is approximately at the centre of its run

6- Focussing the eye-piece:-

A piece of while paper is held infront of the object glass and the eye-piece is moved in or out by turning it clockwise or anti-clockwise untill the cross-hairs can be seen clearly.

7- Taking the staff Readings:-

Finally, the levelling of the instrument is verified by turning the telescope in any direction when the bubbles remain in the central position for any dirn of the telescope, the staff readings are taken.

Types of levelling operations

1> simple leveling
2> Differential levelling
3> Fly levelling
4> Profile levelling
5> Cross-sectional levelling
6> Check-levelling

Permanent Adjustment of level

Two adjustments are required in the dumpy level.

1> The first adjustment is to make the axis of the bubble tube ⊥ar to the vertical axis.

2> The second adjustment is to make the line of collimation parallel to the axis of the bubble tube.

1. First Adjustment:-

The following procedure is adopted to make the line of collimation parallel to the axis of the bubble tube:-

a> The level is set up on fairly level and firm ground, with its legs will apart. It is firmly fixed to the ground.

b> The telescope is placed parallel to any pair of foot screws and by turning the foot screws either both inward or both outward, the bubble is brought to the centre.

4) Perfect levelling by foot screws :-

As the longitudinal bubble is on the top of the telescope, the latter is placed parallel to any pair of foot screws and the bubble is brought to the centre by turning the foot screws equally either both inwards or both outwards.

The telescope is then turned through 90° and brought over the third foot screw, and the bubble is brought to the centre by turning this foot screw clockwise or anti-clockwise. The telescope is again brought to its original position and the bubble is brought to the centre. The process is repeated several times untill the bubble remains in the central position in the first as well as the second position. Then the telescope is turned through 180°.

If the bubble still remains in the central position, the temporary adjustment is perfect and if the bubble is deflected from its central position, then the permanent adjustment is not perfect & needs to be modified.

5) Focussing the ~~eye-piece~~ Object Glass :-

The telescope is directed towards the leveling staff. Looking through the eye-piece the focussing screw is turned clockwise or anti-clockwise untill the graduation of the staff is distinctly visible and the parallax is eliminated. To eliminate the parallex, the eye is moved up and down to verify whether the graduation of the staff remains fixed relative to the cross-hairs.

c> The telescope is then turned through 90°, so that it lies over the third foot screw. Then by turning the third foot screw the bubble is brought to the centre.

d> The process is repeated several times untill the bubble is in the central position in both the directions.

e> Now the telescope is turned through 180° and the position of the bubble is noted. If the bubble still remains in the central position, the desired relationship is perfect.

f> Suppose, the deviation is of 2n divisions, now by turning the capstan headed nut, the bubble is brought half-way back, the remaining half-deviation is adjusted by the foot screw or screws just below the telescope.

g> The procedure of adjustment is continued till the bubble remains in the central position at any position of the telescope.

2> Second Adjustment

The second adjustment is done by two-peg method, which is described below:-

a> Two pegs A and B are driven at a known distance apart on level and firm ground. The level is set up at P, just mid-way between A and B. After bringing the bubble to the centre of its run, the staff readings on A and B are taken. suppose the readings are a and b.

Now the diff. of level between A and B is calculated, this difference is the true difference, as the level is set up just midway between BS and FS.

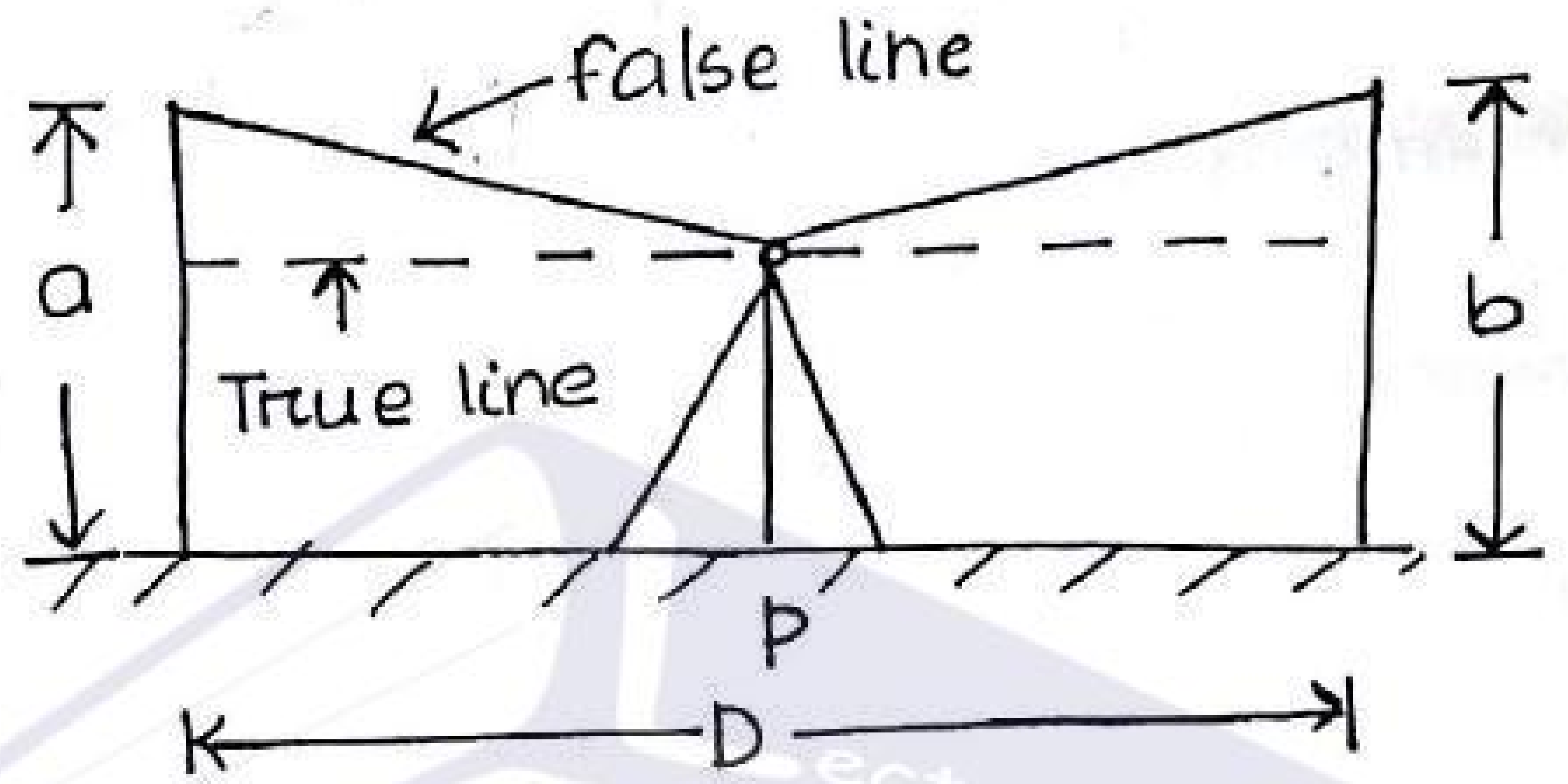
b> Then level is shifted and set up at P_1, say at a distance d from A. Then after proper leveling, staff readings at A and B are taken. Suppose the readings are a_1 & b_1, then the apparent diff. of level is calculated.

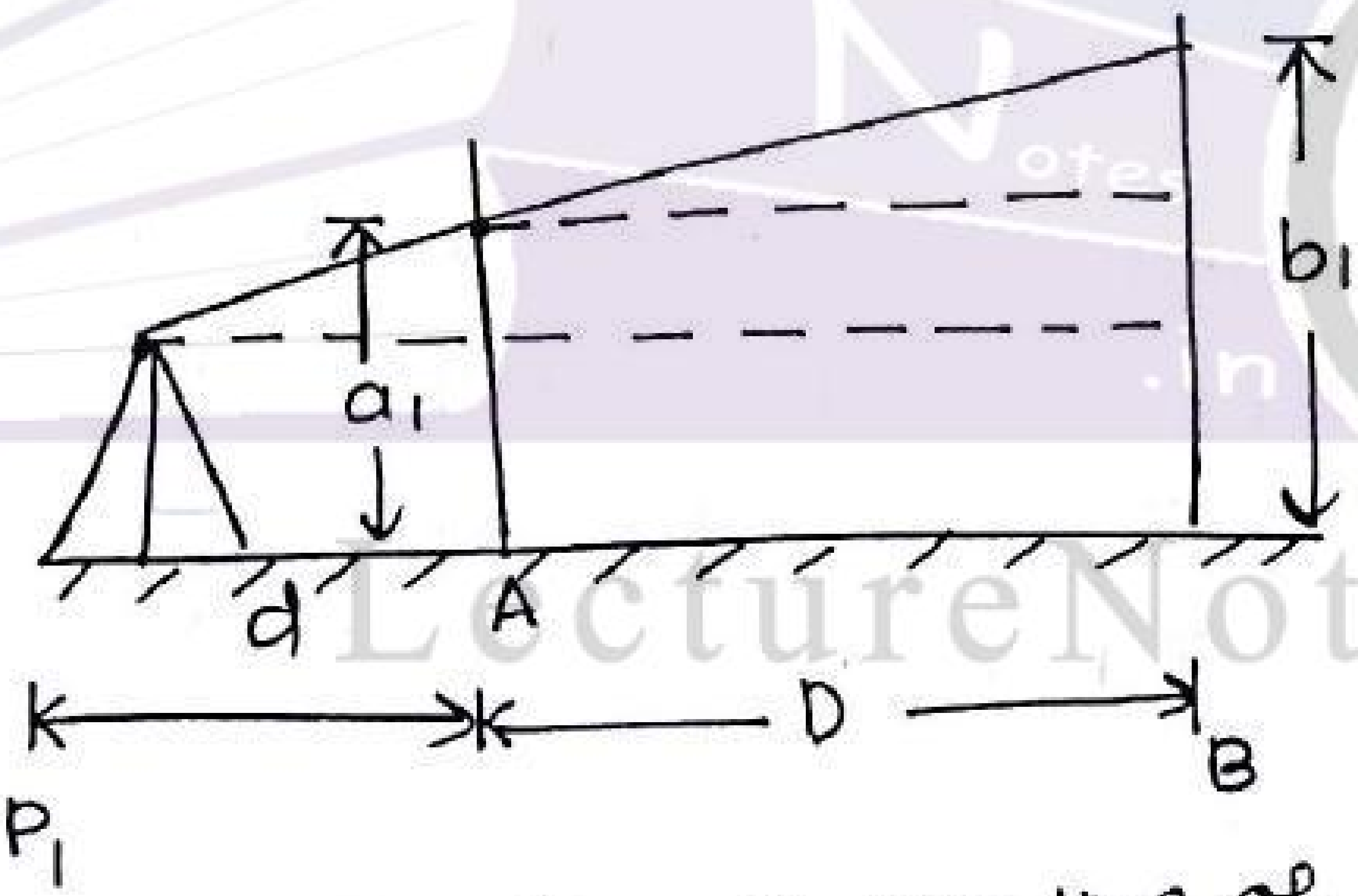
c) If the true different and apparent difference are equal, the line of collimation is in adjustment. If not, the line of collimation is inclined.

d) In the second set up, let e be the staff reading on B at the same level of the staff reading a_1

Then $e = a_1 \pm$ true difference

Use +ve sign in the case of a fall and the -ve sign when there is a rise.





e) If b_1 is greater than e, the line of collimation is inclined upward and if b_1 is less than e, It is inclined downwards.

f) By applying the principle of similar triangles correction to near peg, $c_1 = \frac{d}{D}(b_1 - e)$, correction to far peg, $c_2 = \frac{D+d}{D}(b_1 - e)$

correction staff reading on $A = a_1 \pm c_1$, correct staff reading on $B = b_1 \pm c_2$.

(Use the +ve sign when the live of collimation is inclined downwards & the -ve sign when it is inclined upwards).

9.) Then the cross-hair is brought to the calculated correct reading by raising or lowering the diaphragm by means of the diaphragm screw.

CALCULATION OF REDUCED LEVEL

The following are the two systems of calculating reduced level:-

1) The collimation system or height of instrument system (HI)

2) The rise and fall system.

1) Height of instrument System (HI)

The reduced level of the line of collimation is said to be the height of the instrument. In this system, the height of line of collimation is found out by adding the back-sight reading to the RL of the BM on which the BS is taken. Then the RL of the intermediate points and the change point are obtained by subtracting the respective staff readings from the height of the instrument (HI).

⇒ The level is then shifted for the next set up and again the height of the line of collimation is obtained by adding the backsight reading to the RL of the change point.

⇒ So the height of the instrument is different in different setups of the level. Two adjacent planes of collimation are correlated at the change point by an FS reading from one setting and a BS reading from the next settings.

Arithmetical check:- $\Sigma BS - \Sigma FS$ = last RL - 1st RL.

The diff. between the sum of backsights and that of foresights must be equal to the difference between the last RL and first RL. This check verifies the calculation of the RL of the HI and that of the change point.

There is no check on the RLs of the intermediate points.

2> Rise and fall system

⇒ In this system, the difference of level between two consecutive points is determined by comparing each forward staff reading with the staff reading at the immediately proceding point.

⇒ If the forward staff readings is similar than the immediately preceding staff reading, a rise is said to have occured. The rise is added to the RL of the proceding point to get the RL of the forward point

⇒ If the forward staff readings is greater than the immediately preceding staff reading, it means there has been a fall. The fall is subtracted from the RL of preceiding point to get the RL of the forward point.

For Arithmetical check:-

$$\Sigma BS - \Sigma FS = \Sigma rise - \Sigma fall$$
$$= \text{Last RL} - 1^{st} \text{ RL}$$

In the method, the difference between the sum of BSs and that of FSs, the difference between the sum of rises and that of falls and the diff. between the last RL and the first RL must be equal.

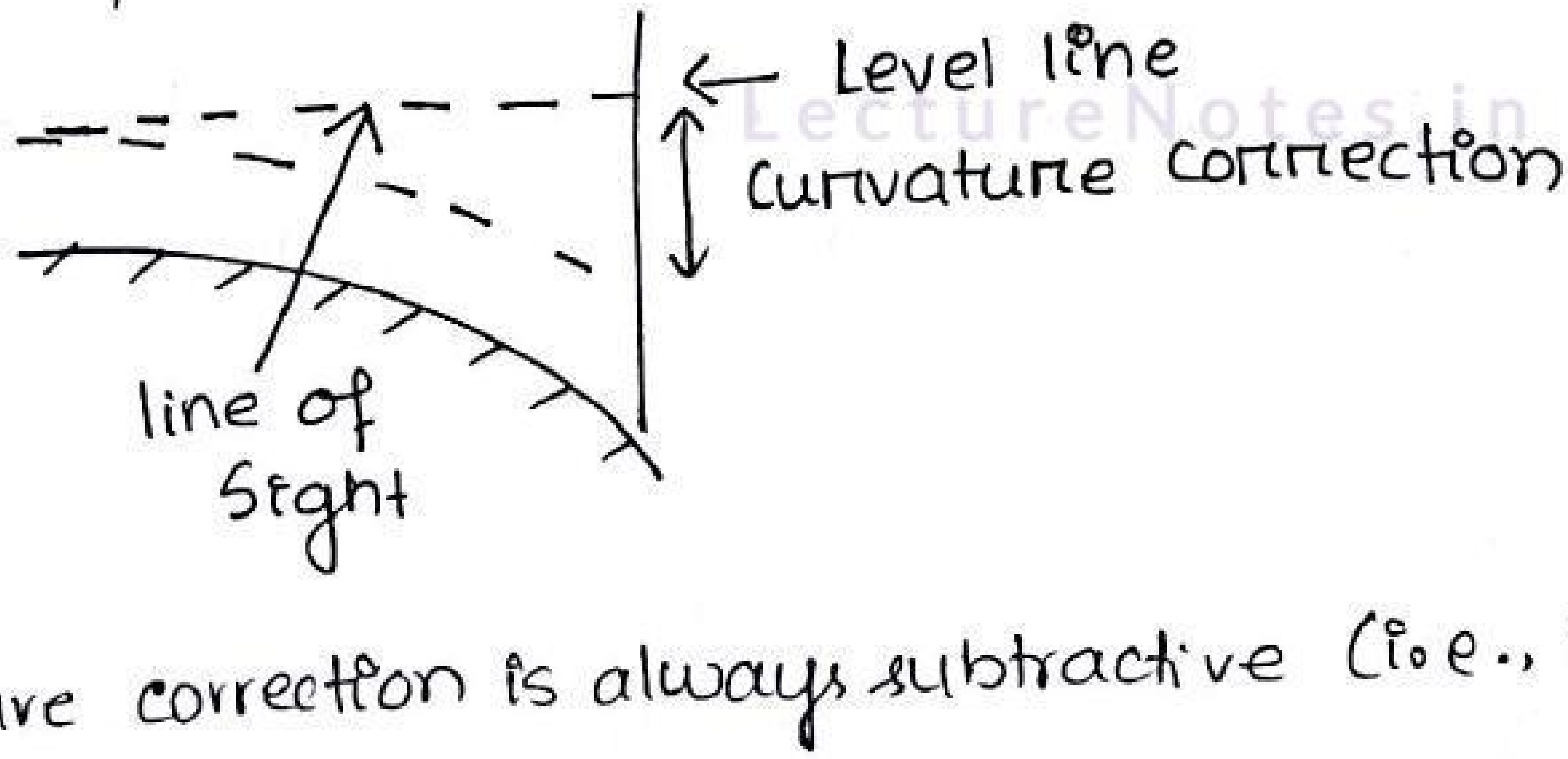
Comparison of Two systems:-

Collimation System	Rise and Fall method
→ It is rapid as it involves few calculations.	→ It is laborious, involving several calculation.
→ There is no check on the RLs of intermediate points	→ There is a check on the RL of intermediate points.
→ Errors in intermediate RLs cannot be detected	→ Errors in intermediate RLs can be detected as all the points are correlated.
→ There are two checks on the accuracy of RL calculation	→ There are three checks on the accuracy of RL calculations.
→ This system is suitable for longitudinal leveling where there are no. of intermediate sights	→ This system is suitable for fly levelling where there are no intermediate sights.

Corrections to be Applied

1> Curvature correction

For long sights, the curvature of the earth affects staff reading, the line of sight is horizontal, but the level line is curved and parallel to the mean spheroidal surface of the earth.



Curvature correction is always subtractive (i.e., Negative).

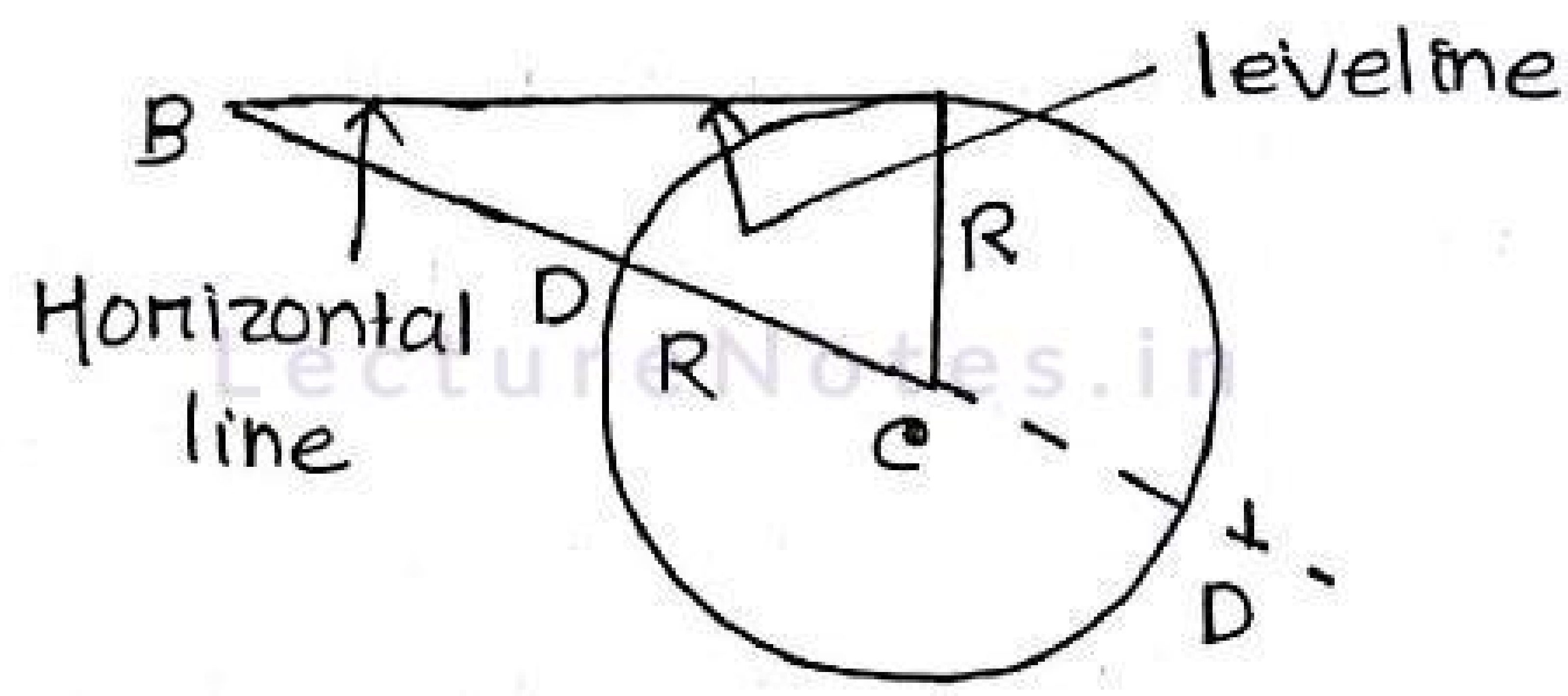
The formula for curvature correction is derived as follows:-

Let AB = D = horizontal distance in Kms.

