GOVERNMENT POLYTECHNIC JAJPUR

Lecture Note on

Mine Survey-I

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Case-II

method (a)

Select point B on one side and A & C on the other side. Erect AD and CE as perpendiculars to AB and range B, D & E in one line. measure AC, AD and CE. If a line DF is drawn parallel to AB, cutting CE in F perpendicularly, then triangles ABD & FDE will be similar.

$$\frac{AB}{AD} = \frac{DF}{FE}$$

$FE = CE - CF = CE - AD$ and $DF = AC$.

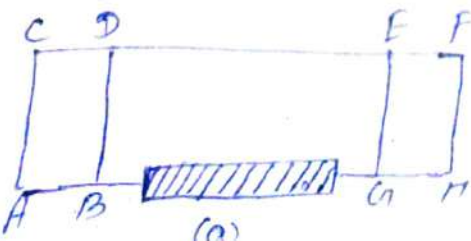
$$\frac{AB}{AD} = \frac{AC}{CE - AD} \quad \text{from which} \quad AB = \frac{AC \times AD}{CE - AD}$$

(c) Obstacles to both chaining and Ranging :-

A building is the typical example of this type of obstacle. The problem lies in prolonging the line beyond the obstacle and determining the distance across it.

method-a

Choose two points A and B at one side and erect perpendiculars AC and BD of equal length. Join CD and prolong it past the obstacle. Choose two points E and F on CD and erect perpendiculars EG and FH equal to that of AC. Join GH and prolong it. measure DE. Evidently, EG = DF.



(a)

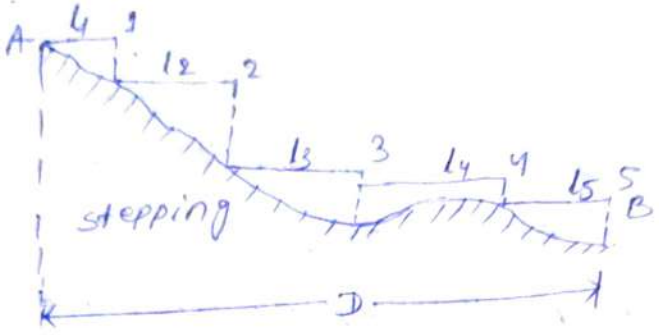
chaining on sloping ground:-

There are two methods

(1). Direct method

(2) Indirect method.

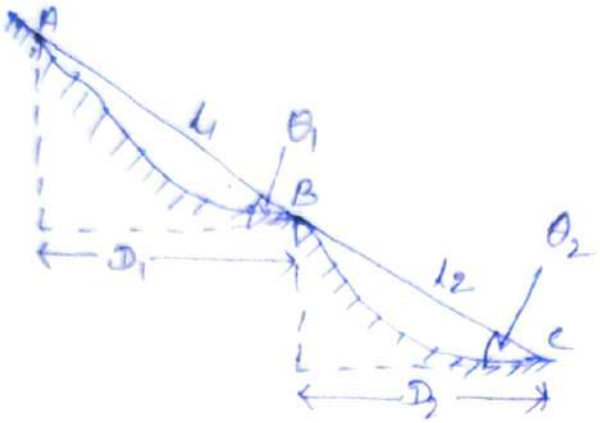
(1) Direct method:-



In the direct method or the method of stepping, as is sometimes called, the dist is measured in small horizontal stretches or steps.

The follower holds the zero end of the tape at A while the leader selects any suitable length L of the tape and moves forward. The follower directs the leader for ranging. The leader pulls the tape tight makes it horizontal and the point 1 is then transferred to the ground by a plumb bob. Sometimes, a special form of chalk arrow is used to transfer the point to the surface. The procedure is then repeated. The total length D of the line is then equal to $(L + l_2 + l_3 + \cdots)$: In the case of irregular slopes, this is the only suitable method.

(2) Indirect method :-



In the case of a regular or even slope, the sloping distance can be measured and the horizontal distance can be calculated. In such cases, in addition to the sloping distance, the angle of the slope or the difference in elevation between the two points is to be measured.

Method – 1

Angle measured :-

~~In fig 3.24,~~

Let, L_1 = measured inclined distance between A and θ_1 = slope of AB with horizontal.

The horizontal distance D_1 is given by $D_1 = L_1 \cos\theta_1$

similarly, for BC, $D_2 = l_2 \cos\theta_2$

The required horizontal distance bet^n any two points = $\Sigma L \cos\theta$

The slope of the line can be measured with the help of a clinometer.

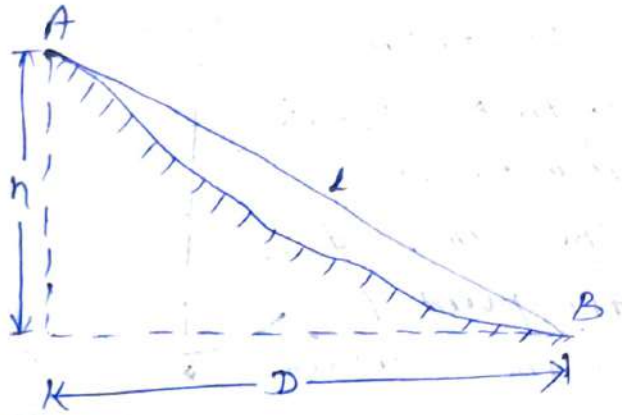
Method-2.

Difference in level measured :-

sometimes, in the place of measuring the angles, the difference in the level between the points is measured with the help of a levelling instrument and the horizontal distance is computed.

Thus if h is the diff in level, we have

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



Locating ground features; offsets :-

→ An offset is the lateral distance of an object or ground feature measured from a survey line.

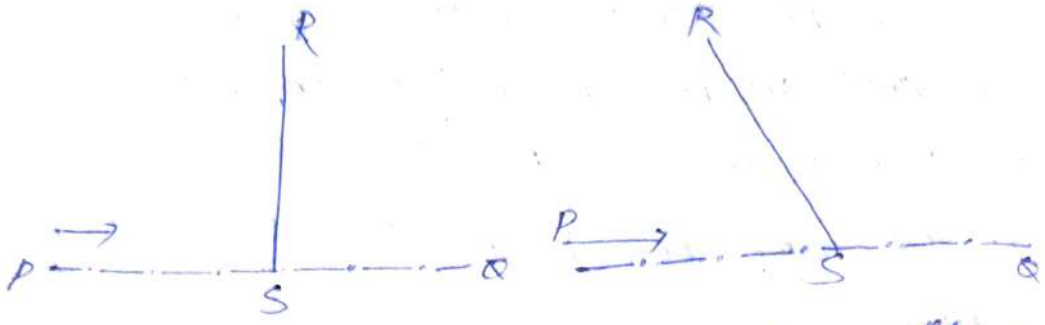
→ By method of offsets, the point on object is located by measurement of a distance and angle from a point on the chain line.

→ When the angle of offset is 90°, it is called perpendicular offset.

→ When the angle is other than 90°, it is called oblique offset.

→ The method of locating a point is called the method of ties.

→ offset should be taken whereever the outline of an object changes.



(a) perpendicular offset

(b) oblique offset

Taking perpendicular offset :~

It illustrates the procedure for finding the length and position of the perpendicular offset. The leader holds the zero end of the tape at the point P to be located and the follower carries the tape bow and swings the tape along the chain. The length of the offset is the shortest distance from the object to the chain obtained by swinging the tape about the object as centre. such an offset is called swing offset.

Long offset :~

The aim should always be to make the offset as small as possible.

Field Book :-

The book in which the chain or tape measurement are entered is called the field book.

→ The size of book is 20 cm × 12 cm and open lengthwise

→ The chain line may be represented either by a single line or by two lines spaced about $1\frac{1}{2}$ to 2 cm apart.

CHAIN SURVEY

Surveying:

Surveying is the art of determining the relative position of different object on the surface of earth by measuring the horizontal distance between them.

plane survey:

- The survey in which the mean spheroidal surface of earth is taken into account is called plane survey.
- → In this survey the curvature of earth is neglected.
- → The line joining any two point is straight line.
- → The triangle formed by any three points is considered a plane triangle.
- → plane surveying is done on an area of less than 250 km^2.

Geodetic survey:-

- → The survey in which the curvature of earth is taken into consideration is called geodetic survey.
- → The line joining any two points is considered a curve line.
- → The triangle formed by any three points is considered as spherical triangle.
- → It is carried out over an area exceeding 250 km^2.

Accessories for Linear measurement:-

Ranging rod:-

Rod which are used for ranging a line is known as ranging rod.

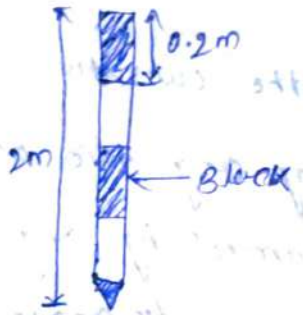
These rod of made up of seasoned wood or seasoned bamboo.

→ sometimes GI pipes of 25 mm diameter are used as ranging rod.

→ They are generally cirular is section, width 25 mm dia & 2 m length

→ The rod is divided into equal part each of 20 cm and the division are printed black and white or red and white alternately so that the rod is visible from a long distance

→ The lower end is provided with an iron shoe.



(2) Chains :-

→ A chain is prepared with 100 or 150 pieces of galvanised mild steel wire of 4mm diameter.

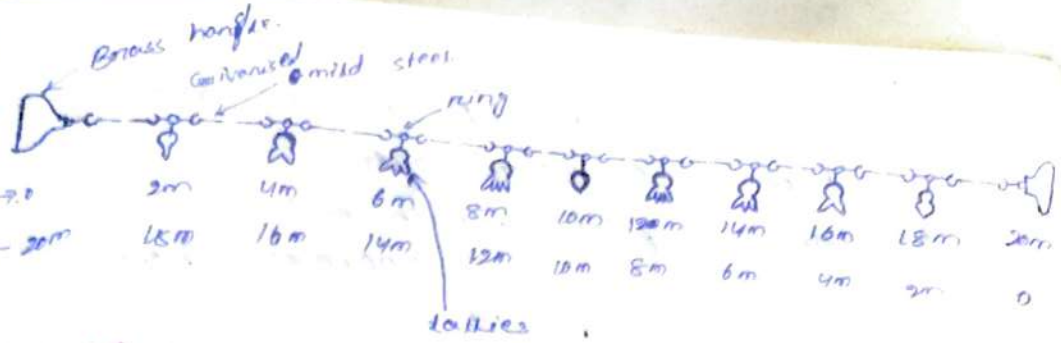
→ The ends of the pieces are bent to form loop.

→ Then the pieces are connected together by three oven rings, which make the chain flexible.

→ Two brass handles are provided at both end of the chain.

→ After each 10 or 25 link, tallies are provided for facility of counting.

→ 'one link' means the distance between centres of adjacent middle ring



Types of chain

(1) metric chain

metric chain are available in length 20m & 30m

→ The 20m chain is divided into 100 link.

→ each link is 0.2 m.

→ Tallies are provided at each 10 link.

→ The 30 m chain is, divided into 150 link.

→ Each link is 0.2 m.

→ Tallies are provided at each 25 link.

(2) Engineer's chain :-

→ The engineer chain is 100 ft long and is divided into 100 links.

→ Each link is of 1 ft.

→ Tallies are provided at every 10 links.

→ It is used Previously in engineering work.

(3) Gunters' chain :

→ The Gunter chain is 66 ft long and is divided into 100 links.

→ Each link is of 0.66 ft.

(4) Revenue chain :

→ It is 33 ft long and divided in 16 link.

→ It is mainly used in cadastral survey.

(5) Steel band :-

→ It consists of a ribbon of steel of 16 mm width and of 20 or 30 m length.

→ It has brass handle at each end.

→ The steel band is used in projects where more accuracy is required.

(3) Tape :-

The following are the different types of tapes

(1) Cloth or Linen tape

(2) Metallic tape.

(3) Steel tape.

(4) Invar tape.

(1) Cloth or Linen tape :-

→ The tape is made up closely wooven linen and is varnished to resist moisture.

→ It is 15 mm wide and available in length 10 m & 15 m.

(2) metallic tape :-

→ When linen tape is reinforced with brass or copper wire to make it durable then it is called a metallic tape.

→ It is available in length to 15 m, 20 m or 30 m.

(3) Steel tape

→ The steel tape is made of steel ribbon are of width varying from 6 to 16 mm.

→ It is available in length 10, 15, 20, 30 & 50 m.

(4) Invar tape :-

Invar tape is made of an alloy of steel (64 %) and nickel (36 %).

→ Its width is 6mm and available in length 30, 50 & 100 m.

(4) Arrows:

→ Arrows are made of tempered steel wire of 4mm dia.
→ one of its end is bent to form ring of 50 mm dia and the other end is pointed.
→ Its overall length is 400 mm.
→ Arrows are used for counting the number of chains while measuring a chain line.

(5) Pegs:

→ wooden pegs are used to mark the position of the station or terminal point of a survey line
→ They are generally 2.5 to 3 cm square and 15 cm long.

Ranging:

The process of establishing intermediate points on a straight line beteen two end points is known as ranging.

→ Ranging may be of two kinds
(1) Direct ranging.
(2) Indirect or reciprocal ranging.

(1) Direct ranging:

→ When intermediate ranging rod is fixed on a straight line by direct observation from end station the process is known as direct ranging.
→ Direct ranging is possible when the end stations are intervisible.

PROCEDURE :-

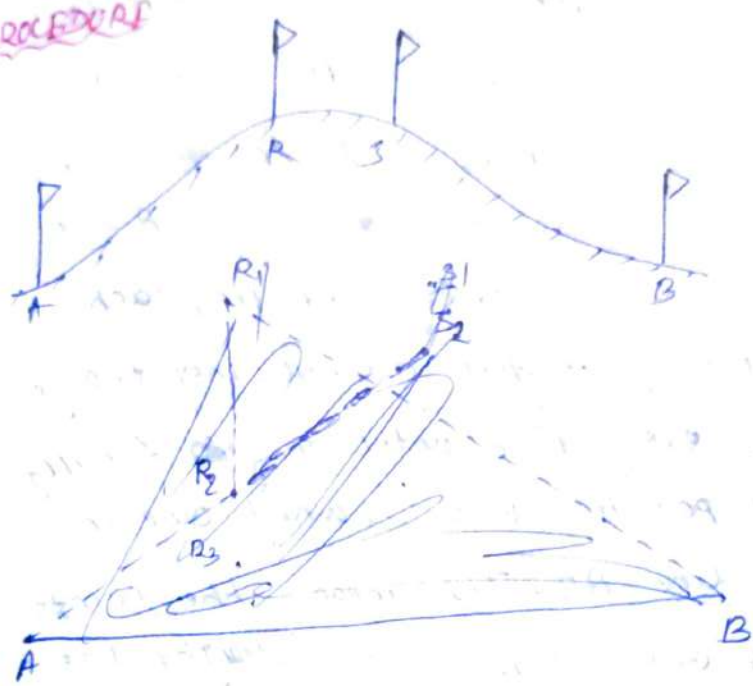
Assume that A & B be the two point on the end of the chain line. ~~suppose~~ where ranging rod are already fixed. Suppose it is required to ~~esta~~ fix the ranging rod at intermediate point P in such a way that the three point A, P & B ~~ranging rod~~ are in a straight line.

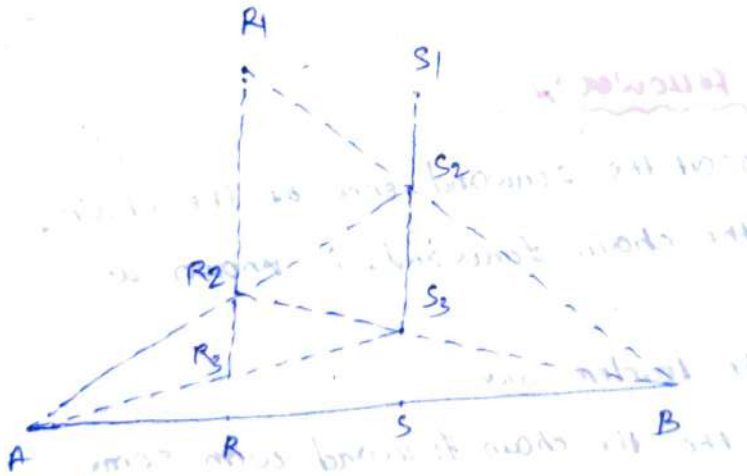
The surveyor stands at 2m behind the ~~rod~~ A and looking towards the line AB. The assistant hold the ranging rod at P vertically at arm length. The rod should be held lightly by thumb and forefinger. Then the surveyor directs the assistant to move the ranging left or right until the the three rod are in the same straight line. To check the verticality of rod, the surveyor bends down and looks through the bottom of the rods. The ranging will be perfect when the three ranging rod are ~~coin~~ coincide and appear as a single rod. When the surveyor is satisfied that the ranging is perfect, he signal the assistant to fix the ranging rod on the ground. By following this procedure the other ranging rod may be fixed on the line.

Indirect or reciprocal Ranging :-

When the end stations are not intervisible due to there being high ground bet" them, intermediate ranging rod are fixed on the line in an indirect way. This method is known as indirect or reciprocal ranging.

PROCEDURE





Let A & B are two end station which are not intervisible due to a high ground is existing between them. suppose it is required to fix intermediate point between A & B. Two chainman take up position at R_1 & S_1 with ranging rod in their hands. The chainman at R_1 stands with his face towards the point B so than he can see the Ranging rod

at S_1 & B. Again the chainman at S_1 stands with his face towards the point A so that he can see the ranging rod at R_1 and A. Then the chainman proceed to range the line by directing each other alternately. The chainman at R_1 direct the chainman at S_1 to come to the position S_2 so that R_1, S_2 and B are in the same straight line. Again, the chainman at S_2 direct the chainman at R_1 to come to the position R_2 so that S_2, R_2 & A are in the same straight line. By directing each other alternately in this manner, they change their position every time until they finally come to the position R & S, which are in the straight line AB. This means the points A, R, S & B are in the same straight line.

Leader and follower :-

→ The chainman at the forward end of the chain, who drags the chain forward, is known as the leader.

→ Duties of the leader are

(1) To drag the the chain forward with some arrows and a ranging rod.

(2) To fix the arrows on the ground at the end of every chain.

