A LECTURE NOTE

ON

LAND SURVEY-I

(TH-3)

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CHAPTER-1

SURVEYING

Surveying is the art of determining the relative position of different objects on the surface of the earth by measuring the horizontal & vertical plane is called surveying.

→ Surveying is devided into two classes.

(i) Plane surveying

(ii) Geodetic surveying

(i) Plane surveying :-

→ The surface in which the curvature of earth is not taken into consideration are known as plane surveying.

→ These survey extend over small area.

→ Generally areas less than 250 km^2.

(ii) Geodetic surveying :-

→ The surveying in which the curveture of earth is taken into consideration is known as Geodetic surveying.

→ These survey extend over large area.

→ Generally areas more than 250 km^2.

General classification of survey :-

(i) According to the instrument use :-

The survey according to the instrument used are :-

(a) Chain surveying.

(b) Compass surveying.

(c) Plane table surveying.

(d) Theodolite surveying
(e) Tacheometric surveying
(f) Photographic surveying

(ii) According to proposal or objects surveyings :-
(a) Geological Surveying
(b) Mine surveying
(c) Archaeological surveying
(d) Military Surveying

(iii) According to method employed :-
The survey according to method employed are triangulation surveying & transverse surveying.

(iv) According to the place of work or nature of field :-
(a) Land surveying
(b) Marine surveying
(c) Astronomical surveying
The land surveying is devided into the following classes :-

(1) Topographical Surveying :-
→ This surveying is carried out the determine the natural features of the country Such as hills, lakes, river etc.
→ It is also used for artificial objects such as canals, railway, towns & villages.

(2) Cadastral Surveying :-
→ This survey is perform to determine the additional details such as boundries of fields, houses & others property.

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(3) City Surveying :-

→ These survey is performing connection with town planning schemes such as - water supply streets, stanitory system etc.

(4) Engineering Surveying :-

→ This survey is done to prepare detailed drawing of projects involving roads, railways etc.

→ The engineering survey made in subdevide into 3 classes.

(A) Reconnaissance Survey :-

→ It is used for determining the rough cost of scheme.

(B) Prelimehary Survey :-

→ It is used for collecting more precise data to choose the best location for the work.

(C) Location Survey :-

→ It is used for setting out the work in the ground.

LEVELING :-

→ It is a branch of surveying which is to find the elevation of a point with respect to a given datum.

→ To establishing point at a given elevation.

→ Leveling deals with measurements in a vertical plane.

Units of Measurement :-

→ These are four kinds of measurements used in plane surface.

(i) Horizental distance.
(ii) vertical distance
(iii) Horizental angle
(iv) vertical angle.

Basic units of length :-

British Unit :-

12 inches = 1 foot
3 feet = 1 yard
5 ½ yards = 1 rod, pole
4 roles = 1 chain (66 feet)
10 chains = 1 furlong
8 furlongs = 1 mile
100 links = 1 chain (66 feet)
6 feet = 1 fathom
120 fathom = 1 cable length
6080 feet = 1 nautical mile.

Metric Units :-

10 milimeters = 1 centimeters
10 centimeters = 1 decimeter
10 decimeters = 1 meter
10 meters = 1 decameter
10 decameters = 1 hectometers
10 hectometers = 1 kilometers
1852 meter = 1 nautical mile

Basic units of area :-

British unit :-

144^2 inches = 1^2 feet

9^2 feet = 1^2 yard

$30\frac{1}{4}^2$ yards = 1^2 rod, pole

40^2 rods = 1 rood

4 roods = 1 acre

640 acres = 1^2 mile

484^2 yards = 1^2 chain

10^2 chains = 1 acre

Metric units :-

100^2 milimeters = 1^2 cm

100^2 cm = 1^2 decimeter

100^2 decimeters = 1^2 meter

100^2 meter = 1^2 decameter

100^2 decameter = 1^2 hectameter

100^2 hectameter = 1^2 kilometer

Basic units of volume :-

British units :-

1728 cube inches = 1 cube foot

27 cube feet = 1 cube yards

Metric units :-

1000 cube milimeters = 1 cube cm

1000 cube centimeters = 1 cube decimeter

1000 cube decimeters = 1 cube meters

PRINCIPLE OF SURVEYING :-

→ The principle of surveying is devided into two parts.

(1) Work from the whole to the part.

(2) To locate a new station by at least two measurements (linear or angular) from fixed reference point.

(i) According to the first principle the whole area is enclosed by the main station & main survey line.

(ii) The area is than devided into no. of parts by forming ~~d~~well condition triangle.

(iii) Equilateral triangle is consider the best ~~d~~well condition triangle.

(iv) The main survey line are major very accurately with a standard chain, then the sight of the triangle are major.

(v) The purpose of this forces of working is to prevent accumulation of error.

(vi) During this procedure if their any error in the measurement from any sign of angle than it will not effect the whole work.

(2) According to the second principle the new ~~second~~ station always be fixed by at least two measurement from fixed different point.

(i) Linear measurement refers to horizental distance measurement by chain or tape.

(ii) Angular measurement refers to be horizontal angle taken by a theodolite.

Methods of linear measurement :-

(a) By passing and stepping method :-

→ For rough & speedy work distance are measure by passing of stepping that is by counting no. of working step of a man is consider 2.5 feet or 80 cm.

(b) By passometer :-

→ A small instruments just like a stop watch. The passometer is used for counting the no. of steps automatically by some mechanical device. It is advance method of passing or stepping which is measure very long distance.

(c) By speedometer :-

→ This is used in automobile for recording distance.

(d) By perambulator :-

→ It is wheel fitted with a handle. The wheel is graduated & show the distance per revolution. Their is a dial with records the no. of revolution.

(e) By Chaining :-

→ This is an accurate a common method of measuring distance.

- In this method the distance are directly measured in the field by chain or tape.

Electronic distance measurements :-

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

- The electronic distance measurement as made the task of measuring event along distance with a high level accuracy.

Accessories for Linear Measurement :-

(1) Ranging rods
(2) Chains

(1) Ranging rods :- (Process of straight line)

→ The rods which are which used for ranging a line are known as ranging rod.

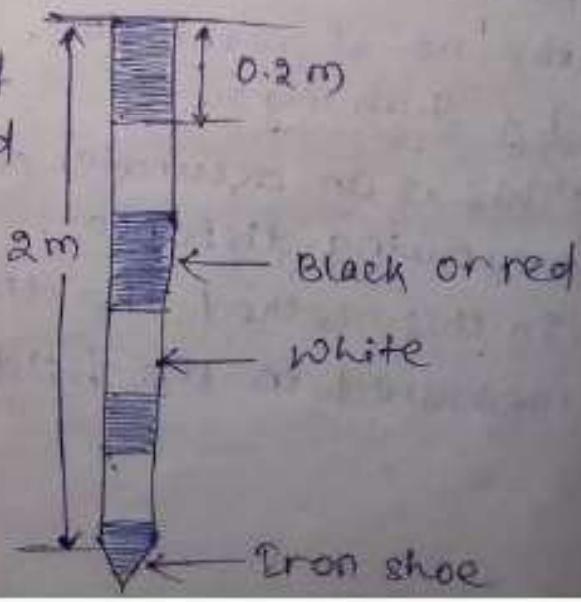
→ Such rods are made of timber or bamboo.

→ Some time GI (Galvanised Iron) pieces of 25 mm diameter are also used as ranging rods.

→ Ranging rod are generally circular in sectio of 25 mm diameter & 2 m length.

→ The rod is devided into equal parts of 20 each & the division are pointed Black or white or red.

→ The lower end of the rod is pointed or provided with an iron shoe.



(a) Chain :- A chain is prepared with 100 or 150 pieces of galvanised mild steel wire of 4mm diameter to form
- The end of the pieces are bend ~~to~~ form loops.
- Then the pieces are connected together with the help of three oval rings which make the chain flexible.
- Two brass handles are provided at the two ends of the chain.
- Tallies are provided at every 10 or 25 links for facility of counting.
- One Link means the distance between the centres of the adjacent middle rings.
- The chain are devided into five parts.

(i) Metric chain
(ii) Steel band
(iii) Engineering chain
(iv) Gunter chain
(v) Revenue chain

(i) Metric chain :-
- The length of this chain is 20 m or 30 m.
- The 20 m chain devided into 100 links each of 0.2 m.
- The 30 m chain is devided into 150 links each of 0.2 m.
- In this chain is suitable for measuring the distance farely level ground.
- Tallies are provided at every 10 links each of 2 m.

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- The tallies are provided at every 25 links &
- This chain is heavy & also suitable for measuring the distance in level ground.

(ii) Steel band :- It consist of a ribbon of steel of 66 mm width & length of 20 m or 30 m.
- It has a brass handle at each end.
- It is graduated in meters, decimeters & centimeters on one side and has 0.2 m links on the other.
- The steel band is used in projects.

(iii) Engineering chain :-
- The engineering chain is 100 feet long & is devided into 100 links. So each links is of 1 feet.
- Tallies are provided at every 10 links (10 fee
It is used for all engineering works.

(iv) Gunters Chain :-
- It is 66 feet long & devided into 100 links, so each links ~~of~~ is of 0.66 feet.
- It was used for measuring distance in miles or furlongs.

(v) Revenue chain :-
- The revenue chain is 33 feet long & devided into 16 links. It is may be used in cadastra surveying.

Advantages of chain :-
- They can be read easily & quickly.
- They can be easily repaired or rectified the field.

- They can with stand wear & pear.

Disadvantages of chain :-

- They become longer or shorter due to continuous used.
- They are very heavy.
- When the measurement is taken, the chain sags excessively.

Advantages of steel Bands :-

- They are very light & easy to open or fold.
- They maintain their standard length given after continuous used.
- When the measurement is taken they sag slightly.

Disadvantages of steel Band :-

- If handled carelessly, they broad easily.
- They cannot be repaire in the field.
- They can not be read easily.

TAPES :-

The following are the different types of tape.

(1) Cloth or Linen tape.
(2) Metalic tape
(3) steel tape
(4) Invar tape

(1) Cloth or Linen tape :-

- It is 15 mm wide & available in length of 10 & 15 m.
- These tape is generally use for measuring offsets & for ordinary works.

- This tape is made of closely woven linen.

(2) Metallic tapes :-

- When linen tape is rein forced with brass or cupper wires to make it durable then it is called a metallic tapes.
- These tape is available in length of 15, 20 & 30 meter.
- It is commonly used for all survey works.

(3) Steel tapes :-

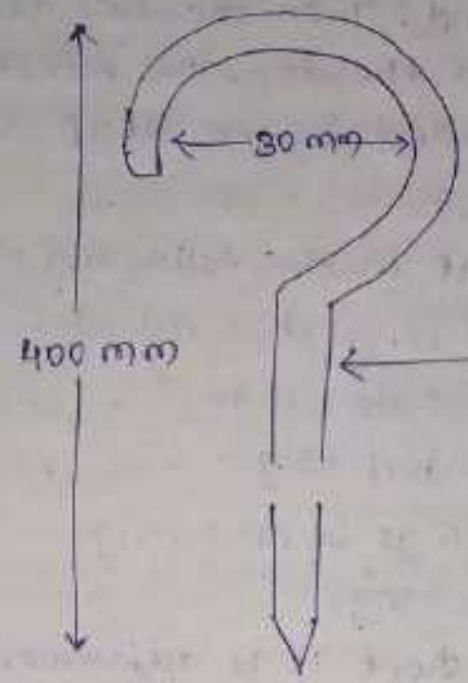
- The steel tape is made up steel ribbon of width varying for 6 to 66 mm.
- The commonly available length are 10, 20, 30 & 50 meter.
- It is measurements in construction works.

(4) Invar tapes :-

- Invar tapes is made of & alloy of steel (64% & Nickel (36%). It is made in the form ribbo of 6 mm width & is available in length of 30, 50 & 100 meters. It is generally used in the triangulation survey.

ARROWS :-

- Arrows are made of steel wire of 4 mm diameter. One end of the arrow is bend into arising of 50 mm. diameter & other en is pointed.
- It's over all length is 400 mm.
- Arrows are used for counting the no. of chains. While measuring a chain lines.



UNFOLDING AND FOLDING OF A CHAIN :-

Unfolding :-

→ To open a chain the strap is untastended and the two brass handles are held in the left hand & the bunch is thrown forward with the right hand. The chain man stands at the standing station by holding one handed & another moves forward by holding the other handle untill the chain is completely extended.

Folding :-

→ To fold the chain a chain should move forward by the chain at the middle. Then the two halves of a chain we come size by size.

- After this commencing from the central position of the chain two pairs of links are taken at a time with the right hand at

placed on the left hand. Then the two brass handles will appear at the top. The bunch should be than tastended by the strap.

Adjustment of chain :-

- Chains are adjustment in the following ways.

(1) When the chain is too Long it is adjustment by
(a) Closing of the joints of the rings
(b) Hammering the elongated rings.
(c) Replacing some old rings by new rings.
(d) Removing some of the ring.

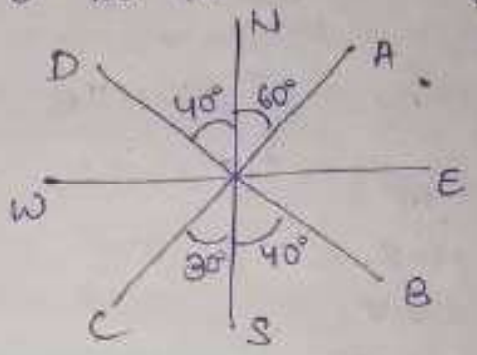
(2) When the chain is too short it is adjustment by-
(a) Straightening the bend rings.
(b) Opening the joints of the rings.
(c) Replacing the old rings by some larger rings.
(d) Inserting new rings where necessary.

TESTING A CHAIN :-

- Due to continuous use, a chain may be elongated or shortened.
- So the chain should be tested & adjusted accordingly.
- If full adjustment is not possible then the amount of shortening (known as too short) & elongation (known as too long) should be noted clearly for necessary correction applicable to the chain.
- For testing the chain, a test gauge is establish on a level platform.

Reduced Bearing :-

- In this system the bearing is measure clock wise or ~~conter~~ anti clock wise from the north or south toward the east or west.
- Here four quardrants are consider and are denoted as 'NE', 'NW', 'SE', 'SW'.
- The values of reduced bearing may lie between 0° to 90°.

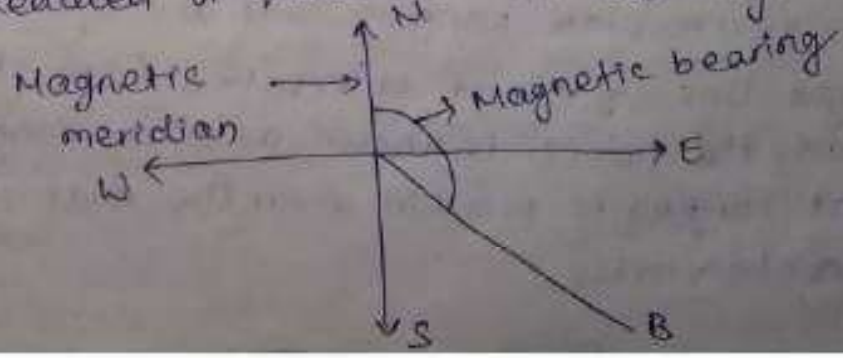


RB of OA = N 60° E
OB = S 40° E
OC = S 30° W
OD = N 40° W

~~Methods of chaining~~ :-

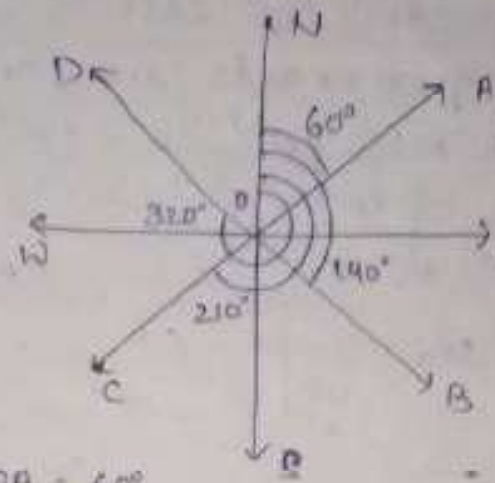
Conception of Magnetic bearing :-

- When a magnetic needle is suspended freely it will show a direction which is known as the magnetic meridian.
- The angle that a line makes with magnetic meridian is known as the magnetic bearing of the line.
- Magnetic bearing is impressed as
  (i) Whole circle bearing
  (ii) Reduced or quadrilateral bearing.



(i) whole circular bearing :-

- In this system the magnetic bearing of a line is measured clockwise from the north point upto the line.



WCB of OA = 60°

OB = 140°

OC = 210°

OD = 320°

Ranging :- The ~~t~~ process of establishing intermediate points on a straight line between two end points is known as ranging.

- Ranging must done before a survey line is chained
- Ranging may be done by direct observation by the naked eye obey line ranger or by theodolite.
- Ranging may be two types.

(i) Direct ranging

(ii) Indirect / reciprocal ranging.

(i) Direct ranging :-

- When intermediate ranging rods are fixed on the straight line by direct observation from end station, the process is known as direct ranging.
- Direct ranging is possible when the ends station are intervisible.

- The following procedure is adopted for direct ranging.

(a) Suppose 'A' & 'B' are two ends station of a chain line where two ranging rods are already fixed.

(b) Suppose it is required to fixed a ranging rod at the intermediated point 'P' on the chain line in such a way that the point 'A', 'P', 'B' are in the same straight line.