BD = C = Curvature correction

BC = AC = R = radius of earth

DD' = diameter, considered 12,742 Km.



$$BC^2 = AC^2 + AB^2$$

$$(R+C_c)^2 = R^2 + D^2$$

$$\Rightarrow R^2 + 2RC_c + C_c^2 = R^2 + D^2$$

$$\Rightarrow C_c \times 2R = D^2$$

$$\Rightarrow C_c = \frac{D^2}{2R} \quad \text{curvature Correction}$$

C_c^2 is neglected as it is very small in comparison to the diameter of the earth

$$C_c = \frac{D^2 \times 100}{12,742} = 0.0785\, D^2\, m \quad \text{(negative)}$$

Hence, True staff reading = Observed staff reading - curvature correction.

2) Refraction correction:-

Rays of light are refracted when they pass through layers of air of varying density. So, when long sights are taken, the like of sight is refracted towards the surface of the earth in a curved path. The radius of this curve is seven times that of the earth under normal atmospheric conditions. Due to the effect of refraction, objects apper higher than they really are. But the effect of curvature varies with atmospheric conditions.

However, on an average, the refraction correction is taken as one-seventh of the curvature correction.

$$C_r = \frac{1}{7} \times \frac{D^2}{2R}$$

Refraction correction, $C_r = \frac{1}{7} \times 0.0785D^2$

$= 0.0112D^2 m$ (+ve)

Refraction correction is always additive (+ve)

True staff reading = Observed staff reading + Refraction correction

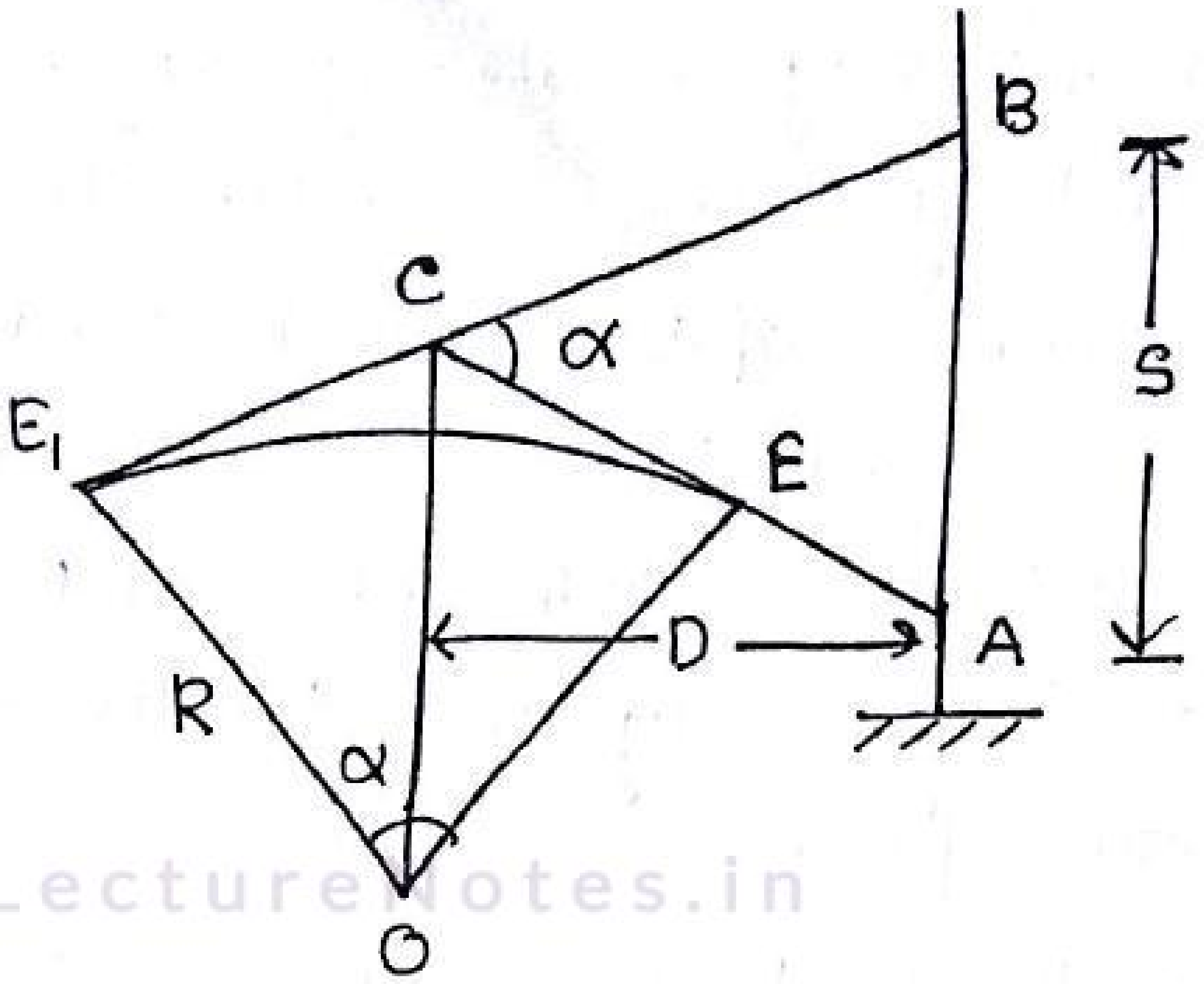
SENSITIVENESS OF THE BUBBLE

The term sensitiveness in the context of a bubble means the effect caused by the deviation of the bubble per division of the graduation of the bubble tube.

Sensitiveness is expressed in terms of the radius of curvature of the upper surface of the tube or by an angle through which the axis is tilted for the deflection of one division of the graduation.

Determining sensitiveness:-

Suppose the level was set up at O at a distance D from the staff at P. The staff reading is taken with the bubble at the extreme right end. Say it is PA. Another staff reading is taken with the bubble at the extreme left end. Let it be PB.



Let D = distance between the level and staff

S = intercept between the upper and lower sights

n = no. of divisions through which the bubble is deflected.

R = Radius of curvature of the tube

α = angle subtended by arc EE_1 and

d = length of one division of the graduation, expressed in the same units as D and S.

Movement of centre of bubble = EE_1 = nd

Δs OEE_1 and ACB are similar

Here, Rα = arc EE_1

$\Rightarrow \alpha = \frac{EE_1}{R} = \frac{nd}{R}$ —① (as arc EE_1 = Chord EE_1)

Again, $\frac{EE_1}{R} = \frac{S}{D}$ (height of ΔOEE_1 may be considered as R)

$\Rightarrow \frac{nd}{R} = \frac{S}{D}$ — ②

$\Rightarrow \alpha = \frac{nd}{R} = \frac{S}{D}$ —③

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

Let α' = angular value for one division in radians

$\alpha' = \frac{\alpha}{n} = \frac{S}{D} \times \frac{1}{n}$ radians

$\Rightarrow$ $\boxed{\alpha' = \frac{S}{Dn} \times 206,265 \text{ seconds}}$ (1 radian = 206,265 secs)

SUMMARY:-

In this chapter of levelling we discussed about the use of dumpy level, its various parts. Temporary and permanent adjustment of dumpy level was also discussed. Discussed about various methods on finding the RLs of different points by HI method and rise & fall method. Discussed about curvature and Refraction error and how to calculate and adjust was also discussed sensitiveness of level tube was studied and also the reciprocal levelling and various common errors was discussed and finally in the last part various digital levels were discussed.

CONTOURING

Objective of preparing Contour Map:-

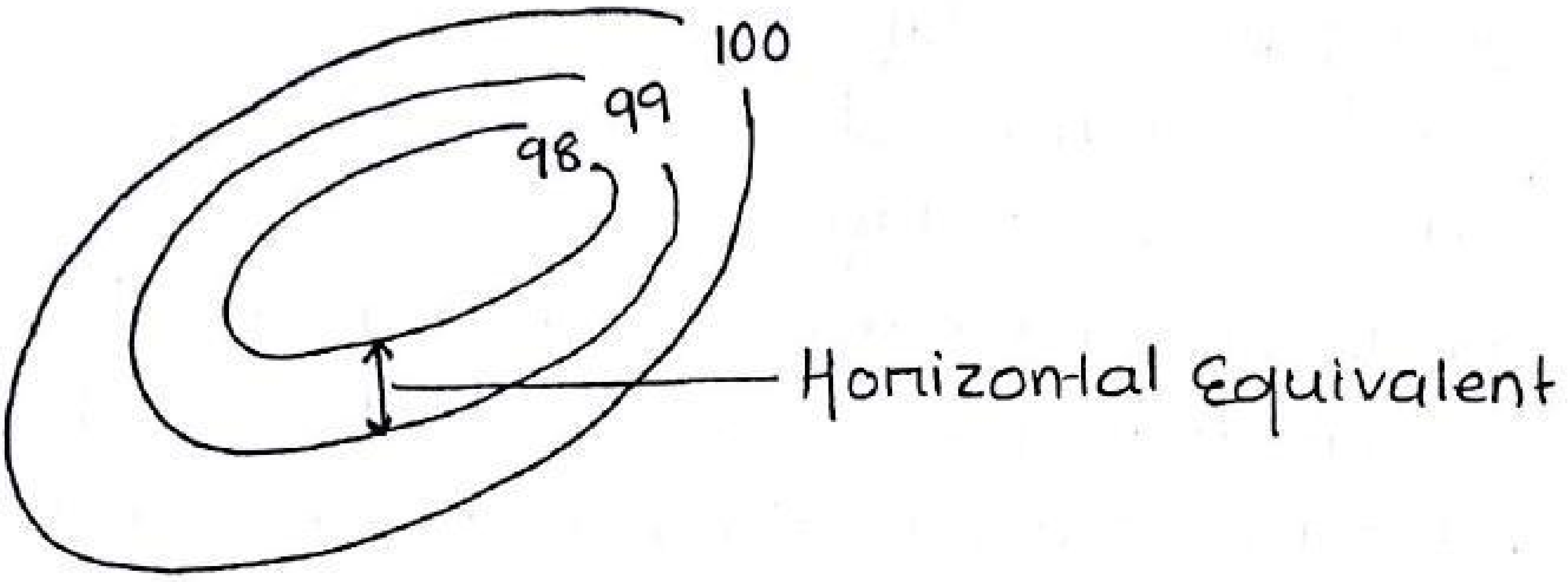
The general map any country includes the location of roads, building, railways, rivers, villages, towns etc.
But the nature of the ground surface cannot be realised from such a map. however, it requires the knowledge of the nature of ground surface for locating alignments and estimating the volume of earth work. So, to know the details of ground surface contour maps are required for any kind of engineering projects.

Introduction:-

Contouring is basically, a levelling operation. The equipments are same for leveling and contouring.
The main objective of contouring is to determine the points on the ground having the same reduced level (RL). The contour lines join the points of same elevation directly or by inter-polation technique. It gives the topographical features of the ground, comparing different contour lines of diff. elevations for a closed area. Based on the topographical features, calculations for engineering projects can be carried out. There are different methods of drawing such closed or open contour lines within a specific area.

Contour line:-

The line of intersection of a level surface with the ground surface is known as the contour line. It is also defined as a line passing through points of equal reduced level.
for ex: A contour of 100 m indicates that all the points on this line have as RL of 100m and similarly in a contour of 99 m, all points have an RL of 99m.



A map showing only the contour lines of an area is called a contour map.

Contour Interval:-

The vertical distance betn any two consecutive contour is known as a contour interval. Suppose a map includes contour lines of 100 m, 98 m, 96 m, etc. The contour interval here is 2m.

This interval depends upon:-

i) Nature of ground
ii) Scale of map
iii) the purpose of survey.

Horizontal Equivalent

The horizontal distance between any two consecutive contour is known as horizontal equivalent.

→ It is not constant, it varies according to steepness of the ground.

→ for steep slopes, the contour lines run close together, and for flatter slopes they are widely spaced.

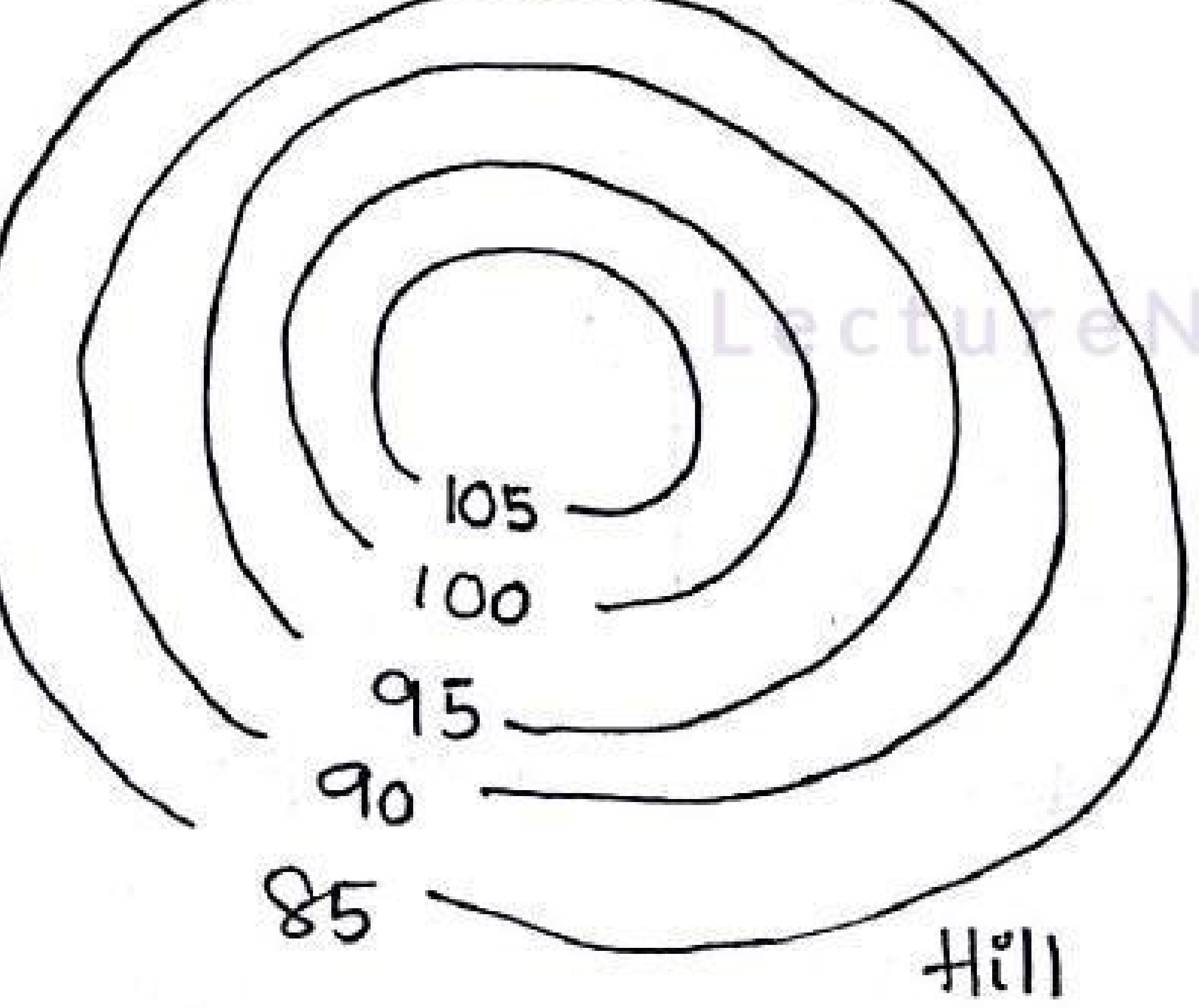
Uses of contour Map

~~The horizontal distance betn any two~~

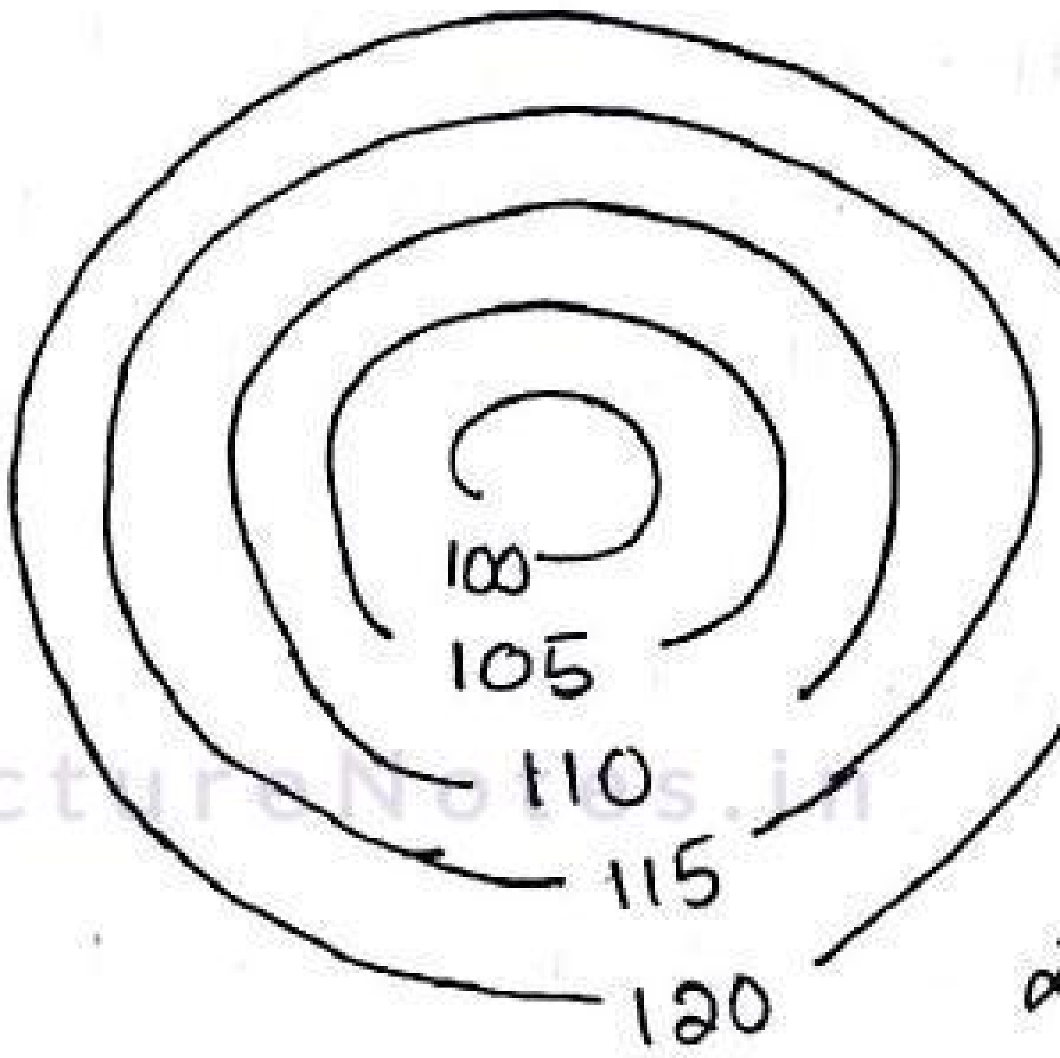
1) The nature of the ground surface of a country can be understood by studying a contour map. Hence, the possible route of communication between different places can be demarcated.
2) A suitable site on an economical alignment can be selected for any engineering project.
3) The capacity of a reservoir or the area of a catchment can be approximately computed.
4) The intervisibility or otherwise of different points can be established.
5) A suitable route for a given gradient can be marked on map.
6) A section of the ground surface can be drawn in any dirn from the contour map.
7) Quantities of earth work can be approximately computed.

characteristics of contours

1) The contour lines are closer near the top of a hill or high ground and wide apart near the foot. This indicates a very steep slope towards the peak and the flatter slope towards the foot.