(3) To obey the instruction of the follower.

→ The chainman at the rear end of the chain, who holds the zero end of the chain at the starting is known as the follower.

→ The Duties of the follower are as follows:

(1) To direct the leader at the time of ranging.

(2) To pick up the arrows inserted by the leader.

(3) To carry the rear handle of the chain.

Method of chaining on level ground:-

Before starting the chaining operation, two ranging rod are fixed at the end of the chain line. The other ranging rod should be fixed near the end of each chain length during the ranging operation.

To chain the line, the leader moves forward by dragging the chain and by taking with him a ranging rod and ten arrows. The follower stands at the starting station by holding the other end of the chain. When the chain is fully extended, the leader hold the ranging rod vertically at arm's length. The follower direct the leader to move the ranging rod left or right so that the rod is exactly in line. Then the follower hold the zero end of the chain by touching the station peg. The leader stretches the chain by moving it up and down with both hand, and finally places it on the line. Then he insert an arrow on the ground at the end of the chain and mark with a cross(x)

Again the leader moves forward by dragging the chain with one arrows and the ranging rod. At the end of the chain, he fixes another arrow as before. As the leader moves further, the follower pick up the arrows which are inserted by the leader. During chaining the surveyor or an assistant should conduct the ranging operation.

In this way chaining is continued, when all arrows are inserted and no one arrow is left in the leader the follower hands them over to the leader. This should be noted by the surveyor. To measure the remaining fractional length, the leader drag the chain beyond the station and the follower should hold the zero end of the chain at the last arrows. Then the odd link should be counted.

METHOD OF CHAINING ON SLOPING GROUND:

(1) Direct method or stepping method.
(2) Indirect method.

(1) Direct method or stepping 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 stepping method. The length of the horizontal portion are measured and added to get the total horizontal distance between the points.

PROCEDURE

Suppose the horizontal distance between points A & B is to be measured. The line AB is first ranged properly. Then, the follower holds the zero end of the tape at point A. The leader select a suitable length AP, so that P_1 is at chest height and 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 select a suitable length P_2P_3 in such a way that P_2P_3 is horizontal and P_3 & P_5 is horizontal. Then the horizontal length P_2P_3 and P_4P_5 are measured.

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

Indirect method :-

When the slope of the ground surface is long and gentle the stepping method is not suitable. In such case the horizontal distance may be obtained by the following process.

(1) By measuring the slope with a clinometer

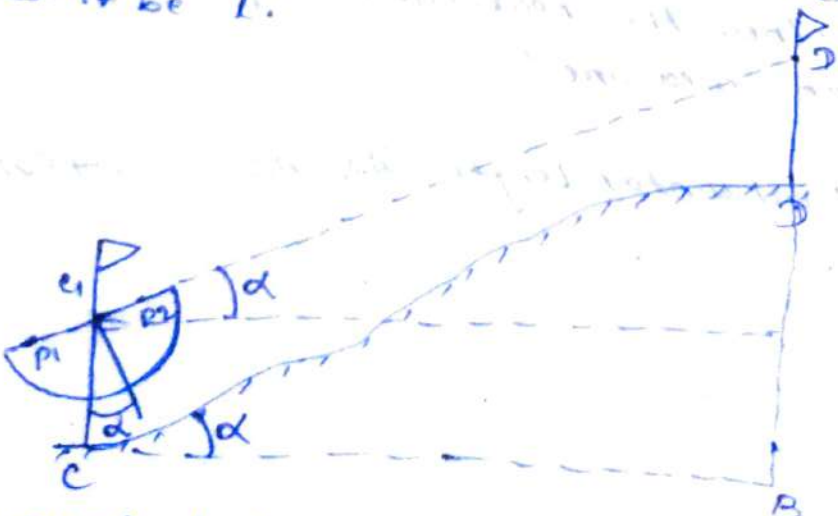
(2) By knowing the difference of level between the points.

(3) By applying hypotenusal allowance

(1) Measuring the slope with clinometer :-

Suppose C and D are two point on the sloping ground. Two ranging rod are fixed at these point. Then two other points C_1 & D_1 are marked on the ranging rod so that $CC_1 = DD_1$.

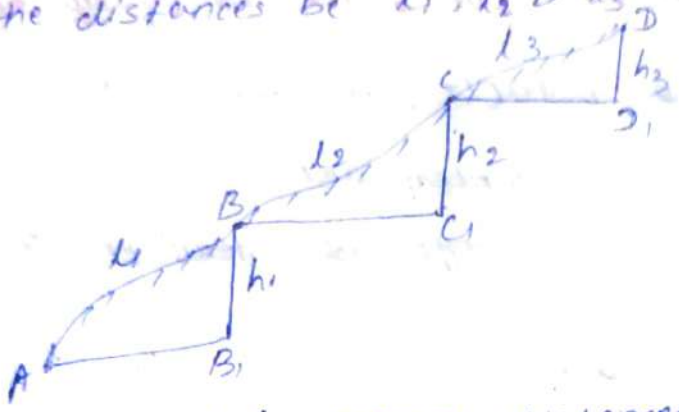
→ The clinometer is placed in such a way that its centre just touches the mark C_1. the clinometer is then inclined gradually until the point P_1, P_2 & D_1 are in the same straight line. At this position, the thread of the clinometer will show an angle which is the angle of slope of the ground. Suppose this angle is α. The sloping distance CD is also measured. Let it be l.



The required horizontal distance CB = l cos α

(2) Knowing the difference of level :-

suppose A, B, C & D are different points on sloping ground. The difference of level between these point is determined by a levelling instrument suppose the respective differences be h_1, h_2 & h_3. Then the slopping distances AB, BC, CD are measured. Let the distances be l_1, l_2 & l_3 respectively.



The required horizontal distances are given by

$$AB_1 = \sqrt{l_1^2 - h_1^2}, \quad BC_1 = \sqrt{l_2^2 - h_2^2}, \quad CD_1 = \sqrt{l_3^2 - h_3^2}$$

Total horizontal distance = $AB_1 + BC_1 + CD_1$.

OBSTACLE IN CHAINING

(1) When chaining is free, but vision is obstructed
(2) When chaining is obstructed, but vision is free.
(3) When chaining and vision are both obstructed.

(1) When chaining is free, but vision is obstructed:

In this type of obstacle, the end station are not intervisible. Such problem arises when a a high ground or jungle is interrupts the chain line.

→ There are two cases.

(i) Both end stations are visible from some intermediate point on the line.
(ii) Both end stations are not visible from some intermediate point on the line.

Case-I

method of reciprocal ranging may be used. and the chaining is done by stepping method.

Case-II

Let AB be the line in which A & B are not visible from intermediate point on it. Through A, draw a line AB, in any convinient direction but as nearly towards B as possible. The point B_1 should be so chosen so that

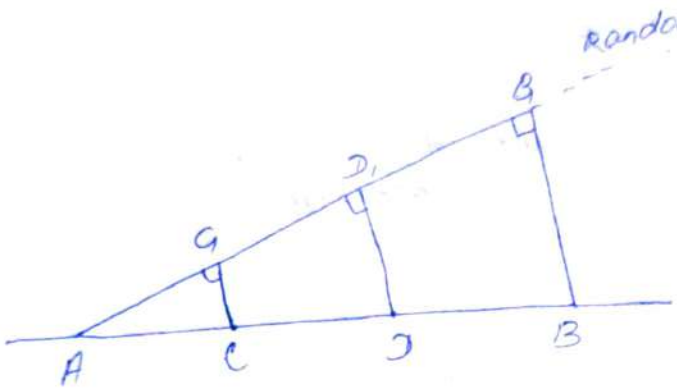
(i) B_1 is visible from B (ii) BB_1 is perpendicular to the random line. measure BB_1. select points C_1 & D_1 on the random line and erect perpendicular at C_1 & D_1 on it.

mark

$$CC_1 = \frac{AC}{AB_1} \cdot BB_1$$

$$DD_1 = \frac{AD}{AB_1} \cdot BB_1$$

Join C and D, and prolong.



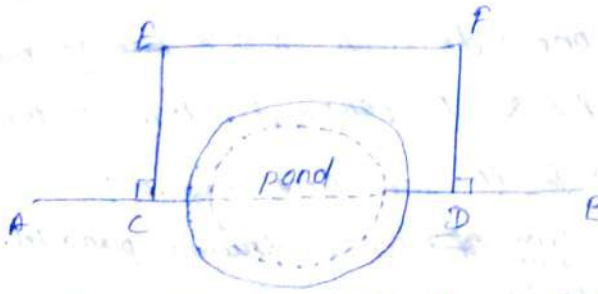
(2) When chaining is obstructed but vision free

Such a problem arises when a pond or river is interrupt the chain line.

→ There may be two cases.

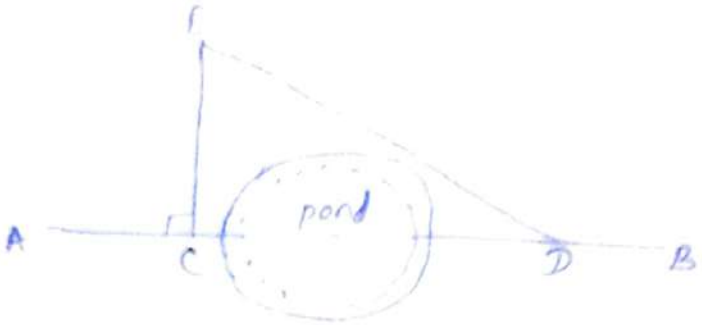
Case -1

When a pond interrupt the chain line, it is possible to go around the obstruction.



Suppose AB is the chain line. C & D are two point selected on the opposite bank of the pond. Draw equal perpendicular CE & DF from point C & D respectively. Then the distance EF is measured

Here, CD = EF

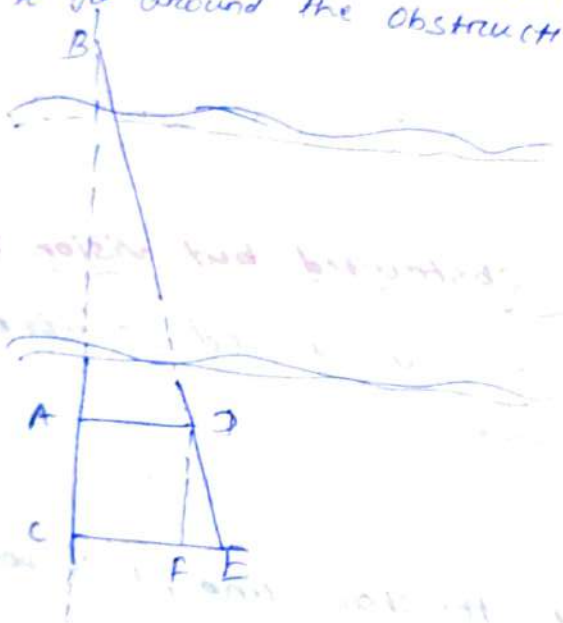


Let AB is the chain line. Select a point C on the line. From point 'c' draw a perpendicular line CE. From E draw a suitable line ED. measure the distance CE & ED.

$$CD = \sqrt{ED^2 - CE^2}$$

Case-II

when a river interrupt the chain line, it is not possible to go around the obstruction



Select point B on one side and A & C on the other side. Erect AD & CE perpendicular to the AB and range B, D & E in one line measure AC, AD & CE. If a line DF is drawn parallel to the line AB, and cutting CE in F perpendicularly, the triangle BAD & DFE are similar

$$\frac{AB}{AD} = \frac{DE}{FE}$$

$$AB = \frac{DE}{FE} \times AD$$

$$= \frac{AC}{CE - CF} \times AD$$

$$= \frac{AC \times AD}{CE - AD}$$

(3) When chaining and vision are both obstructed

Such a problem arises when a building comes across the chain line.

Suppose AB is the chain line. Two points C and D are selected on it at one side of the building. Equal perpendiculars 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 and F_1 are selected. Then perpendiculars E_1E & 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,

The distance D_1F_1 is measured. and it's equal to the required distance DE.

CHAIN SURVEYING:

principle of chain surveying:-

The principle of chain surveying is triangulation. This means that the area to be surveyed is divided into a number of small triangle which should be well conditioned.

→ In chain surveying, the sides of the triangle are measured directly on the field by chain or tape and no angular measurement are taken.

Survey stations:-

Survey stations are the points at the beginning and the end of a chain line.

→ They may also occur at any convinient point on the chain line. Such stations may be

(1) main station
(2) subsidiary station
(3) Tie stations.

(1) main station:-

Stations taken along the boundary of an areas as controlling points are known as main stations.

→ The line joining the main stations are called main survey lines.

(2) subsidiary station:-

stations which are on the main survey lines or any other survey lines are known as subsidiary station.

(3) Tie stations :-

These are also subsidiary stations taken on the main survey lines.

→ Lines joining the tie stations are known as tie lines

(4) Base Line :-

The line on which the framework of the survey is built is known as the base line.

→ The longest of the main survey lines is considered the base line.

(5) Check Line :-

The line joining the apex point of a triangle to some fixed point on its base is known as the check line.

→ It is taken to check the accuracy of the triangle

Offset :-

The lateral measurement taken from an object to the chain line is known as offset.

→ Offset are taken to locate objects with reference to the chain line.

→ They are two types.

(1) perpendicular offset

(2) Oblique offset.

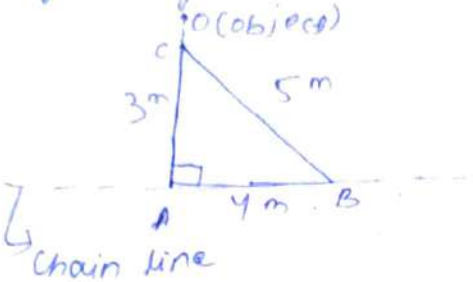
Perpendicular offset :-

When the lateral measurement are taken perpendicular to the chain line, they are known as perpendicular offset.

Perpendicular offset may be taken in the following ways

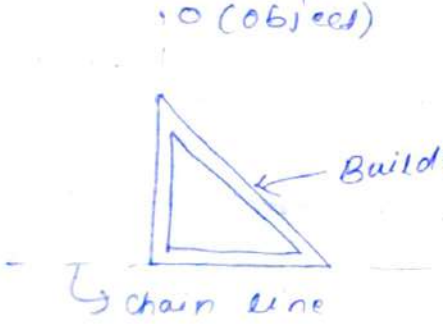
(a) By setting a perpendicular by swinging a tape from the object to chain line. The point of minimum reading on the tape will be the base of the perpendicular.

(b) By setting a right angle in the ratio 3:4:5.



(c) By setting a right angle with the help of builder's square or tri-square

(d) By setting a right angle by cross-staff or optical square.

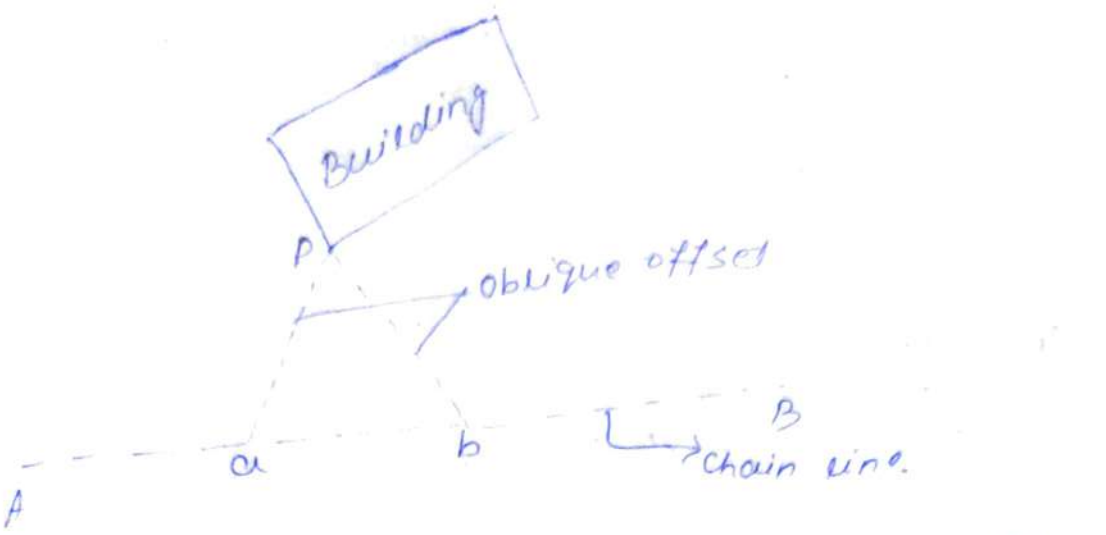


Oblique offset:-

Any offset not perpendicular to the chain line is said to be oblique offset.

→ Oblique offset are taken when the objects are at a long distance from the chain line or when it is not possible to set up a right angle due to some difficulties.

Such offset are taken in the following manner.



suppose AB is a chain line. P is the corner of a building. Two point a and b are taken on the chain line. The chainages of a and b are noted. The distances ap and bp are measured and noted in the field book. Then ap and bp are the oblique offset. When the triangle apb is plotted, the apex point p will represent the position of the corner of the building.

COMPASS SURVEY

compass surveying is a type of surveying in which the direction of surveying lines are determined with a magnetic compass, and the length of the survey lines are measured with a tape or chain or laser range finder. The compass is generally used to run a traverse line

Types :-

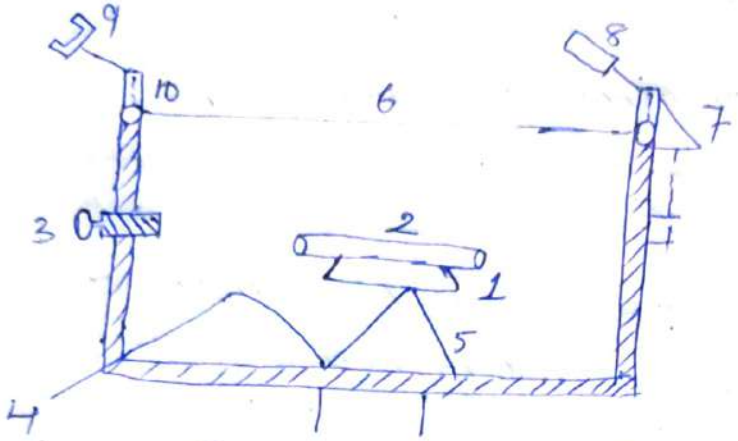
(1) Surveyor compass

(2) prismatic compass

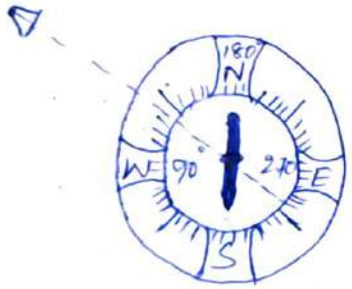
(1) surveyor compass :-

It is an instrument used for frequently by surveyors for measuring horizontal angles and also for determining the magnetic bearing of a line of sight. The compass consist of a pivoted magnetic needle, a graduated horizontal circle and a sighting device. The magnetic needle swings freely over the horizontal circle which is divided into 360°. The horizontal angle is measured using a pair of sights located on the north south axis of the compass. They are usually mount ed over a tripod and leveled using a ball and socket mechanism.