(c) The survivours stand about 2m behind the ranging rod at 'A' by looking towards line 'A', 'B',

(d) The assistant holds a ranging rods at 'P' vertically at comprtes length.

(e) The rod should be held lightly by the thumb & four finger.

(f) Now the survivour directs the distante to more the ranging rods to the wei
the three ranging rod come exactly in the same straight line.

(g) To check the non-verticality of the rods the survivour bends down & looks through the bottom of the rods.

(h) The ranging will be perfect when the three ranging rods coincides & appear a single rod.

(i) When the survivour is satisfied that the ranging is perfect the signal the assistant to fixed the ranging rod on the ground by a u both his by up & down.

(Direct ranging)

(ii) Indirect / Reciprocal Ranging :-

- When the ends station are not intervisible due to this being high ground between them, intermediated ranging rods fixed on the line in an indirect way. These method is known as indirect / reciprocal ranging.
- The following procedure is adopted for indirect ranging.

(a) Suppose 'A' & 'B' are two ends station which are not intervisible due to high ground between them

(b) Suppose it is required to fix intermediate points between 'A' & 'B'. Two chain man take up position at R_1 & S_1 with ranging rods in their hands.

(c) The chain man at R_1 stands with his face towards 'B' & that he can see the ranging rods at S_1 & B. Then the chain man proceed to range the line by directing each other alternately

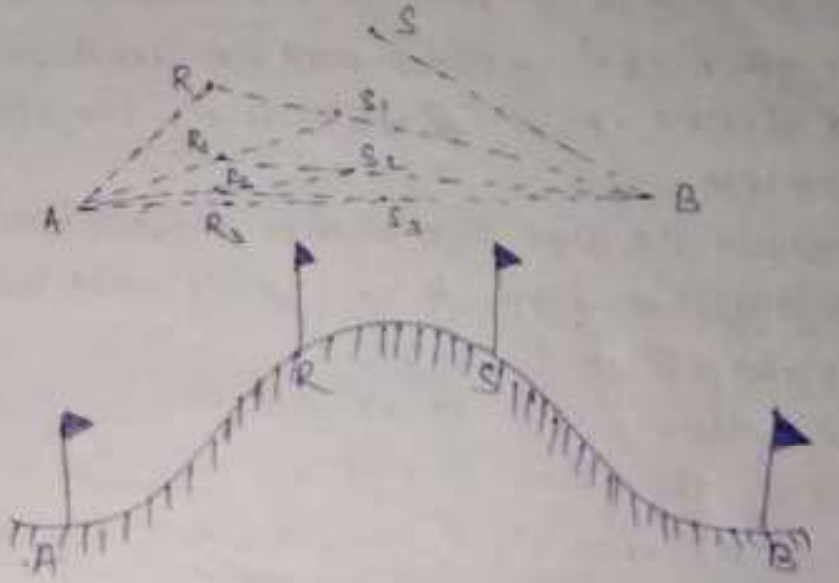
(d) Again the chainman at S_1 stands with his face towards 'A' so that he can see the ranging rods at R_1 & A.

(e) The chain man & R_1 directs the chain man at S_1 to come to the position S_2, so that R_1, S_2 & B are in the same straight line.

(f) Again the chain man at S_2 directs the chainman at R_1 to more the position at R_2, so that S_2, R_2 & 'A' are in the same straight line.

(g) By directing each other alternately in this manner, they change its positions every time until they finally come to the position R & S_1

which are in the straight line AB. These means the points A, R, S & B are in same straight line



Leader & Followers :-

Leader :- The chain man at the forwarded of the chain who drage the chain forwarded is known as the leader. The duties of the leader are as follows.

(a) To drag the chain forward with the arrows & ranging rods.
(b) To fix arrows on the ground at the end of each chain.
(c) To obey the instrument of the follower.

Follower :- The chainman at the near end of the chain, who holds the zero end of the chain at the station is known as followers. The duties of the followers are as follows.

(a) To direct the leader at the time of ranging
(b) To carry the read handle of the chain
(c) To pickup the arrows inserted by the leader.

Methods of chaining on ground level:-

(i) Before starting the chaining operation two ranging rods should be fixed on the chain line at the end station.

(ii) The other ranging rod should be fixed near the end of each chain length during the ranging operation.

(iii) To chain the line, the leader moves forward by dragging the chain & by taking with him a ranging rod & 10 arrows.

(iv) The follower stands at the starting station by holding the other end of the chain.

(v) When the chain is fully extended the leader holds the ranging rod vertically.

(vi) The follower directs the leader to move his rod to the left or right until the ranging rod is exactly in line.

(vii) Then the follower holds the end of the chain by touching the station peg.

(viii) The leader stretches the chain by moving it up & down with both hands & finally place it on the line.

(ix) He then inserts an arrow on the ground at the end of the chain & marks with a cross (x).

(x) Again the leader moves forwards by dragging the chain with a aerrows & the ranging rods At the end of the chain he fix another as before.

(xi) As the leader moves further the follower picks up the arrows which inserted by the leader

(xii) In this way chaining is continued.

(xiii) When all the arrows have been inserted & the leader has none left with him, the follower hands them over to the leader, this should be noted by the surveyor.

Methods of chaining in slopping ground :-

- Horizontal distance are required in surveying. So in chaining along a slopping ground, the horizontal distance between two stations are measured carefully by applying some methods.
- The methods are

(i) Direct methods or stepping methods

(ii) Indirect methods

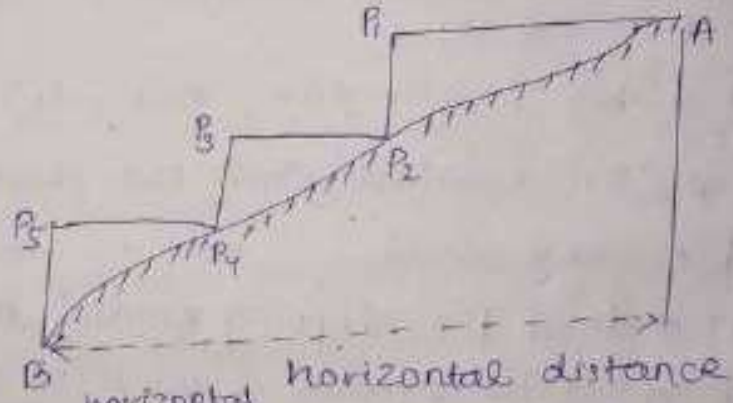
(i) Direct methods or stepping methods :-

- This method is applied when the slope of the ground is very slope.
- In this method the slopping ground is divided into a no. of horizontal & vertical strips like steps. So this method is also known as stepping method.
- The lengths of horizontal portions are measured & added to get the total horizontal distance between the point.

Procedure :-

- Suppose the horizontal distance between points 'A' & 'B'
- The line AB is first ranged properly.
- Then the follower holds the zero end of the tape at at A.

- The leader select a suitable length AD so that D_1 is at the chest height & AD is just horizontal
- The horizontally is maintained by eye estimation
- 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 & holds the zero end of the tape at that point
- Again the leader selects a suitable length P_2P_3 is such a way that P_2P_3 is horizontal distance & P_3P_4 vertical.
- Then the horizontal lengths P_2P_3 & P_4P_5 are measur



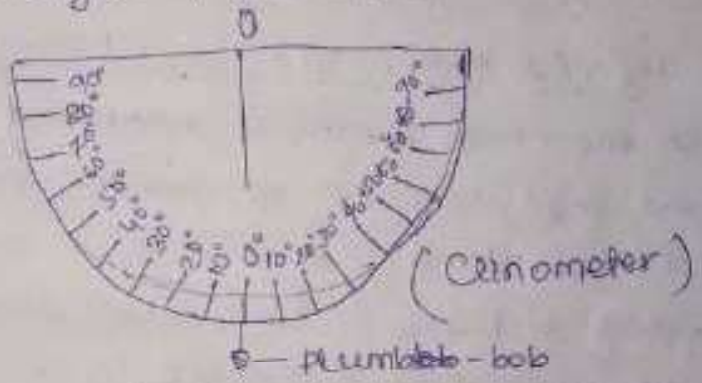
The total length AB = $AP_1 + P_2P_3 + P_4P_5$

(ii) Indirect method :-

- When the slope of the ground surface is long & gentle, the stepping method is not suitable. In such a case the horizontal distance may be obtained by the following process.
- By measuring the slope with a clinometer.
- By applying high potential allowance.
- By knowing the different of level between the points.

Measuring the slope with a clinometer :-

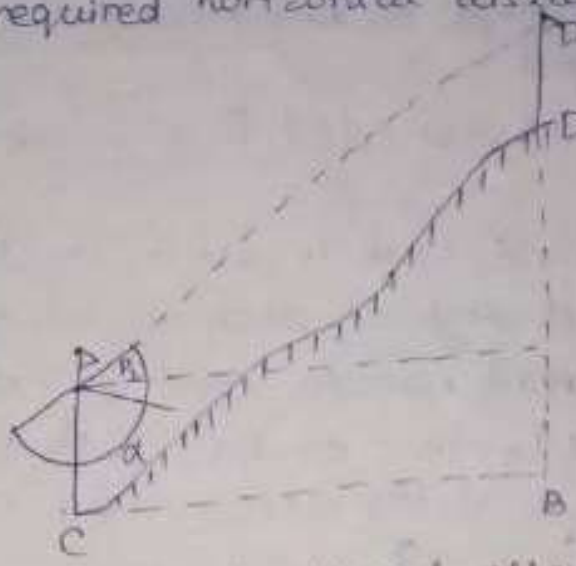
- A clinometer is a graduated semi-circular protactor. It consist of two pins (P_1 & P_2) for sighting the object.
- A plumb-bob is suspended from point 'O' with a thread.
- When the straight edge is just horizontal the thread passes through 0°. When the straight edge is tilted the thread remains vertical but passes through a graduation on the earth which shows the angle of the slope.



Measurement of slope & slopping distance :-

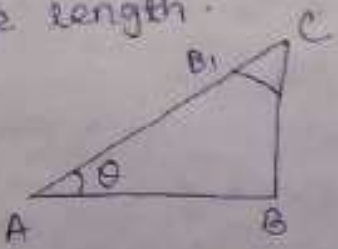
- Suppose 'C' & 'D' are two points on the slopping ground. Two ranging rods are fixed at these point
- Then two other point 'C' & 'D' are mark on the ranging rods so that $CC_1 = DD_1$.
- The clinometer is placed in such a way that its centre just touches the mark C_1.
- The clinometer is then inclined until the points 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 slopping distance CD is also measured. Let it will be L
- The required horizontal distance CB = L cos α



By applying ~~hag~~hypotential allowance :-

- When one chain length is measured of slopping ground than it shows as shorter distance on the horizontal plane. The difference between the slopping distance & horizontal distance is known as ~~hag~~hypotential allowance.
- In this method the slope of the ground is first found out by using the clinometer.
- Hypotential allowance is then made for each tape length.



θ = Angle of slope

$AB = AB_1 = 20\,M = 100$ links

$B_1C = AC - AB_1$

$AC = AB \sec\theta$ $\quad \frac{ABC}{AB}, \sec\theta$

$AC = 100 \sec\theta$

$B_1C = AC - AB_1 = 100 \sec\theta - 100$

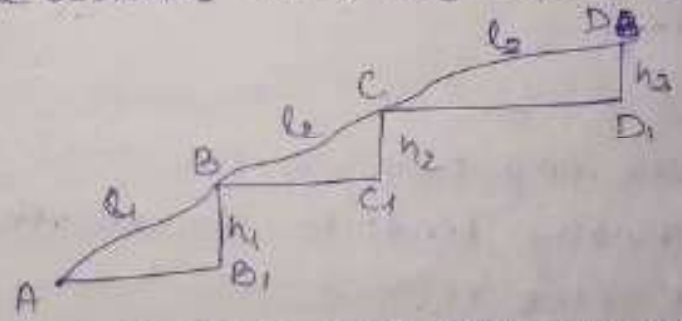
$= \boxed{B_1C = 100(\sec\theta - 1)}$

- The amount $100(\sec\theta - 1)$ is said to be the hypotential allowance

- While chaining along the slope, one chain would be located at B_1, but the arrow should be placed at C. After making hypotential allowance allowance. The next chain length will start from C. The same principle is followed until the end of the line is reached.

By knowing the difference of level :-

- Suppose A, B, C & D are different points on sloping ground.
- The difference of level between these points is determined by a levelling instruments.
- Let the reactive differences be h_1, h_2 & h_3. Then the slopping distance AB, BC, CD are measured. Let the distance L_1, L_2 & L_3 respectively.



The required horizontal distance are :-

$AB_1 = \sqrt{l_1^2 - h_1^2}$

$BC_1 = \sqrt{l_2^2 - h_2^2}$

$CD_1 = \sqrt{l_3^2 - h_3^2}$

Total horizontal distance = $AB_1 + BC_1 + CD_1$

Errors & Mistake of chaining :-

- Errors in chaining may be caused due to variation in temperature & bull, defects in instruments etc
- In chaining the error is two types
  (1) Compensating Error
  (2) Comulative Error.

(1) Compensating error :- Error which may occurs in both directions positive, negative & which finally stands to compensate are known as compensating error.

- These errors donot effect survey work.
- They are proportional to $\sqrt{L}$ where 'L' is the length of the line.
- Such errors may be caused due to

→ Incorrect holding of the chain :-

- Horizontally & vertically of steps not being properly maintained during the stepping operation
- Fractional parts of the chain or tape not ____ through out its length.
- In accurate measurement of right angles with chain & tape.

(2) Comulative error :-

- Error which may occur in the same direction & which finally tends to accumulate are said to be comulative error.
- They effect the accuracy of the work they are proportional to the length of the line 'L'.
- The error may be positive or negative.

(a) Positive error :-

- When the measure length is more than the actual length the error is said to be +ve.

Such errors occur due to

(i) The length of chain of tape being be shorter length of standard length.

(ii) Slope correction not be applied.

(iii) Correction for sag not being made.
(iv) Measurement being taken in high winds with the tapes in suspension.
(v) Measurement being taken with faulty alignment
(b) Negative errors :- When the measured length of the line is less than the actual length the error is said to be Negative.
- Such errors are occur due to
(i) The opening of ring joints.
(ii) Elongation of the links due to heavy pull.
(iii) The temperature during measurement being must higher than the standard temperature.
(iv) The applied pull being much greater than the standard pull.

Mistakes :- Errors occuring due to the carelessness of the chainman are called mistakes
- The following are few common mistakes.
(i) Displacement of arrows one ends arrows is with drawn from the ground during chaining, it may not be replaced in proper position. If required due to some reason.
(ii) A pull chain length may omitted or added. This happens when arrow are lost or wrongly counted.
(iii) A reading may be taken from the wrong end of the chain. This happens when the tooth of the tally is rotate without observing the central tally.
(iv) The numbers may be read from the wrong direction, for instance six may be read as nine

Scanned with CamScanner

(v) Some numbers may be called wrongly.
(vi) While making entries in the field book the figures may be inter change due to carelessness.

(1) Chain & Tape correction :-

(A) CHAIN CORRECTION :-

i) Correction applied to incorrect length.

True length (TL) of the line = $\left[\frac{L'}{L} \times ML\right]$

where, ML = Measured length
L = True length of the chain/tape
L' = True length ± error
= L ± e (e = Error in chain / tape)

Here the +ve sign will be use when the chain or tape is too long & the -ve sign will be use if the chain or tape is too short.

(2) Correction of incorrect area :-

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

(3) Hypotential allowance :-

Hypotential allowance for tape = $L(\sec\theta - 1)$

where, L = Length of tape
θ = slope of the ground

Q. The distance between two point measured with a 20 m chain was recorded as 327 m. It was afterwards found that the chain was 3 cm too long. What was the true distance between the points.

L = 20 m e = +3 cm = 0.03 m
ML = 327 m

$L' = L + e = 20 + 0.03 = 20.03$ m.

$TL = \frac{L'}{L} \times ML = \frac{20.03}{20} \times 327 = 327.49$ m

Q. The distance between two points measured with a 30 m chain was recorded as 540 m. It was afterwards found that the chain was 5 cm too short. What was the true distance between the points.

$L = 30$ m

$ML = 540$

$e = -5$ cm $= 0.05$ m

$L' = L - e = 30 - 0.05 = 29.95$

$TL = \frac{L'}{L} \times ML = \frac{29.95}{30} \times 540 = 539.1$ m

Q. The distance between two station was 1200 m. When measured with a 20 m chain. The same distance when measured with a 30 m chain was found to be 1195 m. If the 20 m chain was 0.05 m too long, what was the error in the 30 m chain.

Given Let us consider 20 m chain

$L = 20$ m $\quad L' = L + e = 20 + 0.05 = 20.05$ m

$ML = 1200$ m

$e = 0.05$ m

$TL = \frac{L'}{L} \times ML = \frac{20.05}{20} \times 1200 = 1203$ m.

True length of the line = 1203 m

(Obtained from 20 m chain)

In 30 m chain measured length (ML) = 1195 m

From the relation $TL = \frac{L'}{L} \times ML$

$1203 = \frac{L'}{30} \times 1195 \Rightarrow L' = \frac{1203 \times 30}{1195}$

$L' = 30.20$

$L' = L + e \Rightarrow e = L' - L$

$= 30.20 - 30 = 0.20$ m

(B) Tape correction :-

(1) Temperature correction :- This correction is necessary because the length of the tape or chain may increased or decreased due to rise of fall of temperature during measurement.