2> The contour lines are closer near the bank of a pond or depression and wide apart towards the centre. This indicates a steep slope near the bank and a flatter slope at the centre

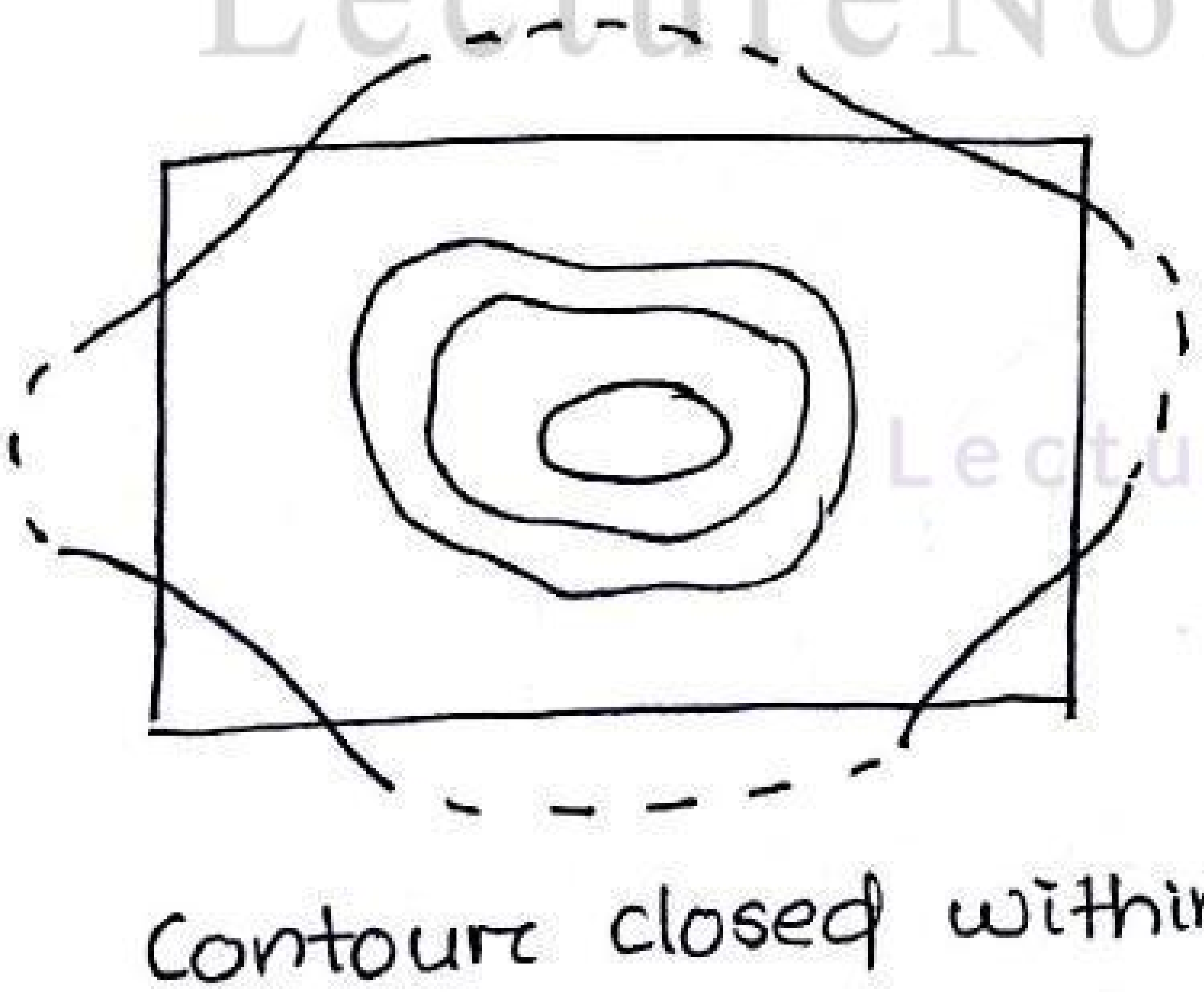


Depression

3> Uniformly spaced contour lines indicates a uniform slope.

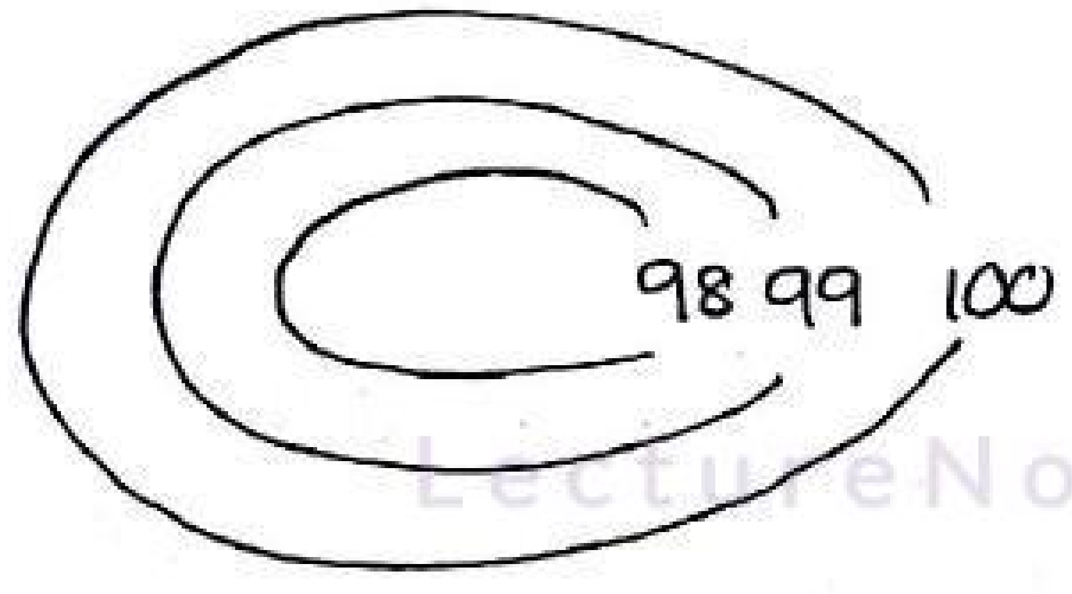
Uniform slope

4> Contour lines always form a closed circuit. But these lines may be within or outside the limits of the map.

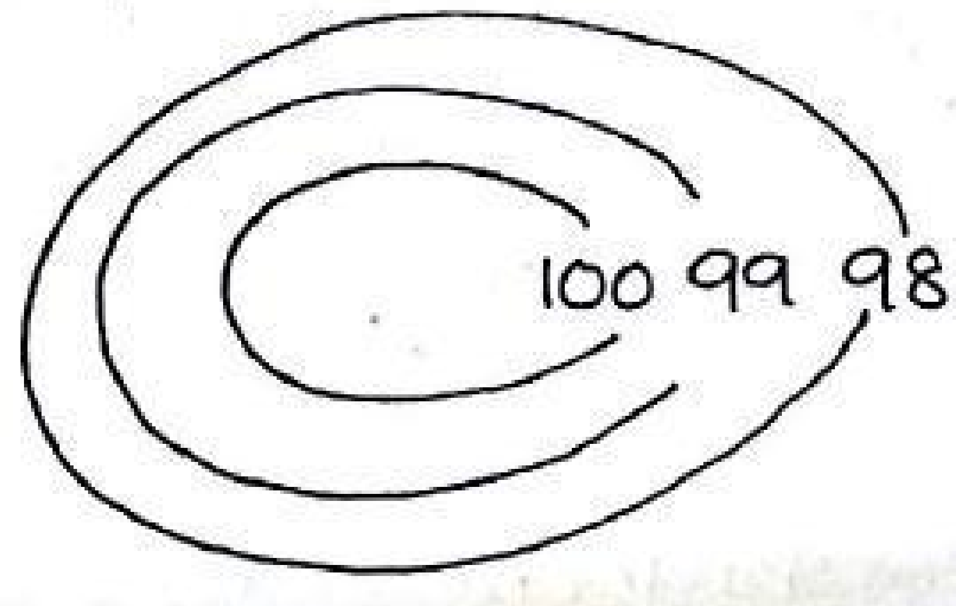


Contour closed within Map.

8) A series of closed contours always indicates a depression or summit. The lower values being inside the loop indicates a depression and the higher values being inside the loop indicate a summit.



a) Depression

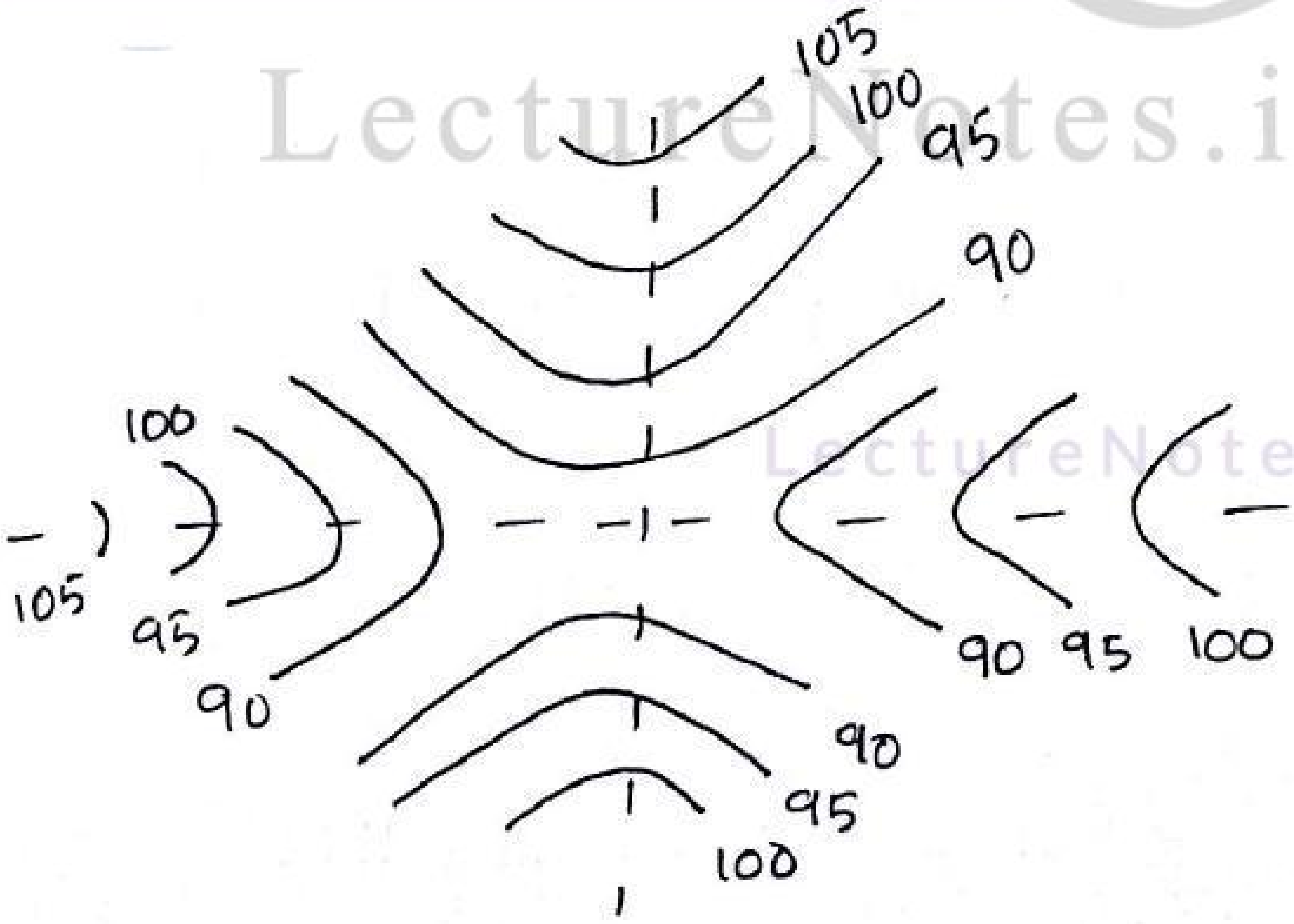


b) Summit

9) Depressions between summits are called saddles.

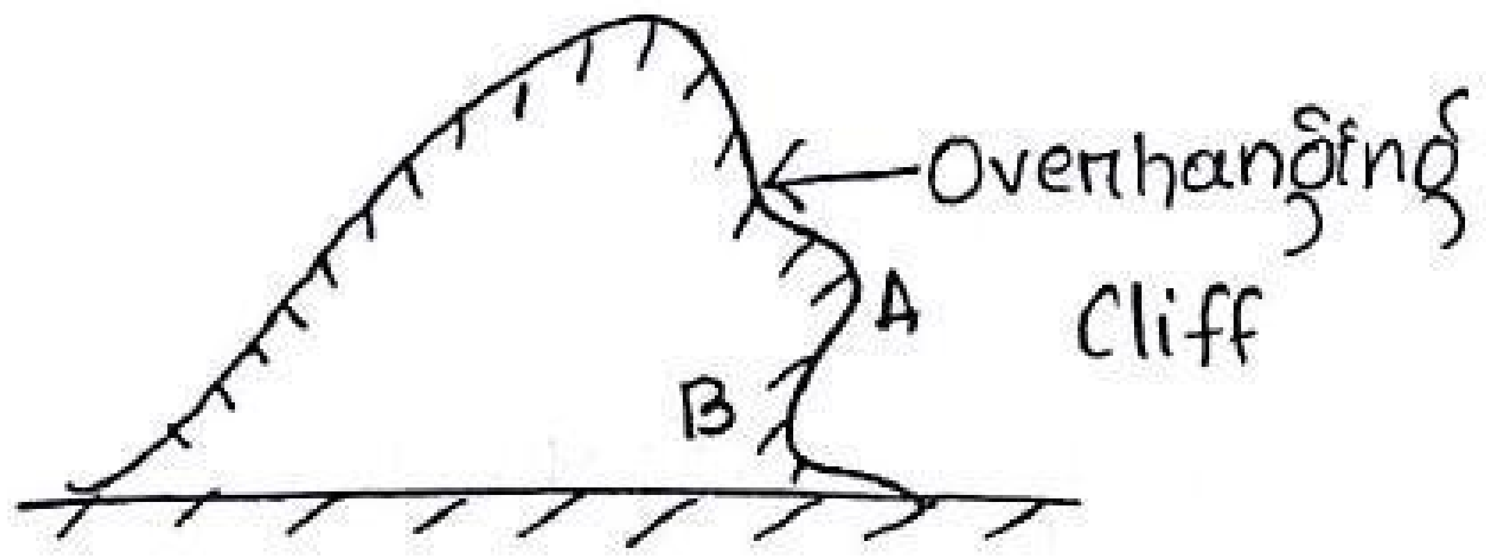
10) Contour lines meeting a point indicate a vertical cliff.

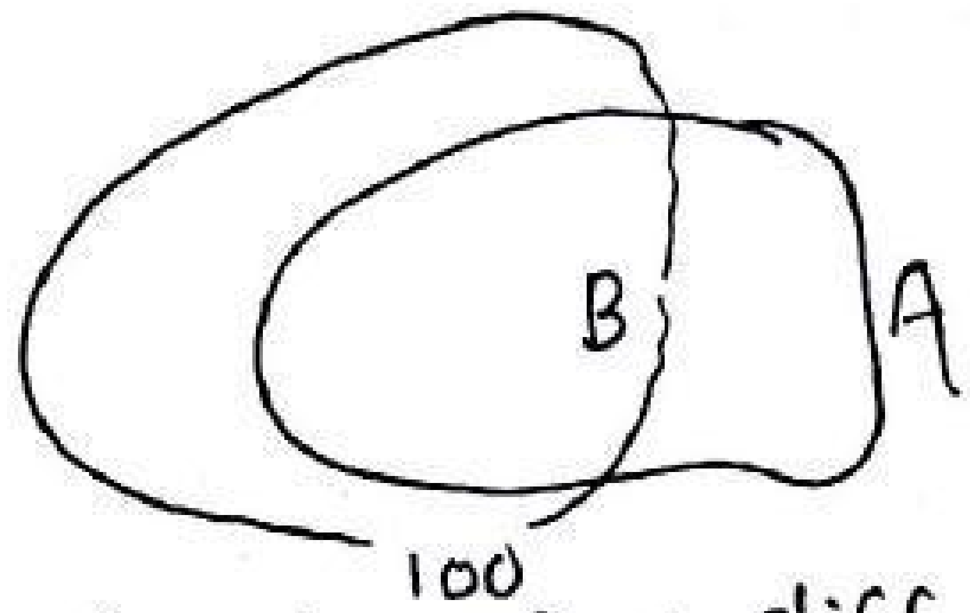
a) vertical cliff



b) Saddle

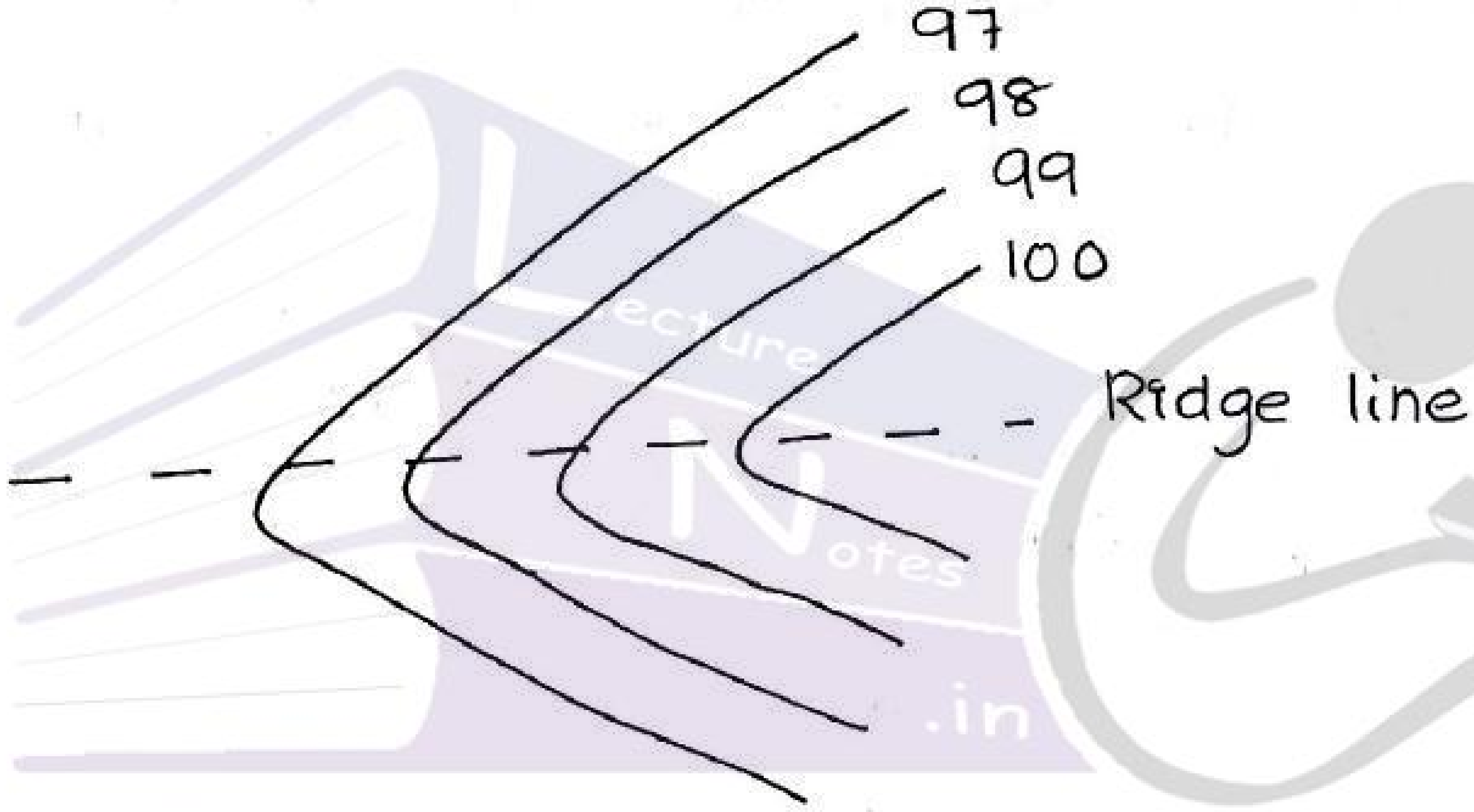
5> Contour lines cannot cross one another, except in the case of an overhanging cliff. But the overlapping portion must be shown by a dotted line.