(2) prismatic compass :-



[prismatic compass]



[2 Graduated ring]

(1) magnetic needle
(2) Graduated ring
(3) Needle Damper
(4) Needle Lifter
(5) Pivot
(6) Thick glass cover
(7) prism
(8) Sunglass
(9) Adjusting glass
(10) sighting vein

Prismatic compass consist of a graduated ring made of alluminium and it is attached with magnetic compass, the graduation are ingrade on the circular ring inverted. The sighting vein is rotated around the ring. where as the ring is in rest position. There are two sighting veins which can be folded on the glass cover provided for saving the internal part of the instrument from dust and moisture free. when instrument is not in use.

one of its sighting vanes is provided with sunglass and other with adjustable glass. The compass equipped with a prism for the purpose of taking observation. This compass can be used by setting it on a tripod or holding it on hand. This instrument measure the bearing in whole bearing system.

Adjustment of prismatic compass

(a) Temporary adjustment

(i) centring (ii) Levelling (iii) Focusing the prism

(b) permanent adjustment :-

The permanent adjustment are those adjustment of prismatic compass are almost the same as that of the surveyor's compass except that there are no bubble tubes to be adjusted and the needle can't be straightened.

(i) centering :-

Normally the compass is centroid by droping a piece of stone from the bottom of the compass bow.

→ It is also be done with by the using of plumb bob

(ii) Levelling :-

Levelling is done with the help of a ball-shaped arrangement provided on the top of the tripod stand.

(3) Adjustment of prism :-

A prism is move up and down till the figures on the graduated ring are seen freely and sharp.

Bearing :-

The horizontal angle between the magnetic meridian and the survey line measured in a clockwise direction is called bearing.

meridian :-

The fixed direction on the surface of the earth, with reference to which, bearing of survey lines are expressed, is called a meridian

(1) True meridian :-

The line passing through the geographical north pole, geographical south pole or any point on the surface of the earth is known as true meridian

(2) magnetic meridian :-

When the magnetic needle is suspended freely and balanced properly, unaffected by magnetic substances, it indicate a direction, this direction is known as magnetic meridian.

True bearing :-

The angle between the true meridian and a line is known as true bearing or Azimuth.

(3) Arbitary meridian :-

sometime for survey of a small area a convinient direction is assumed as a meridian known as the arbitary meridian.

Arbitary bearing :

The angle between arbitary meridian and a line is known as arbitary bearing.

(4) Grid meridian

for preparing a map some state agency assume several line parallel to the true meridian for a particular zone, this lines are called grid line and the central line is the grid meridian

Grid bearing :

The bearing of a line w.r.t the grid meridian is known as grid bearing.

Designation of magnetic bearing :-

→ magnetic bearing are designated by 2 systems.

(1) whole circle bearing (W.C.B)

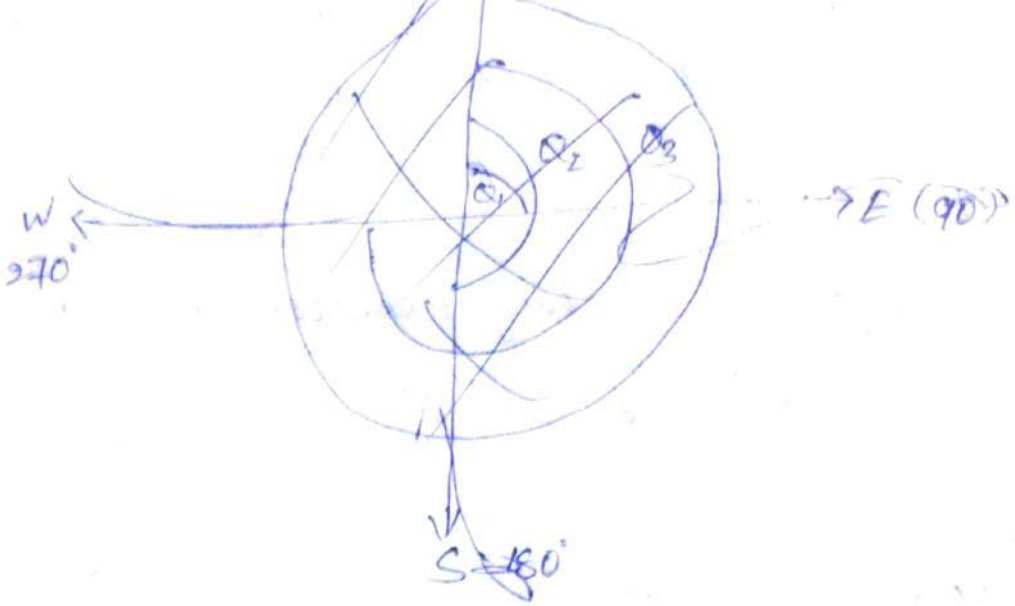
(2) Quadrantal bearing (Q.B)

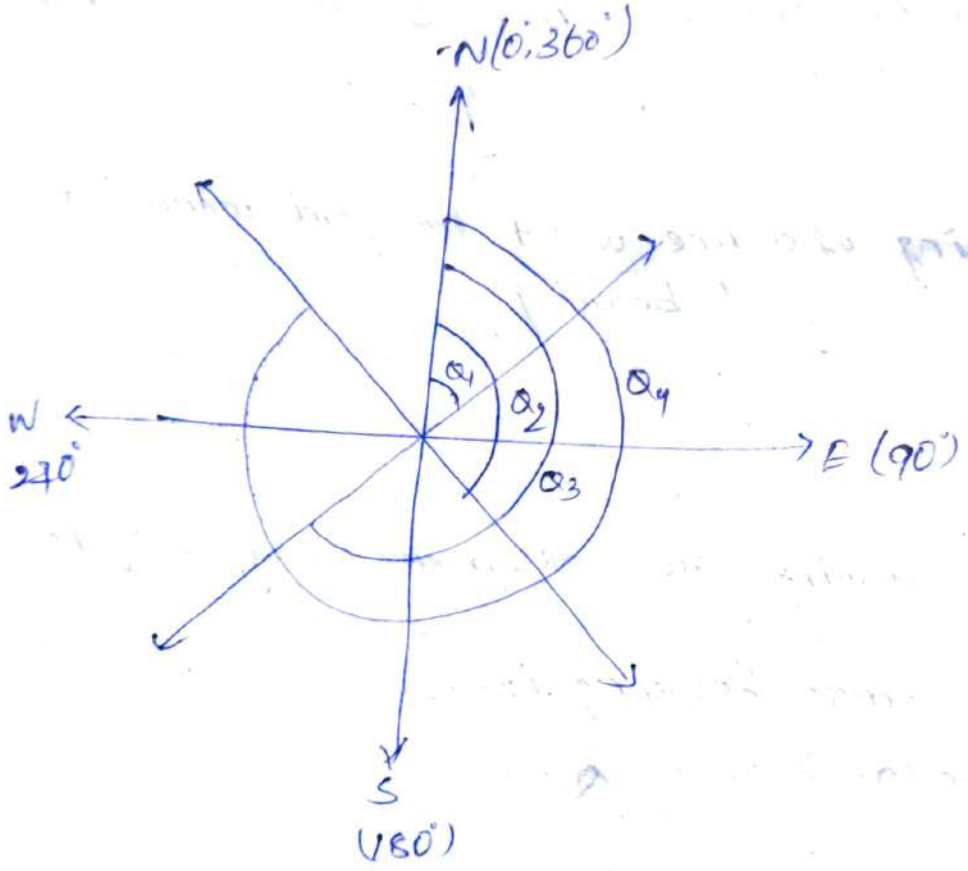
(1) whole circle bearing :-

- The magnetic bearing of a line, measure clockwise from the north pole towards the line is known as whole circle bearing of that line.

→ such a bearing may have any value bet° 0° & 360°.

⇒ The W.C.B is obtained by prismatic compass



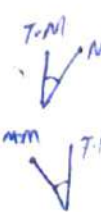


magnetic declination :-

It is the horizontal angle between the true meridian and magnetic meridian

→ If the magnetic meridian is to right side then it is +ve.

→ If the " " " left side " " " -ve.

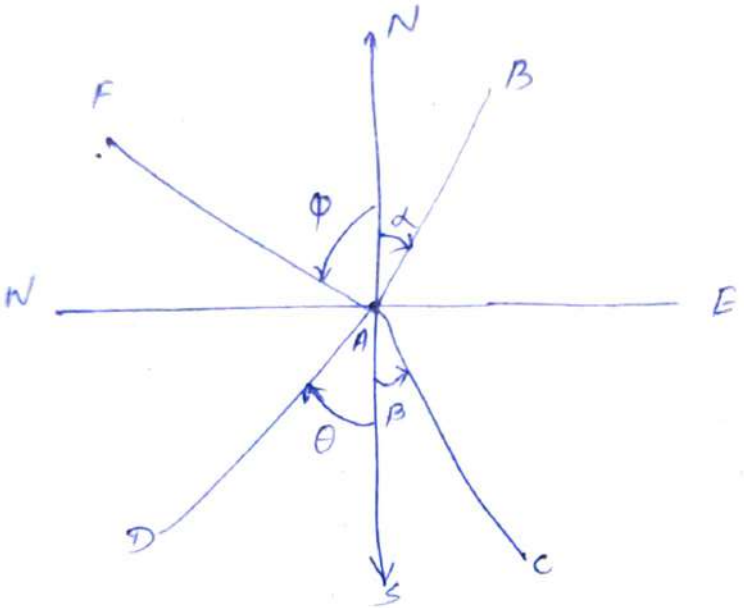


Quadrantal Bearing :-

The magnetic bearing of a line measure clockwise or anticlockwise from the north pole or south pole (which ever nearer the line) towards the east or west is known as quadrantal bearing.

→ This system consist of four quadrant.

N-E, N-W, S-E, S-W.



For. Line AB, Q.B is α & written as N α E

AC, Q.B is β & written as S β E

AD, Q.B is θ, & written as S θ W

AF, Q.B is Φ & written as N Φ W

Reduced bearing :-

→ When the W.C.B of a line is converted into Q.B it is termed as Reduced bearing.

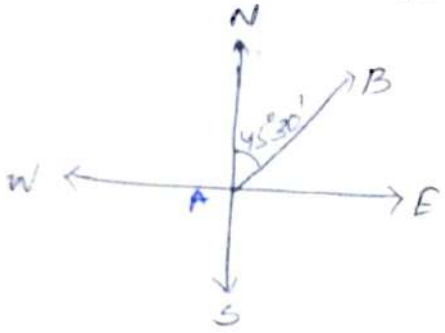
→ Its value lies between 0° & 90°.

Conversion of W.C.B to R.B

W.C.B	Corresponding R.B	Quadrant
0° and 90°	R.B = W.C.B	NE
90° and 180°	R.B = 180° − W.C.B	SE
180° & 270°	R.B = W.C.B − 180°	SW
270° & 360°	R.B = 360° − W.C.B	NW

a) Convert the following W.C.B to Q.B.

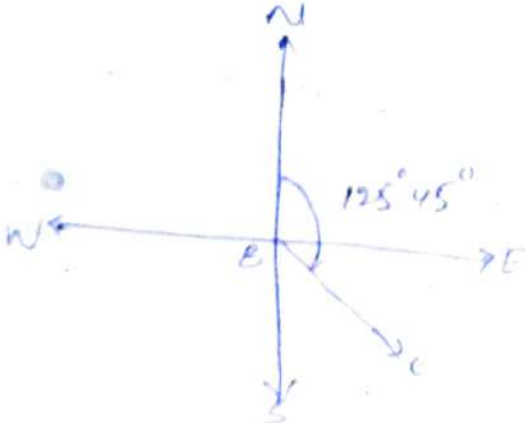
(1) W.C.B of AB' = 45° 30'



R.B = W.C.B

R.B = N 45° 30' E

(2) W.C.B of BC = N 125° 45' E



Q.B = 180° − 125° 45'

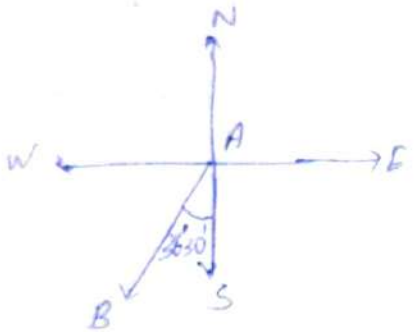
= S 55° 45' E

Conversion of R.B to W.C.B

R.B	Rule for W.C.B	W.C.B between
N∝E	W.C.B = R.B	0 & 90°
S∝E	W.C.B = 180° − R.B	90° & 180°
S∝W	W.C.B = 180° + R.B	180° & 270°
N∝W	W.C.B = 360° − R.B	270° & 360°

a)

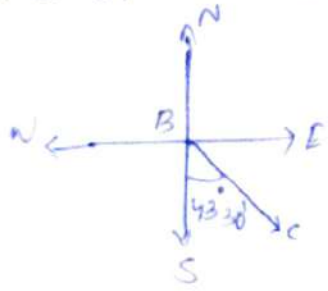
Q.B of AB = S 36°30' W



W.C.B = 180° + 36°30'

= 216°30'

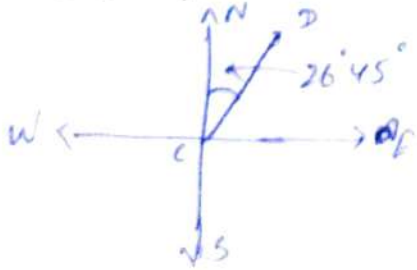
b) Q.B of BC = S 43°30' E



W.C.B = 180° − 43°30'

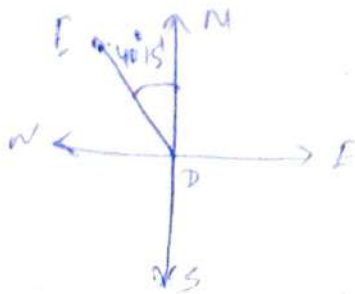
= 136°30'

c) Q.B of CD = N 26°45' E



W.C.B = 26°45°

d) Q.B of DE = N 40°15' W



W.C.B = 360° − 40°15°

= 319°45°

Fore bearing :

The bearing of a line measured in the direction of progress of survey called fore bearing.

Back Bearing :

The bearing of a line measure in the opposite direction of progress of survey called back bearing.

→ Considering the W.C.B system, the difference between FB & BB should be exactly 180°

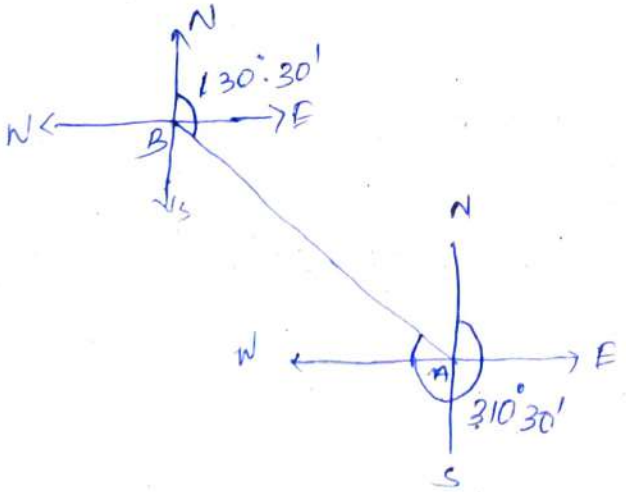
$BB = F.B. \pm 180^\circ$

using plus sign when F.B is less than 180°

using minus sign when F.B is greater than 180°.

Problem on FB & BB

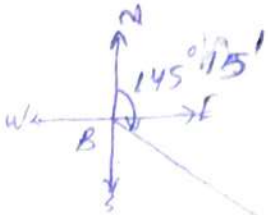
ex. F.B of AB = 310° 30'



$BB = 310^\circ 30' - 180$

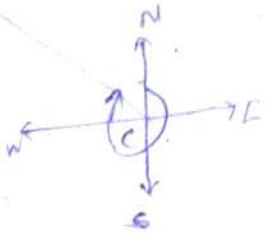
$= 130^\circ 30'$

Q.) F.B of BC = 145° 15'

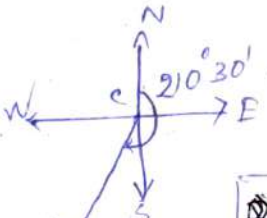


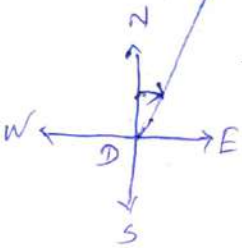
B.B = 145° 15' + 180°

= 325° 15°



Q) F.B of CD = 210° 30'

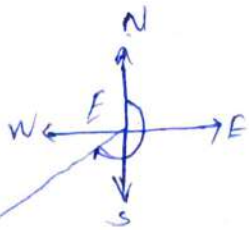


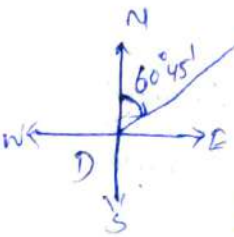


B.B = 210° 30' − 180

= 30° 30'

Q) F.B of DE = 60° 45'





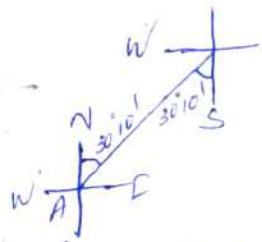
B.B = 60° 45' + 180

= 240° 45'

Q) Fore bearing of AB & BC respectively N 30° 10' E and S 20° 20' W. Find B.B.