Correction is $\boxed{C_t = \alpha (T_m - T_0) L}$

Where, C_t = Correction for temperature in meters

α = Coefficient of thermal expansion.

T_m = Temp during measurement in degree C.

T_0 = Temp at which the tape was standardise in degree centigrade.

L = Length of tape in meters.

- The sign of correction may be +ve or -ve according as T_{mean} is greater or less then T_0.
- When α for the steel tape is not given it may be assume to 11×10^{-6} per °C or celcius.

(2) Pull correction (C_p) :- During measurement the applied pull may be either more or less then the pull at which the chain or tape was standardise.

Correction is $\boxed{C_p = \frac{(P_m - P_0)}{A \times E} \times L}$

Where,

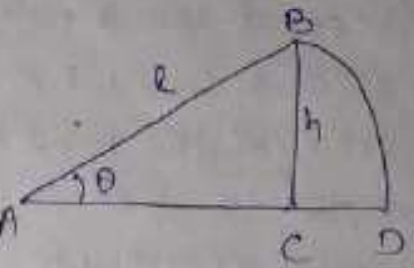
C_p = Pull correction in meters

P_m = Pull applied during measurement in Kg

P_0 = Pull at which the tape was standardise

L = Length of tape
A = Cross-sectional area of tape
M = Modulus of elasticity
When E is not given it may be assume 2.1×10^6 Kg/cm²

(3) Slope Correction :-



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

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

$= \frac{h^2}{2l}$ (This correction always negative)

(4) Sag Correction :- This correction is necessary when the measurement is taken with the tape is suspension. It is given by the expression

$C_s = \frac{l (WL)^2}{24 n^2 p^2 m}$ (when unit weight is given)

& $C_s = \frac{L w^2}{24 n^2 p^2 m}$ when total weight is given

Where C_s = Sag correction in meter
L = Length of chain or tape in meters
w = weight of tape per unit length
W = Total weight of tape
n = no. of span
P_m = Pull applied during measurement
- The sign of correction is always -ve.

(5) Normal tension :- The tension at which the effect of pull is neutralised by the effect of sag is known as normal tension.

$\frac{P_n - P_0}{AE} = \frac{W^2}{24 P_n^3}$

$\Rightarrow \boxed{(P_n - P_0) P^2 n = \frac{W^2 AE}{24}}$ $\boxed{n = 1}$

P_n = Normal pull or tension

Q. A steel tape was exactly 30 m long at 20°c when supported through out its length under a pull of 10 kg. a line was measured with the tape under a pull of 15 kg & at a mean temp of 32°c & found to be 780 m long. The cross sectional area of the tape is 0.03 cm^2 & its total weight equal to 0.693 kg. α for steel equal 11×10^{-6} per degree centigrade & E for steel equal to 2.4×10^6 kg/cm^2. Compute the true length of the line. If the tape was supported during measurement

(i) At every 30 m (n=1)

(ii) At every 15 m (n=2)

Given data when supported at every 30 m.

(i) $L = 30$ m, $A = 0.03\ cm^2$

$T_0 = 20°C$, $\alpha = 11 \times 10^{-6}$ per °C

$P_0 = 10$ kg, $E = 2.1 \times 10^6\ kg/cm^2$

$P_m = 15$ kg, $W = 0.693$ kg

$T_m = 32°C$, $ML = 780$ m

$C_t = \alpha (T_m - T_0) l$

$C_t = 11 \times 10^{-6} \times (32 - 20) \times 30$

$= 3.96 \times 10^{-3}$ m $= 0.00396$

(ii) At every 15 m $= 11 \times 10^{-6} (32 - 30) \times 15$

$= 2.33 \times 10^{-3}$ m $= 0.00267$ m

$$C_s = \frac{L (WL)^2}{24 n^2 p^2 m} = \frac{30 \times (0.693 \times 30)^2}{24 \times 1^2 \times 15^2}$$

$\Rightarrow C_s = 266.$

Total correction = 0.00396 + 0.00238 - 0.00267
= 0.00367 m (+ve)

e = 0.00367 m too long

$L' = L + e = 30 + 0.00367 = 30.00367$ m

$TL = \frac{L'}{L} \times ML = \frac{30.00367}{30} \times 780$

$= 780.094$ M

When supported at very 15 m (n = 2)

$C_t = \alpha (T_m - T_0) l$

$C_t = 11 \times 10^{-6} (32 - 20) \times 15$

$= 3.3 \times 10^{-4}$ m = 0.0033 m)

$C_p = \frac{P_m - P_0}{A \times E} \times L$

$C_p = \frac{15 - 10}{0.03 \times 2.1 \times 10^6} \times 15$

$= 1.19 \times 10^{-3} = 0.00119$ m

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

$= \frac{15 \times (0.693)^2}{24 \times 2^2 \times 15^2} = 3.33 \times 10^{-4} = 0.00033$ m)

Total correction) = 0.0033 + 0.00119 - 0.00033

$= 1.16 \times 10^{-3} = 0.00116$ m (+ve)

e = 0.00116 m too long

$L' = L + e = 15 + 0.00116 = 15.00116$ m

$TL = \frac{L'}{L} \times ML = \frac{15.00116}{15} \times 780$

$= 780.060$ m)

Obstacles in chaining :-

- A chain line may be interrupted in the following situation.

(i) When chaining is free, but visioned is obstructed.
(ii) When chaining is obstructed but visioned is free.
(iii) When chaining & visioned both are obstructed.

(i) When chaining is free but visioned is obstructed :-

- Such a problem arises when a rising round or a jungle area interrupted chain like
- Here the end stations are not visible
- There may be two cases

Case-I

- The end station may be visible from some intermediated point all the rising ground.
- In this case reciprocal ranging is resourced & chaining is done by the stepping method.

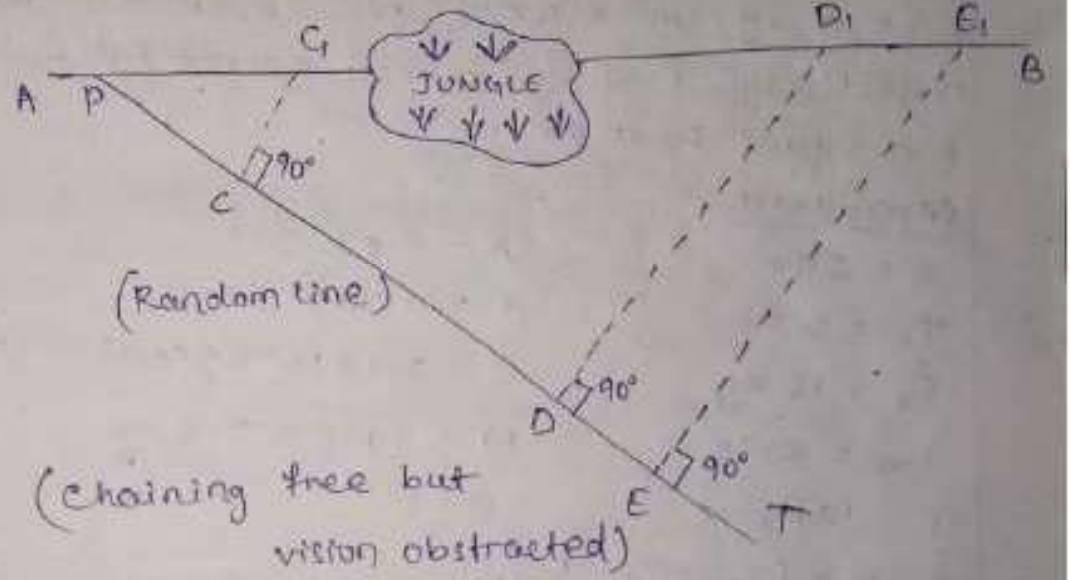
Case-II

- The end station are not visible from intermediate points when a jungle area comes across the chain line. In this case the obstacle may be crossed over using a random line, explain below.

Procedure :-

- Let AB be the actual chain line which can't be ranged & extended because of interruption by a jungle.
- Let the chain line extended upto 'R'. A point 'P' is selected in ~~the~~ the chain line & a random line PT is taken ~~at~~ on a suitable dimension.

- Points C, D & E are selected on the random line & perpendiculars are projected from them. The perpendicular at C meets the chain line at C_1.
- The perpendicular at D & E will meet the chain line at D_1 & E_1. Now the distance PC, PD, PE & CC_1 are measured.



- From triangle PDD_1, PCC_1

$$\frac{DD_1}{PD} = \frac{CC_1}{PC}$$

$$DD_1 = \frac{CC_1}{PC} \times PD \quad \text{——(1)}$$

Again from triangle PEE_1 & PCC_1

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

From the above equation DD_1 & EE_1 are calculate these calculated distance are measured along the perpendicular the D & E.

- Point D_1 & E_1 should lie on the chain line AB which can be extended accordingly.

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

Q. A 20 m steel tape was standardise on flat ground At temp of 20°C & under pull of 15 kg the tape was used in a temp of 30°C & under a pull of P kg. The crosi sectional area of the tape is 0.22 cm^2 & its total weight is 400 g. the — & coefficient of linear expansion of steel are 2.1×10^6 kg/cm^2 & 11×10^{-6} per degree centigrade respectively. Find the correct horizontal distance P is equal to 10 kg.

Given data :-

$L = 20$ m
$T_0 = 20°C$
$P_0 = 15$ kg
$T_m = 30°C$
$P = 10$ kg
$A = 0.02$ cm^2
$\alpha = 11 \times 10^{-6}$ per °C
$E = 2.1 \times 10^6$ kg/cm^2
$w = 400g = 0.4$ kg
$n = 1$

$C_t = \alpha (T_m - T_0) L$

$C_t = 11 \times 10^{-6} (30 - 20) \times 20 = 2.2 \times 10^{-3} = 0.0022$ m

$C_p = \frac{(P_m - P_0)}{A \times E} \times L$

$C_p = \frac{P_m - 15}{0.02 \times 2.1 \times 10^6} \times 20$

$= \frac{10 - 15}{0.02 \times 2.1 \times 10^6} \times 20$

$= -2.380 \times 10^{-3} = -0.00238$ m

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

$C_s = \frac{20 \times (0.4)^2}{24 \times 1^2 \times 10^2} = 1.33 \times 10^{-3} = 0.00133$ m

Total correction $0.0022 - 0.00238 - 0.00133$

$= -1.5 \times 10^{-3} = 0.00151$ m

Correctional horizontal distance

$\Rightarrow 20 - 0.00157 = 19.9984$ m

Q. A 30 m steel tape was standardise at a temp of 20°C & under a pull of 5 kg. The tape was used in a temp at 25°C & under a pull of P kg. The cross-sectional area of the tape is 0.02 cm². Its weight for unit length is 22 gm specific 2×10^6 Kg/cm² $\alpha = 11 \times 10^{-6}$ per °C. Find the correct horizontal distance if P is equal to 5 kg & 11 kg.

Given data :-

$L = 30$ m, $T_0 = 20°C$

$P_0 = 5$ kg, $w = 22$ g/m, $22 \text{ gm} \times 30 \text{ m} = 660 \text{ g} = \frac{660}{1000} = 0.66$ kg

$T_m = 25°C$

$P = 5$ kg & 11 kg

$n = 1$ $A = 0.02$ cm²

$E = 2 \times 10^6$ kg/cm²

$\alpha = 11 \times 10^{-6}$ per °C.

(i) $C_t = \alpha (T_m - T_0) \times L$

$= 11 \times 10^{-6} (25 - 20) \times 30 = 1.65 \times 10^{-3} = 0.00165$ m

(ii) $C_p = \frac{P_m - P_0}{A \times E} \times L = \frac{5 - 5}{0.02 \times 2 \times 10^6} \times 30 = 0$

(iii) $C_s = \frac{L w^2}{24 n^2 P_m^2} = \frac{30 \times (0.66)^2}{24 \times 1 \times 5^2} = 0.02178$ m

Total correction

$0.00105 + 0 - 0.02178 = -0.02013$

Correct horizontal distance

$\Rightarrow 30 - 0.02013 = 29.97$ m

At P = 11 kg

(i) $C_t = \alpha (T_m - T_0) \times L$

$= 11 \times 10^{-6} (25 - 20) \times 30 = 1.65 \times 10^{-3} = 0.00165$ m

(ii) $C_p = \frac{P_m - P_o}{A \times E} \times L = \frac{11-5}{0.02 \times 2 \times 10^6} \times 30$

$= 4.5 \times 10^{-3} = 0.0045$ m

(iii) $C_s = \frac{L w^2}{24 n^2 P_m^2} = \frac{30 \times (0.66)^2}{24 \times 1 \times 11^2}$

$= 4.5 \times 10^{-3} = 0.0045$ m

Total correction

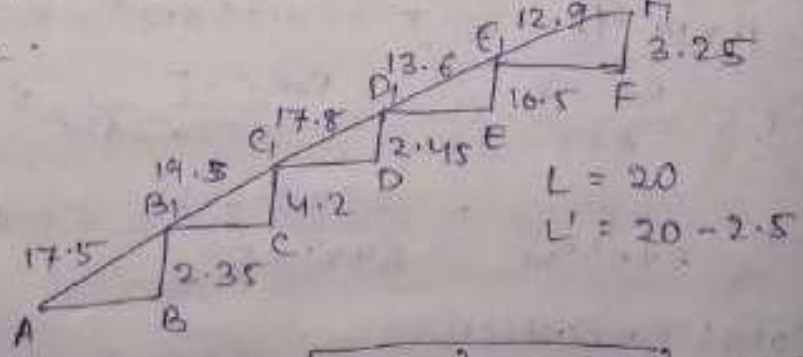
$0.00165 + 0.0045 - 0.0045 = 1.65 \times 10^{-3}$

$= 0.00165$ m

Correct horizontal distance

$\Rightarrow 30 - 0.00165 = 29.99$ m

(3) The following slope distance where measured along a chain line with a 20 m steel tape. Slope distance = 17.5 m, 19.3 m, 17.8 m, 13.6 m & 12.9 m. Difference of elevation between ends equal to 2.35 m, 4.2 m, 2.95 m, 1.65 m, 3.25 m. It was noted afterwards that the tape was 2.5 cm too short. Find the true horizontal distance.



$AB = \sqrt{AB_1^2 - BB_1^2} = \sqrt{(17.5)^2 - (2.35)^2} = 17.34$ m

$B_1C = \sqrt{B_1C_1^2 - CC_1^2} = \sqrt{(19.3)^2 - (4.2)^2} = 18.83$ m

$C_1D = \sqrt{C_1D_1^2 - DD_1^2} = \sqrt{(17.8)^2 - (2.95)^2} = 17.55$ m

$D_1E = \sqrt{D_1E_1^2 - EE_1^2} = \sqrt{(13.6)^2 - (1.65)^2} = 13.49$ m

$E_1F = \sqrt{E_1F_1^2 - FF_1^2} = \sqrt{(12.9)^2 - (3.25)^2} = 12.48$ m

Total Length = AB + B,C + C,D + D,E + E,F

= 17.34 + 18.83 + 17.55 + 13.49 + 12.48

= 79.69 m

L' = L - e , e = 2.5 cm = 0.025 m

= 20 - 0.025 m = 19.975 m

$TL = \frac{L'}{L} \times ML$

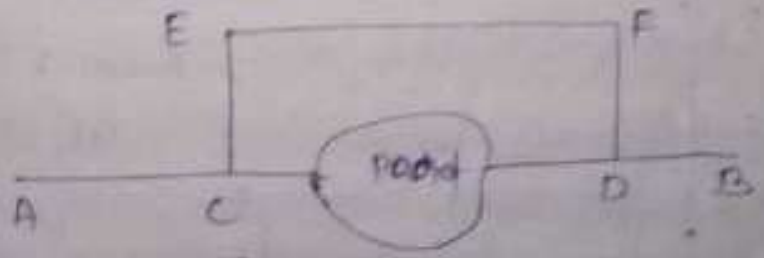
$\Rightarrow TL = \frac{19.975}{20} \times 79.69 = 79.59$ m

2) Chaining obstructed but vision free :-

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

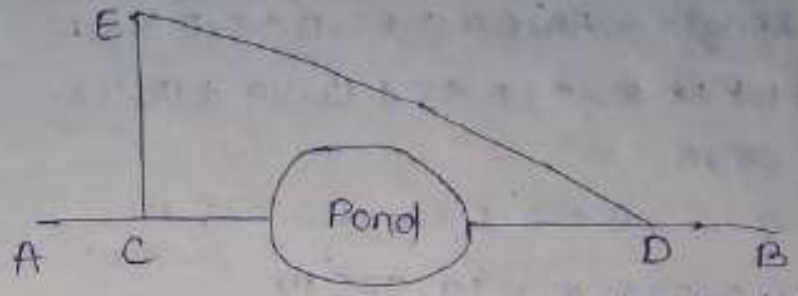
Case - I

- When a pond intercepts the chain line, it is possible to go around the obstructed.
- Suppose A,B is the chain line. Two points C & D are selected on it on opposite banks of the pond. equal perpendicular CE & DF are erected at C & D. The distance EF is measured.



(a) CD = EF

- The pond may also be trussed by a triangle as soon in figure. A point C is selected on the chain line. The perpendicular CE is set out at C, and a line ED is suitably taken. The distance CE & ED are measure.