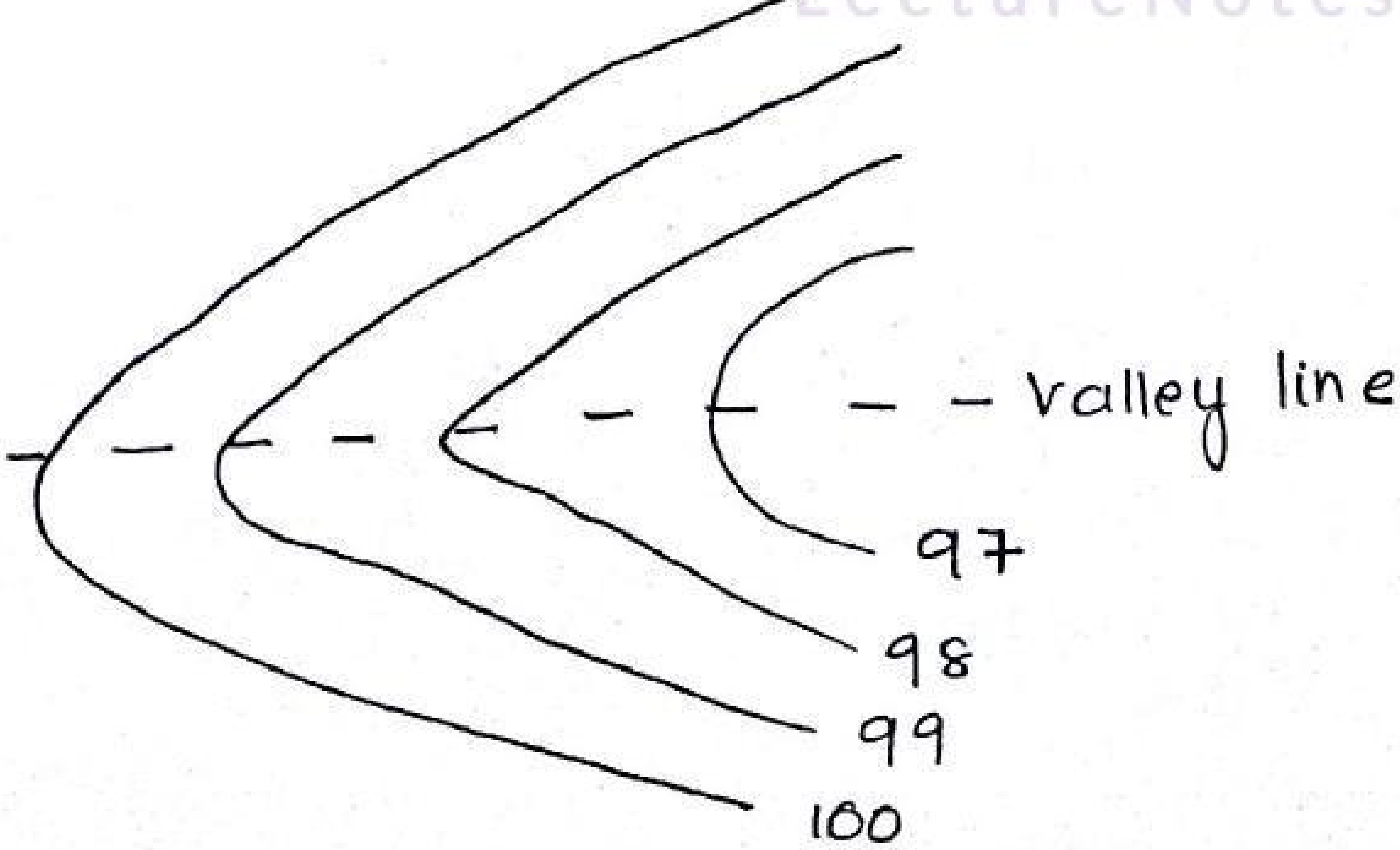


Overhanging cliff

6> When the higher values are inside the loop, it indicate a ridge line.
Contour lines cross ridge lines at right angles



7. When the lower values are inside the loop it indicates a valley line.
Contour line cross the valley line at right angles



Methods of contouring

Basically there are two methods of contouring - direct and Indirect

Direct method

Direct method can be done by following two cases:-

Case - I:-

when the area is oblong and cannot be controlled from a single station.

In this method, the various points on any contour are located on the ground by taking levels. These points are marked by pegs.

After this, the points are plotted on the map, to any suitable scale, by plane table. This method is very slow and tedious and close gives accurate contour lines.

Procedure:-

1- Suppose a contour map is to be prepared for an ablong area. A temporary bench-mark is setup near the site by taking fly- level readings from a permanent bench mark (PBM).

2. The level is then set up at a suitable position L from where maximum area can be covered.

3. The plane table is set up at a suitable station P from where the above area can be plotted.

4. A backsight reading is taken on the TBM. Let just say, the RL of the TBM is 249.500 m and the BS reading is 2.250 m, then the RL of HI is 251.750 m.

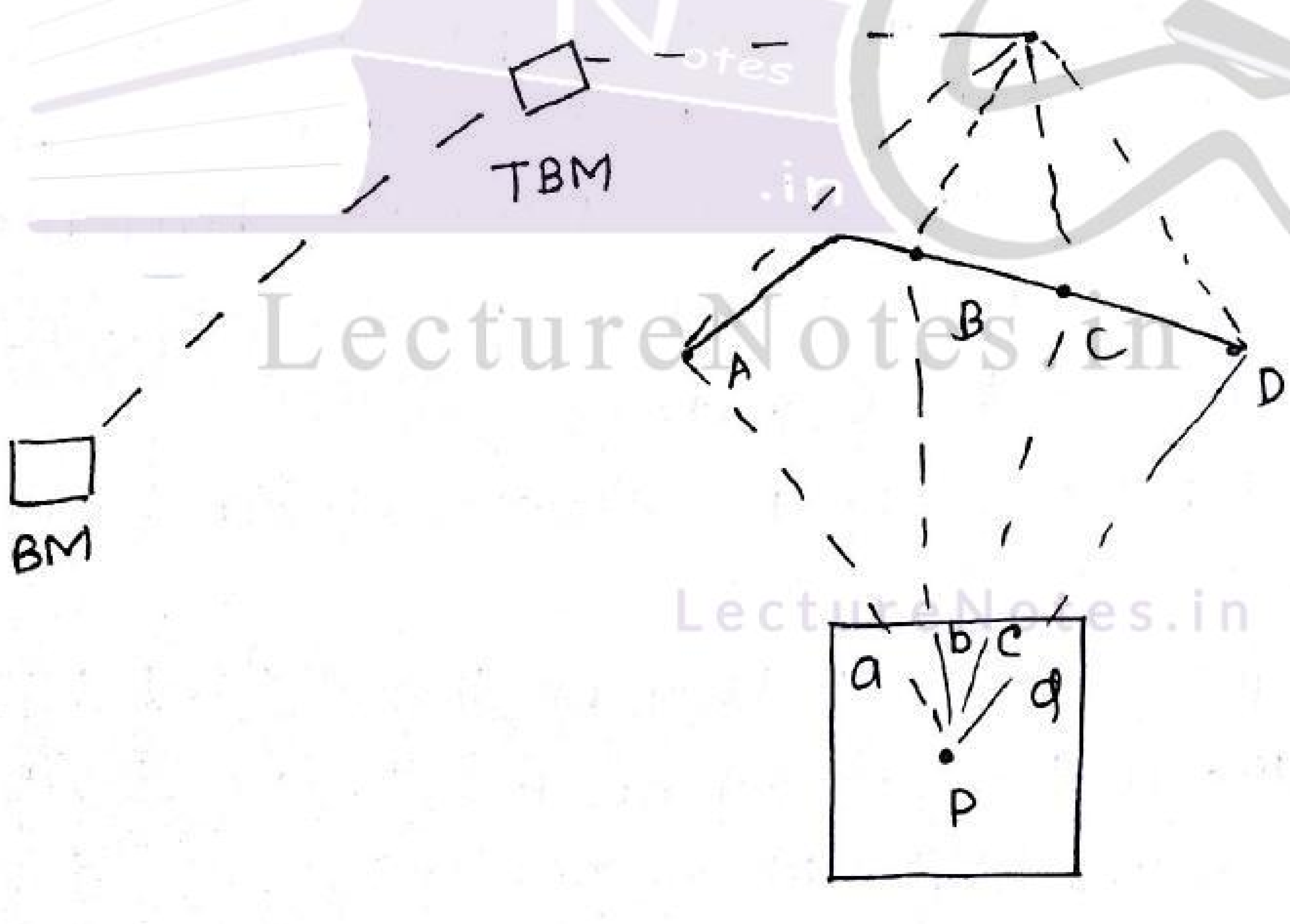
If a contour of 250 m is required, the staff reading should be 1.750 m. If a contour of 249.000 m is required, the staff reading should be 2.750 m and so.on.

5> The staffman holds the staff at different points of the area by moving up and down or left and right, untill the staff reading is exactly 1.750. Then the points are marked by pegs. Suppose these points are A, B, C, D...

6> A suitable point P is selected on the sheet to represent the station P. Then, with the alidade touching P, ray are drawn to A, B, C & D. The distances PA, PB, PC and PD are measured and plotted to a suitable scale. In this manner, the points a, b, c & d of the contour lines of RL 250.00 m are obtained. These points are joined to obtain the contour of 250.000 m.

7) Similarly, the points of the other contours are located.

8) when required, the leveling instrument and the plane table are shifted and set up in a new position in order to continue the operation along the ablong area.



Direct method case I

case - II when the area is small and can be controlled from a Single station

The method of radial lines is adopted to obtain contour map. This method is also slow & tedious but gives actual contour lines.

Procedure:-

1- The plane table is set up at a suitable station P from where the whole area can be commanded.

2. The point P is suitably selected on the sheet to represent the station P. Radial lines are then drawn in different directions.

3- The temporary BM is established near the site, The level is set up to a suitable position α and a BS reading is taken on the TBM. Let the HI in this setting be 153.250 m.

So, to find the contour of 152.000 m RL, a staff reading of 1.250 m. is required at a particular point, so that the RL of contour of that point comes to 152.000 m

RL = HI - Staff reading

= 153.250 - 1.250

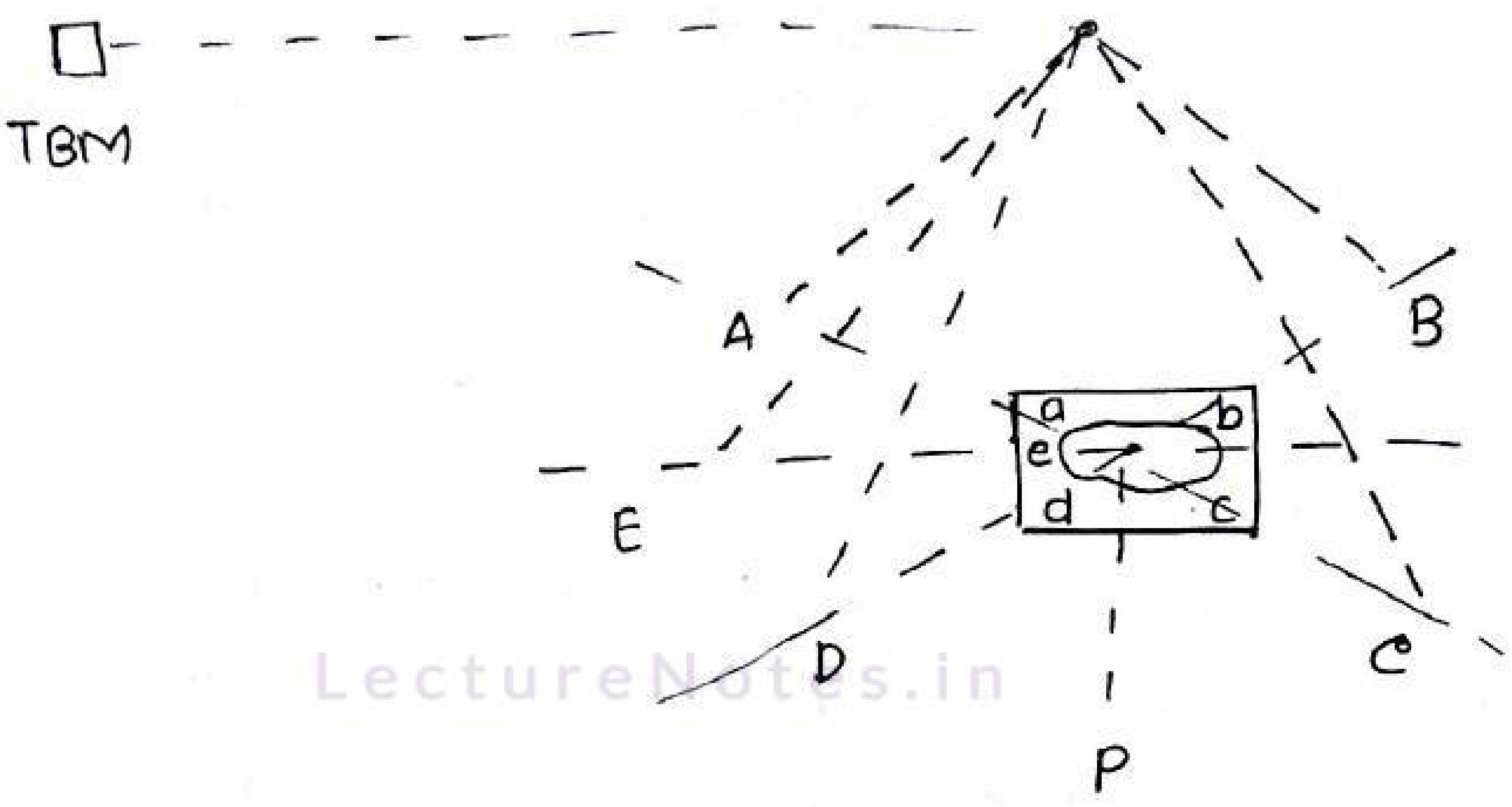
= 152.000 m

4- The staffman holds the staff along the rays drawn from the plane table station in such a way that the staff reading on that point is exactly 1.250.

In this matter, points A, B, C, D and E are located on the ground, where the staff readings are exactly 1.250.

5- The distance PA, PB, PC, PD and PE are measured and plotted to be suitable scale. Thus, the points a, b, c, d & e are obtained which are joined in order to obtain a contour of 152,000.

6) The other contours may be located in similar ways.



Direct method Case - II

Indirect method

The RLs of diff. points are taken at regular intervals along a series of lines set up on the ground.

The positions of these points are plotted on a sheet to any suitable scale, the spot levels are noted at the respective points. Then the points of contour lines are found out by interpolation after which they are joined to get the required contour lines.

This method gives only the approximate positions of the contour lines.

This method can done in two ways :-

i - Cross - section   ii - Squares.

a) Using cross-section:-

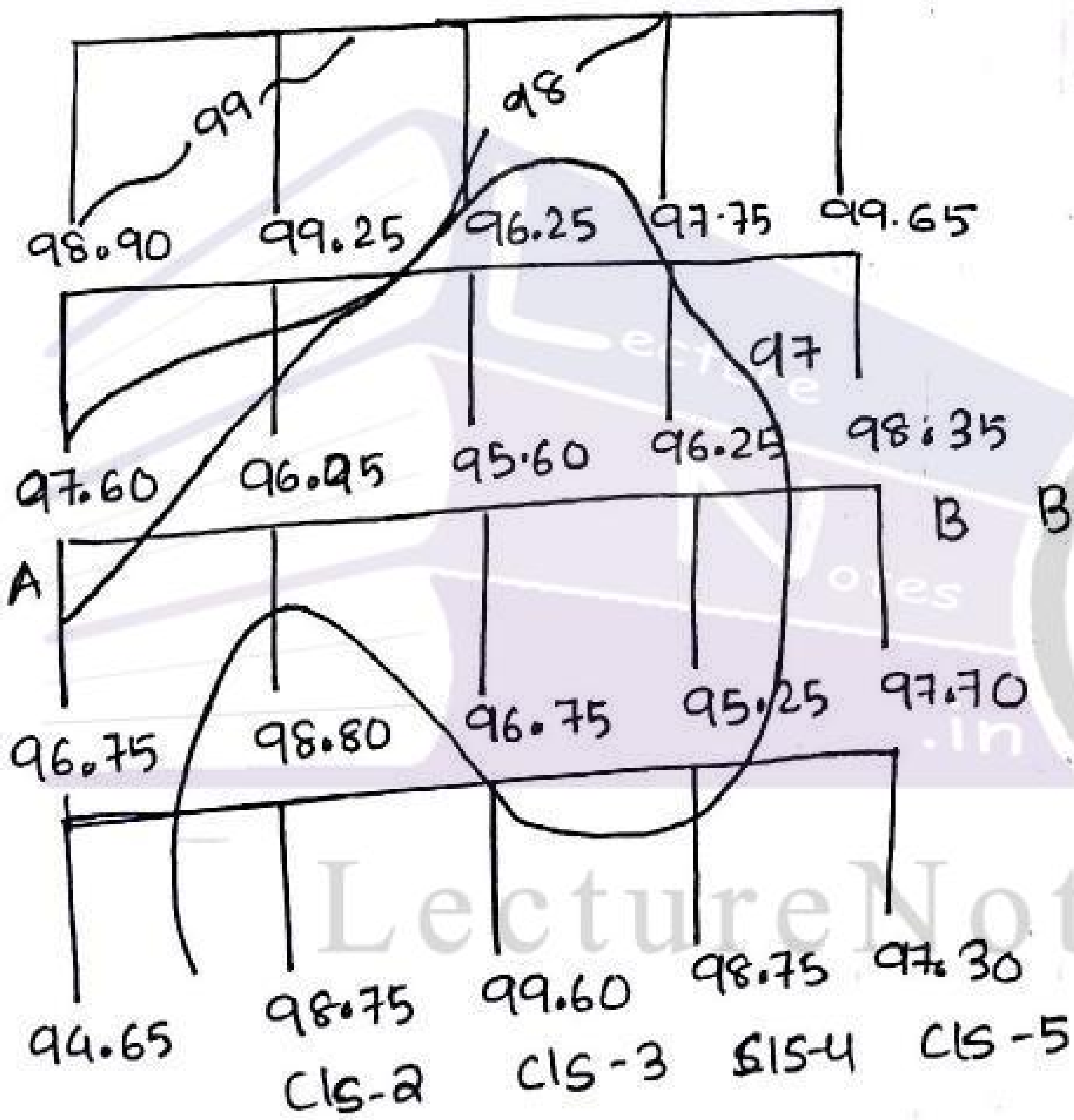
In this method a base line, centre line or profile line is considered. Cross-sections are taken ⊥ar to this line at regular intervals (say 50 m, 100 m). After this, points are marked along the cross-section at a regular intervals (say 5m, 10 m etc)

A TBM is set up near site

→ Staff readings are taken along the base line and the cross-sections. These readings will be mentioned in the level book. The RL of each point will be calculated. Then the base-line and cross section are plotted to a suitable scale.

→ Subsequently, the RLs of the respective points are noted on the map, after which the required contour line is drawn by interpolation.

This method is suitable for route survey, when cross-sections are taken transverse to the longitudinal section.