ANS

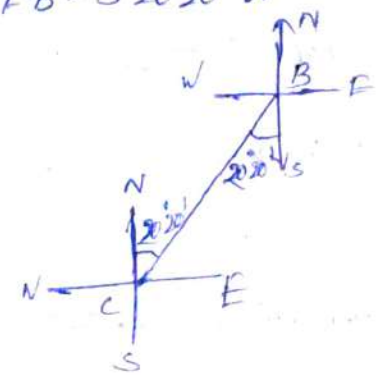
F.B = N 30° 10' E



B.B = S 30° 10' W

(2)

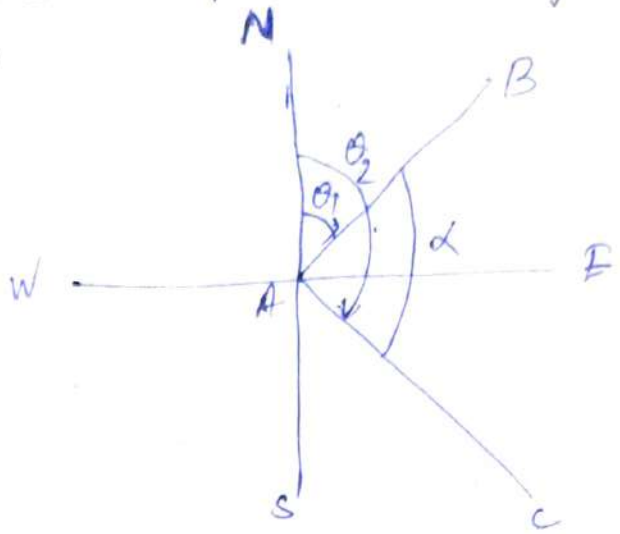
F.B = S 20° 20' W



B.B = N 20° 20' E

Calculation of angle from bearing :-

In WCB



Let,

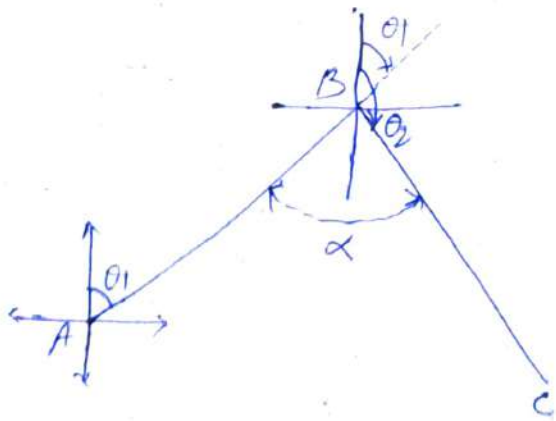
W.C.B of AB $= \theta_1$

W.C.B of AC $= \theta_2$

∴ The included angle BAC

$\alpha = \theta_2 - \theta_1$

OR



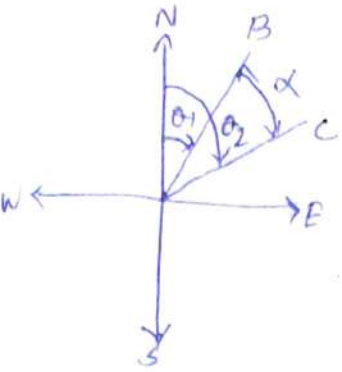
$\alpha = (180^\circ + \theta_1) - \theta_2$

= Back bearing of previous line − Fore bearing of next line

For clockwise = B.B − F.B If F.B > B.B, then angle = 360 − angle

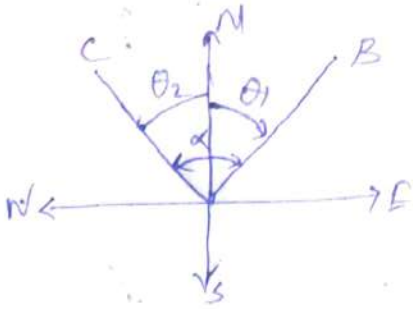
For anticlockwise = F.B − B.B, If B.B > F.B, then angle = 360° − angle

In Q.B



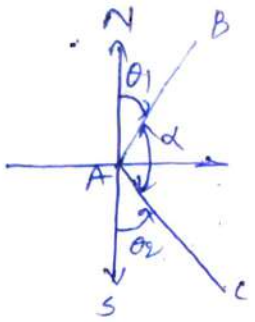
$\alpha = \theta_2 - \theta_1$

(a)



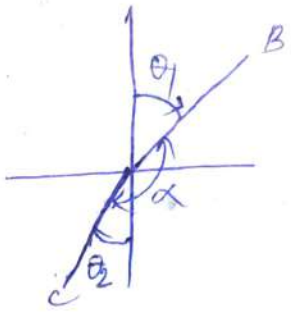
$\alpha = \theta_1 + \theta_2$

(b)



$\alpha = 180^\circ - (\theta_1 + \theta_2)$

(c)



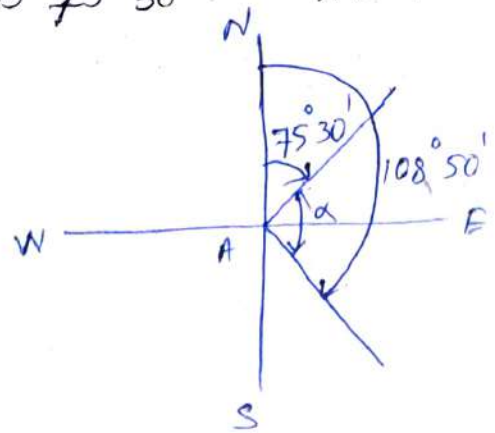
$\alpha = 180^\circ + \theta_2 - \theta_1$

(d)

Q. Find the included angle between AB & AC if their W.C.B are.

(i) AB $75^\circ 30'$ AC $108^\circ 50'$

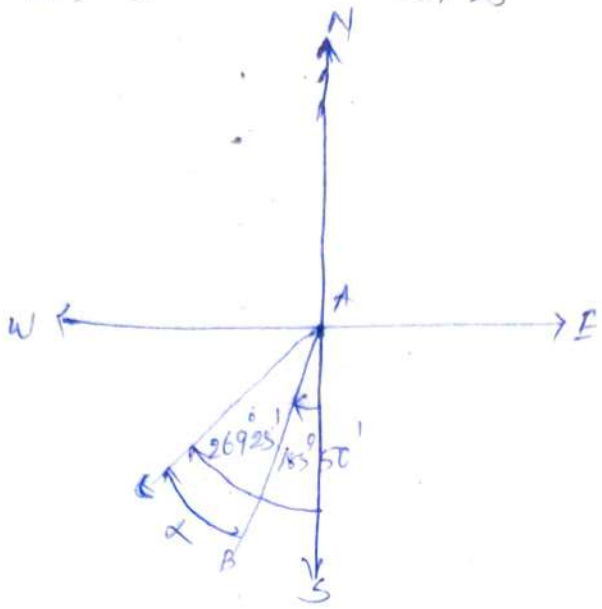
ANS



$\alpha = 108^\circ 50' - 75^\circ 30'$

$= 33^\circ 20'$

(ii) AB 185° 50′ AC 269° 25′



$\alpha = 269^\circ 25' - 185^\circ 50'$

$= 83^\circ 35'$

(iii)

AB $60^\circ 10'$ AC $245^\circ 10'$

$\alpha = 245^\circ 10' - 60^\circ 10'$

$= 185^\circ 0'$

As it is more than 180° deduct it from 360°

$\alpha = 360^\circ - 185^\circ 0'$

$= 175^\circ 0'$.

(iv) AB $70^\circ 20'$ AC $= 285^\circ 40'$

$\alpha = 285^\circ 40' - 70^\circ 20'$

$= 215^\circ 20'$

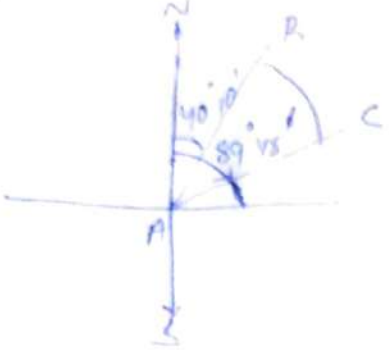
As it is more than 180°, d

$\alpha = 360^\circ - 215^\circ 20'$

$= 144^\circ 40'$

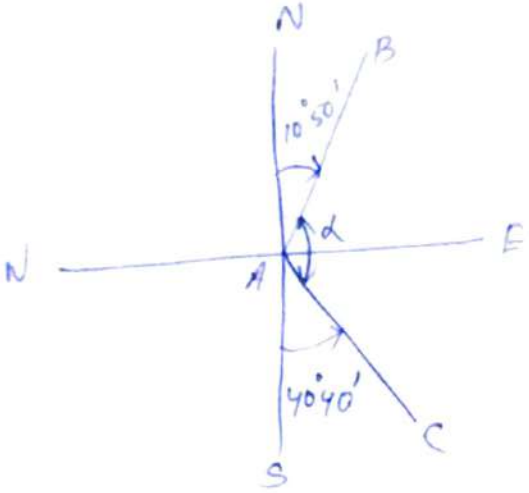
Q) Find the included angle between line: AB & AC & their reduced bearing are

i) AB N 40° 10' E AC N 89° 45' E



$\angle BAC = 89°45' - 40°10' = 49°35'$

(ii) AB N 10° 50' E AC S 40° 40' E

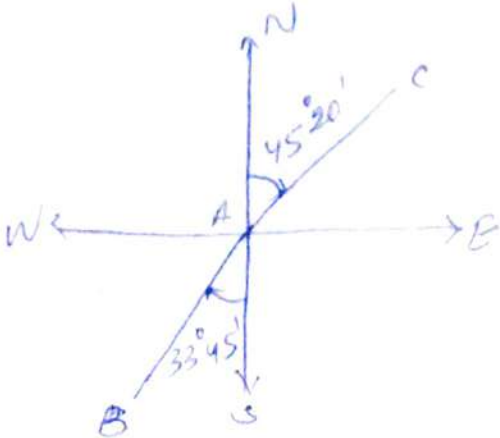


$\angle BAC = 180° - (10°50' + 40°40')$

$= 180° - 51°30'$

$= 128°30'$

(iii) AB S 33° 45' W AC N 45° 20' E

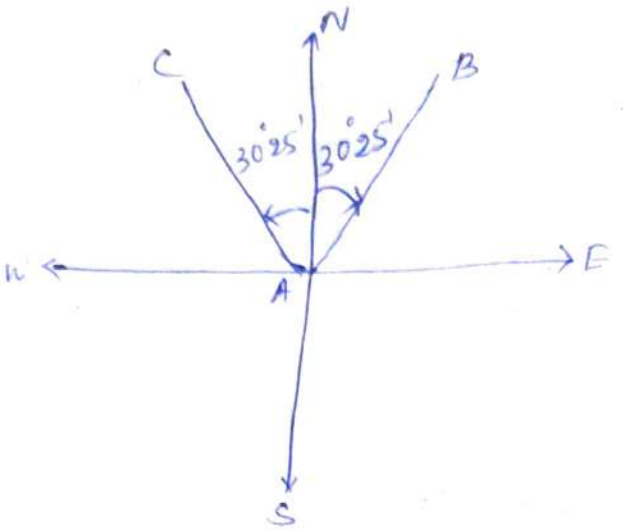


$\angle BAC = 180 + 33°45' - 45°20'$

$= 213°45' - 45°20'$

$= 168°25'$

(iv) AB N.30°25'E AC N.30°25'W



$\angle BAC = 30°25' + 30°25'$

$= 60°50'$

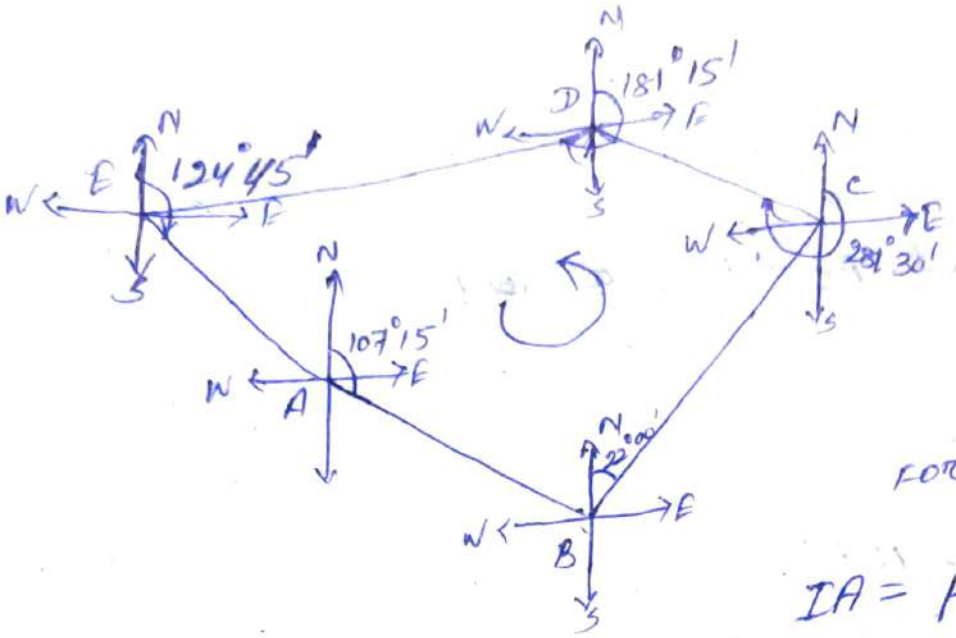
Question

The bearing of the sides of a closed traverse ABCDEA are as follow

Side	F.B.	B.B
AB	107°15'	287°15'
BC	22°00'	202°00'
CD	281°30'	101°30'
DE	181°15'	1°15'
EA	124°45'	304°45'

Compute the interior angles of the traverse and exercise necessary checks.

ANS



FOR anticlockwise

$IA = F.B - B.B$

(i) ~~$\angle B$ = B.B of Line AB ~ F.B of BC~~

$= (107°15' + 180°) - 22°00'$

$= 287°15' - 22°00'$

$= 265°15'$

$\angle B = 360° - 265°15' = 94°45'$

(ii) $\angle C$ = B.B of Line BC ~ F.B of CD

$= (180° + 22°00') - 281°30'$

$= 202°00' - 281°30'$

$= -79°30'$

$= 280°30'$

$\angle C = 360° - 280°30' = 79°30'$

$= $ B.B of CD $-$ F.B of DE

(i) ~~$\angle A$ = F.B of EA - B.B of AB~~

~~$= 72\frac{1}{4}^\circ$~~

~~(ii) Factor~~

(i) IA = FB of AB - B.B of EA

B.B > FB

EA = BB - FB

$= 304^\circ 45' - 107^\circ 15'$

$= 197^\circ 30'$

$IA = 360^\circ - 197^\circ 30'$ $\quad \angle A = 162^\circ 30'$

$= 162^\circ 30'$

(ii) IA = F.B of BC ~~-~~ B.B of AB

As B.B > F.B

EA = B.B - F.B

$= 287^\circ 15' - 22^\circ 00'$

$= 265^\circ 15'$

$IA = 360^\circ - 265^\circ 15'$ $\quad \angle B = 94^\circ 45'$

$= 94^\circ 45'$

(iii) IA = F.B of CD - B.B of BC

$= 281^\circ 30' - 202^\circ 00'$

$= 79^\circ 30'$

$\angle C = 79^\circ 30'$

(iv) $IA = I.B \text{ of } DE - B.B. \text{ of } CD$

$= 181^\circ 15' - 101^\circ 30'$

$= 79^\circ 45'$

$LD = 79^\circ 45'$

(v) $IA = F.B \text{ of } EA - B.B \text{ of } DE$

$= 124^\circ 45' - 1^\circ 15'$

$= 123^\circ 30'$

Check

Sum of the included angle of a pentagon

$= (2 \times 5 - 4)$

$= 6$ right angle

$= 6 \times 90^\circ$

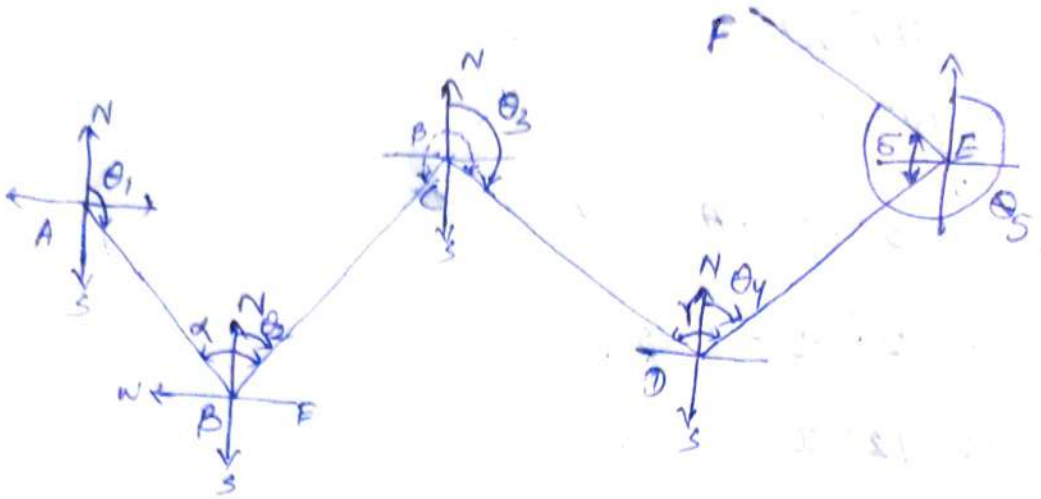
$= 540^\circ$

Sum of the included angle $= A + B + C + D + E$

$= 169^\circ 30' + 94^\circ 45' + 79^\circ 30' + 79^\circ 45' + 123^\circ 30'$

$= 540^\circ 00'$

Calculation of angle from bearing:



The bearing of the next line $BC = \theta_2 = \theta_1 + \alpha - 180^\circ$

$CD = \theta_3 = \theta_2 + \beta - 180^\circ$

$DE = \theta_4 = \theta_3 + \gamma - 180^\circ$

$EF = \theta_5 = \theta_4 + 180^\circ + \delta$

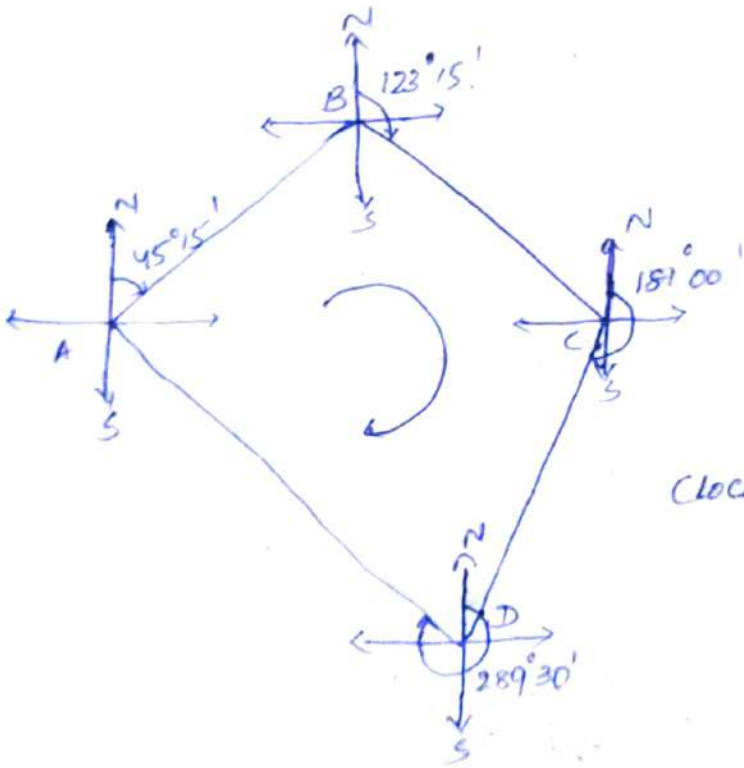
Add the measured clockwise angle to the bearing of the previous line. If the sum is more than 180°, deduct 180°. If the sum is less than 180°, add 180°.