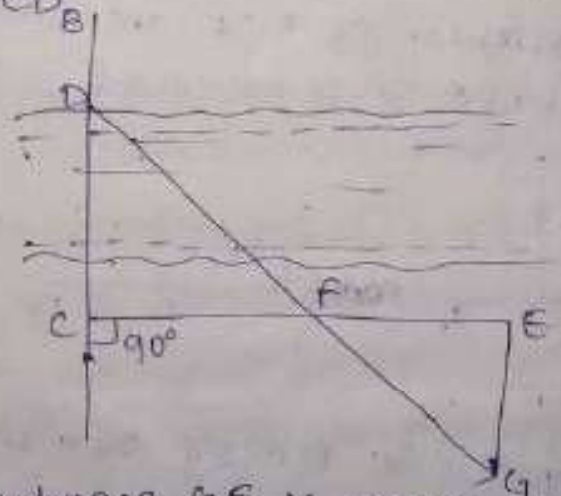


$CD = \sqrt{ED^2 - CE^2}$ (Chaining obstracted but visioned free) - (Pond)

Case - II

- Imagine a small river comes across the chain line. Suppose AB is the chain line. Two points C & D are selected this line on opposite banks of the river. At C perpendicular CE is erected & bisected at 'F'. A perpendicular is set out at 'E' & a point 'G' is so selected on it that 'D' F & G are in the same straight line.
- For triangle $\triangle DCF$ & GEF

$GE = CD$



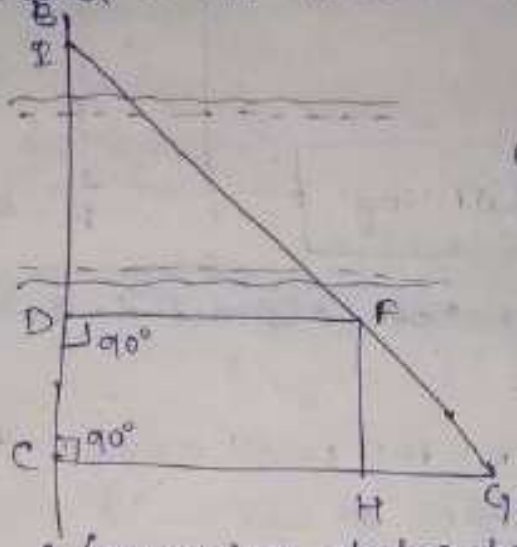
From $\triangle DCF$ & GE

$GE = CD$

- The distance GE is measured & thus the distance CD is obtained indirectly.
- Consider the case when a large river intersect the chain line.
- Let AB be the chain line D & E are selected on this line such that D & E are on opposite

banks of the river.

- The perpendicular DF & CG are erected on the chain line in such a way that E, F & G are on the same straight line. The line 'FH' is taken parallel to CD. Now from triangle DEF & HFD.



$$\frac{ED}{DF} = \frac{FH}{HG}$$

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

$$= \frac{FH}{CG - CH} \times DF$$

$$= \frac{FH}{CG - DF} \times DF$$

Where FH = CD

CH = DF

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

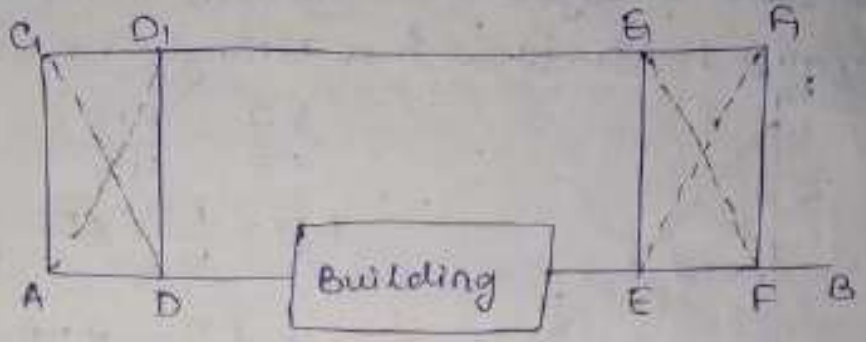
(3) Chaining & vision both obstructed :-

- Suppose AB is the chain line. Two points C & D are selected on it at one side of the building. Equal perpendicular $C C_1$ & $D D_1$ are erected. The line $C_1 D_1$ is extended until the building is crossed on the extended line Two points C_1 & F_1 are selected.
- The perpendicular E_1E & F_1F are erected so that $E_1E = F_1F = D_1D = C_1C$

Thus the points C_1, D_1, E & F will on the same straight line AB.

Here $DE = D_1E_1$

The distance D_1E_1 is measure & is equal to the required distance DE.



(Chaining & vision both obstructed - Building)

$DE = D_1E_1$

Q. The distance between two point measured with 20 m chain, was recorded as 327 m. It was afterwards found that the chain was 3 cm too long. What are the true distance between the point

Given :-

$L = 20$ m $e = 3$ cm $= 0.03$ m

$ML = 327$ m

$L' = L + e = 20 + 0.03 = 20.03$ m

$TL = \frac{L'}{L} \times ML = \frac{20.03}{20} \times 327 = 327.49$ m

Q. The distance between two points measured with a 30 m chain was recorded as 456 m. It was afterwards found that the chain was 5 cm too short what was the true distance between the point.

Given :

$L = 30$ m $ML = 456$ m

$e = 5$ cm $= 0.05$ m

$L' = L - e = 30 - 0.05 = 29.95$ m

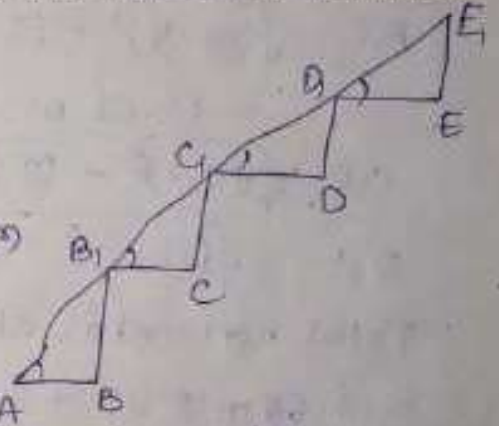
$TL = \frac{L'}{L} \times ML = \frac{29.95}{30} \times 456 = 455.24$ m

Q. The following slope distance were measured along a chain line with a 30 m chain.

Slope distance	Angle of slope
28.7 m	5°
23.4 m	7°
20.9 m	10°
29.6 m	12°

- It was noted afterwards that the chain was 0.025 m too short. Find the true horizontal distance.

Given $L = 30$ m



$AB = AB_1 \cos\theta$

$= 28.7 \cos 5° = 28.59$ m

$BC = B_1C_1 \cos\theta$

$= 23.4 \cos 7° = 23.22$ m

$C_1D = C_1D_1 \cos\theta = 20.9 \cos 10 = 20.58$ m

$D_1E = D_1E_1 \cos\theta = 29.6 \cos 12 = 28.95$ m

Total horizontal distance $= AB + B_1C + C_1D + D_1E$

$= 28.59 + 23.22 + 20.58 + 28.95 = 101.34$ m

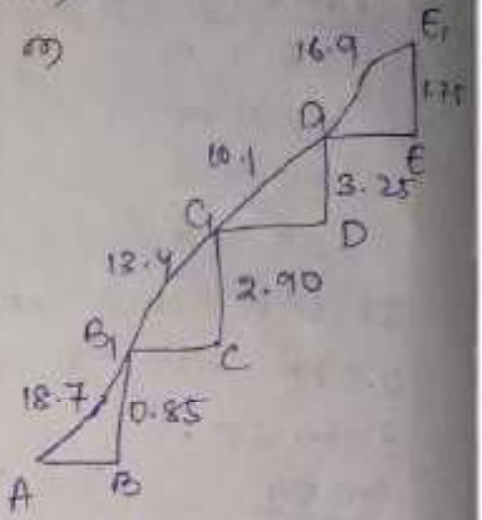
$ML = 101.34$ m

$L' = L - e = 30 - 0.025 = 29.975$ m

$TL = \frac{L'}{L} \times ML = \frac{29.975}{30} \times 101.34 = 101.25$ m

Q. The following slope distance were measured along along a chain lying with a 20 m steel tape. It was noted afterwards that the tape was 2.5 cm too long. Find the true total horizontal distance

Slope distance	Difference in elevation between ends of tape
18.7 m	0.85 m
13.4 m	2.90 m
10.1 m	3.25 m
16.9 m	1.75 m



Given

$AB = \sqrt{A_1B_1^2 - BB_1^2}$

$AB_0 = \sqrt{(18.7)^2 - (0.85)^2}$

$= 18.68$ m

$B_1C = \sqrt{(13.4)^2 - (2.90)^2}$

$= 13.08$ m

$C_1D = \sqrt{(10.1)^2 - (3.25)^2} = 9.562$ m

$D_1E = \sqrt{(16.9)^2 - (1.75)^2} = 16.80$ m

Total horizontal distance $= AB_1 + B_1C + C_1D + D_1E$

$= 18.68 + 13.08 + 9.56 + 16.80 = 58.12$ m

$L = 20$ m. $e = 2.5$ cm $= 0.025$ m

$L' = L + e = 20 + 0.025 = 20.025$ m

$TL = \frac{L'}{L} \times ML = \frac{20.025}{20} \times 58.12 = 58.19$ m

Q The distance between two points A & B measure along a slope was 280 m. Determine the horizontal distance between A & B when

(a) The angle of slope is 10°.

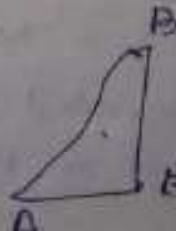
(b) When the difference of level between A & B is 8 m

Sol^n:- $\theta = 10°$

$AB = AB_1 \cos\theta$

$AB = 280 \cos 10° = 275.14$ m

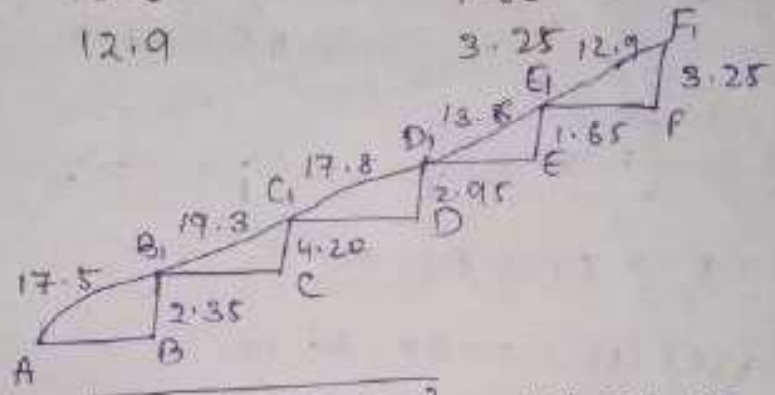
$AB_1 = \sqrt{(280)^2 - (8)^2} = 279.8$ m



8. The following slope distance were measured along a chain line with 20 m steel tape. It was noted afterwards that the tape was 2.5 cm too short. Find the true horizontal distance.

Slope distance	Difference of elevation between ends
17.5	2.35
19.3	4.20
17.8	2.95
13.6	1.65
12.9	3.25

Soln



$AB = \sqrt{(17.5)^2 - (2.35)^2} = 17.32$ m

$B_1C = \sqrt{(19.3)^2 - (4.20)^2} = 18.83$ m

$C_1D = \sqrt{(17.8)^2 - (2.95)^2} = 17.75$ m

$D_1E = \sqrt{(13.6)^2 - (1.65)^2} = 13.49$ m

$E_1F = \sqrt{(12.9)^2 - (3.25)^2} = 12.48$ m

Total horizontal distance = $AB_1 + B_1C + C_1D + D_1E + E_1F$

$= 17.32 + 18.83 + 17.75 + 13.44 + 12.48$

$= 479.87$ m

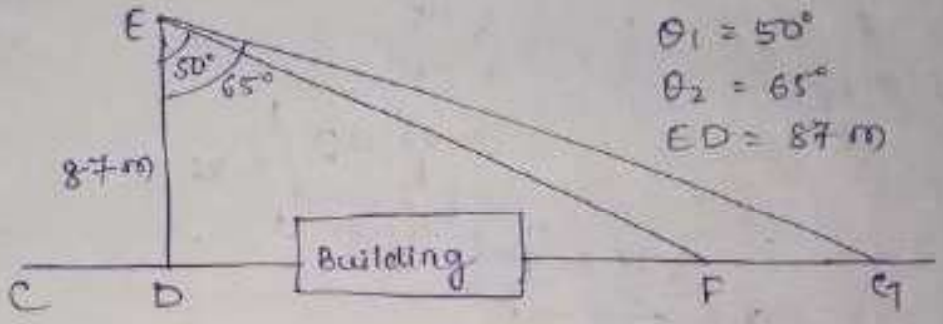
$L = 20$ m $\quad e = 0.025$

$L' = 20 - 0.025 = 19.975$

$TL = \frac{L'}{L} \times ML = \frac{19.975}{20} \times 79.87 = 79.77$ m

Q. A survey line CD intersects a building to overcome the obstacles. A perpendicular DE 87 m long is said out at D From E, two lines EF & EG are said out of angle of 50° & 65° respectively ED. Find the length of EF & EG such that points F & G fall of the line CD also find the obstracted distance DF.

Sol^{n}



$\theta_1 = 50°$

$\theta_2 = 65°$

$ED = 87$ m

$\frac{EF}{ED} = \sec\theta \Rightarrow EF = ED \sec\theta_1$

$EF = 87 \times \sec(50°) = 135.34$ m

$\frac{EG}{ED} = \sec 65°$

$EG = ED \sec 65°$

$= 87 \times \sec 65° = 205.85$

$DF =$

Q. The distance between two points measure with a 30 m chain was recorded as 287 m. It was afterwards found that the chain was 3 cm too long what was the true distance between the points

Sol^{n} $L = 30$ m

(ML) Measured Length $= 287$ m

$e = 3$ cm $= 0.03$ m

$L' = L + e = 30 + 0.03 = 30.03$ m

$TL = \frac{L'}{L} \times ML = \frac{30.03}{30} \times 287 = 287.287$

Precautions against error & mistake :-

- The following precaution should be taken to guard against errors & mistake.
- The point where the arrow is fixed on the ground should be mark with a cross.
- The zero end of the chain or tape should be properly held.
- During chaining the no. of arrows carried by the follower & leader should always tally with the total numbers of arrows taken.
- While noting the measurement from the chain, the teeth of the tally should be varied with respect to the correct end.
- The chain man should all the measurement loudly & the survivour should repeat then while booking.
- Measurement should not be taken with the tape in suspention during high wilds.
- In stepping operations horizontally & vertically should be properly maintain.
- Ranging should be done accurately.
- No measurement should be taken with the chain is suspension.
- Care should be taken so that the chain is properly extended.

CHAIN SURVEYING

Principle of chain surveying :-

- The principle of chain surveying is triangulation. This means that area to be surveyed is devided into a no. 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 & angular measurement are taken.
- Here the tie lines & check lines control the accuracy of work.

Chain surveying is suitable when :-

(i) The ground surface is more or less level.
(ii) A small area is to be surveyed
(iii) A small scale mape is to be prepare
(iv) The formation of well condition triangle is easy

Chain surveying is unsuitable when :-

(i) The area which crowded with many details.
(ii) The area is very large.
(iii) The formation of well condition triangle becomes difficult due to obstructed.

Well condition triangle :-

- A triangle is said to be well condition when no angle in it is less than 30° or greater than 120°
- An equilateral triangle is consider to be the best condition or ideal triangle.
- A triangle is it which an angle is less than 30° or more than 120° is said to be ill condition triangle.

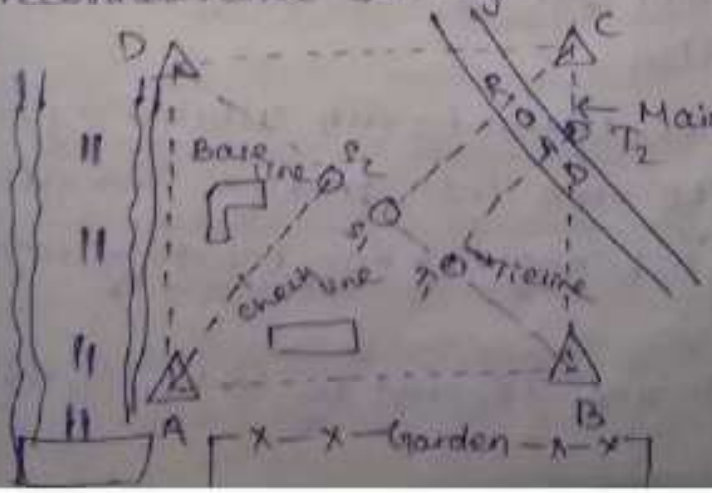
Equipment used in chain surveying :-

(1) Metric chain (20 m or 30 m) - 1 nos.
(2) Arrows - 10 Nos.
(3) Metallic tape - 1 Nos.
(4) Ranging rods - 3 Nos.
(5) Offset rods - 1 Nos.
(6) Clinometer - 1 Nos.
(7) Plumb-bob with thread - 1 No.
(8) Cross staf or optical square - 1 No.
(9) Prismatic compass with stand - 1 No.
(10) Wooden pegs - 10 Nos.
(11) Mallet - 1 No.
(12) Filled book - 1 No.
(13) Good pencil - 1 No.
(14) Eraser - 1 No.

Reconnaisance survey & Index sketch :-

→ Before the commencement of any survey work the area to be surveyed is thoroughly examined by the survivour, to then things about possible arrangement of the frame work of survey.

→ This primary investigation of a area is known as reconnaisance survey.



Defination & illustration :-

(A) Survey station :- Survey station are the point at the beginning & the end of a chain line. They may also accurate at any convenient at any chain line. Such station may be

(1) Main station
(2) subsidiary station
(3) Tie station

(1) Main station :- Stations taken along ~~of a~~ the boundry of an area controlling points are known as main stations.