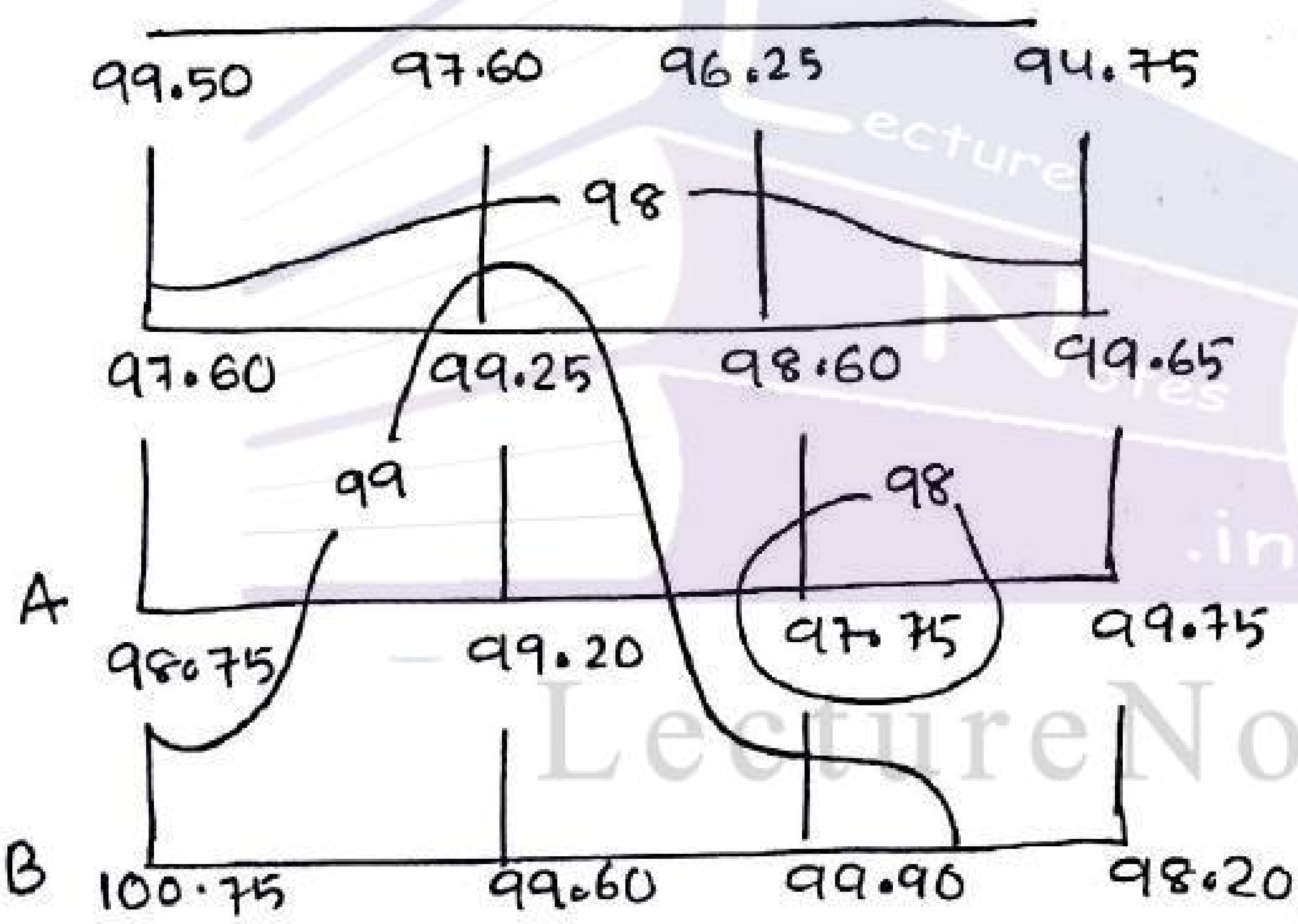


b) Using squares

The area is divided into a no. of squares. The size of these squares depends upon the nature and extent of the ground. Generally, they have a sides varying from 5 to 20m. The corners of the squares are numbered serially as 1, 2, 3...

A temporary B.M is set up near the site and the leve is set up at a suitable position. The staff readings on the corners of the squares are taken and noted in the level book maintaining the sequence of the serial numbers of the

corners. The RLs of all the corners are calculated.
The skeletons of the squares are plotted to a suitable scale.
The respective RLs are noted on the corners, after which the contour lines are drawn by interpolation.



RK noted as per skeleton

Using squares

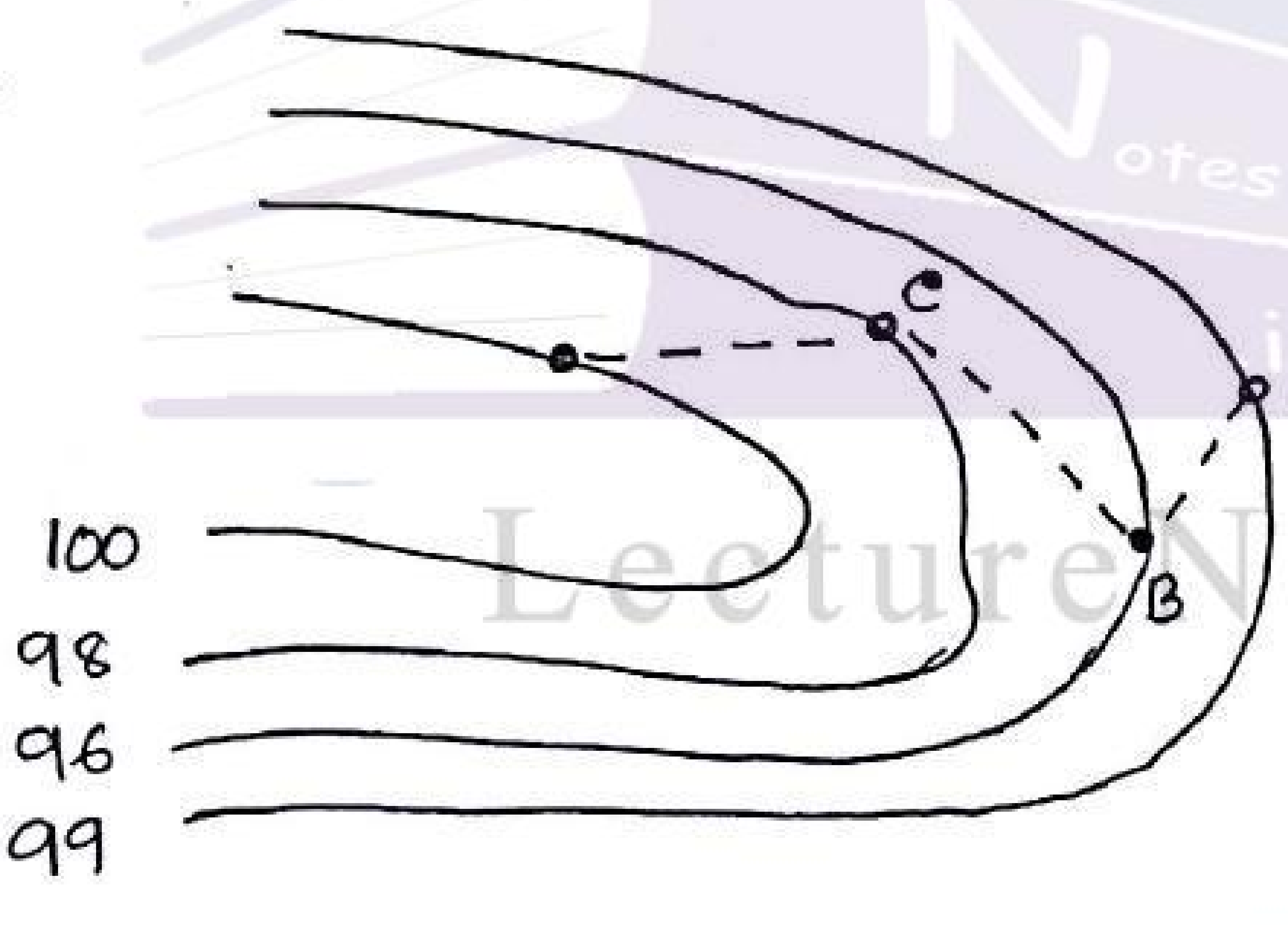
CONTOUR GRADIENT

During preliminary survey for roads in a hilly area, the required points are first established along the gradient. The line joining these points is known as the contour gradient or grade contour.

Initially, the points are established approximately by an Abney level and then accurately fixed by a levelling instrument. 13

Location of contour Gradient :-

Suppose it is required to locate centre line of a road in a hilly area with a ruling gradient of 1in20. Let the starting point A be on a 94.00m contour line. Since the contour interval is 2m and gradient is 1in20, the horizontal distance between A and the point on the next contour (96.00 m) is 2×20 = 40m. With the centre at A and radius equal to 40 m on the scale scale, an arc is drawn cutting the contour line of 96.00 at the point B. Taking B as the centre and with the same radius another arc is drawn to get the next point C. The other points are located in a similar manner.



FIELD LOCATION OF GRADE CONTOUR

Field location of grade contour can be done by :-

1.) By Abney level

2.) By leveling Instrument.

SUMMARY:-

In this section, you got to know about the contouring. Then some definitions of contour line & interval and also focussed on some of the uses of contour map. Then the various characteristics of contours which includes the hills, depressions, uniform slope etc Also focused on different direct and indirect method and also the contour gradient by Abney level and by levelling Instrument and also its usefulness to the society determining the points on the ground having the same RL - by joining the contour lines of same elevation or by interpolation technique.

Objective of using theodolite:-

The theodolite is an intricate instrument used mainly for accurate measurement of horizontal and vertical angles upto 10" or 20", depending upon the least count of the instrument.

→ This instrument sometimes known as an universal instrument. Its main objective is to measure vertical, horizontal and deflection angles and also to compute the area of a traverse.

→ Theodolites may be of two types :-

i) Transit theodolite ii) Non-transit theodolite

In the transit theodolite, the telescope can be revolved through a complete revolution about its horizontal axis in a vertical plane.

In the non-transit theodolite, the telescope cannot be revolved through a complete revolution in the vertical plane. But it can be revolved to a certain extent in the vertical plane, in order to measure the angle of elevation or depression.

Use of theodolite:-

The theodolite is most accurate instrument used mainly for measuring horizontal and vertical angles. It can be used for locating points on a line, prolonging survey lines, finding difference in elevations, setting out grades, ranging curves etc.

Some Definitions:-

1- Centring:- The setting of a theodolite exactly over a station mark by means of a plumb-bob is known as centring.

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

3) Face left:-
It means the vertical circle of the theodolite is on the left of the observer at the time of taking readings. The observation taken in the face left position is called face-left observation.

4) Face Right:-
This indicates when the vertical circle of the instrument is on the right of the observer at the time of taking readings. The observation taken in the face right position is called face-right observation.

5) Telescope Normal:-
The face left position is known as 'telescope normal' or 'telescope direct'. It is also referred to as bubble up.

6) Telescope Inverted:-
The face right position is called 'telescope inverted' or 'telescope reversed'. It is also termed bubble down.

7) Changing face:-
The operation of bringing the vertical circle from one side of the observer to the other is known as changing face.

8) Swinging the telescope:-
It indicates turning of the telescope in a horizontal plane. It is called 'right swing' when the telescope is turned clockwise and left swing when the telescope is turned anti-clockwise.

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

10) Axis of the telescope :-

This axis is an imaginary line passing through the optical centre of the object glass and the optical centre of the eye piece.

11) Axis of the Bubble tube :-

It is an imaginary line tangential to the longitudinal curve of the bubble tube at its middle point.

12) Vertical Axis :-

It is the axis of rotation of the telescope in the horizontal plane.

13) Horizontal Axis :-

It is the axis of rotation of the telescope in the vertical plane. It is also known as the trunnion axis.

14) Temporary Adjustment :-

The setting of the theodolite over a station at the time of taking any observation is called temporary adjustment.

15) Permanent Adjustment :-

when the desired relationship b/w the fundamental lines of a theodolite is disturbed then some procedures are adopted to established this relationship. This adjustment is known as permanent adjustment.

TEMPORARY ADJUSTMENT OF THEODOLITE :-

Temporary adjustment of theodolite involves following steps, they are as follows:-

1> Setting the Theodolite over the station

⇒ The tripod stand is placed over the required station. The theodolite is then lifted from the box and fixed on top of the stand by means of a wing nut or according to the fixing arrangement provided along with the instrument.

2> Approximate levelling by Tripod stand

⇒ The legs of the tripod stand are placed well apart and firmly fixed on the ground. Then, approximately levelling is done using this stand.

3> Centring

⇒ It is the process of setting the instrument exactly over a station. At the time of approximate leveling by means of the tripod stand, it should be ensured that the plumb bob suspended from the hook under the vertical axis lies approximately over the station peg.

The centering is accurate when the plumb bob is exactly over the nail of the station peg.

4> Levelling

Before starting the levelling operation, all the foot screws and brought to the centre of their run.

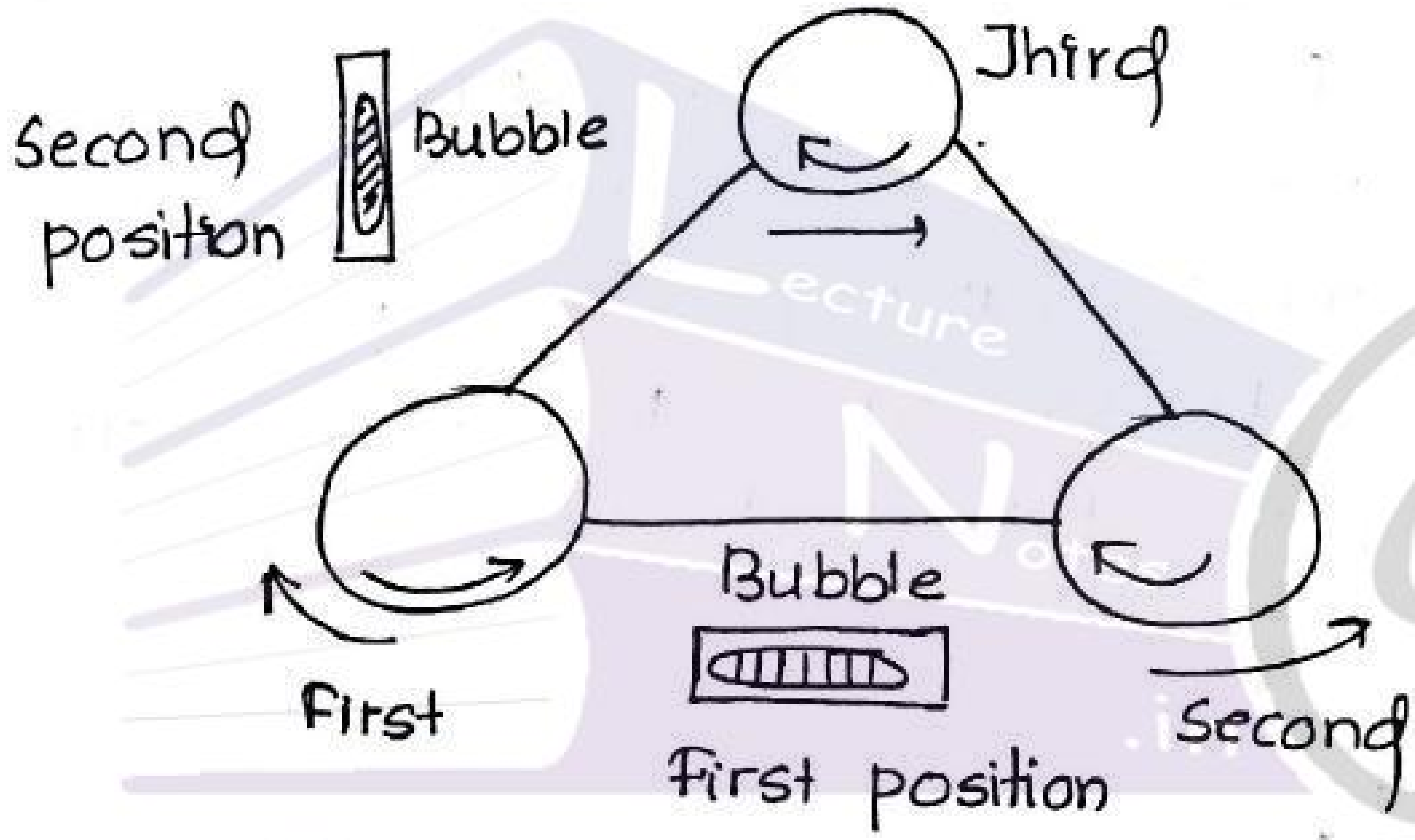
The following procedure are adopted:-

i- The plate bubble is placed parallel to any pair of foot screws. By turning both these screws equally inwards or outwards, the bubble is brought to the centre.

ii) The plate bubble is turned through 90° so that it is ⊥ar to the line joining the 1st and 2nd foot screws.
Then by turning the 3rd foot screw either clockwise or anti-clockwise the bubble is brought to the centre.

c) The process is repeated several times so that the bubble remains in the central position of the plate bubble, both dirn ⊥ar to each other.

d) The instrument is rotated through 360° about its vertical axis. If the bubble still remains in the central position, the adjustment of the bubble is perfect and the vertical axis is truly vertical.



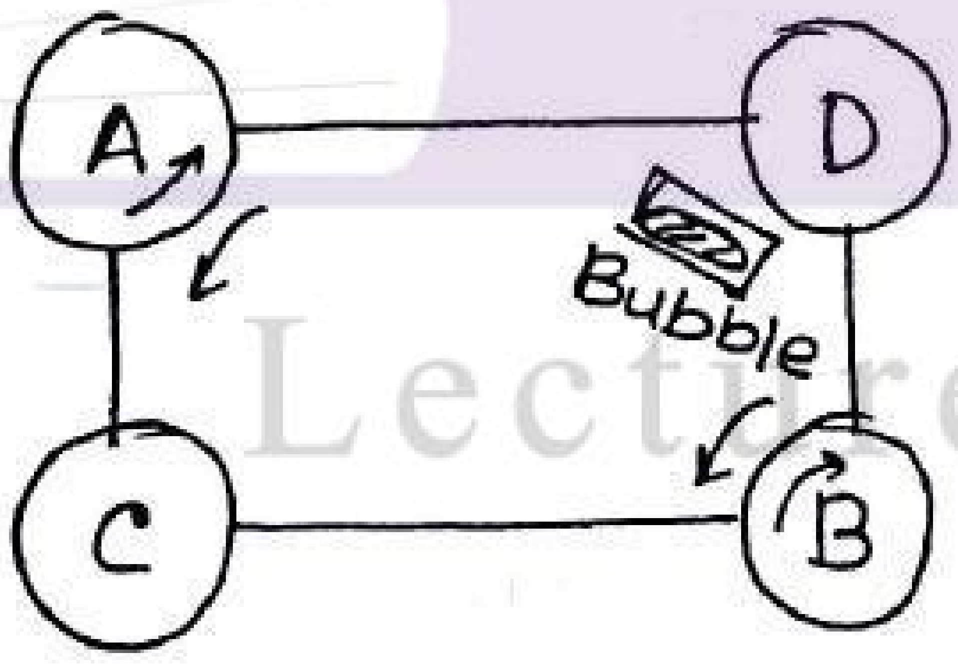
5) <u>Focusing the eye-piece</u>:-
The eyepiece is focussed so that the cross-hairs can be seen clearing. To do this, the telescope is directed towards the sky or a piece of white paper is held in front of the object glass and the eye-piece is moved in or out by turning it clockwise or anticlockwise until the cross-hairs appear distinct and sharp.

6) Focussing the object Glass:-

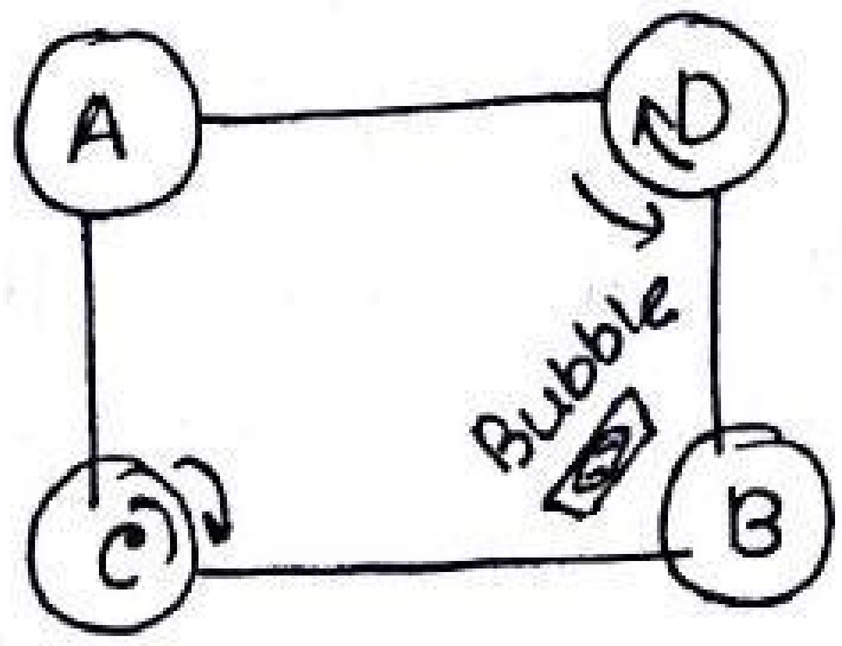
This is done to bring a sharp image of the object or target in the plane of c/s hairs and to eliminate parallax. To do this, the telescope is directed towards the object or target and the focussing screw is turned clockwise or anti-clockwise untill the image appears clear and sharp and there is no relative movement between the image and cross-hairs. The absence of relative movement can be verified by moving the eye up & down.

7) Setting the vernier:-

The vernier A is set to 0° and vernier B to 180°. To do this, the lower clamp is fixed. The upper clamp is loosened and the upper plate turned until the arrow of vernier A approximately coincides with zero and that of vernier B approx. coincides with the 180° mark. Then the upper clamp is tightened and by turning the upper tangent screw, the arrows are brought to a positon of exact coincidence.



First position



Second position.