Q) The following bearing were taken of a closed traverse ABCD

Line	F.B	B.B
AB	45°15'	225°15'
BC	123°15'	303°15'
CD	181°00'	1°.00'
DA	289°30'	109°30'

Calculate the interior angles of the traverse ABCD

ANS



Clockwise = B.B − F.B

(i) $\angle A = \angle A$ = B.B of DA − F.B of AB

= 109°30' − 45°.15'

= 64°15'

(ii) $\angle A = \angle B$ = B.B of AB − F.B of BC

= 225°15' − 123°15'

= 102°00'

(iii)

$IA = \angle C = B.B \text{ of } BC - F.B \text{ of } CD$

$= 303^\circ 15' - 181^\circ 00'$

$= 122^\circ 15'$

(iv) $IA = \angle D = B.B \text{ of } CD - F.B \text{ of } DA$

As $F.B > B.B$

$IA = F.B - B.B$

$= 289^\circ 30' - 1^\circ 00'$

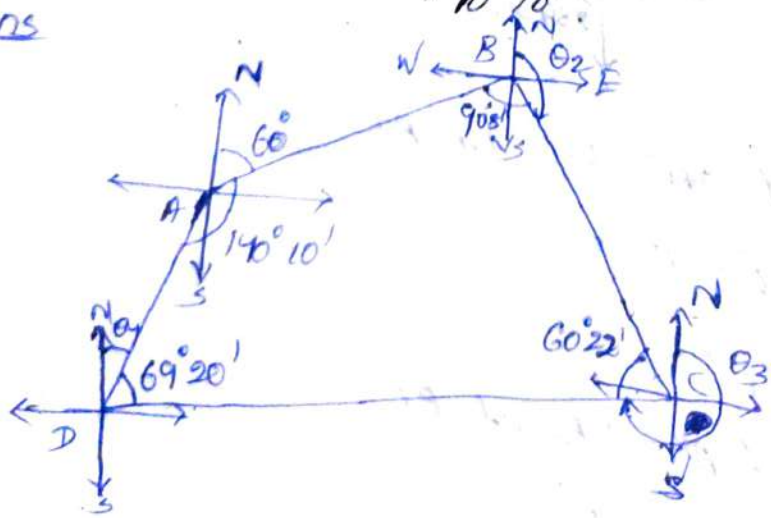
$= 288^\circ 30'$

$\therefore IA = 360^\circ - 288^\circ 30'$

$= 71^\circ 30'$

Q) The following interior angles are measured with a sextant in a closed traverse. The bearing of the line AB was measured as $60^\circ 00'$ with prismatic compass. calculate the bearing of all the four lines. if $\angle B = 90^\circ 8'$, $\angle C = 60^\circ 22'$, $\angle D = 69^\circ 20'$, $\angle A = 140^\circ 10'$

Ans



(i) $\theta_2 = ?$

$\theta_2 = BB$ of line $AB - LB$

$= (60° + 180°) - 90°8'$

$\theta_2 = 149°52'$

(ii) $\theta_3 = ?$

$\theta_3 = B.B$ of line $BC - LC$

$= (149°52' + 180°) - 60°22'$

$\theta_3 = 269°30'$

(iii) $\theta_4 = ?$

$\theta_4 = B.B$ of line $CD - LD$

$= (269°30' - 180°) - 69°20'$

$\theta_4 = 20°10'$

~~LOCAL ATTRACTION~~

Magnetic declination :-

The horizontal angle between magnetic meridian and true meridian is called magnetic declination

→ When the north end of magnetic needle is pointed towards the west side of the true meridian the position is termed as declination west. (-ve)

→ When the north end of the magnetic needle is pointed towards the east side of the true meridian the position is termed as declination east (+ve)

ISOGONIC AND AGONIC LINE

→ Line passing through points of equal declination are known as isogonic line.

→ The line passing through point of zero declination is said to be agonic line.

→ If it is no, so the total error is equally distributed among all the angle of the traverse.

Local Attraction :-

→ A magnetic needle indicates the north direction when freely suspended or pivoted.

→ But if the needle comes near some magnetic substances such as iron ore, steel structure or electric cable etc. then it is found to be deflected from its true north direction and doesn't show actual north.

→ This disturbing influence of magnetic substance is known as local attraction.

→ To affect the presence of local attraction the FB and BB of line should be taken.

→ If the difference of FB and BB is lying exactly 180° then their is no local attraction.

→ If the FB and BB of a line do not differ by 180° then the ~~need~~ needle is said to be affected by local attraction provided their is no instrumental er

Method of application of correction :-

1st method :-

→ The interior angle of traverse are calculated from the observed bearing then an angular check is applied.

→ The summession of interior angle should be equal to $(2n-4)\,90°$

→ Then starting from the all unaffected line the bearing of all lines may be corrected by using the corrected interior angle.

Method-2

In this method, the interior angle are not corrected. From the given table, the unaffected line is first detected. Then starting from the unaffected line, the bearing of the other affected lines are corrected by finding the amount of correction at each station.

Traversing :-

→ Surveying which involves a series of connected line is known as traversing.

→ The sides of the traverse are known as traverse legs

→ A traverse may be of two types.

(1) closed traverse

(2) open traverse.

Closed traverse :-

→ When a series of a connected lines form a closed circuit i.e. when the finishing point coincide with starting point of a survey, it is called closed traverse.

→ closed traverse is suitable for the survey of boundaries of ponds, forest.

Open traverse :-

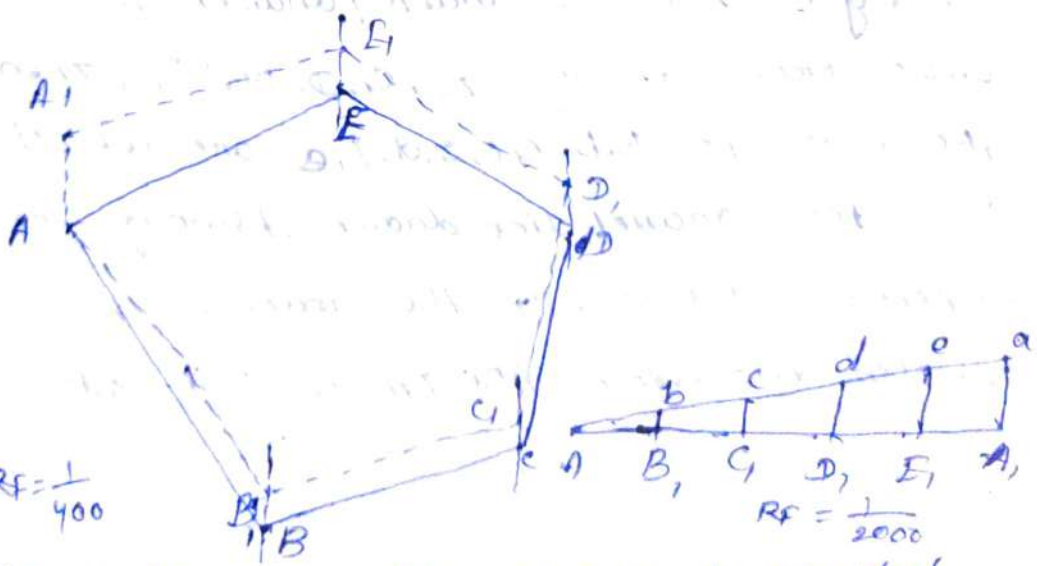
→ When a series of connected lines extends along a general direction and doesn't return to the starting point, it is known as open traverse.

→ Open traverse is suitable for the survey of road, ~~road~~ rivers etc.

Adjustment of closing error in compass traversing

When a closed traverse is plotted, the finishing point may not coincide with starting point. The distance by which the traverse fails to close is said to be the closing error.

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



Suppose a traverse AB, C, D, E, A, is plotted according to any suitable scale (RF = 1/400)

→ 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).

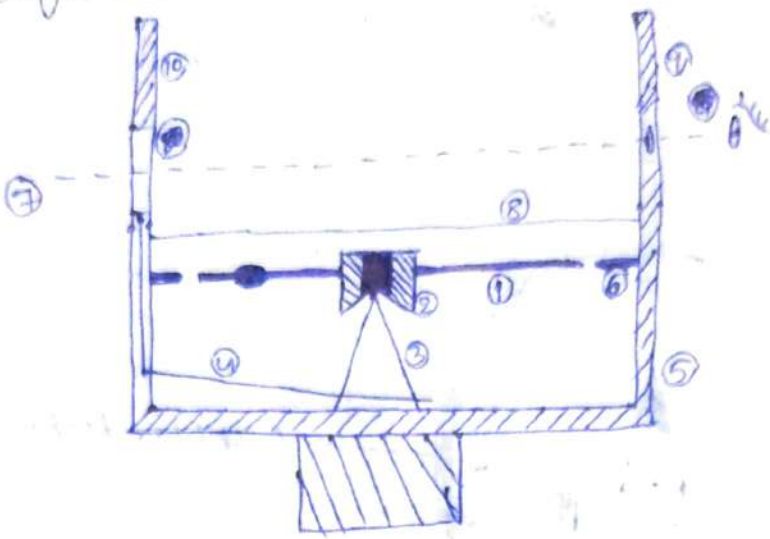
→ On this line, distances AB_1, B_1C_1, C_1D_1, D_1E_1, & E_1A_1 are set off according to the corresponding measured lengths of the traverse leg.

→ A perpendicular A_1a is drawn equal to the amount of closing error, after which the line Aa is drawn.

→ From points B_1, C_1, D_1, & D_1, the lines B_1b, C_1C, D_1d & E_1e are drawn parallel to the line A_1a. These intercepts represent the amount by which the respective stations are shifted.

→ In fig (a), lines are drawn parallel to the closing error through B_1, C_1, D_1 and E_1. Then the intercepts B_1b, C_1C, D_1d, E_1e are set off along the parallel line drawn through the respective stations. In this manner, the adjusted traverse ABCDEA is obtained.

Surveyor compass :-

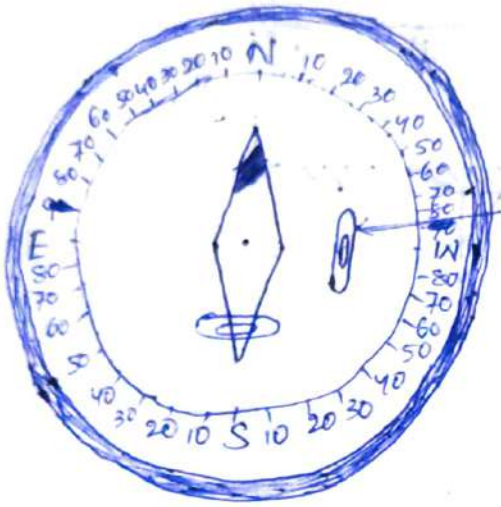


(1) magnetic needle.
(2) Jewel bearing
(3) pivot
(4) lifting lever
(5) circular box
(6) Graduated circle
(7) Line of sight
(8) Top Glass
(9) Eye vane
(10) object vane

→ magnetic needle is free from graduated circle and circular box.
→ For the free movement of magnetic needle Jewel bearing is used.
→ Pivot is that over which Jewel bearing is hin mounted.
→ Lifting lever is used to fold the object vane at ~~hinge~~ or closed the compass.
→ circular box is connected with the graduated circle
→ with the movement of circular box, graduated circule move.

→ Line of sight is a line which bisect the eye vane, object vane and the target

→ Top glass cover the instrument.

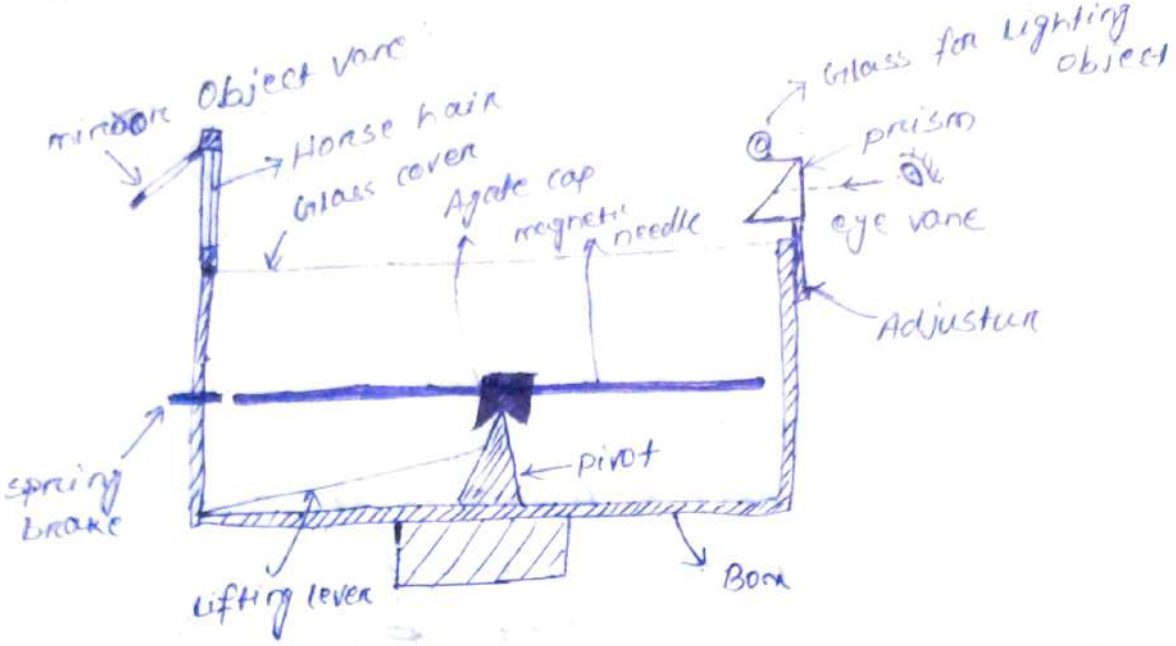


→ with the movement of line of sight the graduated circle moved, but the magnetic needle is constant.

→ In graduated circle E = 90°, W = 90°, N = 0°, S = 0°

→ In graduated circle west is in the place of east and east in the place of west.

Prismatic compass



→ In this compass the reading are taken with the help of prism.

Parts of the compass :-

(1) compass bow

It is a circular metallic bow of diameter 8-10 cm.

(2) pivot :-

A pivot is provided at the centre of the bow and jwel bearing is mounted over it.

(3) magnetic needle & Graduated ring :-

The magnetic needle is made up of bread magnetised iron bar. The bar is pointed at both ends. The magnetic needle is attached to a graduated alluminium ring. The ring is graduated from 0° to 360° clockwise and the graduation begans from south end of the needle. Thus 0° at south, 90° at west, 180° at north, 270° at east and 360° at south.

(4) sight vane and prism

The sight vane and prism are fixed diametrically opposite to the bar. The sight vane is hinged with the metal bar and consist of a horse hair at the centre.

→ prism is used to shows the reading in bigger size.

(5) Glass for lighting object:-

When we can survey a lighting object, we can't see the object. To reduce the lighting of the object or to see the object this glass is used.

(6) Adjustable mirror:-

→ This mirror is provided with the sight vane.

→ This mirror can be lower, rise, can also be inclined.

→ If any object is too low or too height from the line of sight, the mirror can be adjusted to observed it through reflection.

(7) Adjuster:

Some time we can't see the reading. To see the reading or focusing the reading the prism is adjusted by adjuster.

(8) Spring brake:-

A spring brake is provided just at the base of the sight vane. If the spring brake is pressed gently it stops the oscillation of the ring.

(9) Lifting lever :-

A lifting lever is provided below the sight vane. when the sight vane is folded, press the lifting lever

(10) Glass cover

A glass cover is provided at the top of the box to protect the alluminium ring.

Adjustment of prismatic compass :-

Temporary adjustment of prismatic compass :-

(1) centering
(2) Levelling
(3) Focussing the prism.

(1) centering :-

→ centering is the process of keeping the instrument exactly over the station.

→ The centering is done by adjusting the legs of the tripod. A plumb-bob may be used to judged the centering. It may be judged by dropping a stone from the centre of the bottom of the instrument.

(2) Levelling :-

Generally, a tripod is provided with ball and socket arrangement with the help of which the top of the box can be levelled.

→ the instrument is said to be levelled when the graduated circular ring freely swings on the pivot.