- The line joining the main stations are called main survey line.
- The main survey line should cover the whole area to be surveyed.
- The main station are denoted by '△' with letter A, B, C, D etc.
- The chain line are denoted by "—.—.—.—"

(2) Subsidiary station :-

- The station which are on the main survey line or any other survey lines are known as subsidiary station.
- This station are taken to run subsidiary lines for dividing the area into triangle, for checking the accuracy of triangle & for locating interior details.
- These stations are denoted by '⊙' with letters S_1, S_2, S_3 etc.

(3) Tie-station :- There are also subsidiary station taken on the main survey line.
- The line joining the tie station are known as tie-lines.
- There are also taken to from chain angle in chain traversing when triangulation is not possible.
- Some time the lines are taken to locate interior details.
- The station are denoted by '⊙' with letters T_1, T_2, T_3 etc.

Base line :- The line on which the frame work of the survey is built is known as Base line.
- It is the most important line of the survey.
- Generally the longest of the main survey line is consider the base line.
- This line should be taken through level ground & should be measure very carefully & accurately.
- The magnetic bearing of the base line are taken to fixed the north line of the map.

Check line :- The line joining the apex ~~line~~ 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 triangl
Some time this lines helps to locate interior detai

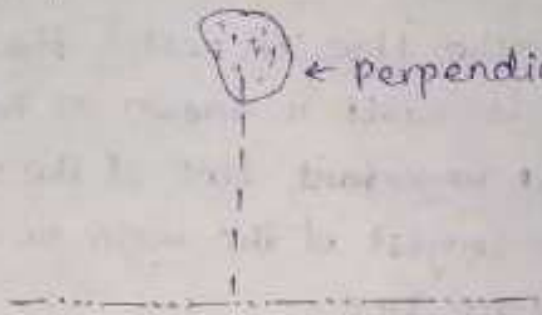
Offsets :- The lateral measurement taken from an object to the chain line is known as offset. Offsets are taken to locate objects with reference to the chain line. They may be two types.
(1) Perpendicular offset
(2) Oblique offset

Scanned with CamScanner

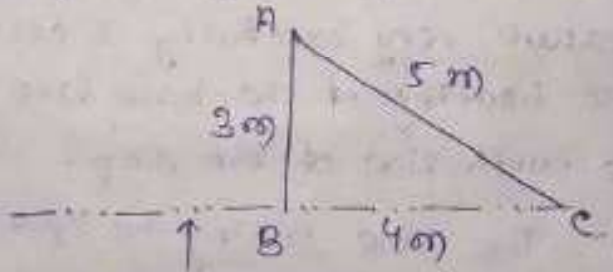
(1) Perpendicular offset :- When the lateral measurement taken perpendicular to the chain line they are known as perpendicular offset.

- Perpendicular offset may be taken in the following ways.

(a) By setting a perpendicular by ~~swimming~~ suining a tape from the object to the chain line, the point of minimum reading on the tape while be the base of the perpendicular.



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



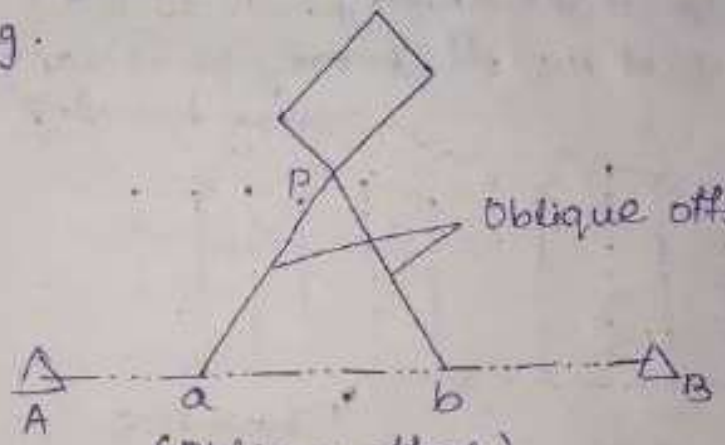
Chain line (setting a right angle)

- By setting a right angle with the help tri-squar
- By setting a right angle by cross staff or optical square.

(2) Oblique offset :- Any offset are not perpendicular to the chain line is said to be oblique.

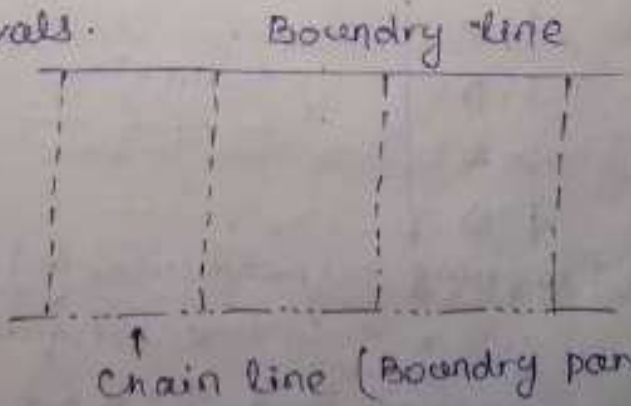
- Oblique offsets are taken when the objects are at a long distance from the chain line or when it is not possible to set up a right angle due to some difficulties.

- Such offsets are taken in the following manner.
- Suppose 'AB' is a chain line & P is the corner of a building. Two points a & b are taken on the chain line. The chain edges of a & b are noted. The distance aP & bP are measured & noted in the field book. Then aP & bP are the oblique offsets.
- When the triangle abp is plored, the apex point 'p' will represent the position of the corner of the building.

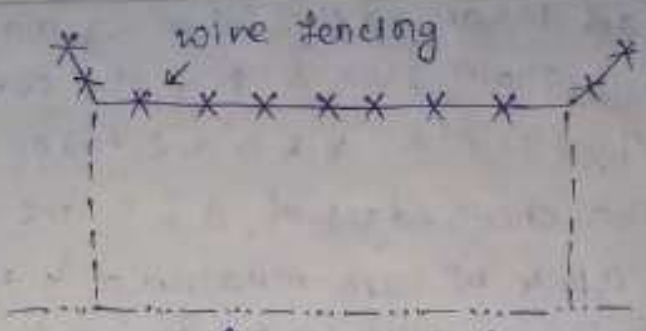


(Oblique offset)

No. of offset :- When the boundry of the object is approximately parallel to the chain line perpendicular offset are taken at rectangular intervals.

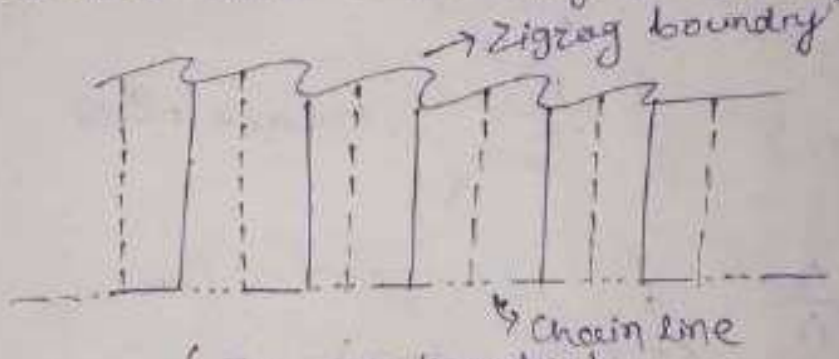


3) When the boundary is straight perpendicular axis are taken at both ends of it.



(Straight boundry)

(3) When the boundry line is zig-zag, perpendicular offsets are taken at every point of bend to represent the shape of the boundry. In such a case the interval of the offset may be rectangular.



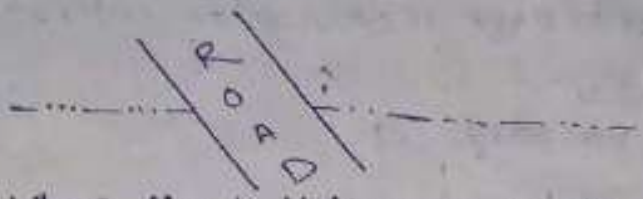
(Zig-zag boundry)

(4) When a road crosses the plain line perpendicularly, the change of the inter section point is to be noted.

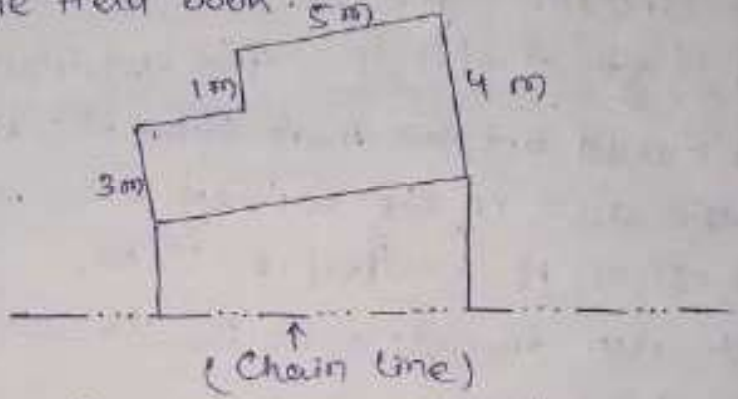
(Road crossing perpendicularly)

(5) When a road crosses a chain line obliquely, the chainage of intersection point a & b are noted. Then at least one offset is taken on both sides of the intersection point. More offsets may be taken depending on the nature of road.

- Here, perpendicular offsets are taken as c & d.

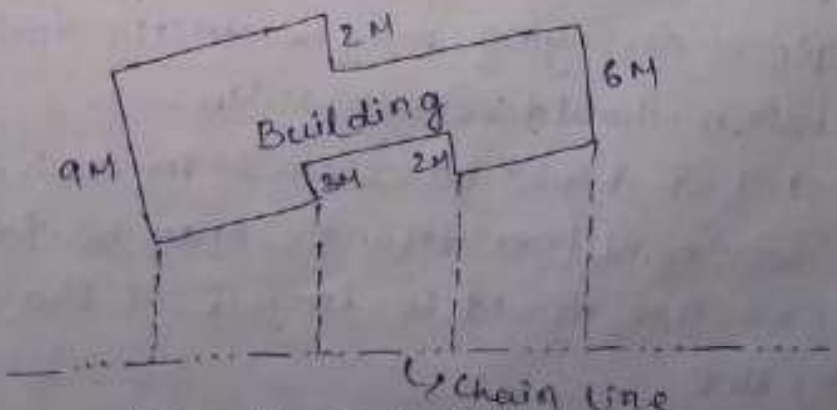


(6) When the building is small its corners are fixed by a perpendicular or oblique offsets & other dimension are taken directly on the field & noted in the field book.



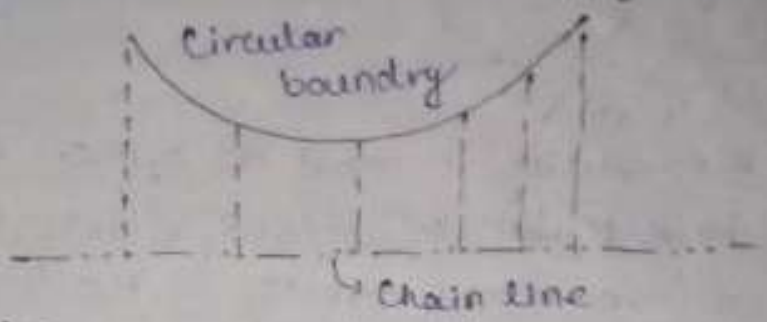
(For small building)

- When the building is large, zig-zag in shape & oblique to the chain line then the corners are fixed by perpendicular or oblique offsets. Then the full plan or the building is drawn on a separate page along with all the dimension. This page should be attached with the field book at the proper place.



(For large building)

- When the object is circular, perpendicular offsets are taken at short and rectangular intervals



(For circular object)

Limiting length of offsets :- The maximum length of offsets should not be more than the length of the tape used in the survey. The maximum length of offset is limited to 15 m.

- This length also depends upon the following factors

1) The scale of the map
2) The accuracy of the map
3) The nature of the ground
4) The maximum deflection of the offset from its true direction.

Selection of survey station :- The following point should be remember during the selection of survey station.

1) The station should be selected that the general principle of surveying may be strictly follow.
2) The station should be intervisible.
3) The station should be selected in such a way that well condition triangle may be formed.
4) The base line should be longest of the main survey line.

5) The survey line should be taken through fairly level ground as per as practicable.
6) The main survey line should be pass, close to the boundry line of the area to be surveyed.
7) The survey line should be taken close to the objects so that they can be located by short offsets.
8) The tie-station should be suitably selected to fixed the directions of the sites.
9) The subsidiary station should be suitably selected for taking check line.
10) station should be selected than that obstacles to chaing avoided as per as possible.
11) The survey line should not be very close to main roads, as survey work may be interrupted by traffic.

The field book:- The note book in which field measurement are noted is known as the field book.

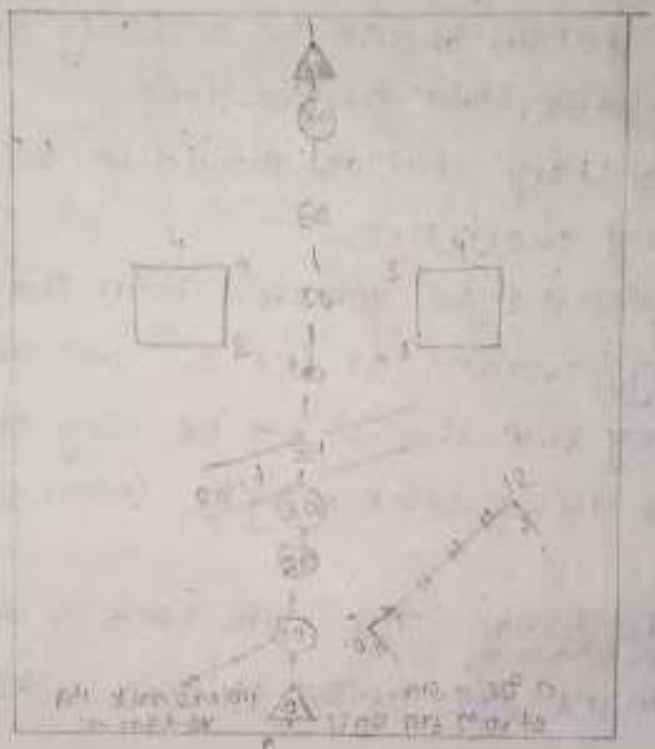
- The size of the field book is 20 cm x 12 cm & it open length wise.
- Field book may be 2 types.

(1) Single line field book
(2) Double line field book

(1) Single line field book:-

- In this type of field book, a single red line is drawn through the middle of each page.
- This line represents the chain line & the chain ages are written as it.

- The offsets are recorded with sketches to the left or right of the chain line.
- The recording of the field book is started from the last page & continued towards the first page.
- The main station are mark by 'Δ' & subsidiary station or tie-station are mark by 'O'.

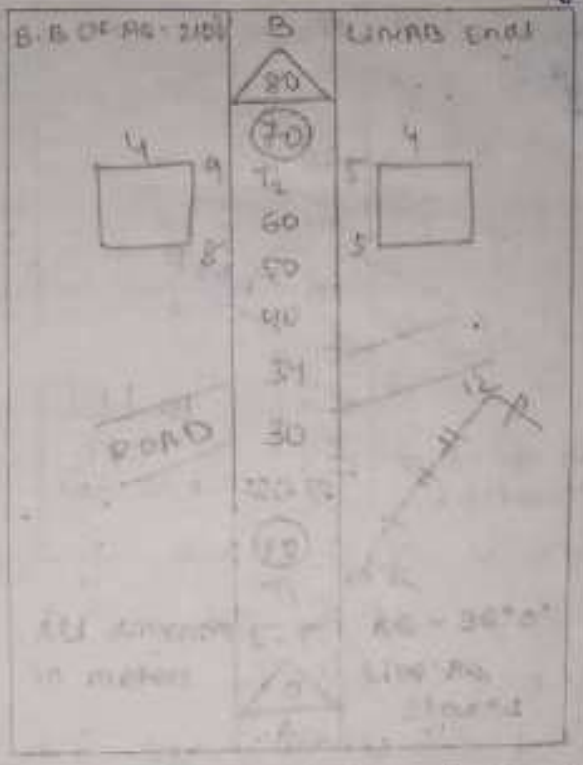


(Single line field book)

(2) Double Line :-

- In this type of field book, two red lines, 1.5 cm apart along are long through the middle of each page.
- The column represent the chain line & the chain ages are written in it.
- The offsets are recorded with scatches to the left or right of this column.
- The recording is started from the last page & continue towards the first page.

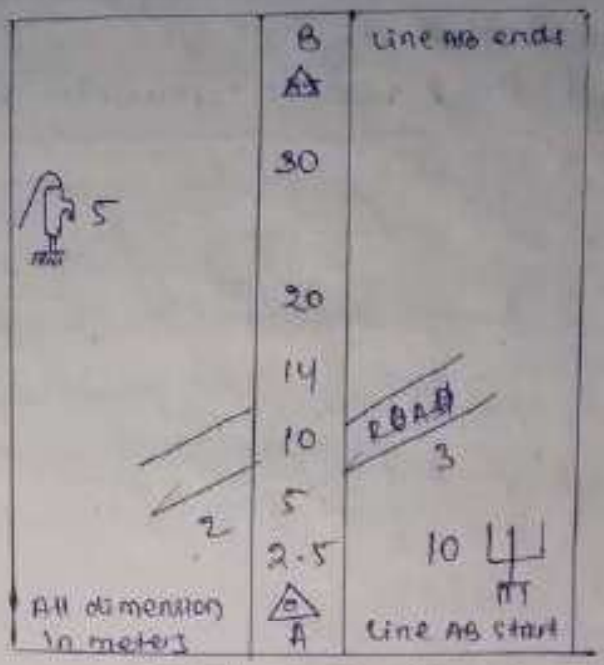
- The main stations are mark by '△' & subsidiary station are marked by '⊙'.
- This type of field book is commonly used.