Direct method of measuring Horizontal Angle

There are two methods of measuring horizontal angle

1) Repeatition method
2) Reiteration method

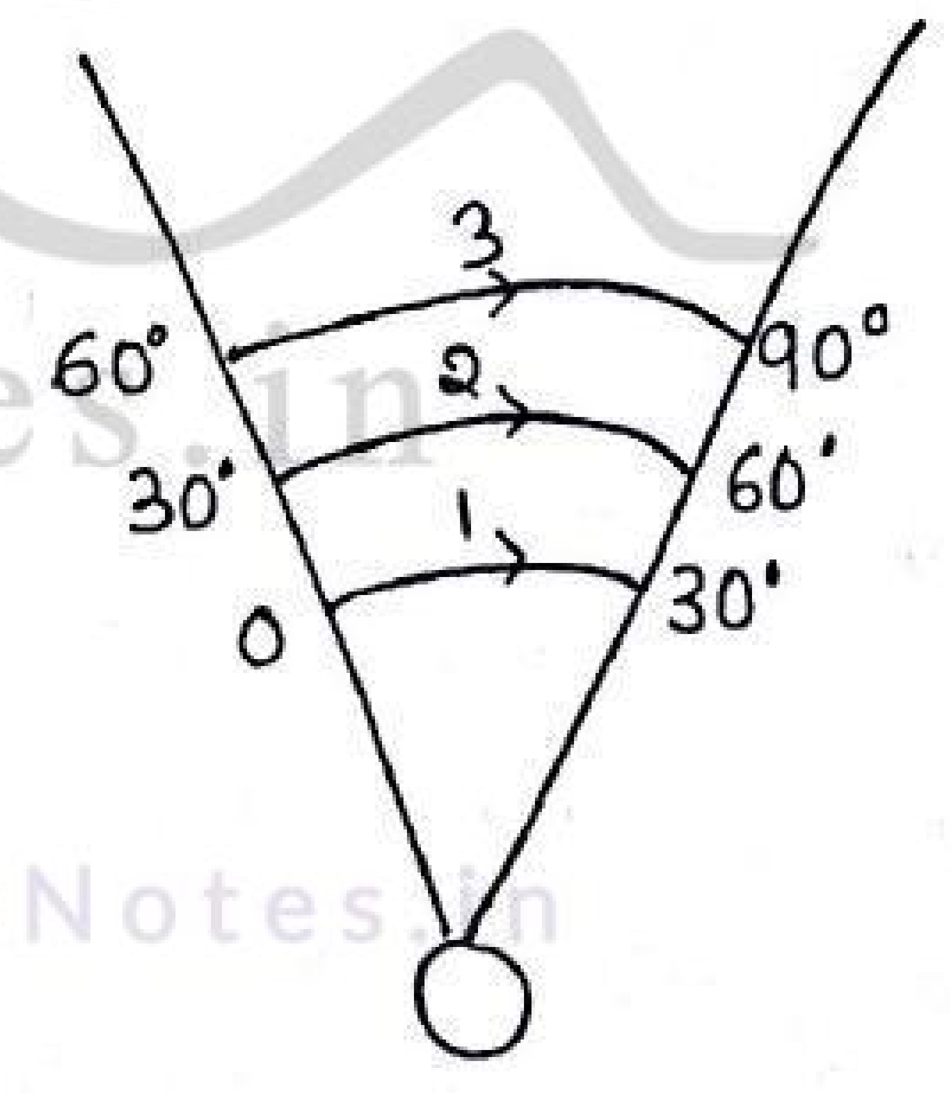
A. Repetition method

In this method, the angle is added a no. of times. The total is divided by the no. of readings to get the angle. The angle should be measured clockwise in the face left and face right positions, with three repetition of each face. The final reading of the 1st observation. will be the initial reading of the 2nd observation and so. on. The following procedure should be accepted.

Procedure:—

1) Suppose the angle ∠AOB is to be measured by the repetition process. The theodolite is set up to O. The instrument is centered and levelled properly. Vernier A is set to 0° and vernier B to 180°.

2) The upper clamp is fixed, and the lower one loosened. By turning the telescope, the ranging rode at A is perfectly bisected with the help of the lower clamp screw and the lower tangent screw. Here, the initial reading of vernier A is 0°.



Repetition method

3) The upper clamp is loosened and the telescope is turned clockwise to perfectly bisect the ranging rod at B. The upper clamp is clamped. suppose the reading on Vernier A is 30°

4) The lower clamp is loosened and the telescope is turned anti-clockwise to exactly biset the ranging rod at A. Here, the initial reading is 30° for the 2nd observation.

5) The lower clamp is tightened. The upper one is loosened and the telescope is turned clockwise to exactly bisect the ranging rod at B. Let the reading on vernier A be 60°.

6) The initial reading for the 3rd observation is set to 60°. ∠AOB is again measured. Let the final reading on the vernier A be 90°, which is the accumulated angle.

$$\angle AOB = \frac{\text{accumulated angle}}{\text{no. of readings}}$$

$$= \frac{90}{3} = 30^\circ$$

7) The face of the instrument is changed and the previous procedure is followed.

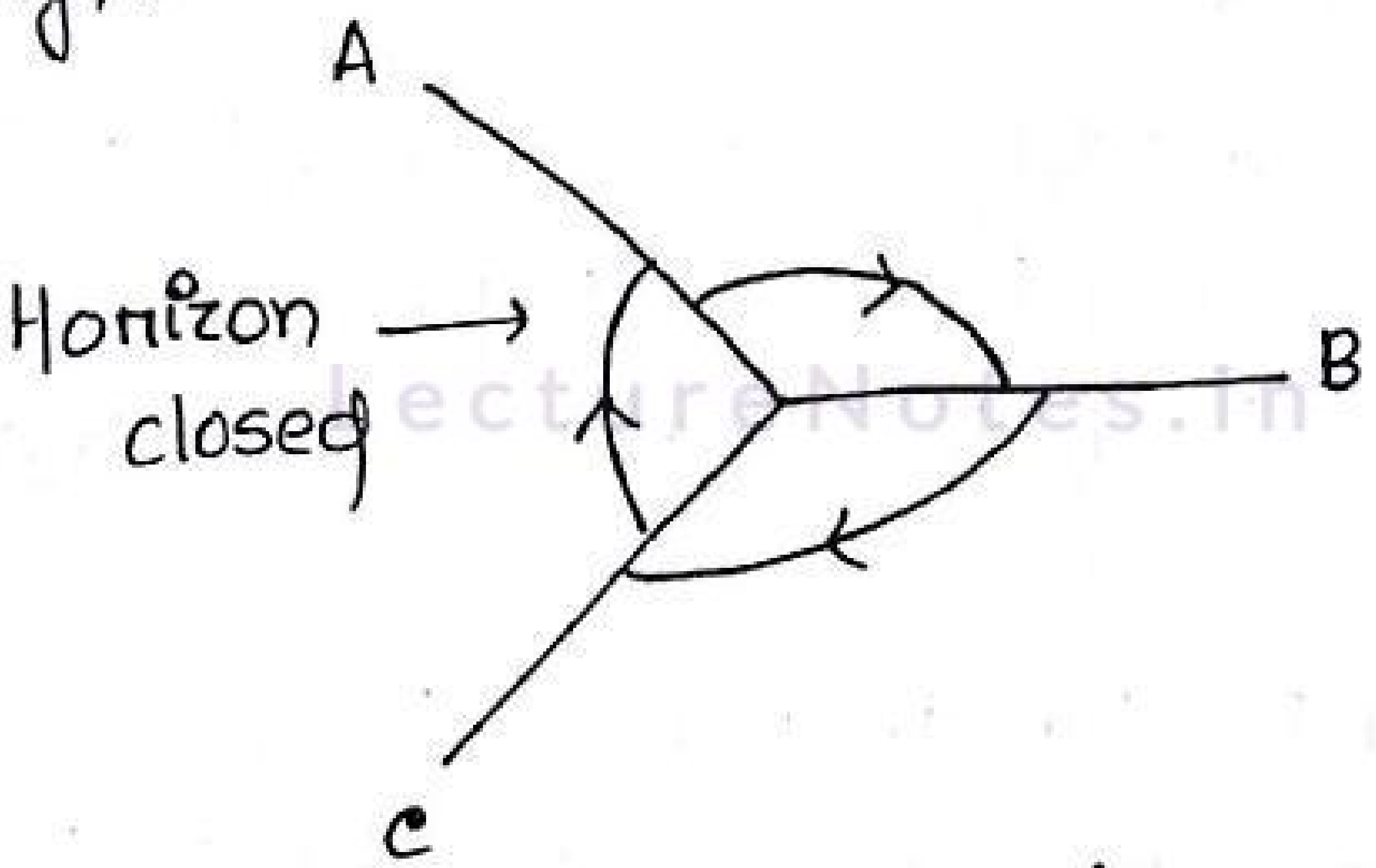
8) The mean of the 2 observations given the actual angle ∠AOB.

B. Reiteration method:-

This method is suitable when several angles are measured from a single station. In this method, all the angles are measured sucessively and finally the horizon is closed.
So, the final reading of the leading vernier should be the same as its initial reading.
If the discrepancy is small, the error is equally distributed among all the observed angles. If it is large, the reading should be cancelled and new sets taken.
Suppose it is required to measure ∠AOB and ∠BOC from station O.

First set :-

1) The theodolite is perfectly centred over O and levelled properly in the usual manner. Suppose, the observation is taken in the face left position and the telescope is turned clockwise (right swing).



2) Vernier A is set to 0° (i.e., 360°) and vernier B to 180°.

3) The upper clamp is fixed and the lower one loosened. The ranging rod at A is perfectly bisected. Now, the lower clamp is tightened.

4) The upper clamp is loosened, and the ranging rod or object at B is bisected properly by turning the telescope clockwise. The reading on both the verniers are taken. ∠AOB is noted.

5) Similarly, the object C is bisected properly, and the readings on the verniers are noted. ∠BOC is recorded.

6) Now the horizon is closed, i.e., the last angle ∠COA is measured. The position of the leading vernier is noted. The leading vernier should show the initial reading on which it was set. If it does not, the amount of discrepancy is noted.

If it is small, the error is distributed among the angles. If the discrepancy large, the observation should be taken again.

SECOND SET

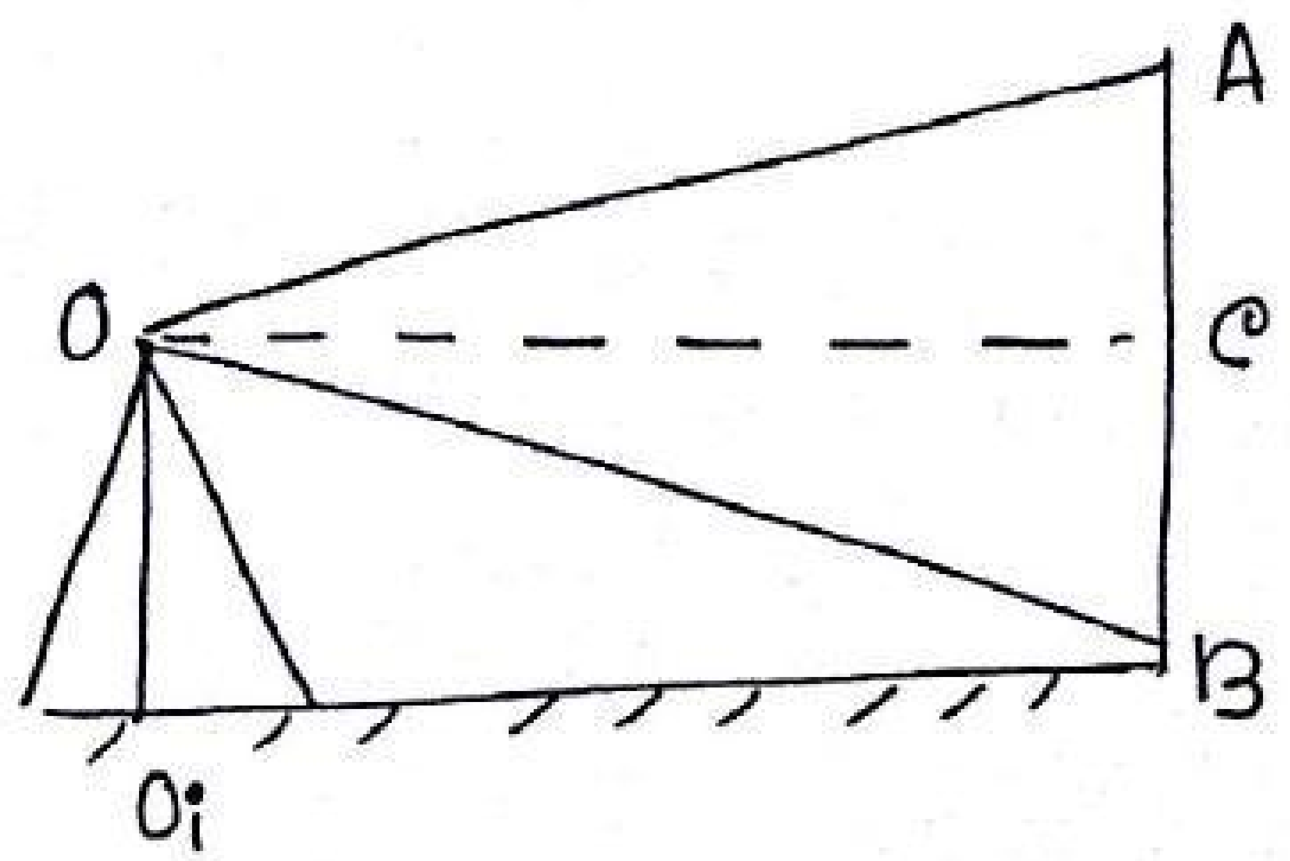
1. The face of the instrument is changed. Again the verniers are set at their initial positions. This time the angles are measured anti-clockwise.
2. The upper clamp is fixed, and the lower one loosened. Then the object A is perfectly bisected.
3. The lower clamp is tightened. The telescope is turned anti-clockwise and the object C bisected by loosening the upper clamp screw. The readings on both the verniers are taken ∠COA is noted.
4. Then the object B is bisected by turning the telescope anticlockwise and the reading on the verniers are taken ∠BOC is recorded.
5. Finally, the horizon is closed i.e., the object A is bisected. Here, the leading vernier A should show a reading of 0°. The last angle ∠AOB is noted.

MEASURING VERTICAL ANGLES :-

The vertical angle is the one between the horizontal line and the inclined line of sight. When it is above the horizontal line, it is known as the angle of elevation.

When this angle is below the horizontal line, it is called the angle of depression.

Suppose the angle of elevation ∠AOC and that of depression ∠BOC are to be measured. The following procedure is adopted.



Measuring Vertical Angles

The vertical angle is the one between the horizontal line and the inclined line of sight. When it is above the horizontal line, it is known as the angle of elevation.

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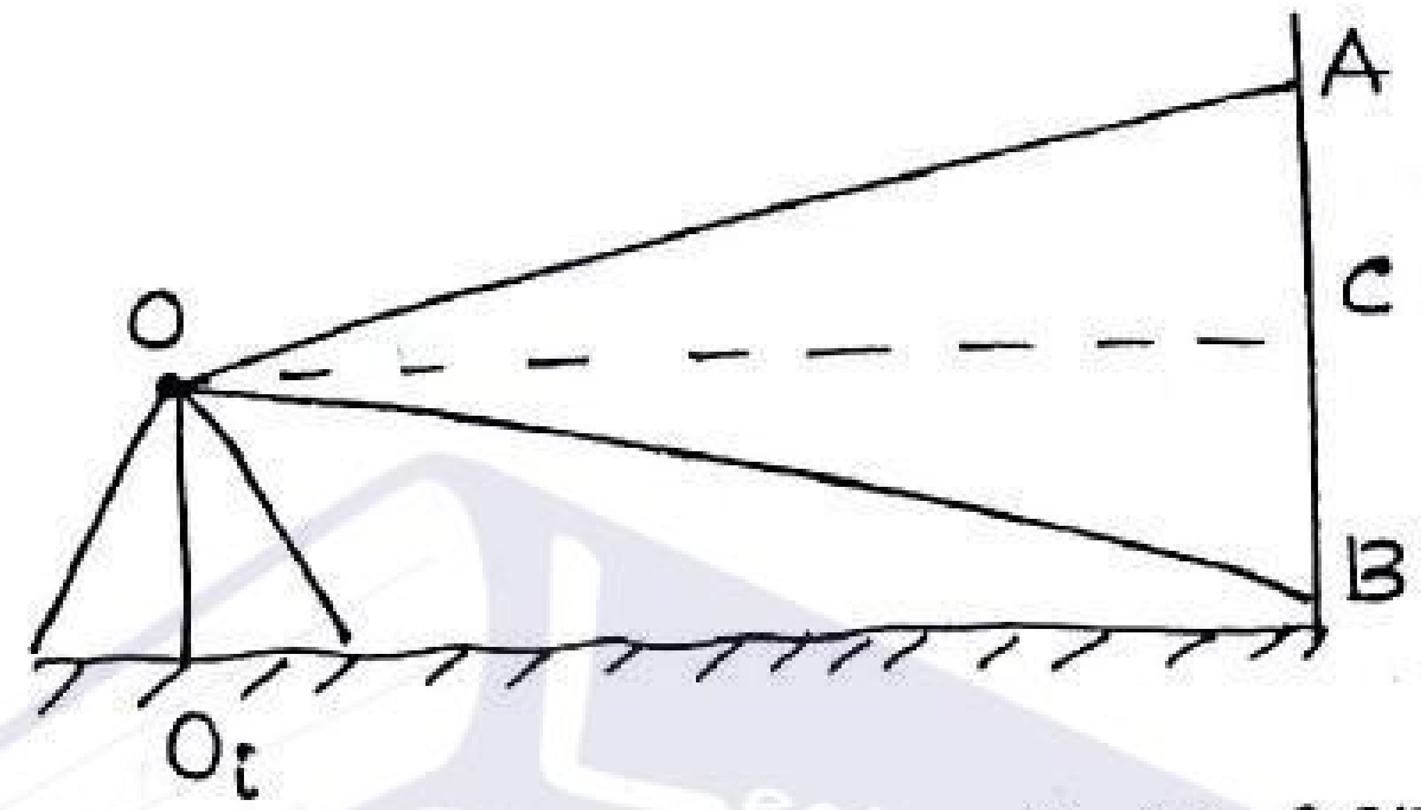
Suppose the angle of elevation ∠AOC and that of depression ∠BOC are to be measured. The following procedure is adopted.



1) The theodolite is set up at O. It is centred and levelled properly. The zeroes of the verniers are set at the 0°-0° mark of the vertical circle. The telescope is then clamped.
2) The plate bubble is brought to the centre with the help of foot screws. Then the altitude bubble is brought to the centre by means of a clip screw. At this position the line of collimation is exactly horizontal.
3) To measure the angle of elevation, the telescope is raised slowly to bisect the point A accurately. The readings on both the verniers are noted and the angle of elevation recorded.
4) The face of the instrument is changed and the point A is again bisect. The readings on the verniers are noted. The mean of the angles of the observed is assumed to be the correct angle of elevation.

5) To measure the angle of depression, the telescope is lowered slowly and the point B is bisected. The readings on the verniers are noted for the two observations. The mean angle of the observation is taken to be the correct angle of depression.

Methods of Traversing:-

The following are the different methods of traversing:

1) Included - angle method
2) Deflection - angle method
3) Fast - angle method

Included-angle method:-

This method is most suitable for closed traverse. The traverse may be taken in clockwise or anti-clockwise order. Generally, a closed traverse is taken in the anti-clockwise. In this method the bearing of the initial line is taken. After, this, the included angles of the traverse are measured. These angles may be interior or exterior.

Procedure:-

1. The theodolite is set-up and centered over A. The plate bubble is levelled. Vernier A is set at 0 and vernier B at 180° The upper clamp is fixed.
2. The telescope is oriented along the north line with the help of the tubular compass fitted to the instrument. Then the magnetic bearing of AB is measured.
3. Again Vernier A is set at 0° and the upper clamp is kept fixed.
4. The lower clamp is loosened and the ranging rod at E is bisected. Now, this clamp is tightened and the upper one opened. By turning the telescope clockwise, the ranging

rod at B is bisected. The readings on the verniers are noted. ∠A is obtained in this fashion.

5) Similarly, the other angles are measured by centering the theodolite at B, C, D & E.