(3) Focussing the prism

The prism is move up & down till the figures of the graduated ring are seen freely & sharp.

Surveyor compass	prismatic compass
(1) It has edge bar type needle.	(1) It has flat edge type needle
(2) Graduated ring is made of brass	(2) graduated ring is made of Alluminium.
(3) Graduation ring is attached with sighting vane.	(3) Graduation ring is attached with needle.
(4) Graduations are in quadrantal bearing system.	(4) Graduations are in whole circle bearing system.
(5) The reading is taken through the glass cover.	(5) The reading is taken through the prism.
(6) It has not prism	(6) It has a prism.
(7) The observer has to move around the instrument for taking the reading.	(7) Observer take reading by standing on his place.
(8) It is used by sitting it on a tripod	(8) It can be used either sitting on a tripod or holding in hand.
(9) Graduation are ~~inverted~~ direct	(9) Graduation are ~~direct~~ inverted.

PLANE TABLE SURVEY

→ Plane table surveying is a graphical method of surveying in which field observation and plotting are done simultaneously.

→ It is easiest and cheef method other than theodolite survey. It is used for small scale map.

Equipment and Accessories used in plane table survey :-

(1) Tripod stand.
(2) Plane table.
(3) Alidade.
(4) Sprit level.
(5) Plumbing fork.
(6) Compass
(7) Drawing sheet.

(1) Tripod stand :-

Tripod stand is an instrument which hold the drawing sheet at a some height from the ground.

(2) Plane table :-

Three different types of table having devices for levelling the plane table and controlling its orientation are in common used.

(i) Traverse table.
(ii) Junction table.
(iii) The coast survey table.

(iii) Alidade :-

A plane table alidade is a straight edge with some form of sighting device.

→ These are two type

(i) plain alidade

(ii) Telescopic alidade

~~(iv) Plumbing fork~~

(iv) Spirit level :-

A small sprit level may be used for ascertaining if the table is properly leveled.

(v) Plumbing fork :-

Plumbing fork is used in a large scale work is meant for centering the table over the point or station occupied by plane table when the plotted position of that point is already known on the sheet.

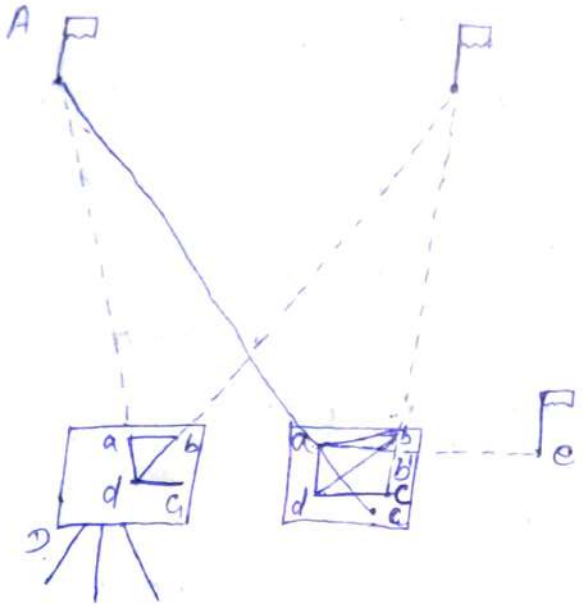
(6) Compass :-

The compass is used for orienting the plane table to magnetic north.

(7) Drawing Sheet :-

The drawing paper used for plane table must be of superior quality.

Two point problem :-



Let us take two point A & B the plotted position of which are known. Let 'c' be the point to be plotted; the whole problem is to orient the table at 'c'.

→ Choose an auxiliary point d' near 'c' to assist the orient at 'c'. set the table at D in a such a way that ab is approximately parallel to AB

→ If the alidade at point a and sight A. Similarly draw a resection from b & and B. to intersect at d.

→ Transfer the point d' to the ground and drive the peg.

→ If the alidade at d' and sight 'c' draw a ray mark at the point c_1 on the ray by estimation to represent the distance ~~dc~~ Dc.

→ Shift the table at point 'c' orient by having the back side to D. and centre it with reference to C

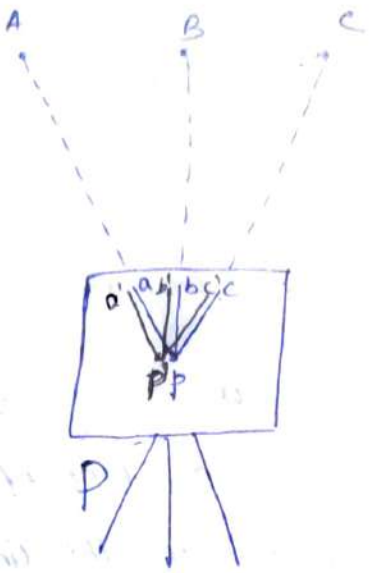
→ pivoting the alidade at point c and sight B. Draw the ray to intersect with the ray drawn from d to b in b'

→ If the alidate at a and sight A. draw a ray to intersect with the previous ray drawn from d to c.

→ The angle between ab & ab' is the error in orientation and must be correct for it. In orient that ab and ab' may coinside by rotating the table.

→ After having orient the table as above draw a resection from a to A. and another from b to B, the intersection of which will give the position 'c' occupied by the table.

Three point problem (By tracing



Let A, B & C be the known points and a, b & C be their plotted position. Let p' be the position of the instrument station to be located on the map.

→ Set the table on p' orient the table approximately with eye so that ab is parallel to AB.

→ Fixed a tracing paper on the sheet and mark on it p', as the approximate location of p' with the help of plumbing fork.

→ pivoting the alidade at p', sight A, B & C in turn and drawn the corresponding line p'a', p'b' & p'c'

→ Loose the tracing paper and rotate it on the drawing paper in such a way that the line p'a', p'b' & p'c' passes through a, b & c respectively. Transfer p' on to the sheet and represent it as p. Remove the tracing paper and join pa, pb & pc.

→ Keep the alidade on pa, the line of sight will not passes through A as the orientation has not been corrected. To correct the orientation loose the clamp and rotate the plane table so that the line of sight passes though A. Clamp the table, the table is thus oriented.

→ To test the orientation keep the alidade along Pb, if the orientation is correct the line of sight will passes through B. similarly the line of sight will passes through C when the alidade is kept on pc.

Advantages and disadvantages of plane table survey

Advantages:-

→ It is the most rapid method of surveying.

→ There is no need for a field book.

→ It is suitable in magnetic area.

→ The map can be prepare easily and doesn't required any great skill

→ There is not possibility of overlooking any important object.

Disadvantages:-

→ The plane table is not suitable for accurate work

→ The plane table surveying is not suitable in wet climate

→ The instrument is very heavy and difficult to carrying
→ The map can't be replotted. to a different scale as there is no field book.
→ The number of accessories required in such survey is large and they are lightly to be lost.

(1) The plane table :-

The plane table is a drawing board of 750mm×600mm size made of well seasoned wood like ~~tea~~, teak, pine etc.

→ The top surface of the table is well levelled
→ The bottom surface consists of a threaded circular plate for fixing the table on the tripod stand by a wing nut

(2) The Alidade :-

→ There are two types of alidade
  (1) plain alidade
  (2) Telescopic alidade.

(1) plain alidade :-

The plain alidade consist of a metal or wooden ruler of length about 50 cm.
→ One of its edge is bevelled and is known as fiducial.
→ It consist of two vanes hinged with the ruler
→ One is known as the object vane and carries horse hair, the other is called the sight vane.

(2) Telescopic alidade :-

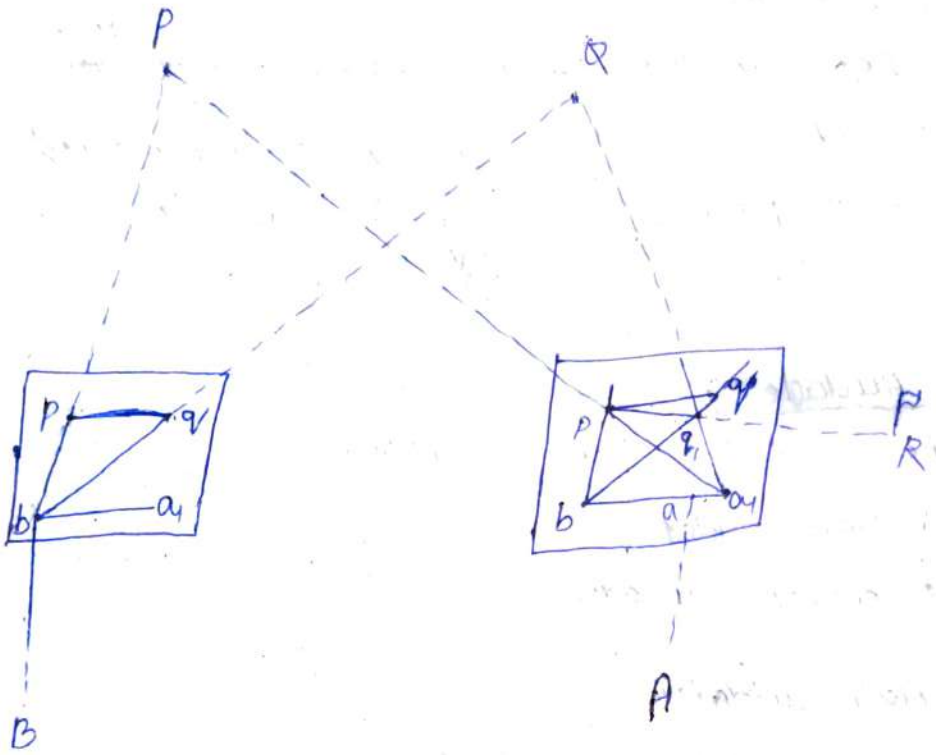
→ The telescopic alidade consists of a telescope meant for inclined sight or sighting distance object clearly.

(3) The Spirit level :~

The spirit level is a small metal tube containing a small bubble of sprit.

→ The spirit level is meant for levelling the plane table.

TWO POINT PROBLEM :~



~~stat~~

→ In this problem, two well-defined points whose position are already plotted on ~~map~~ the plan are selected. Then, by perfectly bisecting these points, a new stations is established at the required position.

procedure:-

→ Let P & Q be the two known point and p & q be their plotted position. It is required to locate a new station at A by perfectly bisecting P & Q.

→ An auxiliary station B is selected at a suitable position. The table is set up at B, and levelled and oriented by eye estimation. It is then clamped.

→ pivoting the alidade at 'p' and bisecting P & rays is drawn. Then the alidate is pivoted at 'q' and bisecting Q & ray is drawn suppose these two rays meet at point b.

→ The alidade is pivoted at pt, b & bisect the ranging rod at A and a ray is drawn. Then by eye estimation, a point a_1 is marked on this ray.

→ The table is shifted at point A. Then the table is levelled and oriented by backsighting. Then the alidade is pivoted at p' and bisect the point P and the ray is drawn. Suppose this ray intersect the line ba, at the point a_1.

→ Then the alidade is pivoted at point a_1 and bisecting Q and a ray is drawn. suppose this ray intersect the line bq at a point q_1. The triangle pqq_1 is known as the triangle of error. and is to be eliminated.

→ The alidade is placed along the line pq, and a ranging rod R is fixed at some distance from the table. Then the alidade is placed along the line pq and the table is rotated to bisect R. At this position, the table is said to be perfectly oriented.

→ Finally, the alidade is centered on P & q, the points p & Q are bisected and the rays are drawn. Suppose these rays intersect at a point a. This would represent the exact position of the required station A. Then the station A is marked on the ground.

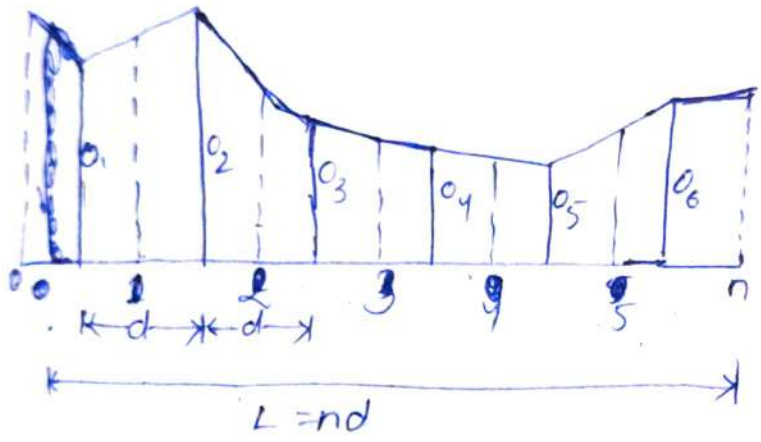
CALCULATION OF AREA

Area from offset to a base line :-

(1) Mid-ordinate rule :-

The method is used with the assumption that the boundaries between the extremities of the ordinates (or offsets) are straight line.

→ The base line is divided into a number of divisions and the ordinates are measured at the mid points of each division.



The area is calculated by the formula,

$$\text{Area} = \Delta = \text{Average ordinate} \times \text{Length of base}$$

$$= \left(\frac{O_1 + O_2 + O_3 + \cdots + O_n}{n}\right) \times nd$$

$$= (O_1 + O_2 + O_3 + \cdots + O_n)\, d$$

$$= d \sum O$$

$O_1, O_2 \cdots$ = The ordinate at the mid point of each division

L = Length of base line $= nd$

n = number of division

d = distance of each division

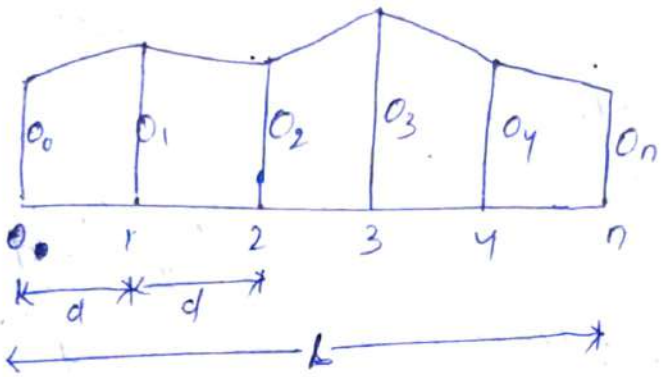
(2) Average ordinate Rule

→ This method is used with the assumption that the boundaries between the extremities ordinates are straight line

→ The offset are measured to each of the points of the division of the base line.

Area = Δ = Average ordinate × length of the base.

$$= \left(\frac{O_0 + O_1 + O_2 + \cdots + O_n}{n+1}\right) \times L$$



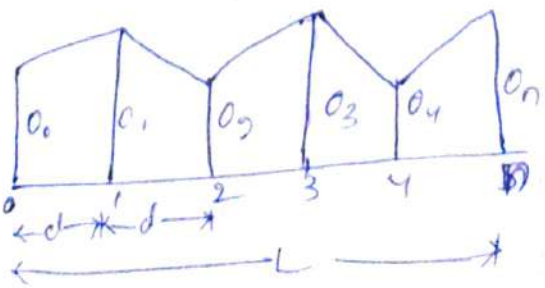
O_0 = ordinate at one end of the base

O_n = ordinate at other end of the base divided into n equal division

(3) Trapezoidal Rule :-

This rule is based on the assumption that the figures are trapezoid.

→ This is more accurate than previous two method



The area of the first trapezoid is given by

$$A_1 = \left(\frac{o_0+o_1}{2}\right)d$$

similarly, the area of the 2nd trapezoid is given by

$$A_2 = \left(\frac{o_1+o_2}{2}\right)d$$

Area of the last trapezoid is given by

$$A_n = \left(\frac{o_{n-1}+o_n}{2}\right)d$$

Hence the total area of the figure is given by

$$A = A_1 + A_2 + \cdots + A_n$$

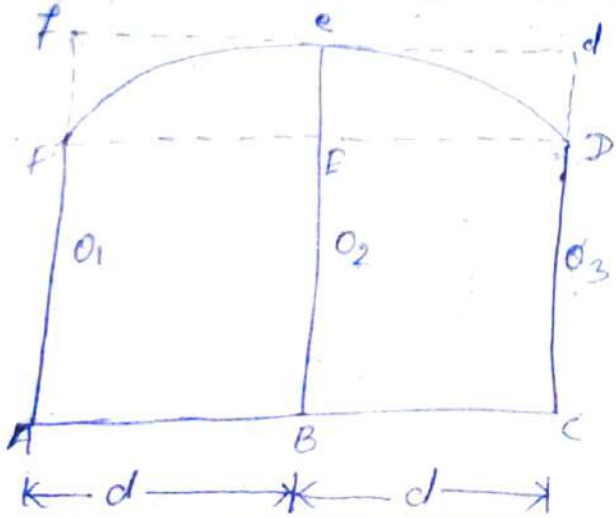
$$= \frac{o_0+o_1}{2}d + \frac{o_1+o_2}{2}d + \cdots + \frac{o_{n-1}+o_n}{2}d$$

$$= \left[\frac{o_0+o_n}{2} + 2\left(\frac{o_1+o_2+o_3+\cdots+o_{n-1}}{2}\right)\right]d$$

$$= \left[\frac{o_0+o_n}{2} + (o_1+o_2+o_3+\cdots+o_{n-1})\right]d$$

(4) Simpson's Rule :-

This method is used with the assumption that the boundaries between the extremities ordinates form an arc of a parabola.



Let,

O_1, O_2, O_3 = three consecutive ordinates

d = common distance between the ordinates

Area of AFeDC = Area of trapezium AFDC + area of segment FeDEF

Here,

Area of trapezium = $\frac{O_1+O_3}{2} \times 2d$

Area of segment = $\frac{2}{3}$ × area of parallelogram FfdD

$= \frac{2}{3} \times Ee \times 2d$

$= \frac{2}{3} \times \left\{O_2 - \frac{O_1+O_3}{2}\right\} \times 2d$

So, the area between the first two division

$$\Delta_1 = \frac{O_1+O_3}{2} \times 2d + \frac{2}{3}\left\{O_2 - \frac{(O_1+O_3)}{2}\right\} \times 2d$$

$$= d\left\{O_1+O_3 + \frac{2}{3}\left(\frac{2O_2 - O_1 + O_3}{2}\right) \times 2\right\}$$

$$= d\left\{O_1+O_3 + \frac{1}{3}(4O_2 - 2O_1 + 2O_3)\right\}$$

$$= \frac{d}{3}\left\{3O_1 + 3O_3 + 4O_2 - 2O_1 + 2O_3\right\}$$

$$= \frac{d}{3}(O_1 + O_3 + 4O_2)$$

$$= \frac{d}{3}(O_1 + 4O_2 + O_3)$$

Similarly the area between the next two divisions

$$\Delta_2 = \frac{d}{3}(O_3 + 4O_4 + O_5) \text{ and so on.}$$

$$\therefore \text{Total area} = \frac{d}{3}(O_1 + 4O_2 + 2O_3 + 4O_4 + \cdots + O_n)$$

$$= \frac{d}{3}\{O_1 + O_n + 4(O_2 + O_4 + \cdots) + 2(O_3 + O_5 + \cdots)\}$$

→ This rule is applicable when the no. of ordinate is odd.