Problems on entering records in field book :-

Problem no. 1 - While measuring a chain line AB the following offsets are taken. How would you enter the field book?

- A telegraph post is 10 m perpendicularly from 25 m chainage to the right of the chain line.
- A road crosses obliquely from left to right at 10 m & 14 m chainage. Perpendicular offsets are 2m & 3m to the side of the road from 5 m & 20 m chainage respectively.
- A tube well is 5m perpendicularly from 30 m chainage to the left of the chain line.
- Total chainage of AB is 45 m.



Q. The base line AC of a chain surveying is measured & the following records are noted. Make the necessaries entry in a field book.

1) The corners of a building are 9 m & 9.5 m from 7.5 m & 18 m chainage to the left of the chain line. The building is 7 m wide.

2) A 4 m wide road runs about parallel to the right of the chain line. offsets are 2, 2.1, 2.2 & 2.15 m at chainage 0, 20, 40 & 55.5 m respectively.

3) A check line is taken from the substation at 25 m chainage to the left.

4) The total chainage of the base line is 55.5 m. The four bearing & back bearing of the base line are 30° 30', 210° 30' respectively.

⇒ Enter the ~~following~~ field book according to the following field notes

- Chain age of line AB is 95.5 m.

6)

- The offsets to the pond at the left of chain line are as follows.

  Chain age – 10, 15, 20, 25, 30 m)

  offsets – 16, 12, 10, 14, 20 m)

- The offsets to the river at the right of chain line are

  chain age = 5, 25, 40, 60 m)

  offset = 13, 130, 170, 190, 195 m)

Precautions to be taken while entering the field book :-

- All measurement should be noted as soon as they are taken.
- Each chain line should be recorded on a separate page. Normally it should start from the bottom of one page & end on the top of another. No line should be started from any intermediate position.
- Over writing should be avoided.
- Figures & hand writing should be neat & clean.
- Index sketch, object sketch & notes should be clean.
- Reference sketch should be given in the field book so that the station can be located when required.
- The field book should be entered in pencil & not in ink.
- If an entry is incorrect or page damaged, cancelled the page & start the entry from a new one.
- Erasing a sketch, measurement the note should be avoided.
- The survior should face the direction of chainin so that the left hand & right hand objects can be recorded without any confusion

- The field book should be carefully preserved.
- The field book should contain the following.
  - → Name
  - → Location
  - → Date of survey
  - → Name of party member
  - → Page index of chain line

Q. The distance between two points measured with a 20 m chain was recorded as 327 m. It was afterwards found that the chain was 3 cm too long. What was the true distance between the points.

Given

$L = 20\ m$ $\quad e = 3\ cm = 0.03\ m$

$ML = 327\ m$

$L' = L + e = 20 + 0.03 = 20.03\ m$

$TL = \frac{L'}{L} \times ML = \frac{20.03}{20} \times 327 = 327.49\ m$

Q. The distance between two station are 1200 m. when measured with a 20 m chain the same distance when measured with a 30 m chain was found to be 1195 m. If the 20 m chain was 0.05 m too long what was the error in 30 m chain ?

Given

$L = 20\ m$

$ML = 1200$

$e = 0.05\ m$

$L' = 20 + 0.05 = 20.05\ m$

$TL = \frac{L'}{L} \times ML = \frac{20.05}{20} \times 1200$

$= 12.03\ m$

63

L = 30 m e = 0.05 m

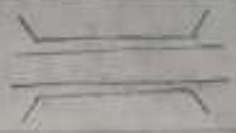
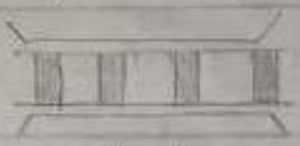
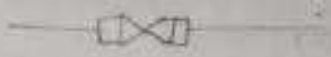
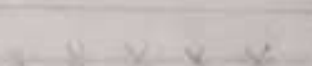
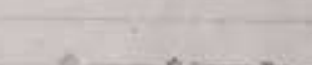
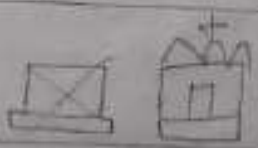
ML = 1195

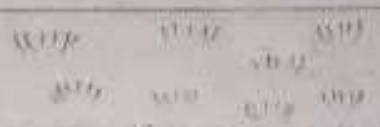
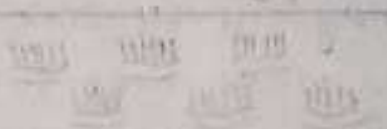
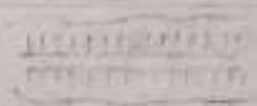
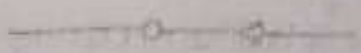
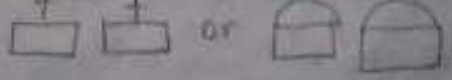
L' = 30 + 0.05 = 30.05

TL = $\frac{L'}{L} \times ML = \frac{30.05}{30} \times 1195 =$

CONVENTIONAL SYMBOLS :-

Sl. No.	Object	Symbol	Colour
1.	North line		Black
2.	Main station or triangulation station		Red or crimson red
3.	Transverse station or substation		Red or crimson lake
4.	Chain line		Red or crimson lake
5.	River		Prussian blue
6.	Canal		Prussian blue
7.	Lake or pond		Prussian blue
8.	Open well		Prussian blue
9.	Tube well		Black
10.	Foot path		Black
11.	Metalled road		Burnt sienna
12.	Railway line (single)		Black
13.	Railway line (double)		Black

14.	Unmetalled Road		Burnt sienna
15.	Road bridge or culvert		Black
16.	Railway bridge or culvert		Black
17.	Level crossing		Black & burnt sienna
18.	Wall with gate		Black
19.	Boundry line		Black
20.	Hedge		Green
21.	Wire fencing		Black
22.	Pipe fencing		Prussian blue
23.	Wood fencing		Yellow
24.	Building (Pukka)		Crimson lake
25.	Building (Kacha)		Umber
26.	Huts		Yellow
27.	Temple		Crimson Lake
28.	Church		Crimson Lake
29.	Bench mark		Black

30.	Tree		Green
31.	Jungle		Green
32.	Orchard		Green
33.	cultivated land		Black & green
34.	Barren land		Black
35.	Rough posture		Black
36.	Marsh or swamp		Black
37.	Mosque		Crimson lake
38.	Embankment		Black
39.	Cutting		Black
40.	Telegraph line		Black
41.	Telegraph post		Black
42.	Electric line		Black
43.	Electric post		Black
44.	Burial ground or cemetry		Crimson lake

(6)

Procedure of field work :-

- Field work of chain survey should be carried out according to the following steps.

(1) Reconnaissance
(2) Index sketch
(3) Marking the station on the ground
(4) Reference sketches
(5) Taking measurements of survey lines & noting them in the field book.

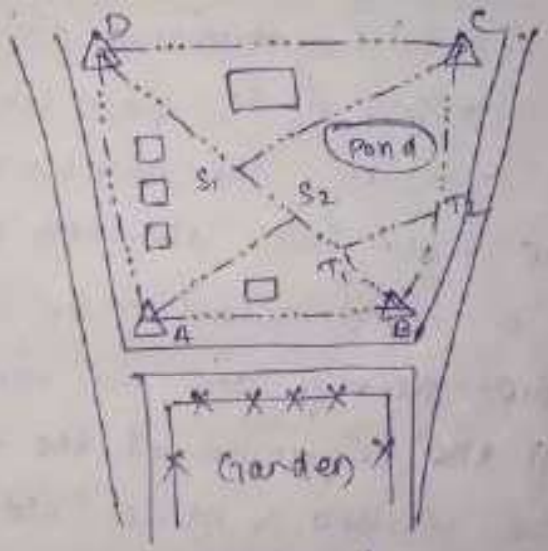
(1) Reconnaissance :-

- Before starting survey work the surveyer should walk over the whole area to be surveyed in order to examine the ground & determine the possible arrangement of freme work of survey.
- During this investigation, he should examine the inter visibility of the main stations.
- He should ensure that the whole area is enclosed by main survey lines & also that it is possible to form well condition triangles.
- He should observe various objects & boundry lines carefully & select the survey lines in such a manner that the objects can be located by short offsets.
- The base line should be taken through the centre of the area & on fairly level ground.

(2) Index sketch :-

- After preliminary inspection of the area the surveyer should prepare a neat hand sketch

showing the arrangement of the frame work & approximate position of the objects.
- He should note the names of the stations the sketch maintaining some order either clock wise or anti clock wise.
- The field work should be executed according to this index sketch.
- The names & sequence of chain lines should be followed as directed in the index sketch.
- The base line should be clearly indicated in the index sketch.



(Index sketch)

(3) Marking the station on the ground :-

- After reconnaissance the station are marked on the ground by wooden pegs. These peg are generally 2.5 cm^2 & 1.5 cm long, & have pointed ends. They are driven into the ground & there should be a height of 2.5 cm above the ground. The station point is marked with a cross, so that it can be traced if the wooden peg is removed by somebody.

(4) Reference sketches :- To take precautions against station pegs being remove or missed, a reference sketch should be made for all main stations. It is nothing but a hand sketch. If the station showing at least 3 measurement from of parmanent object. A 3rd measurement ~~showing at least~~ may also be taken.

(5) Taking measurement of survey line & nothing them in the field book :-

- Ranging & chaining is started from the base line, which should be measure carefully. The mathematic bearing of the base line measure by prismatic compass. The measurements are noted in the field book showing the offsets to the left or right according to their positio Then the other survey line are ranged & chain maintaining the sequence of the travers, AB, BC, CD. The offsets & other field records are noted. The check lines & tie lines are also measured & noted at the proper place The station marks are preserve carefully until field work is completed.

Equipment for plotting :-

(i) Drawing board (Normal size 1000 mm × 700 mm)
(ii) T-square
(iii) set-square
(iv) Protractor
(v) Drawing paper
(vi) Instrument box
(vii) offset scale
(viii) Pencil, Eresor
(ix) Mini dratter
(x) Drawing pin

Procedure of plotting:-

(i) A suitable scale is choosen so that the area can be accumodate in the space available on the map.

(ii) A margin of about 2 cm from the edge of the sheet is drawn around the sheet.

(iii) The title block is prepared on the right hand bottom corner.

(iv) The north line is mark on the right hand top corner & it should prefer vertical.

(v) A suitable position for the base line is selected on the sieve so that the whole area along with all the objects is contents can be drawn with in the space available in the map.

(vi) The frame work is completed with all survey lines, check lines & tie lines.

(vii) Until the frame work is completed in proper form the offset should not be plotted.

(viii) The plotting of offsets should be continued according to the sequence maintain in the field book.

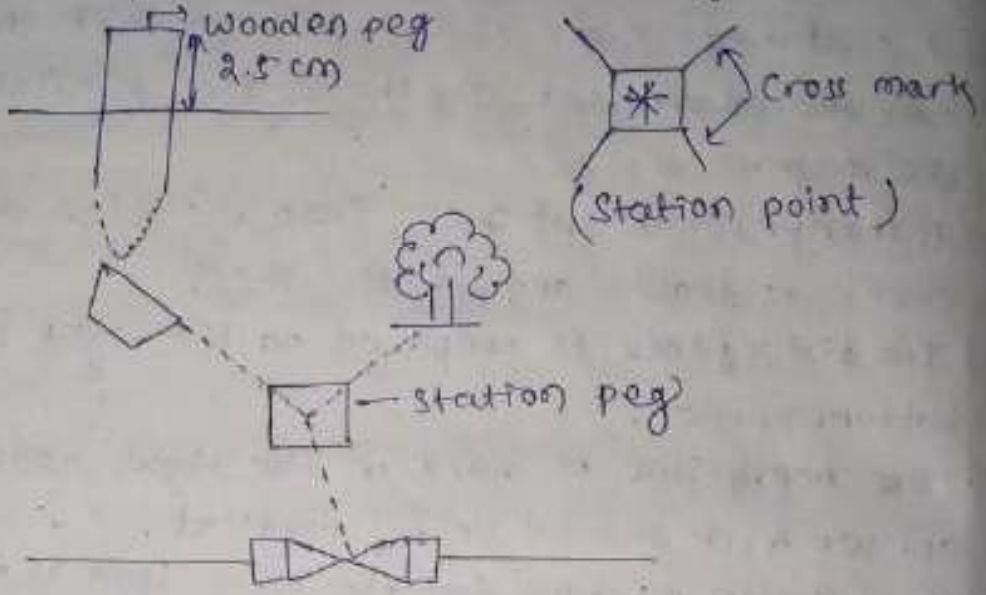
(ix) The main stations, sub stations, chain line, objects etc. should be shown as per standard symbols.

(x) The conventional symbols used in the map should be shown on the right hand side.

(xi) The scale of the map is drawn below the some suitable space. The heading should be written on the top of the map.

(xii) Unnecessary lines, objects etc should be erased.

(xiii) The map should not contain any dimension.



(Reference sketch)

CROSS STAFF & OPTICAL SQUARE :-

CROSS STAFF :-

- The cross staff is a simple instrument for setting out right angle. These are three types of stepes.

(1) Open cross staff
(2) French
(3) Adjustable

(1) Open cross staff :-

- The open cross staff consist of four metal arms with vertical slits.
- The two pairs of arms (AB & BC) are at right angles to each other.
- The vertical slits are meant for sliting the object & the ranging rod.
- The cross staff is mounted on a wooden pole of 1.5 m length & 2.5 cm diameter.

- The pole is fitted with an iron shoe.

Procedure :-

- For setting out a perpendicular on a chain line, the cross staff is held vertically at the approximate position.
- Suppose slits A & B are directed to the ranging rod R, R_1 fixed at the end station.
- Slits C & D are directed to the object (O).
- Looking through slits A & B the ranging rods are bisected.
- At the same time looking through slits C & D the object O is also bisected.
- To bisect the object & the ranging rods, the staff may be moved forward or backward along the chain line.

Optical square :- An optical square is also used for setting out right angles.

- It consist of a small circular metal box of 5 cm diameter & 1.25 cm depth.
- It has a metal cover which slides round the box to cover the slits.

Slits :- The following are the internal arrangement of the optical square.

(i) Horizontal glass (H) is fixed at the bottom of the metal box. The lower half of the glass is unsilvered & the upper half is silvered.

(ii) An index glass (I) is also fixed at the bottom of the box which is completely silvered.

(iii) The angle between the index glass & horizontal glass is maintained at 45°.

(iv) The opening 'e' is a pin hole for eye 'E', 'b' is a small rectangular hole for ranging rod 'B', 'p' is a large rectangular hole for object 'P'.

(v) The line 'EB' is known as horizon sight & 'EP' as index sight.

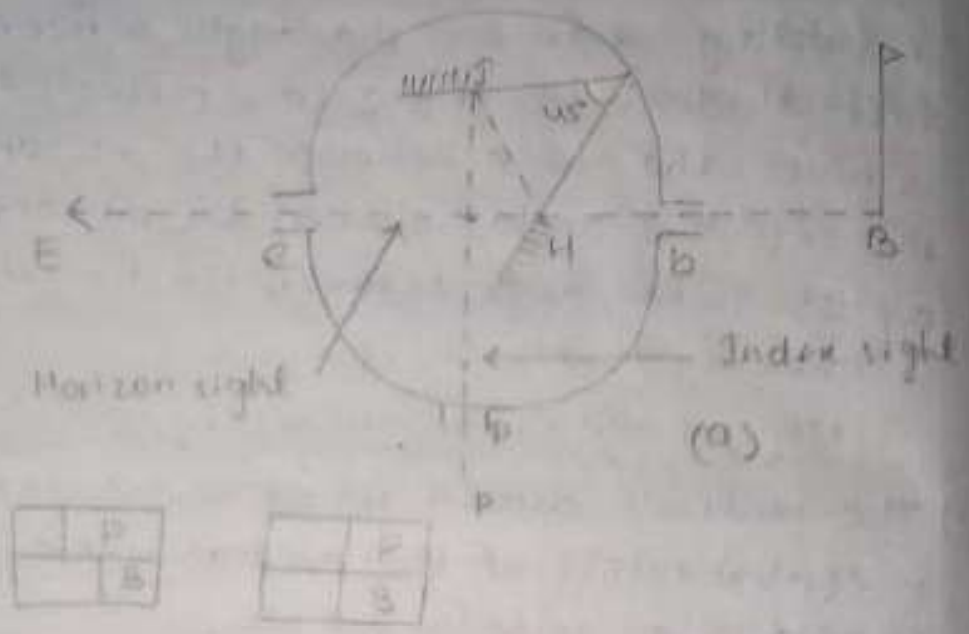
(vi) The horizon glass is placed at an angle of 120° with the horizon sight. The index glass is placed at an angle of 105° with the index sight.

(vii) The ray of light from 'P' is first reflected from 'I', then it is further reflected from H. After which is ultimately reaches the eye 'E'.

Principle :- According to the principle of reflecting surfaces, the angle between the first incident ray & the last reflected ray is twice the angle between the mirrors. In this case the angle between the mirrors is fixed at 45°. So the angle between the horizon sight & index sight will be 90°.