The arithmetical check is applied as follows:-

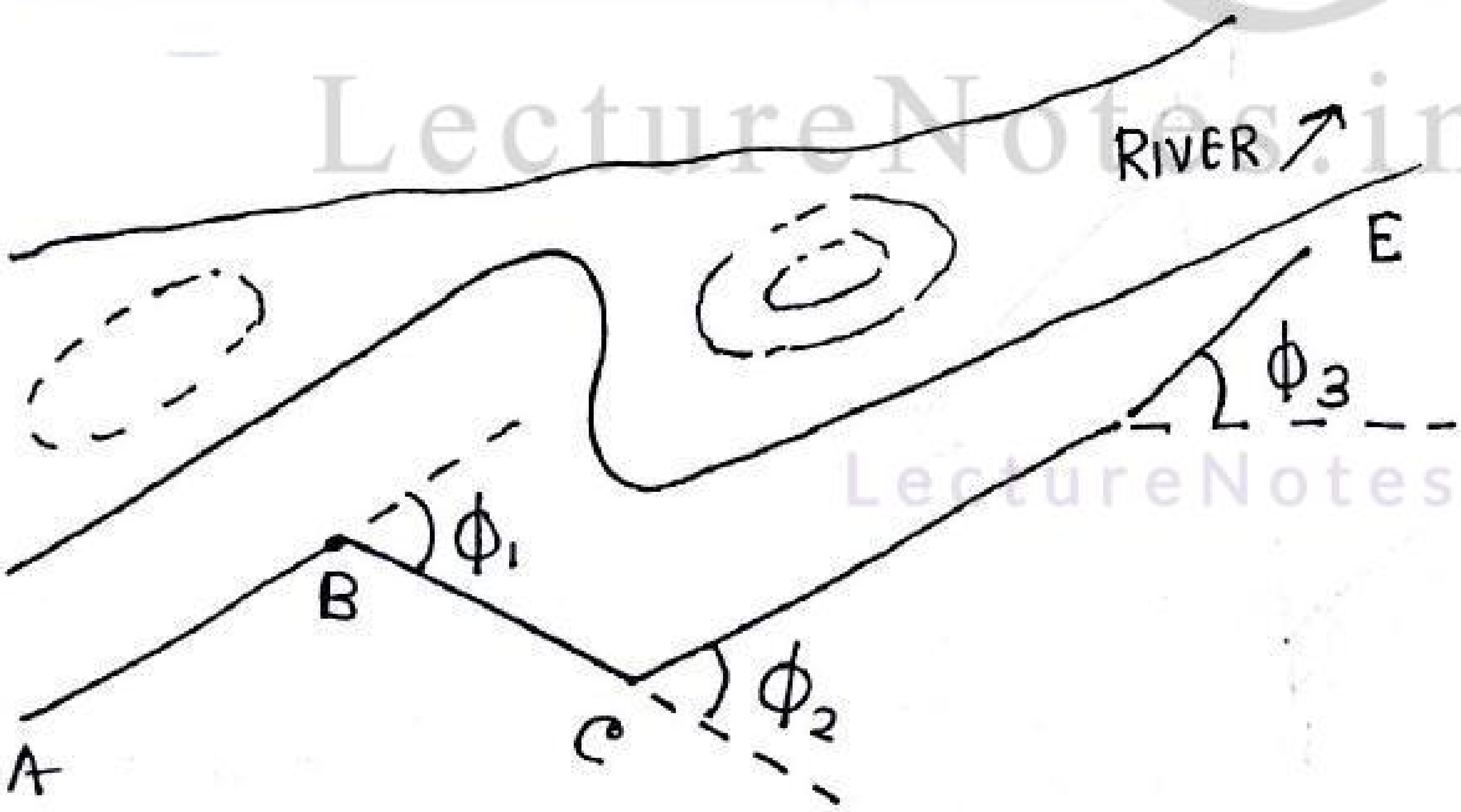
$(2n-4)\times 90°$ = Sum of interior angles.

6) For plotting the traverse, latitudes and departures of the traverse legs are calculated. The interior details are marked by applying the plane-table or transit and tape method.

Deflection-Angle method:-

This method is suitable for open traverse and is mostly employed in the survey of rivers, coast-lines, roads, railways etc.

Suppose an open traverse starts from A. The following procedure is adopted



1) The theodolite is set up at A, and then centered and levelled. After this, the bearing of the line AB is measured in the usual manner.

2) The theodolite is now shifted and centered over B. The plate bubble is levelled and vernier A set at 0°. Then a backsight is taken on A. The telescope is transited and by turning it clockwise the ranging rod at C is bisected. The vernier readings are taken.

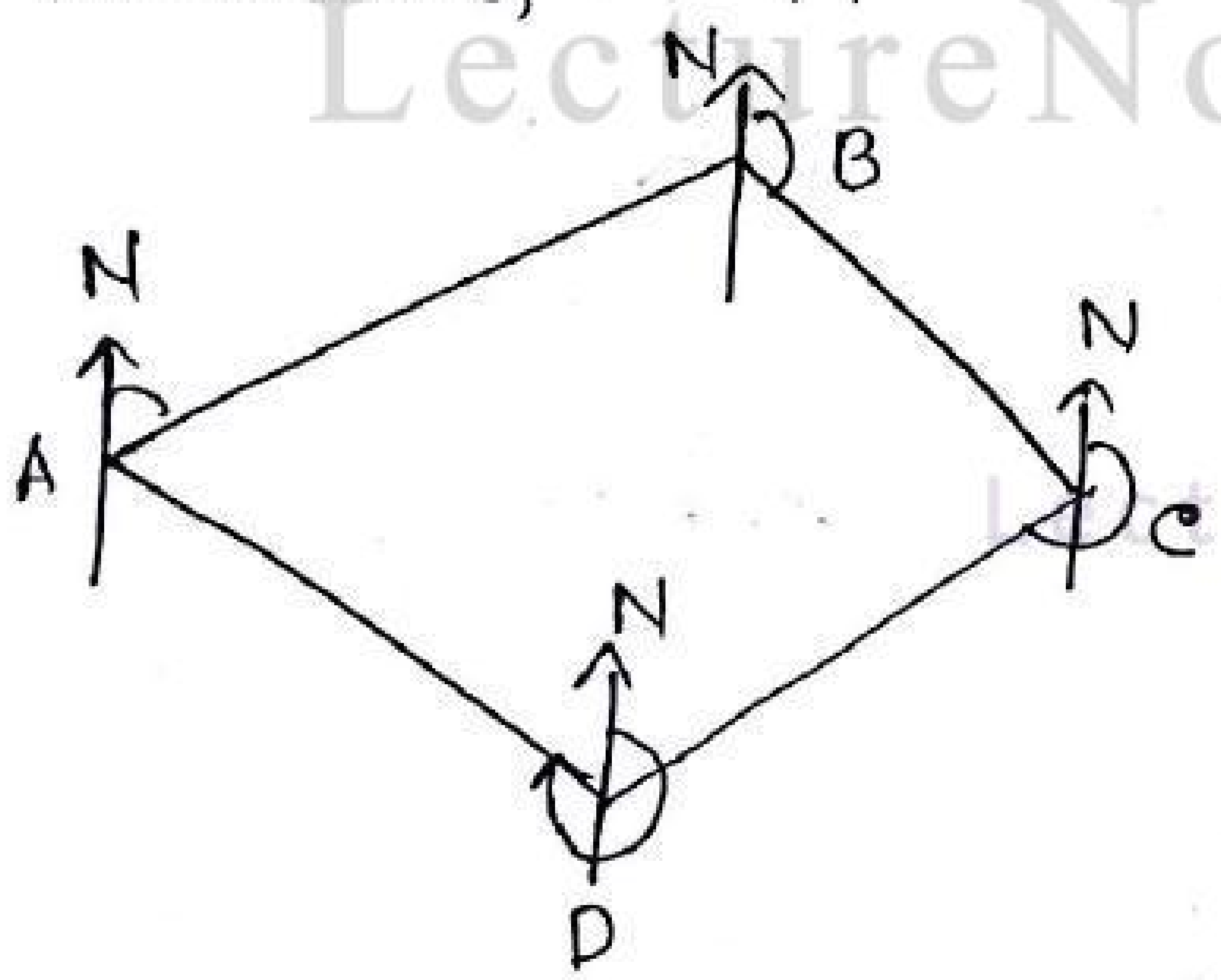
Then the deflection angle ϕ_1 is determined - it is the average value of the angles obtained from verniers A and B.

3) Similarly, the other deflection angles ϕ_2 and ϕ_3 are measured.

4) A field book is prepared in which the deflection angles and offsets are clearly noted.

C. Fast - Angle method:-

This method is used to measure the magnetic bearing and lengths of traverse legs. However the angles betn the lines are not measured. Suppose ABCDA is a closed traverse



1) The theodolite is set up at A. The vernier A is set at 0°. The telescope is oriented along the north line with the help of the trough compass or tubular compass fitted to the theodolite. The lower clamp is fixed.

2> The upper is clamp is loosened and the ranging rod at B is bisected. The reading on vernier A gives the fore bearing of AB. Say it is 30°. The BB of the line DA is also measured from A. Now the upper clamp is also fixed. The traverse is considered in clockwise dirn.

3> The instrument is shifted and set up at B with vernier A fixed at the reading of 30°. The lower clamp is loosened and the ranging rod at A is bisected. The telescope is now transited. The upper clamp is then released and the ranging rod at C is bisected. Now the reading on vernier A gives the bearing of BC. Say it is 100°.

4> Again the instrument is shifted and set up at C with vernier A fixed at 100°.

5> The same process is repeated to get the FB of CD.

6> Similarly, the fore bearing of the remaining sides are measured.

7> At the end of the traverse the FB and BB of DA should differ by 180°

Checks in closed and open traverse

A. Check in closed traverse

1. The sum of the measured interior angles should be equal to $(2N-4) \times 90°$ and the sum of the measured exterior angle should be equal to $(2N+4) \times 90°$, where N is the no. of sides.

2> The algebraic sum of the deflection angles should be equal to 360°, considering right-hand deflection to be +ve and left-hand deflection -ve.

4> The fore bearing and BB of the finishing line should differ by 180°.

5> The chaining of each line should be done twice along opposite directions.

6> Check after computation :- Sum of Northing = Sum of Southings

B. Check in open traverses

In an open traverse, measurements cannot be checked in the field. However, some field measurements are taken in order to ensure accuracy and determine the errors after plotting. The following are the field measurements taken for such check.

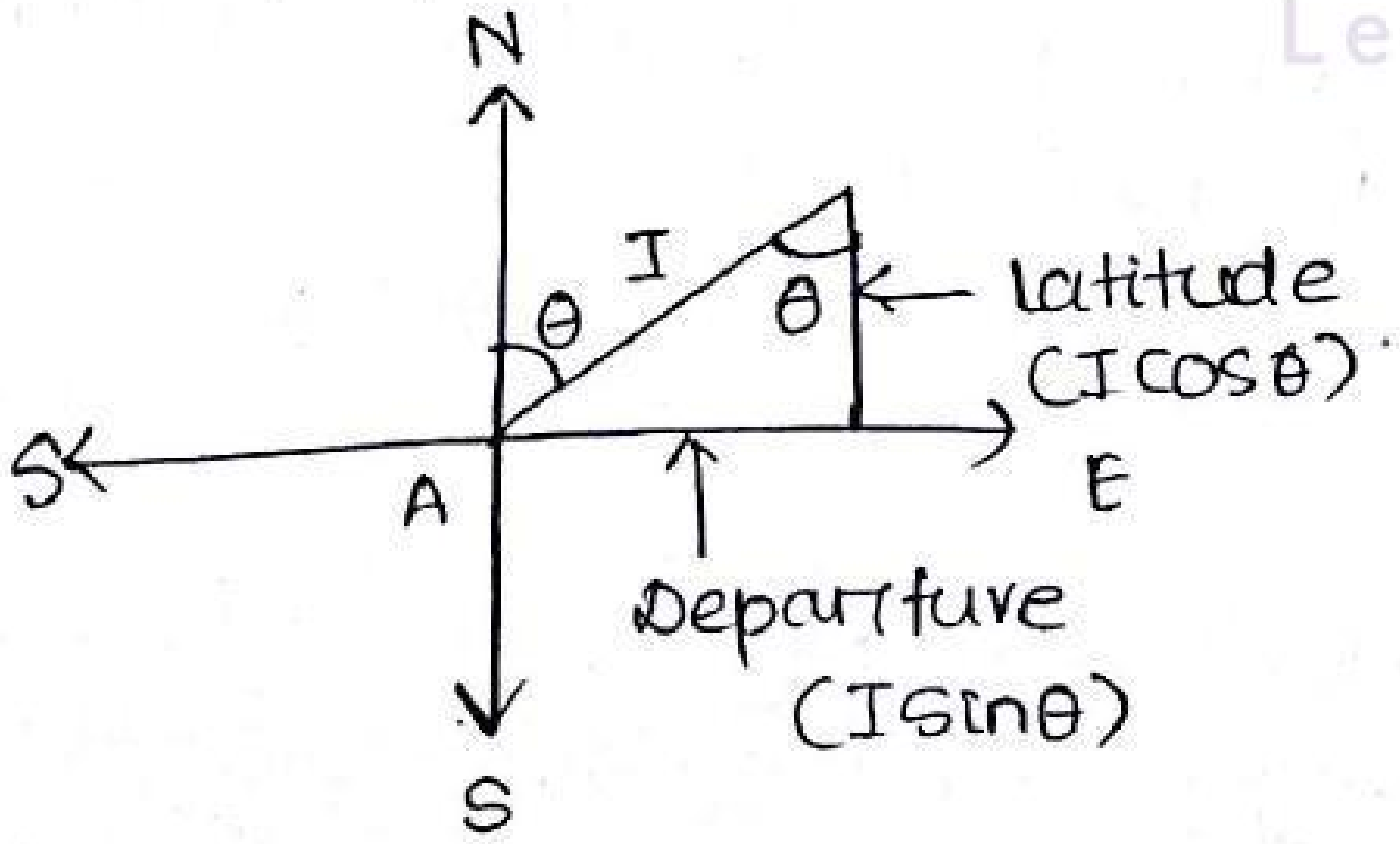
1> The line or cut-off line.

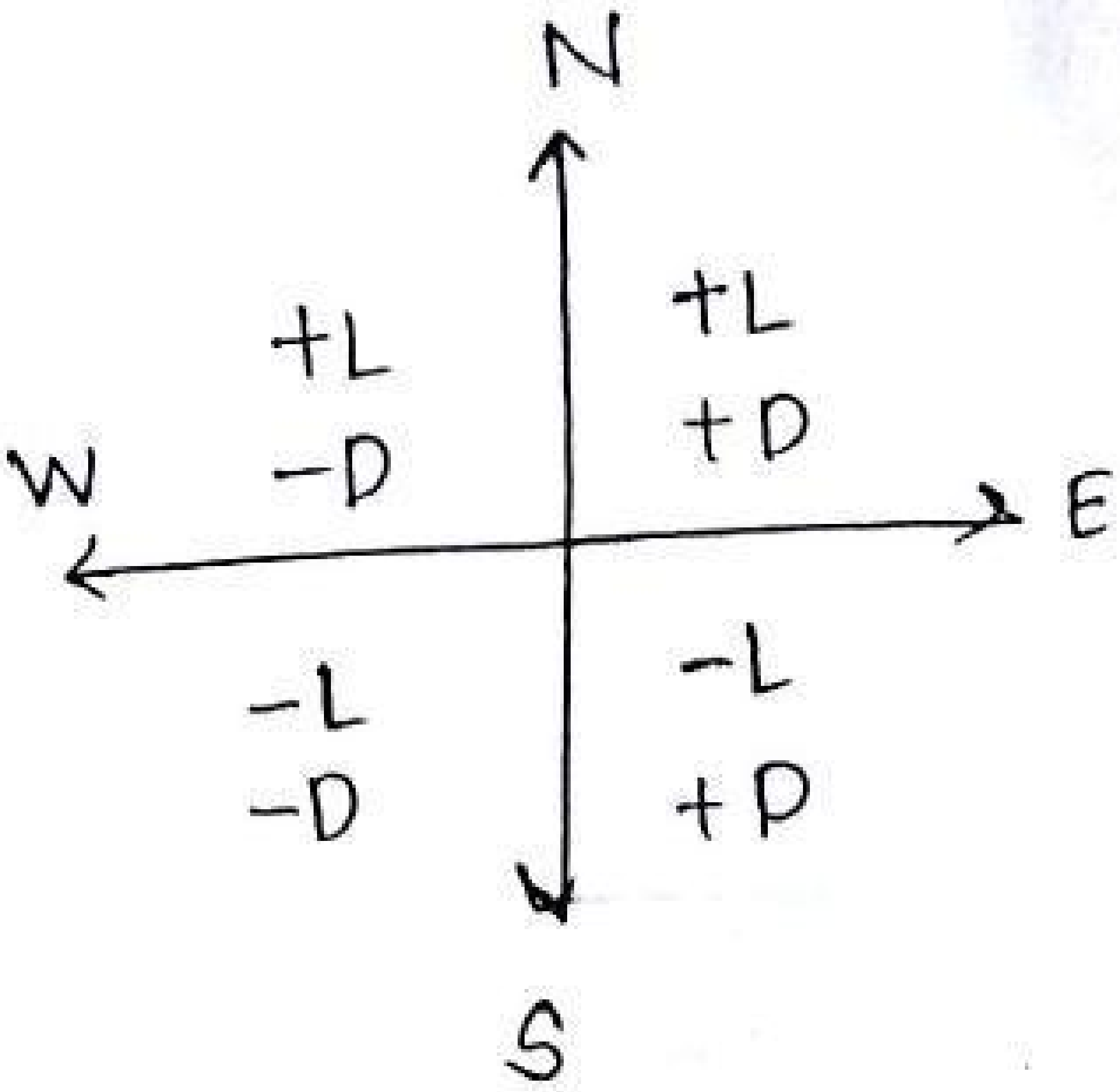
2> Auxillary point.

COMPUTATION OF LATITUDE AND DEPARTURE

The theodolite traverse is not plotted according to interior angles or bearings. It is plotted by computing the lattitudes and departures ~~by~~ of the points and then finding the independent coordinates of the points.

The latitude of a line is the distance measured parallel to the north-south line and the departure of a line is measured parallel to the east-west line.





The latitude and departure of the lines are also expressed in the following ways.

Northing = Latitude towards north = +L

Southing = " " South = -L

Easting = Departure " east = +D

Westing = " " west = -D

check for closed traverse

1) Sum of northing = sum of southing.

2) " " easting = " " westing.

⇒ Algebraic sum of latitudes and departure must be equal to 0.

SUMMARY:-

From this section of surveying, you got to know about the theodolite instrument, it types and uses. It mainly discussed about, how theodolite can be used for measurement of angles, distances, area etc. You also got to know about the detail idea regarding traversing i.e., closed and open, how they can be checked, if necessary it gave a detailed knowledge that this instrument can be useful for engineers to get the accurate angle (both horizontal & vertical) and also the area and bearing of the lines.

Chapter-6 Modern Surveying Instruments :-

Objective of this chapter :-

Modern surveying instruments provides faster and more precise surveying than conventional instruments. They are becoming more popular and replacing old surveying instruments such as Dumpy level and compass.

With these type of instruments the work will be more faster and tedious.

Electromagnetic Spectrum :-

EM spectrum is a continum of all electromagnetic waves arranged according to frequency and wavelength. The sun, earth and other bodies radiate electromagnetic energy of varying wavelengths. Electromagnetic energy passes through space at a very speed of light in the form of sinusoidal waves.

Types of EM Spectrum :-

It consists of
i- Radio waves
ii- Microwaves
iii- Infrared waves
iv- Visible light
v- Ultraviolet radiation
vi- X-rays
vii- Gamma rays

⇒ It is a very useful instrument adopted in modern surveying.

⇒ Electromagnetic energy is the energy source required to transmit information from the target to the sensor. It is a crucial medium that is described as electromagnetic spectrum.

Many of the basic forms of energy in the universe are related as part of the electromagnetic spectrum.

⇒ On this spectrum, many forms exists that describe energy in a specific region of the electromagnetic spectrum.

⇒ These are visible light, radiowaves, microwaves, infra-red, uv rays, x-rays and gamma rays.

⇒ Note that as the wavelengths of energy decreases, the frequency increases.

Major Regions of the electromagnetic spectrum

Region of EM Spectrum :-

Gamma Rays :-

wavelength :- < 0.03 nanometer

Entirely absorbed by the earth's atmosphere are not available for remote sensing.

X-Rays :-

Wavelength :- 0.03 to 30 nanometers

Entirely absorbed by the earth's atmosphere and not available for remote sensing.

UV-rays :-

wavelength :- 0.03 to 0.4 micrometers.

Wavelengths from 0.03 to 0.3 micrometers absorbed by Ozone in the earth's atmosphere.

Photographic U.V :-

wavelength :- 0.3 to 0.4 micrometer

Available for remote sensing the earth. can be imaged with photographic film

Visible :-

wavelength 0.7 to 3.0 micrometers.

Available for remote sensing the earth. Can be imaged with photographic film.

Reflected Infrared :- ~~It~~ .

Wavelength 0.7 to 3.0 mm.

Available for remote sensing the earth. Near infrared 0.7 to 0.9 mm. Can be imaged with photographic film.

Thermal Infrared :-

Wavelength 3.0. to 14 mm.

Available for remote sensing the earth. This wavelength cannot be captured with photographic film. Instead, sensors are used to image this wavelength band.