Question-1

The following offsets were taken from a chain line to an irregular boundary line at an interval of 10m:

0, 2.50, 3.50, 5.00, 4.60, 3.20, 0 m.

Compute the area between the chain line, the irregular boundary line and the end offsets by.

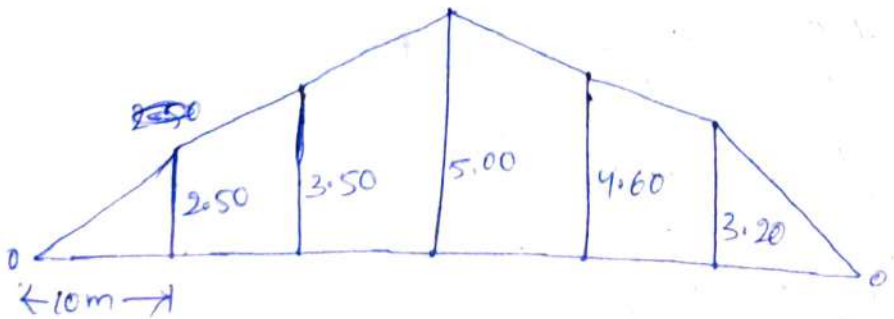
(a) The mid-ordinate rule.

(b) The average-ordinate rule.

(c) The trapezoidal rule.

(d) Simpson's rule.

Ans-



(a) By mid-ordinate rule. The mid-ordinates are

$$h_1 = \frac{0 + 2.50}{2} = 1.25 \text{ m}$$

$h_2 = \frac{2.50+3.50}{2} = 3\ m$

$h_3 = \frac{3.50+5.00}{2} = 4.25\ m$

$h_4 = \frac{5.00+4.60}{2} = 4.80\ m$

$h_5 = \frac{4.60+3.20}{2} = 3.90\ m$

$h_6 = \frac{3.20+0}{2} = 1.60\ m$

Required area $= 10(1.25+3+4.25+4.80+3.90+1.60)$

$= 10 \times 18.80$

$= 188\ m^2$

(b) By Average ordinate rule.

$d = 10\ m, \quad n = 6$

Base length $= 10 \times 6 = 60\ m$

Number of ordinates $= 7$

Required area $= 60 \times \left\{\frac{0+2.50+3.50+5.00+4.60+3.20+0}{7}\right\}$

$= 161.14\ m^2$

(c) By Trapezoidal Rule :-

$d = 10$

Required area $= \frac{10}{2}\{0+0+2(2.50+3.50+5.00+4.60+3.20)\}$

$= 5 \times 37.60 = 188\ m^2$

(d) By simpson's Rule :-

$d = 10$

Area $= \frac{10}{3}\{0+0+4(2.50+5.00+3.20)+2(3.50+4.60)\}$

$= 196.66 m^2$

Question 2

The following offsets were taken at 15 m intervals from a survey line to an irregular boundary line:

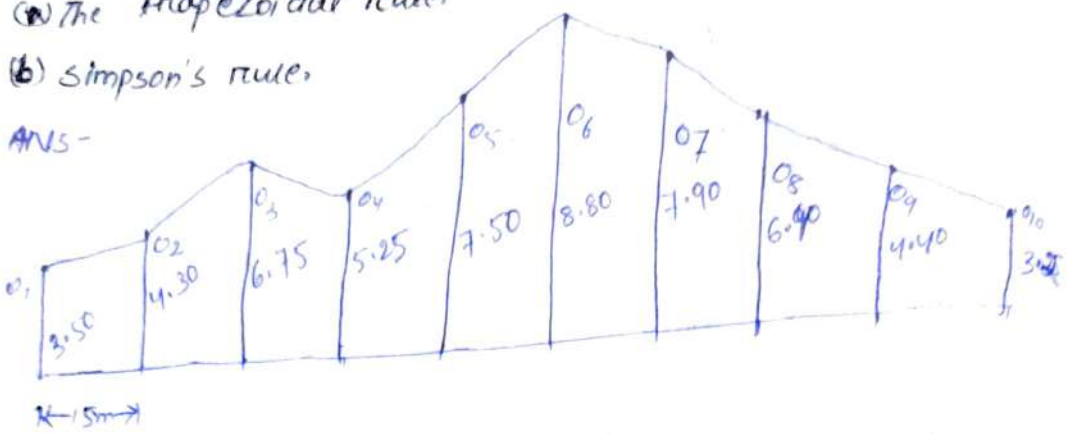
3.50, 4.30, 6.75, 5.25, 7.50, 8.80, 7.90, 6.90, 4.40, 3.25 m

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

(a) The trapezoidal rule.

(b) Simpson's rule.

Ans -



(a) By Trapezoidal rule;

$$\text{Required area} = \frac{15}{2}\{3.50 + 3.25 + 2(4.30 + 6.75 + 5.25 + 7.50 + 8.80 + 7.90 + 6.90 + 4.40)\}$$

$$= \frac{15}{2}\{6.75 + 102.60\}$$

$$= 820.125 \text{ m}^2$$

(b) By simpson's rule;

This rule is applied when the no. of ordinate is odd. But here the number of ordinate is even.

so, simpson's rule is applied from O_1 to O_9 and the area bet^n O_9 and O_{10} is found out by the trapezoidal rule.

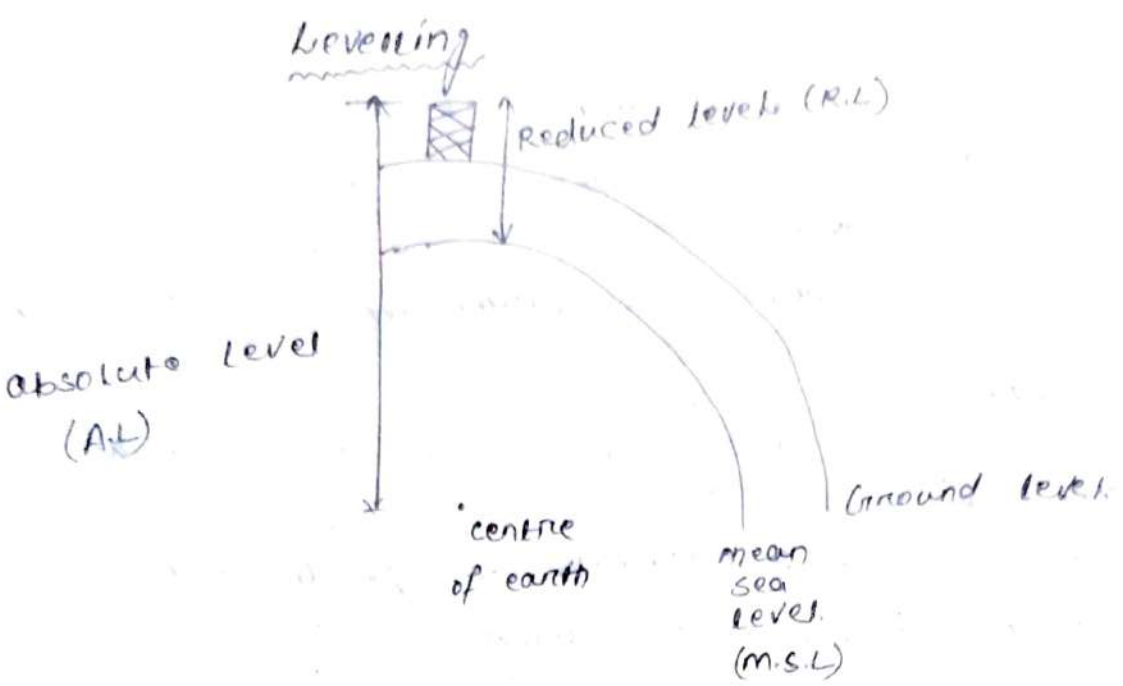
$$A_1 = \frac{15}{3}\{3.50 + 4.40 + 4(4.30 + 5.25 + 8.80 + 6.90) + 2(6.75 + 7.50 + 7.90)\}$$

$$= 756.00 \text{ m}^2$$

$$A_2 = 15\left(\frac{4.40 + 3.25}{2}\right) = 57.38 \text{ m}^2$$

Total area $= A_1 + A_2$

$$= 813.38 \text{ m}^2$$



(1) Reduced level :~

Height of any point measure w.r.t M.S.L is known as reduced level.

→ Height of any point measure w.r.t centre of earth is known as absolute level.

(2) Benchmark :~

Any point of known RL is known as benchmark

(3) Mean sea level (MSL) :~

It is a measurement of the average height of the sea between high and low tide.

Def^n of levelling :-

The art of determining the relative height of different point on or below the surface of the earth is known as levelling.

(1) Level surface :-

The surface which is parallel to the mean spheroidal surface of the earth, is known as level surface.

→ It is also normal to the plumb line at every point.
→ It is a curved surface.

(2) Level line :-

Any line lying on the level surface is known as a level line.

→ Every point of a level line is equidistant from the centre of the earth.

(3) Horizontal surface :-

A surface tangential to the level surface at any point is known as a horizontal surface.

(4) Horizontal line :-

A line lying on the horizontal surface is known as a horizontal line.

→ It is a straight line tangential to the level line.

(5) Vertical line :-

A line perpendicular to the horizontal line is called a vertical line.

→ The direction indicated by plumb line is called the vertical line.

(6) Vertical plane :-

The plane which contains the vertical line at a place is called a vertical plane.

(7) Vertical angle :-

The angle between an inclined line and a horizontal line at a place, in vertical plane is called vertical angle.

(8) Datum surface :-

The imaginary level surface with reference to which vertical distances of the points (above or below) are measured, is called datum surface.

(9) Mean sea level datum :-

Mean sea level datum is obtained by making hourly observation of the tides at any place over a period of 19 year.

(10) Reduced level :-

The height or depth of any point above or below the assumed datum is called reduced level.
→ It is also known as elevation of the point.

(11) Line of sight :-

The line passing through the optical centre of the objective, traversing the eye piece and entering the eye, is known as a line of sight.

(12) Line of collimation :-

The line passing through the optical centre of the objective and the point of intersection of the cross hair at the diaphragm and its continuation is called line of collimation.

(13) optical centre of a lens :-

The point in a lens through which rays pass without any lateral displacement, is called optical centre.

(14) Axis of the telescope :~

The line joining the optical centre of the objective and the centre of the eye piece is called Axis of the telescope.

(15) Bench mark (B.M) :~

A relatively permanent and fixed reference point of known elevation above the assumed datum is called a bench mark.

(15) Reduced level :~

The vertical distance of a point above or below the datum line is known as the Reduced level(RL) of that point.

(16) Bench mark :~

These are fixed points on mark of known RL determined with reference to the datum line.

→ Bench mark may be of four types.

(1) GTS Bench-marks
(2) permanent bench-mark
(3) Arbitrary " "
(4) Temporary " "

(a) GTS Bench-mark :~

→ These bench-mark are established by the survey of India department at large intervals all over the country.

(b) Permanent Bench-mark :~

These bench-mark are established by different government departments like PWD, Railway, Irrigation et

(c) Arbitrary Bench-mark :~

When the RLs of some fixed points are assumed they are termed arbitrary bench-mark.

(d) Temporary Bench-mark :~

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

(17) Backsight Reading (BS) :~

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

(18) Foresight Reading (FS) :~

This is the last staff reading in any set-up of the instrument and indicates the shifting of the later

(19) Intermediate sight reading :~

It is any other staff reading between BS & FS in the same set-up of the instrument

(20) Change point :~

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

(21) Height of the instrument

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

(22) Parallax:

The apparent movement of the image relative to the cross-hair is known as parallax.

→ The parallax is tested by moving the eye up and down.

* Dumpy Level :-

The telescope of the dumpy level is rigidly fixed to its supports. It cannot be removed from its supports, nor it can be rotated about its longitudinal axis.

Temporary Adjustment of Level :-

(1) selection of suitable position :-

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

(2) Fixing Level with Tripod stand :-

The tripod stand is placed at the required position with its leg well apart and pressed firmly into the ground.

→ The level is fixed on the top of the tripod stand according to the fixing arrangement provided on that particular level. The level is not to be set up at any station on point along the alignment.

(3) Approximate levelling by legs of tripod stand :-

The foot screws are brought to the centre of their run. The two legs of the tripod stand are kept firmly fixed on the ground and the third leg is move in or out, left on right until the bubble is approximately at the centre of its run.

(4) perfect levelling by Foot screws :-

As the longitudinal bubble is on the top of the telescope, the telescope is placed parallel to the any pair of foot screws (i.e. first position) and by turning both these screws equally inward or out

the bubble is brought to the centre.

→ Then the telescope is turned through 90° (2nd position) and the bubble is brough to the centre by turning the third foot screws clockwise and anticlockwise.

→ Then the telescope is again brought to their first position and the bubble is brought to the centre. The process is repeated several time until 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 so is the permanent adjustment. But if the bubble is deflected from its central position, the permanent adjustment is not perfect and needs to be modified.

(5) Focussing the Eyepiece:

A piece of white paper is held in front of the object glass and the eyepiece is moved in or out by turning it clockwise or anticlockwise until the cross hairs can be seen clearly.

(6) Focussing the objectglass:

The telescope is directed towards the levelling staff. Looking through the eye-piece, the focussing screw is turned clockwise or anticlockwise until the graduation of the

staff is distinctly visible and the parallax is eliminated. To eliminate the parallax, the eye is moved up and down to verify whether the graduation of the staff remains fixed relative to the cross hairs.

(7) Taking the staff Readings :-

- Finally the levelling of the instrument is verified by turning the telescope in any direction.
- When the bubble remain in the central position for any direction of the telescope, the staff readings are taken.

~~Height of instruments / The collimation System~~

~~Reciprocal levelling~~

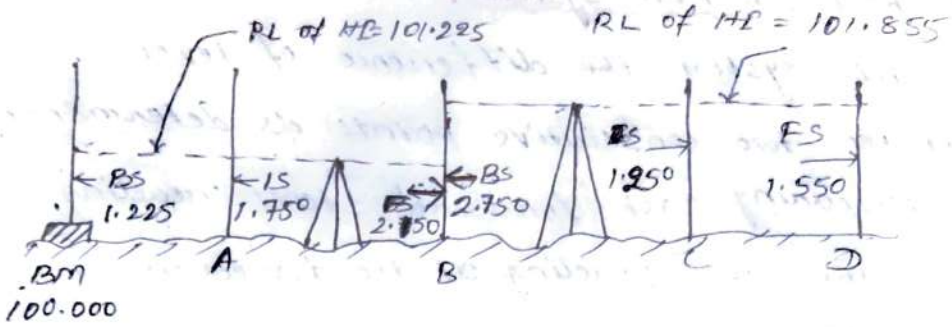
Height of instrument / The collimation system :

- The reduced level of the line of collimation is said to be the height of the instrument. In this system the height of the line of collimation is found out by adding backsight reading to the RL of the BM on which the BS is taken. Then the RL of the intermediate point and the change point are obtained by substracting the respective staff reading from the height of the instrument. The level is then shifted for the next setup and again the height of the line of collimation is obtained by adding the backsight reading to the RL of the change point (which was calculated in the first set-up).

→ so the height of the instrument is different in different setup 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 setting.

→ In this system, the RLs of unknown points are to be found out by deducting the staff reading from the RL of height of the instrument

Ex.



(a) RL of HI in first setting = 100 + 1.225 = 101.225

RL of A = 101.225 − 1.750 = 99.505

RL of B = 101.225 − 2.150 = 99.105

(b) RL of HI in second setting = 99.105 + 2.750 = 101.855

RL of C = 101.855 − 1.250 = 100.605

RL of D = 101.855 − 1.550 = 100.305

Arithmetical check: $\sum BS - \sum FS$ = Last RL − 1st RL

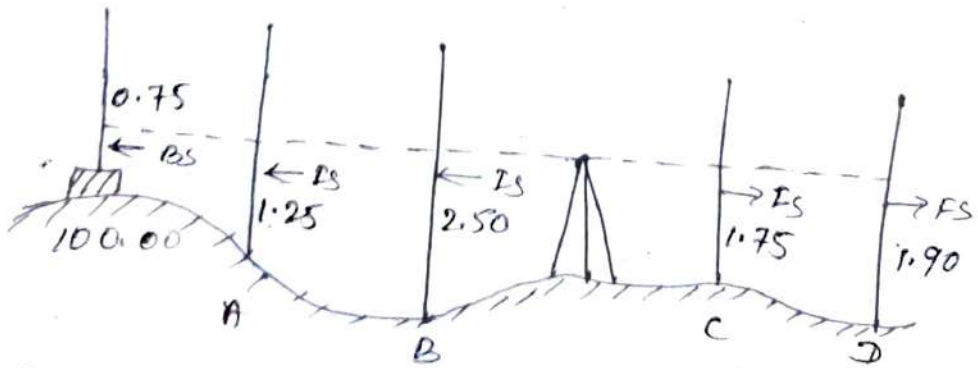
(2) Rise-and-Fall system :-

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 preceding point.

→ If the forward staff reading is smaller than the immediately preceding staff reading, a rise is said to have occured. The rise is added to the RL of the preceding point to get the RL of the forward point

→ If the forward staff reading is greater than the immediately preceding staff reading, a fall is said to have occured. The fall is subtracted from the RL of the preceding point to get the RL of the forward point.