Setting of the perpendicular by optical square :

1) The observer should stand on the chain line & approximately at the position where the perpendicular is to be set off.
2) The optical square is held by the arm at the eye level. The ranging rod at the forward station 'B' is observe through the unsilvered portion on the lower part of the horizon glass.
3) Then the observer loose through the upper silver portion of the horizon glass to see the image of the object 'P'.
4) Suppose the observer finds that the ranging rod 'B' & the image of object 'P' do not co-inside. Then he should move forward or back ward along the chain line until the ranging rod 'B' & the image of 'P' exactly coinside.
5) At this position the observer marks a point on the ground to locate the foot of the perpendiculeur.



COMPASS TRAVERSING

- In chain surveying the area to be surveyed is divided into a no. of triangles. This method is suitable for fairly level ground covering small area. But when the area is large, undulating & crowded with many details triangulation is not possible. In such an area the method of traversing is adopted.
- In traversing, the frame work consist of a no. of connected lines the lengths are measured by chain or tape & the directions identified by angle measuring instruments. In one of the methods the angle measuring instruments used in the compass. Hence the process is known as compass traversing.

Definations :-

1) True meridian :- The line or plane passing

through the geographical north pole, geographical south pole & any point on the surface of the earth is known as the true meridian or geographical Meridian. The true meridian at a stations is constant.

- The true meridian passing through different points on the earth surface are not parallel, but converged towards, the pole.
- But the survey in small area, the true meridian passing through different points are assumed parallel.
- The angle between the true meridian & a line is known as a true bearing of the line. It is also known as the azimuth.

2) Magnetic meridian :- When a magnetic niddle is suspended freely & balanced properly ~~on a direction~~ un effected by magnetic substance it indicates a direction. This direction is also known as the magnetic meridian.

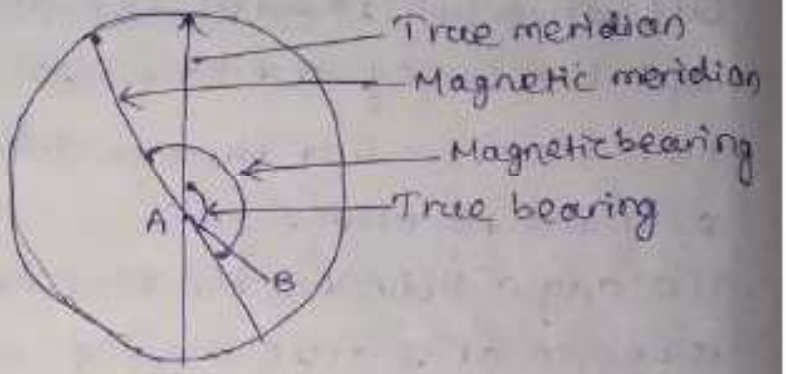
- The angle between the magnetic meridian & a line is known as the magnetic bearing or bearing of the line.

(3) Arbitrary Meridian :- Some times for the survey of a small area, a convenient direction is assumed as a meridian known as the arbitrary meridian. Some time the starting line of a survey is taken as the arbitrary meridian.

- The angle between the arbitrary meridian & a line is known as the arbitrary bearing of the line.

(4) Grid Meridian :- ~~so times~~ Some times for preparing a map, some state agency assume several lines parallel to the true meridian for a particular zone. These lines are termed as grid lines & the control lines are termed as grid Meridian.

- The bearing of a line with respect to the grid meridian is known as the grid bearing of the line.



(Meridians)

Designation of Magnetic bearing :-

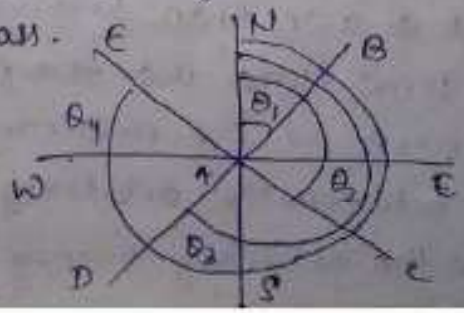
- Magnetic bearings are designated by two systems.

(1) Whole Circle Bearing (WCB)

(2) Quadrantal Bearing (QB)

(1) Whole Circle Bearing (WCB) :-

- The magnetic bearing of a line measured clock wise from the north pole towards the line is known as whole circle bearing of that line.
- The bearing value is between 0° & 360°.
- The whole circle bearing of a line is obtained by prismatic compass.



(Whole circle bearing)

WCB of AB = θ_1

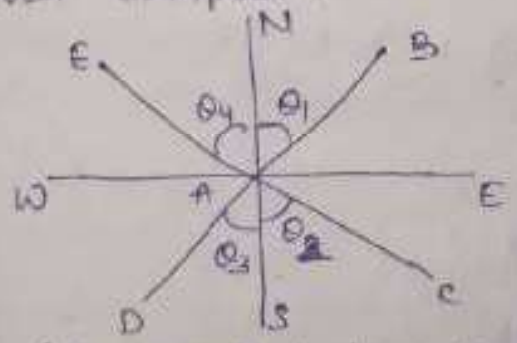
WCB of AC = θ_2

WCB of AD = θ_3

WCB of AE = θ_4

2) Quadrantal Bearing (QB) :-

- The magnetic bearing of a line measured clock wise or anti clock wise from the north pole or south pole towards the east or west is known as quadrantal bearing of the line.
- This system consist of 4 quadrants - NE, SE, SW & NW.
- The value of a quadrantal bearing lies between 0° & 90°.
- Quadrantal bearings are obtained by the surveyor compass.



(Quadrantal bearing)

QB of AB = N θ_1 E

QB of AC = S θ_2 E

QB of AD = S θ_3 W

QB of AE = N θ_4 W

Reduced Bearing (RB) :-

- When the whole circle bearing of a line is converted to quadrantal bearing it is termed as reduced bearing.

The following table should be remember for conversion of WCB to RB :-

WCB between	Corresponding RB	Quadrant
0° & 90°	RB = WCB	NE

90° & 180°	RB = 180° − WCB	SE
180° & 270°	RB = WCB − 180°	SW
270° & 360°	RB = 360° − WCB	NW

Problems on WCB & QB :-

Q. Convert the following WCB to QB.

1) WCB of AB = 45° 30'
2) WCB of BC = 125° 45'
3) WCB of CD = 222° 15'
4) WCB of DE = 320° 30'

Ans-

1) RB of AB = N 45° 30' E
2) RB of BC = 180° − 125° 45' = S 54° 15' E
3) RB of CD = 222° 15' − 180° = S 42° 15' W
4) RB of DE = 360° − 320° 30' = N 39° 30' W

Q. Convert the following WCB to QB.

1) WCB of AB = 69° 45'
2) WCB of BC = 175° 5'
3) WCB of CD = 195° 60'
4) WCB of DE = 356° 45'

Ans-

1) RB of AB = N 69° 45' E
2) RB of BC = S 4° 55' E
3) RB of CD = S 15° 60' W
4) RB of DE = N 3° 15' W

Q. Convert the following QBs to WCBs :-

1) QB of AB = S 36° 30' W
2) QB of BC = S 43° 20' E
3) QB of CD = N 26° 45' E
4) QB of DE = N 40° 15' W

1) WCB of AB = 180° + 36° 30' = 216° 30'
2) WCB of BC = 180° - 43° 30' = 136° 30'
3) WCB of CD = 26° 45'
4) WCB of DE = 360° - 40° 15' = 319° 45'

Q. Convert the following Q.Bs to WBs :-
1) QB of AB = S 49° 45' W
2) QB of BC = S 25° 15' E
3) QB of CD = N 75° 30' E
4) QB of DE = N 63° 45' W

Ans-
1) WCB of AB = 180° + 49° 45' = 229° 45'
2) WCB of BC = 180° - 25° 15' = 154° 45'
3) WCB of CD = 75° 30'
4) WCB of DE = 360° - 63° 45' = 296° 15'

Q. Convert the following WCB to QB :
1) WCB of AB = 45° 15'
2) WCB of BC = 120° 45'
3) WCB of CD = 225° 15'
4) WCB of DE = 320° 30'

Ans-
1) QB of AB = N 45° 15' E
2) QB of BC = 180° - 120° 45' = S 59° 15' E
3) QB of CD = 225° 15' = S 45° 15' W
4) QB of DE = 360° - 320° 30' = N 39° 30' W

Principle of compass surveying :-

- The principle of compass surveying is traversing. which involves a series of connected lines.
- The magnetic bearings of the lines are measured by prismatic compass & the distance of the lines

are measured by chain. Such survey does not require the formation of a network of triangle &

- Interior details are located by taking offsets from the main survey line.
- Sometimes subsidiary lines may be taken for locating those detail.

→ Compass surveying is adopted when

(i) A large area to be surveyed

(ii) The coarse of a river is to be surveyed.

(iii) The area is crowded with many details & triangulation is not possible.

→ Compass surveying is not recomended for areas where local attraction is suspected due to the presence of magnetic substance like steam str, iron-ore deposite, electric cable, conveying current & so-on.

Traversing :- Surveying which involves a series of connected lines is known as traversing.

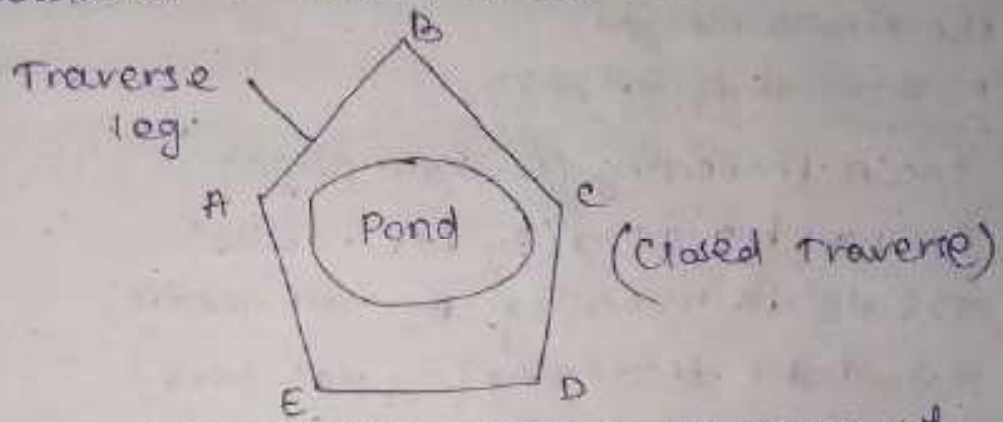
- The sides of the traverse are known as traverse legs.
- In traversing the lengths of the lines are measured by chain & the direction are fixed by compass or theodolite or by forming angles with chain & tape.
- A traverse may be of two types.

(1) close traverse

(2) Open traverse

(1) Closed traverse :- When a series of connected lines form a closed circuit when the finishing point co-incides with the starting point of a survey it is called a closed traverse.

- Here ABCDEA represents a closed traverse.
- Closed traverse is suitable for the survey of boundries of ponds, forests etc.



(2) Opened Traverse :- When a sequence of connected lines extends along a general direction & does not return to the starking point is known as open traverse or unclosed traverse.

- Opened traverse is suitable for the survey of roads, river etc.
- Here A, B, C, D, E represents an open traverse.

(Open traverse)

Check on closed traverse :-

1) Check on angular measurement :-

- The sum of the measured interior angles should

be equal to $(2N+4) \times 90°$.

- The algebric sum of the deflection angle should be equal to 360°.

Check on linear measurement :-

- The line should be measured once each on two different days (along opposite direction).
- Linear measurement should also be taken by the stadia method.

Methods of traversing :-

(1) Chain traversing (By chain angle)
(2) Compass traversing (By free needle)
(3) Theodolite traversing (By fast needle)
(4) Plain table traversing (By plain table)

Types of compasses :-

There are two types of compasses.

(1) The prismatic compass
(2) The Surveyor's Compass

(1) The prismatic compass :- In this compass the readings are taken with the help of a prism. The following are the essential parts of the compass.

(i) Compass box
(ii) Magnetic Niddle & graduated ring
(iii) Siglat vane & prism
(iv) Dark glasses
(v) Adjustable Mirror.
(vi) Break pin
(vii) Lifting pin (viii) Glass cover.

(i) Compass box :- The compass box is a circular metallic box (the metal should be non magnetic) of 8-10 cm diameter.
- A pivot with a sharp point is provided at the centre of the box.

(ii) Magnetic needle & graduated ring :- The magnetic needle is made of a board, magnetised iron bar.
- The bar is pointed at both ends.
- The magnetic needle is attached to a graduated aluminium ring.
- The ring is graduated from 0° to 360° clock wise & the graduations begin from the south end of the needle.
- Thus 0° is marked at the south, 90° at the west, 180° at the north & 270° at the east.
- The degrees are again sub divided in half degrees
- The arrangement of the needle & ring contains an agate cap pivoted on the central pivot point.
- A reader of brass or silver coil is provided with the needle to counter balance its dip

(iii) Sight vane & prism :- The sight vane & the reflecting prism are fixed diametrically opposite to the box.
- The sight vane is hinged with the metal box & consist of a horse hair.
- The prism consist of a sighting slit at the top & two small circular holes, one at the bottom of the prism & the other at the side of the observer eye.

(iv) Dark glasses :- Two dark glasses are provided with the prism.
- The red glass is meant for sighting the objects at night & the blue glass for reducing the strain on the observer's eye bright day light.

(v) Adjustable mirror :- A mirror is provided with the sight vane. The mirror can be lowered or raised, & can also be inclined.
- If any object is too low or too high with respe to the line of sight, the mirror can be adjusted to observe it through reflection.

(vi) Break pin :- A break pin is provided just at the base of the sight vane. If pressed gently, it's stop the oscilation of the ring.

(vii) Lifting pin :- A lifting pin is provided just bela the sight vane. When the sight vane is folded, it press the lifting pin. The lifting pin then lifts the magnetic needle out of the pivot point to prevent damaged to the pivot head.

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

(2) Sureyer's Compass :- The surveyor's compass is similar to the prismatic compass except for the following point.
- There is no prism on it. Readings are taken with the naked eye.
- It consists of an eye-vane implace of prism with

a fine sight slit.
- The graduated aluminium ring is attached to the circular box. It is not fixed to the magnetic needle.
- The magnetic needle moves freely over the pivot. The needle shows the reading on the graduated ring.
- The ring is graduated from 0° - 90° in four quadrants. 0° is marked at the north & south, & 90° at the East & west. The letters 'E' (East) & 'W' (west) are interchange from their true position.
- No mirror is attached to the object-vane.

Temporary adjustment of prismatic compass :-

Field procedure of Observing Bearing :-

1) Fixing the compass with tripod stand.
2) Centring
3) Levelling
4) Adjustment of prism
5) Observation of bearing

1) Fixing the compass with tripod stand :-

- The tripod stand is placed at the required station with its legs well apart. Then the prismatic compass is held by the left hand & placed over the threaded top of the stand. After this the compass box is turned clockwise by the right hand. Thus the threaded base of the compass box is fixed with the threaded top of the stand.

2. Centring :- The compass is centred by dropping a piece of stone from the bottom of the compass box. Centring may also be done with the aid of a plumb-bob held centrally below the compass box.

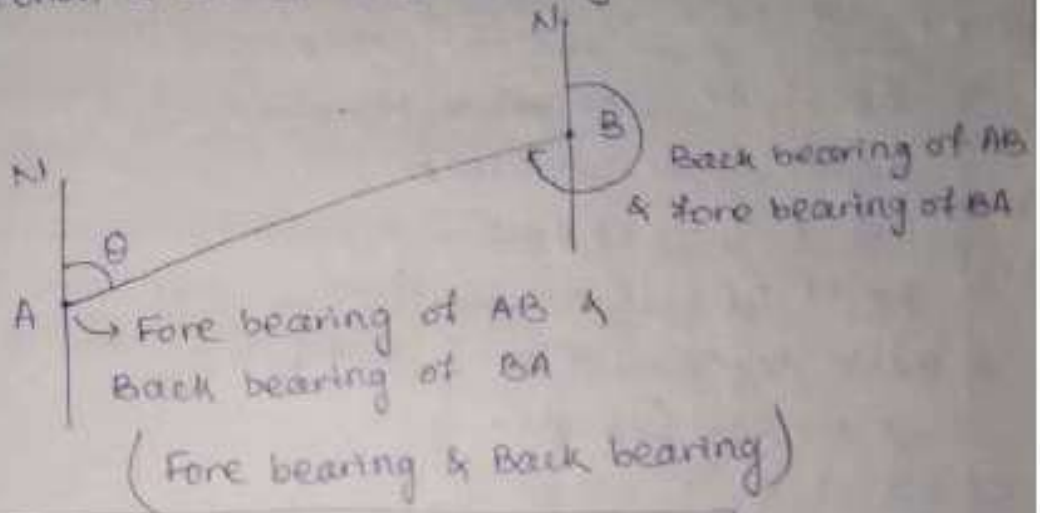
3. Levelling :- Levelling is done with the help of a ball & socket arrangement provided on the top of the tripod stand. The box is placed in such a way that the graduated ring rotates freely without touching either the bottom of the box or the glass cover on top.

4. Adjustment of prism :- The prism is move up & down till the figures on the graduated ring are seen sharp & clear.

5) Observation of Bearing :- After centring & levelling the compass box over the station, the ranging rod at the required station is bisected perfectly by sighting through the slit of the prism & horse-hair at the sight vane.