Microwave or Radar :-

Wavelength :- 0.1 to 100 cms.

Longer wavelengths of this band can pass through clouds, fog and rain. Images using this ban can be made with sensors that actively emit microwaves.

Radio :-

wavelength :- > 100 cms

Not normally used for remote sensing the earth.

Radar :-

The term RADAR was coined in 1940 by the united states Navy as an acronym for Radio detection and ranging.

A radar system makes use of high-speed EM waves to determine the location (distance), the velocity, the dirn being travelled, and the elevation (altitude) of both stationary and non-stationary objects.

These objects can include weather formations, motor vehicles, ships, aircraft and even terrain.

Radar types and functions

- Navigation
- Space exploration / Tracking
- Air traffic control
- Weather
- Threat Detection (Military)
- Missile Guidance (Military)
- Battlefield and Reconnalissance
- Biological Research
- Automobile Traffic / Speed detection.

Basic Principles :-

The basic principles of radar operation is simple to understand. A radar system transmits EM energy and analyzes the energy reflected back to it (by an object).

The theory behind radar, on the other hand, is very complex.

An understanding of the theory is essential in order to be able to specify and design radar systems correctly.

The implementation and operation of any radar system involves a wide range of disciplines such as structures, mechanical and electrical engineering, high power microwave engineering, and advanced high speed signal and data processing techniques. The measurement of an object's range (distance) from the radar antenna is made possible because of these properties of radiated electromagnetic energy:

a) Reflection of electromagnetic waves

b) Electromagnetic energy travels through air at a constant speed, at approx. the speed of light.

c) This energy normally travels through space in a straight line and will vary only slightly because of atmospheric and weather conditions.

Electronic Distance Measurement

In surveying, accurate distance measurement is always the most challenging part.

Introduction of electronic Distance measurement (EDM) has made the task of measuring even a long distance with high-level accuracy a simple operation.

In 1926, Michelson determined the velocity of light as 299796 Km/s by measuring the time taken for light to travel between two concave mirror systems.

In this experiment, an eight-sided rotating drum was set at the principle focus of one system. The drum rotated until a steady image of the source of light was seen in an eye-piece and it occurred at 528 rev/second, and thereby, implying a travel time of 1/4229 s. This method of distance measurement, by a rotating drum, was dishonoured due to mechanical considerations.

Classification of EDM :-

There are two types of EDMs :-

1) Electro-optical Instruments : -

The instrument uses light having wavelengths in the range of 0.7 to 1.2 mm within or slightly beyond the visible range of the spectrum. Due to this shorter wavelength, application of such instruments in dense fog or haze is not possible.

The instrument comprises of

i.) a light source producing visible light by using tungsten lamp / xenon flash tube or laser light.

ii) a photomultiplier and phase meter and

iii) a read-out unit.

Additionally, a retro directive prism at the remote station is needed for measuring distances.

2) Microwave Instrument : -

This instrument transmits microwaves with frequencies ranging from 3 to 35GHz corresponding to wavelengths of about 1.0 to 8.6 mm. Due to this higher wavelength, the penetration capacity of the light beam is sufficient to work in difficult climatic conditions.

Here, the master is set up at one end of the distance to be measured and the remote is established at the other end. An operator is required at each, an inter-communication is possible by an in-built radio telephone. A modulated signal is generated by the master, received by the remote and transmitted back to the master. The phase different between emitted and reflected signals are measured at the master and displayed at the required distance in metres.

The most common type of EDM instrument available in the market is popularly known as total station.

This incorporates a theodolite with electronic circles and an EDM.

The EDM normally works concentric with the telescope eyepiece and is generally housed in a casing that forms a part of the telescope.

<u>Principle of functioning:-</u>

Electromagnetic energy propagates through the atmosphere in accordance with the following eqn:-

$$V = f \times \lambda$$

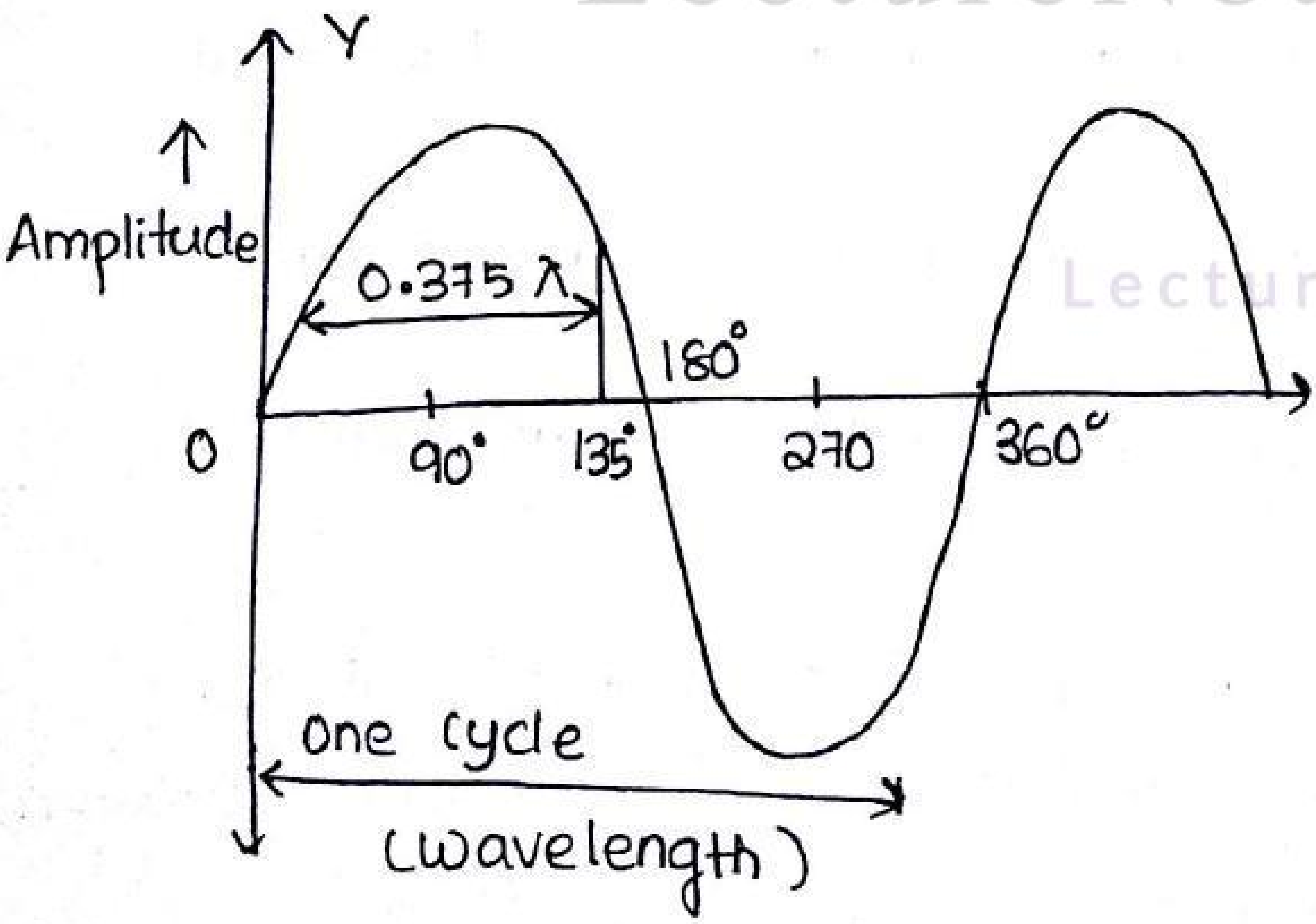
where, V = velocity of EM energy (in metres)

f = modulated frequency of energy (Hz)

λ = wavelength (m)

This propagation can be represented by the sinusoidal curve in the fig, which shows one wavelength or cycle.

The position or points along the wavelength are given by phase angle



Propagation of wave in EDM.

⇒ This instrument measure distances by determining the no. of full and partial wavelengths between the object and the instrument. This results in a two way distance.

⇒ A partial wavelength is determined by the phase shift of the returning wave, compared to the emitted one. If the phase shift is 135° then the partial wavelength is $(135/360)\lambda = 0.375\lambda$

⇒ If there are 'n' full wavelengths and partial wavelengths then the distance $L = (n+p)\lambda/2$. The factor '2' is required for dividing the whole value to obtain one-way distance

Measurement of Distances:-

An EDM can be used to plane objects or points in 3-dimensional relation to the unit.

The EDM emits a beam of infrared light that can be modulated at a controlled rate.

⇒ During use, the light beam is emitted from the EDM reflected off a prism or target held at a point to be mapped, and bounced back to the EDM.

⇒ The phase of the returning beam is shifted from that of the emitted beam.

⇒ This phase shifting is the func of travel time of the light beam.

⇒ The shifting of light wave is to determine the distance travelled by the light.

⇒ The comparison of returning and emitted signal gives the distance between the unit and target with an accuracy of approximately 1/8 inch in 1/4 mile.

It also measure the azimuth and height of an object by using the same principle of physics.

The data obtained from the EDM is stored in a data collector and finally downloaded for processing using computer drawing software (AUTO CAD)

Types of electronic distance measurement Instrument:-

EDM instrument are classified based on the type of carrier wave as follows:-

1> Microwave Instruments
2> Infrared wave Instruments
3> Light wave Instruments

Microwave Instruments :-

⇒ These instruments make use of microwaves. Such instruments were invented as early as 1950 in S.A by Dr. T.L. Wadley and named them as Tellurometers.

⇒ The instruments needs only 12 to 24V batteries Hence they are light and highly portable. Tellurometers can be used in day as well as in night.

⇒ The range of these instruments is upto 100 km. It consists of two identical units.
One unit is used as master unit and the other as remote unit. Just by pressing a button, a master unit and a remote unit into a master unit.

⇒ It needs two skilled persons to operate. A speech facility is provided to each operator to interact during measurements.

2>

Infrared wave Instruments :-

⇒ In this instrument amplitude modulated infrared waves are used. Prism reflectors are used at the end of line to be measured. These instruments are light and economical and can be mounted on the theodolite with these instruments accuracy achieved is ± 10mm. The range of these instruments is upto 3Km.

⇒ These instruments are useful for most of the civil engineering works. These instruments are available in the trade names DISTOMAT DI 1000 and DISTOMAT DI 55.

3> Visible light wave Instruments :-

These instrument rely on propagation of modulated light waves. This type of instrument was first developed in Sweden and was ~~first developed~~ named as Geodimeter. During night its range is upto 2.5 Km while in day its range is upto 3 Km.

Accuracy of these instruments varies from 0.5 mm to 5 mm 1Km distance. These instruments are also very useful for civil engineering projects.

DIGITAL THEODOLITE :-

Electronic digital theodolite is a precision instrument for measuring angles in the horizontal and vertical planes.

⇒ Theodolites are mainly used for surveying applications, and have been adapted for specialized purpose in fields like meteorology and rocket launch technology.

Applications of digital theodolite:-

1- To measure the horizontal angle and vertical angle between two points accurately upto a precision of 1".

2- To check the alignments of roads, railways track tunnel and bridges.

3- It is used in the prolongation of alignment of road, railways etc.

4- It is used for measurements of bearing and measurements of horizontal and vertical distances and determination of the direction of true north.

5- A telescope which can rotate or transit through 360° about a transverse horizontal axis.

6- This bearing for this horizontal or trunnion are mounted in two vertical pillars or standards.

7- The standards are mounted on a horizontal upper plate.

8- The upper plate rotates through 360° about a vertical on alidade axis, the bearing for the alidade axis is mounted in a lower horizontal axis.

Characteristics of electronic theodolite

i- Angle for least count can be 1" with precision ranging from 0.5" to 20".

ii- Digital read-outs eliminate the personal error associated with reading and interpolation of scale and micro-meter settings.

iii- Display window or unit for horizontal and vertical angles available at either or both ends.

iv- Some digital theodolites have modular arrangement where they can be upgraded to be total station or have an EDM attached for distance measurement.

v) Large dot matrix dual line LCD Screen to display both vertical and horizontal angles simultaneously.

vi) Introducting unique linear focussing mechanism to simplifying focussing and

vii) Continuous operation for upto 48 hours with fresh alkaline - manganese batteries.

Specifications for digital theodolites:-

i) Magnification : 26X to 30X

ii) Field of view : 1.5

iii) Shortage viewing distance : 1.0m

iv) Angle read-outs, direct : 5" to 20"

v) Digital ange display is user switchable from 5"/10" to 1"/5".

Total station:-

Total station is the most popular and modernised instument for measuring horizontal and vertical angles along with slope distances of an object in surveying operation in a single set-up.

The instrument is an electronic combined with electronic distance measurement (EDM) device and was first introduced in 1971.

Instrument:-

The total station instrument comprises of three major components:-

1) An electronic measuring device.

2) An electronic distance measurement device, and

3) A microprocessor.

Operation of total station in surveying

The total station is basically a special type of theodolite. The principle operation of total station is almost similar to that of a theodolite, operated in surveying.

There are two main steps:-

1> Orientation

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

<a> Levelling the instrument with the help of an optical plummet.

<b> Use of horizontal clamp and tangent screw for horizontal angle measurement.

<c> Use of vertical clamp and tangent screw for vertical angle measurement.

<d> Focusing the eye-piece lens and objective lens for getting better image and eliminating parallax.

<e> Initalisation of the instrument before commencement of the work.

f> Entering of PPM and reflector offset constant.

<g> Set the angular measurement format as horizontal and vertical angle and

<h> set the distance measurement mode as horizontal, vertical height and slope distance (H, N, ΔH)

2) Setting up:-

The setting up of the instrument over the tripod by clamping the lower base (tribach) is as follows:-

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

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

(c) Firmly fix the tripod legs on the ground.

(d) Mount the total station over the tripod and centre it by using an optical plumnet.

(e) Level the instrument by using a three-foot screw as we do in case of a normal levelling operation.

(f) Centering is checked by an optical plumnet, and centre of the reticule (cross-hair). If the centre is out, repeat the procedure to make it centre once again.

(g) Loosen the tripod base plate screw and use three leveling screws for fime adjustment.

(h) For making centering and leveling of the instrument, the translation of the instrument over the lower plate and movement of the foot screw is done simuntaneously.

Introduction to Remote Sensing and GIS:-

Remote sensing:-

→ Remote Sensing is the science of collecting information about the object, area or phenomenon without making any physical contact with the object.

→ The common remote sensing systems are of two-types:- Imaging (image forming) and non- imaging (non-image forming).

→ Image-forming system are again of two types framing type and scanning type.

→ In scanning type, the info. is acquired sequentially from the surface in bits of picture elements or pixels, point by point and line by line which may be arranged after acquisition into a frame format.

Active systems have their own source of energy such as RADAR, whereas the PASSIVE systems depend upon external source of illumination such as sun for remote sensing.

⇒ The study of various phenomena, with the help of satellite based information that changes continuously over the time in remote areas on the earth's surface is known as natural resource management.

Principle of Remote Sensing

⇒ The detection and discrimination of the targets or to collect the info. about the surface features of the earth basically refers to the recording and analysis of E.M energy that is reflected or emitted by the target object.

⇒ The amount of reflected energy is different for different objects depending upon their physical, chemical and structural properties which is known as spectral signature.

Components of Remote Sensing:-

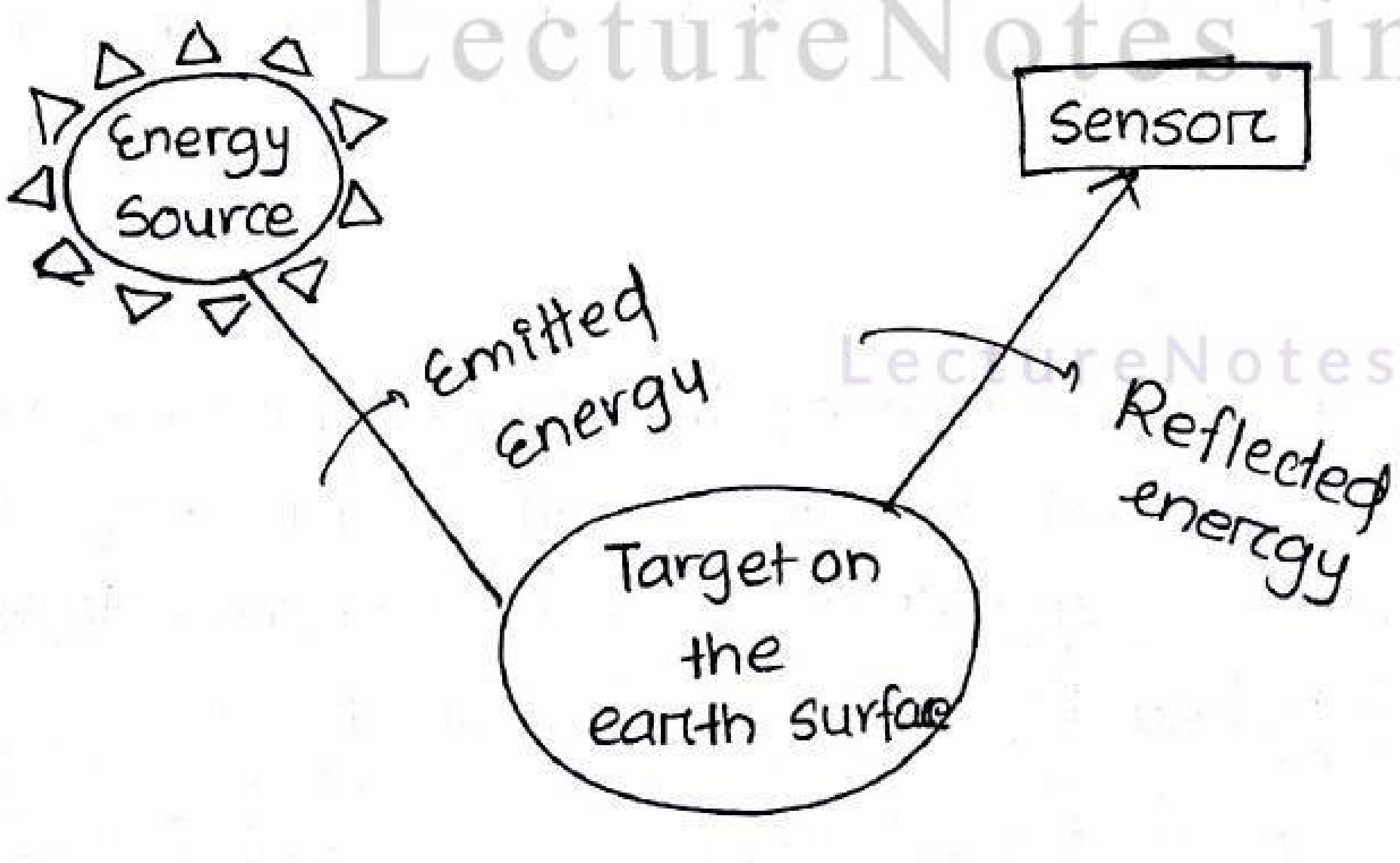
Remote sensing is the most popular and common method of data collection over the world.

The basic mechanisms are more or less same and therefore, the diff. component which make this system sucessful are also the same.

It is understood that there are four fundamental components of remote sensing.

They are as follows:-

1) A target
2) A energy source
3) A transmission path through atmosphere.
4) A sensor.



Process of Remote sensing:-

The process of remote sensing for acquiring information about the target, or even the earth's surface, comprises seven elements.
The interaction between the incident radiation and reflected radiation of energy with the atmosphere is very important.

The following are the seven elements of remote sensing:-
1) Energy source or Illumination
2) Interaction of radiation with atmosphere.
3) Interaction with target.
4) Recording of energy by the sensor
5) Transmission, Reflection and processing
6) Interpretation and Analysis
7) Application.

Geographic Information System (GIS):-

A geographic information system refers to a system of capturing, storing and manipulating spatial information in digital form with the help of computer hardware and software to analyse and present the features of earth.

Importance:-

⇒ Nowadays, GIS is used in public sectors as well as in business, commercial activities and service as a mandatory measure. The technique is adopted to prevent environmental pollution, epidemic and also to take prior measures to combat natural disasters.

⇒ The main importance of GIS is recent years is to assess the natural resources, food sources in the age of a growing population. Resources in the form of food, shelter, energy can be identified and allocated very precisely by using GIS tools.

GIS Components:-

A sucessful GIS operation needs computer hardware, GIS software, spatial data and attributes, people and a well-defined, disciplined methodology of operation. An integration of all 5 components simuntaneously develops a GIS.

SUMMARY:-

In this section of surveying, you got to know about various modern surveying equipments from EDM to GIS and remote sensing. How they are more reliable and fast than usual old surveying equipments basically works on spatial data, geological data, different waves, etc. The interpretation of datas and how to use the datas for surveying was mentioned briefly.