For eg



Point A (w.r.t BM) = 0.75 - 1.25 = -0.50 (fall)

point B (w.r.t A) = 1.25 - 2.50 = -1.25 (fall)

point C (w.r.t B) = 2.50 - 1.75 = 0.75 (Rise)

point D (w.r.t C) = 1.75 - 1.90 = -0.15 (fall)

RL of BM = 100.00

RL of A = 100.00 − 0.50 = 99.50

RL of B = 99.50 − 1.25 = 98.25

RL of C = 98.25 + 0.75 = 99.00

RL of D = 99.00 − 0.15 = 98.85

Arithmetical check: $\Sigma BS - \Sigma FS = \Sigma rise - \Sigma Fall$

= last RL − 1st RL

Reciprocal Levelling :-

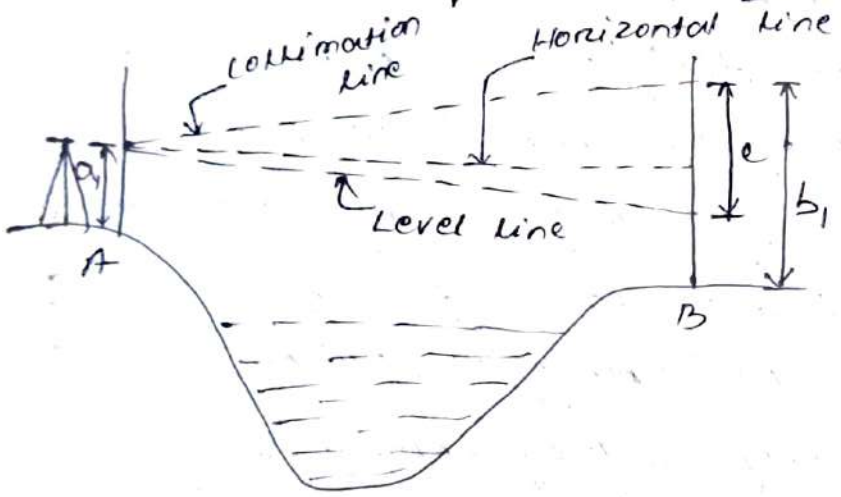
If the level is placed exactly midway between two points and staff readings are taken to determine the difference of level then the errors (due to inclined collimation line, curvature and refraction) are automatically eliminated. But in case of river or valley, There is not possibility of placed the level ~~exactly~~ exactly midway between the two point on opposite bank. In this case, reciprocal levelling is adopted, which involves reciprocal observation from both bank of the river.

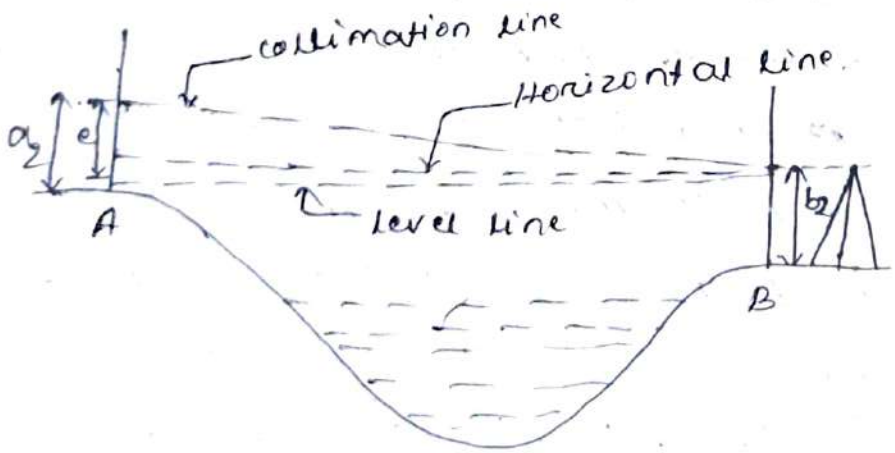
→ In reciprocal levelling, the level is set up at both bank of the river and two sets of staff reading are taken by holding the staff on both bank. In this case, it is found that the errors are completely eliminated and the true difference of level is equal to the mean of the two apparent difference of level.

Procedure:-

→ Let A & B are two points on the opposite bank of the river. The level is set up very near A and after proper temporary adjustment, the staff reading are taken at A & B. Suppose the readings are a_1 & b_1.

→ The level is shifted and set up very near B and after proper temporary adjustment, the staff reading are taken at A & B. Suppose the readings are a_2 & b_2.





Let, h = true difference of level bet A & B.

e = combined error due to curvature, refraction and collimation (The error may be positive, -ve, here the error is assumed positive)

In the first case,

correct staff reading at A = a_1 (as the level is very near A)

correct staff reading at B = $b_1 - e$

True difference of level between A and B.

$$h = a_1 - (b_1 - e) \quad \text{---(1)}$$

In the second case

correct staff reading at A = $a_2 - e$

correct staff reading at B = b_2 (as level is near B)

so, true difference of level,

$$h = (a_2 - e) - b_2 \quad \text{---(2)}$$

From (1) and (2)

$$2h = a_1 - b_1 + e + a_2 - e - b_2$$

$$\Rightarrow 2h = (a_1 - b_1) + (a_2 - b_2)$$

$$\Rightarrow h = \frac{(a_1 - b_1) + (a_2 - b_2)}{2}$$

Theodolite Traversing :-

(1) Fast angle (or magnetic bearing) method.

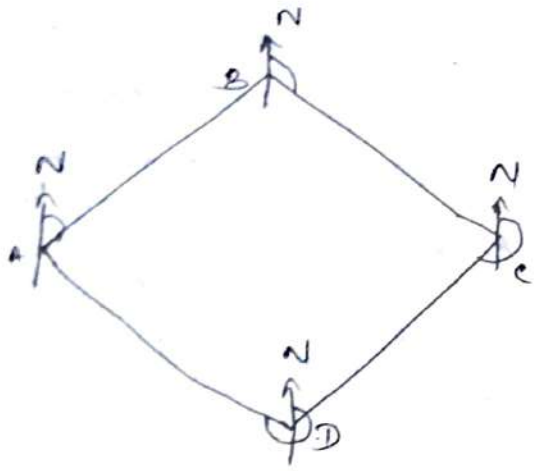
(2) Included angle method

(3) Deflection angle method.

(1) Fast angle method

This method used to measure the magnetic bearing and lengths of traverse legs.

→ Suppose ABCDA is a closed traverse. The following procedure is adopted.



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

→ The upper clamp is loosed and the ranging rod at B is bisected. The reading on the vernier A gives the fore bearing of the line AB. Say it is 30°. The back bearing of the line DA is also measured from A. Now the upper clamp is tight. Consider the traverse is clockwise direction.

→ The instrument is shifted and set up at B. with the vernier A is fixed at the reading 30°. The lower clamp is loosed and the ranging rod at A is bisected. The telescope is now transited. Then loose the upper clamp and the ranging rod at C is bisected. Now the reading on vernier A will gives the forebearing of the line BC. say it is 100°.

→ Again the instrument is shifted and set up at C with the vernier A fixed at the reading of 100°.

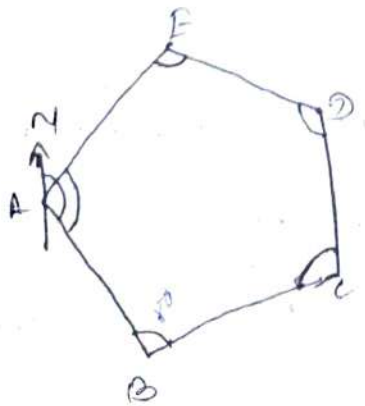
→ The same procedure is repeated to get the FB of all

→ similarly the FB of remaining line are measured.

→ At the end of the traverse, the FB & BB of DA should differ by 180°.

(2) Include angle method :-

This method is suitable for closed traverse. The traverse may be taken clockwise or anticlockwise order. Generally a close traverse is taken in anticlockwise. In this method the bearing of the initial line is taken. After this included angle of the traverse is measured.



Procedure:-

→ The theodolite is set up & centered at A. The plate bubble is levelled. The vernier A is set to 0° and the vernier B at 180°. The upper clamp is fixed.

→ The telescope is oriented along the north line with the help of tabular compass provided fitted to the instrument. Then the magnetic bearing of line AB is measured.

→ Again vernier A is set at 0°.

→ The upper clamp is fixed. Loose the lower clamp and the ranging rod at E is bisected. Now, the upper clamp is loosed. and by turning telescope clockwise, the ranging rod at B is bisected. The reading on vernier are noted. ∠A is obtained in this fasion.

→ face of the instrument is changed and ∠A is measured. The mean of the two observation gives the correct value of ∠A.

→ similarly the other angle ∠B, ∠C, ∠D & ∠E are measured.

The arithmetical check is applied as follows.

$(2n-4) \times 90^\circ$ = sum of interior angle.

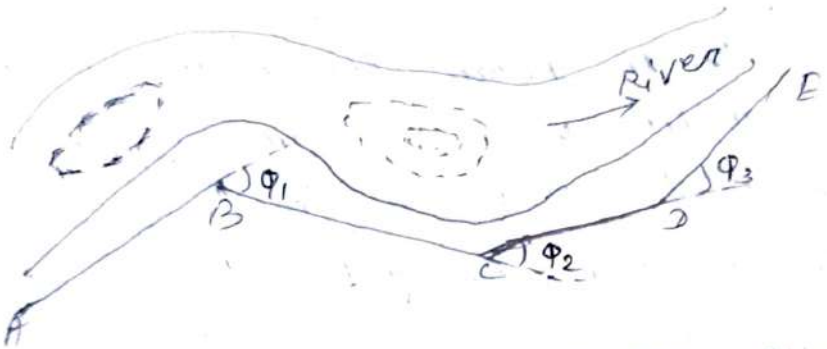
If it is no, so the total error is distributed among the angles.

→ For plotting the traverse, latitude and departures of the traverse legs are calculated.

c) 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 theodolite is set up at A. Then it is centered and levelled. After this, the magnetic bearing of the line AB is measured in the usual manner.

→ The theodolite is then shifted ~~to the~~ and centred over B. The plate bubble is levelled and the vernier A is set to 0°. Then a backsight is taken on A. ~~Then the te~~ Now the telescope is transited. By turning the telescope clockwise the ranging rod at C is bisected. The vernier reading are taken. Then the deflection angle Φ_1 is determined - It is the average value of the angles obtained from vernier A & B.

→ similarly, the other deflection angle Φ_2 & Φ_3 are measured.

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

Plotting of compass traverse :-

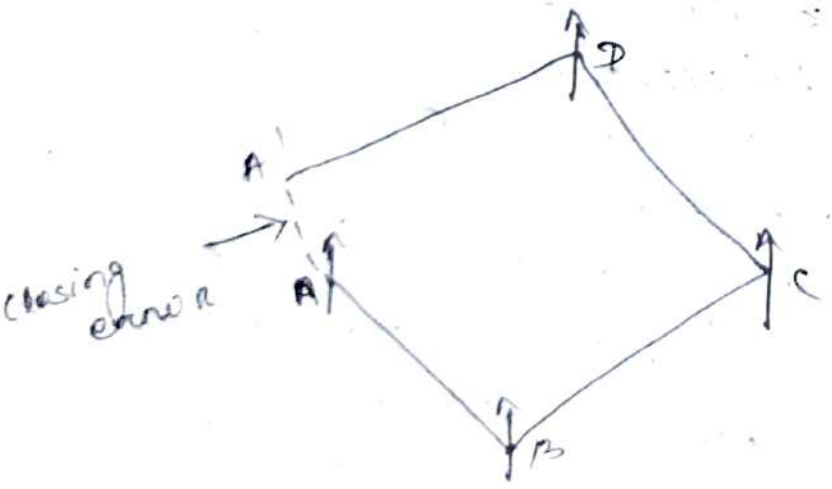
The following are the various method of plotting compass traverse.

(1) By parallel meridian through each station :-

The starting point A is suitably selected on the paper. and a line representing the north line. The bearing of line AB is plotted by protraction and its length is plotted to any suitable scale.

→ At station B, the north line is drawn parallel to the north line which was drawn at A. Then the bearing of the line BC is plotted and its length marked according to the previous scale

→ similarly, all the traverse legs are plotted. In case of closed traverse, there may be a closing error which should be adjusted graphically.



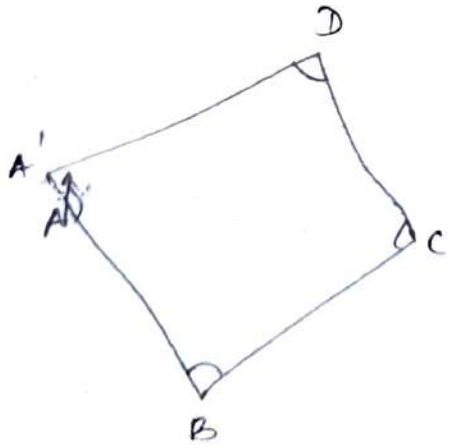
2) By considering included angle :-

The starting point A is suitably selected on the sheet. A line representing the north line is drawn through station A. The bearing of the line AB is plotted by a protractor and its length is plotted according to any suitable scale.

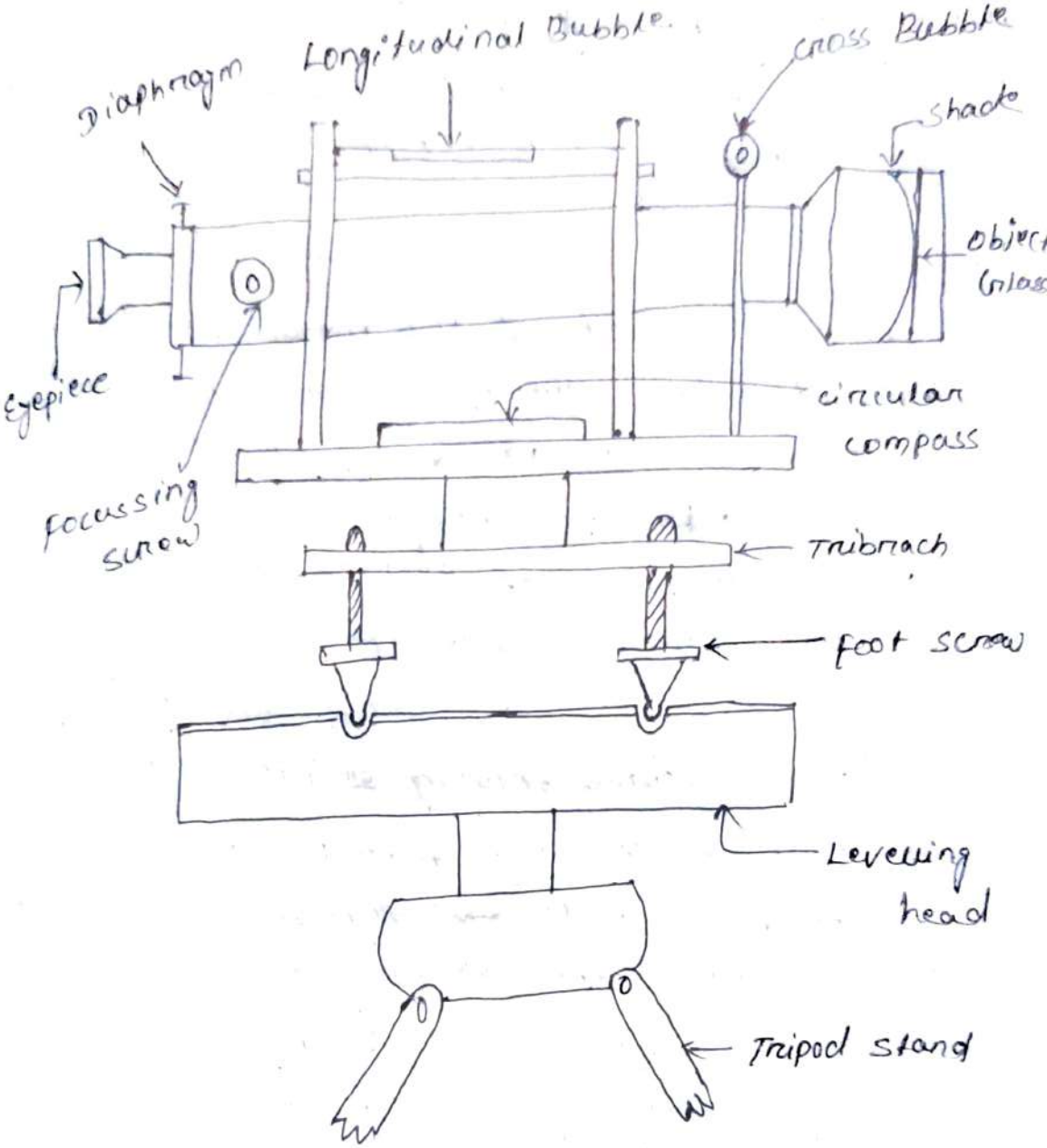
At station B, the angle B is plotted and the length of the line BC is marked according to the previous scale.

Angle C is plotted at station C and the and the distance CD is marked.

The process is continued until all the line have been plotted. In this case, there may be a closing error which has to be adjusted graphically



DUMPY LEVEL



Tripod stand

→ It consist of 3 legs which may be solid or framed. The lower ends of the tripod stand are fitted with steel shoe.

Levelling head

It consist of two parallel triangular plate having three grooves to support the foot screws

Foot screws

→ Foot screws are provided both tribrach and trivet. By turning the foot screws, the tribrach can be raised or lowered to bring the bubble to the centre of its run.

Telescope :-

The telescope consist of two metal tube, one moving within the other. It consist of an object glass and an eye piece on the opposite end. A diaphragm is fitted in the telescope in front of eyepiece. The diaphragm carries cross-hairs. The telescope is focussed by means of a focussing screw and may have either external focussing or internal focussing

→ In the external focussing telescope, the diaphragm is fixed to the outer tube, and the objective to the inner tube. By turning the focussing screw, the distance between the objective and diaphragm is altered to form a real image on the plane of cross-hair.

→ In the internal focussing telescope, the objective and eyepiece don't move. When the focussing screw is turned. Here, a double concave lens is fitted with rack and pinion arrangement between the eyepiece and the objective. This lens moves to & fro when the focussing screw is turned and a real image is formed on the plane of cross hair.

4) Bubble tube

Two bubble tube, one called the longitudinal bubble and the other is called cross bubble are fixed at right angle to each other. This tube contain spirit bubble. The bubble is brought to the centre with the help of foot screws.

5) compass

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