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

Fore & Back Bearing :- Every line has two bearings one is observe along the progress of the survey or forward direction & it is called fore bearing.
- The second is observe in the reverse or opposite direction is called back bearing.



(Fore bearing & Back bearing)

Back bearing = Fore bearing ± 180°

→ Used +ve sight when fore bearing is less than 180° & used -ve sight when it is more than 180°.
In case of quadrantal bearing system, if the fore bearing is N 30° E then its back bearing is S 30° W.

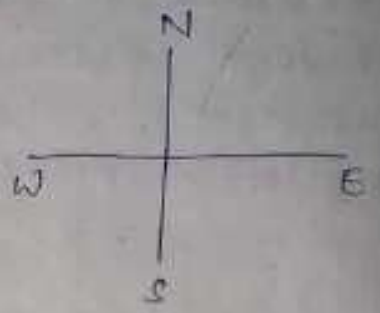
Q. Problems on Fore & Back bearing.
* The fore bearing of the following lines are given. Find the back bearing.

1. FB of AB = 310° 30'
2. FB of BC = 145° 15'
3. FB of CD = 210° 30'
4. FB of DE = 60° 45'

Ans - BB of AB = 310° 30' − 180° = 120° 30'
BB of BC = 180° + 145° 15' = 325° 15'
BB of CD = 210° 30' − 180° = 29° 30'
BB of DE = 180° + 60° 45' = 240° 45'

2) Fore bearing of the following lines are given Find the back bearing.

(i) FB of AB = S 30° 30' E
(ii) FB of BC = N 40° 30' W
(iii) FB of CD = S 60° 15' W
(iv) FB of DE = N 45° 30' E



Ans- BB of AB = N 30° 30' W
BB of BC = S 40° 30' E
BB of CD = N 60 15' E
BB of DE = S 45° 30' W

3) Back bearing of the following lines are given. Find the fore bearing.

(i) BB of AB = 40° 30'
(ii) BB of BC = 310° 45'
(iii) BB of CD = 145° 45'
(iv) BB of DE = 215° 30'

Ans- FB of AB = 180° + 40° 30' = 220° 30'
FB of BC = 310° 45' - 180° = 130° 45'
FB of CD = 180° + 145° 45' = 325° 45'
FB of DE = 215° 30' - 180° = 35° 30'

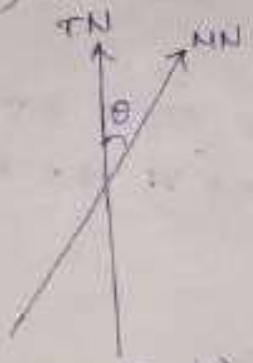
4) Back bearing of the following lines are given. Find the fore bearing.

(i) BB of AB = N 30° 30' W
(ii) BB of BC = S 40° 15' E
(iii) BB of CD = N 60° 45' E
(iv) BB of DE = S 45° 30' W

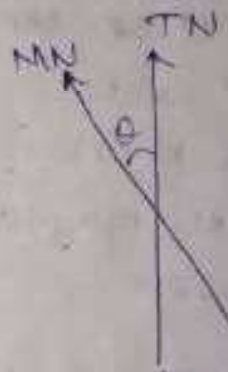
Ans- FB of AB = S 30° 30' E
FB of BC = N 40° 15' W
FB of CD = S 60° 45' W
FB of DE = N 45° 30' E

Magnetic declination :- The horizontal angle between the magnetic meridian & true meridian is known as magnetic declination.

- When the north end of the magnetic needle is pointed towards the west sight of the true meridian the position is termed as declination west (θW).
- When the north end of the magnetic needle is pointed towards the east sight of the true meridian the position is termed as declination east (θE).

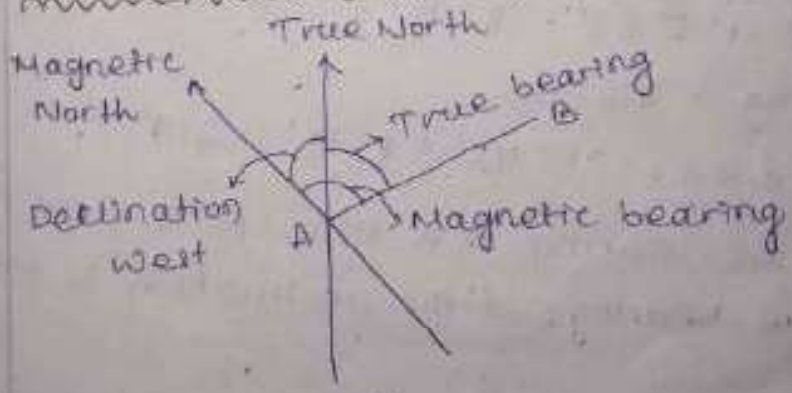


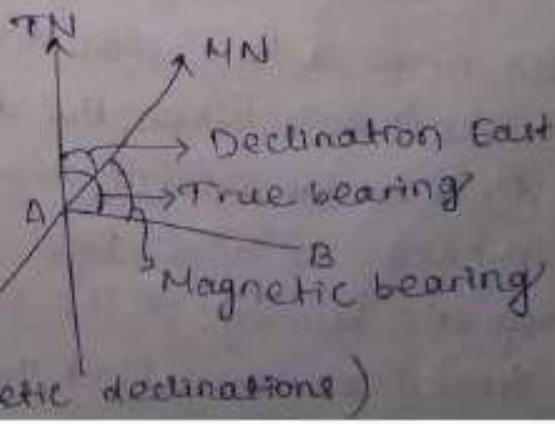
(Declination East)



(Declination west)

Problems on magnetic declination :-





(Magnetic declinations)

Determination of True bearing & Magnetic bearing:

True bearing = Magnetic bearing ± declination

Used +ve sign when declination is East.

Used -ve sign when declination is West.

Magnetic bearing = True bearing ± declination).

Used +ve sign when declination is West.

Used -ve sign when declination is East.

Q.(i) The magnetic bearing of a line AB is 135° 30'. What will be the true bearing, if the declination is 5° 15' west.

(ii) The true bearing of a line CD is 210° 45'. What will be its magnetic bearing, if the declination is 8° 15' west.

Ans-

(i) Magnetic bearing = 135° 30'

True bearing = Magnetic bearing - declination)

= 135° 30' - 5° 15' = 130° 15'

(ii) True bearing = 210° 45'

Magnetic bearing = 210° 45' + 8° 15' = 219°.

Q.2) The magnetic bearing of a line CD is S 30° 15' W. Find its true bearing, if the declination is 10° 15' East.

Q.3) On an old map, a line was drawn to a magnetic bearing of 330° 30', when the declination was 3° 30' west. Find the present bearing of the line, if the declination is 4° 15' East.

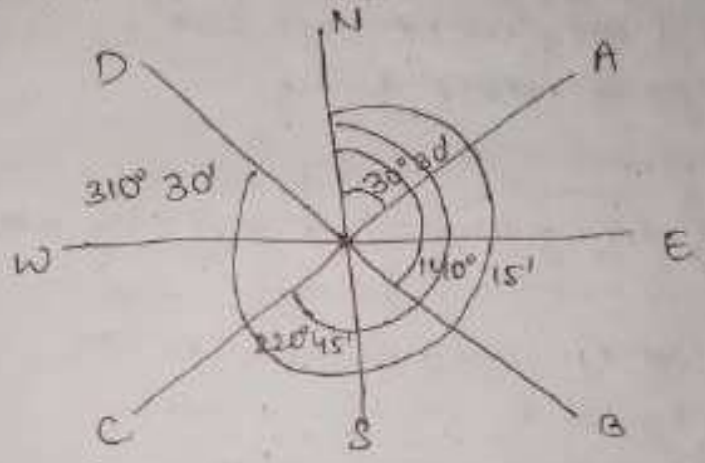
Q.4) (i) The magnetic bearing of the sun at noon is 175° 30' from a station. Find the magnetic

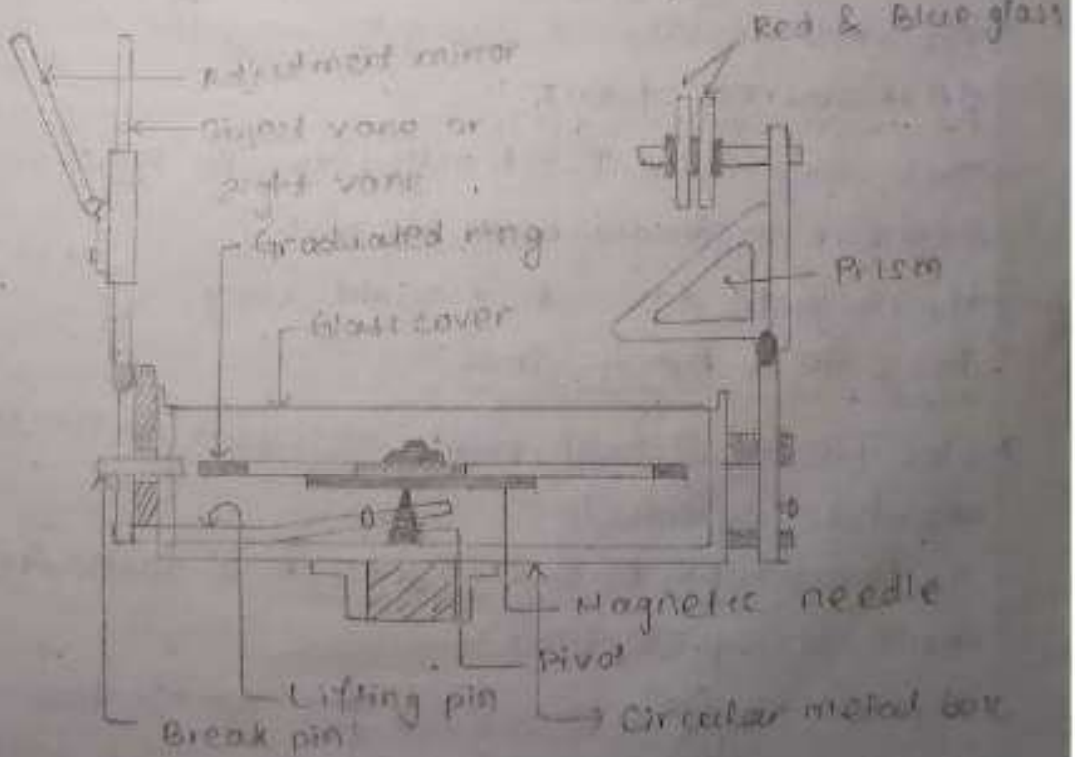
declination at that station.

(ii) The magnetic bearing of the sun at noon is 5° 30' from other station. Find the magnetic declination at that station.

5) Problems on included angle.

(i) The bearing of the lines OA, OB, OC, OD are 30° 30', 140° 15', 220° 45' & 310° 30', respectively. Find the ∠AOB, ∠BOC & ∠COD.





(Prismatic Compass)

Sources of error in a compass :-

(1) Instrumental errors :-

→ The needle may not be perfectly straight & might not be balanced properly.
→ The graduations of the ring may not be uniform.
→ The sight vane may not be vertical.
→ The horse hair may not be straight & vertical.
→ The pivot point may not be eccentric.
→ The ring may not rotate freely.

Personal errors :-

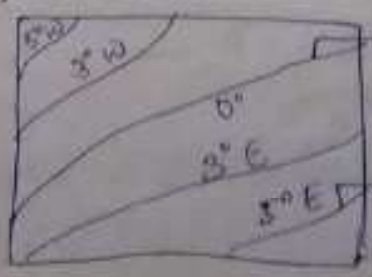
→ The centring may not be done perfectly over the station.
→ The graduation ring may not be levelled.
→ The object may not be bisected properly.
→ The reading may be taken carelessly.
→ The observer may be carrying magnetic substances.

Other sources of error :-

→ Their may be local attraction due to presence of magnetic substance near the station.
→ The magnetic declination might vary.

Isogonic & Agonic lines :-

→ Line passing through points of equal declination are known as isogonic lines.
→ The line passing through points of 0° declination is known as agonic lines.



Variation of magnetic declination :-

(1) Secular variation :- The magnetic meridian behaves like a pendulum with respect to the true meridian. After every 100 years or so, it swings from one direction to the opposite direction & hence the declination varies. These variation is known as secular variation.

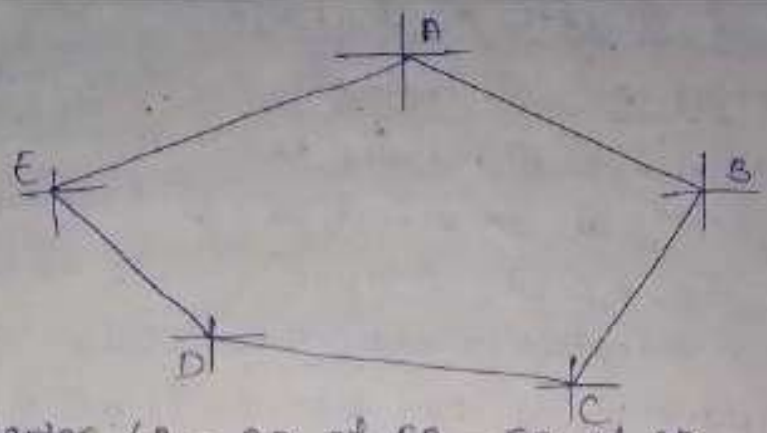
(2) Annual variation :- The magnetic declination varies due to the rotation of the earth, with its axis inclined, in an elliptical path around the sun during a year. This variation is known as annual variation.

(3) Diurnal variation :- The magnetic declination varies due to the rotation of the earth on its own axis in 24 hours. This variation is known as diurnal variation.

(4) Irregular variation :- The magnetic declination is found to very suddenly due to some natural causes, such as earth cracks etc. & so on. This variation is known as irregular variation.

8. The following are the bearing observe in traversing with a compass. Calculate the interior angle of the traverse.

Line	F B	B B
AB	150° 00'	330° 00'
BC	230° 30'	50° 30'
CD	306° 15'	126° 15'
DE	298° 00'	118° 00'
EA	49° 30'	229° 30'



Interior $\angle A$ = BB of EA − FB of AB

$= 229° 30' - 150° 00' = 79° 30'$

Interior $\angle B$ = BB of AB − FB of BC

$= 330° 00' - 230° 30' = 99° 30'$

Interior $\angle C$ = BB of BC + (360° − FB of CD)

$= 50° 30' + (360° - 306° 15') = 104° 15'$

Interior $\angle D$ = BB of CD + (360° − FB of DE)

$= 126° 15' + (360° - 298° 00') = 188° 15'$

Interior $\angle E$ = BB of DE − FB of EA

$= 298° 00' - 229° 30' = 68° 30'$

Sum of the interior angles $= (2N-4) \times 90°$

Here, $N = 5$

$(2 \times 5 - 4) \times 90° = 540°$

The sum of the total calculated interior angle

$= \angle A + \angle B + \angle C + \angle D + \angle E$

$= 79° 30' + 99° 30' + 104° 15' + 188° 15' + 68° 30'$

$= 540°$

Dip of the magnetic needle :-

→ If a needle is perfectly balanced before magnetisation it does not remain in the balanced position after it is magnetised. This is due to magnetic influence

of the earth. The needle is found to be inclined towards the pole. This inclination of the needle with the horizontal is known as the dip of the magnetic needle.

→ It is found that the north end of the needle is defected downwards in the northern hemisphere and that it south end is defected southward in the southern hemisphere.

Local attraction :-

→ A magnetic needle indicates the north direction when freely suspended. But if the needle come near some magnetic substance such as iron ore, steel structures, electric cables conveying current etc, it is found to be defected from its true direction & does not show the actual north. This disturbing influence of magnetic substance is known as local attraction.

→ To detect the presence of local attraction, the fore bearing & back bearing of a line should be taken. If the difference of the fore bearing & back bearing of the line is exactly 180° then there is no local attraction.

→ If the fore bearing & back bearing of a line do not differ by 180° then the needle is said to be effected by local attraction, provided their is no instrumental error.

→ To compensate for the effect of local attraction, the amount of error is found out & is equally distributed between the Fore bearing & back bearing of the line

e.g- Consider a case when, ~~observe~~

Observed FB of AB = 60° 30'

Observed BB of AB = 240° 0'

Calculated the BB of AB = 60° 30' + 180° = 240° 30'

Corrected BB of AB = $(240° 0' + 240° 30') \times \frac{1}{2}$

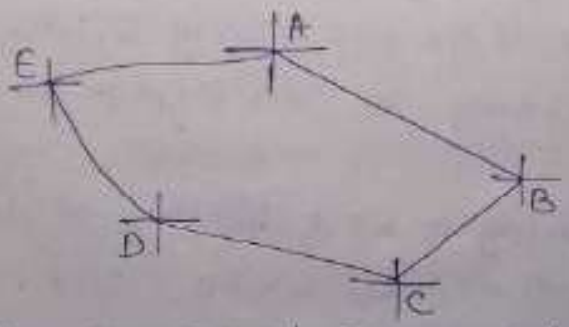
= 240° 15'

Corrected BB of AB = 240° 15' − 180° = 60° 15

Problems on local attraction :-

Q. The followings are the bearings observed in traversing with a compass an area when local attraction was suspected. Calculate the interior angle of the traverse & correct them if necessary.

Line	FB	BB
AB	150° 00'	330° 00'
BC	230° 30'	48° 00'
CD	306° 15'	127° 45'
DE	298° 00'	120° 00'
EA	49° 30'	229° 30'



Interior ∠A = BB of EA − FB of AB

= 229° 30' − 150° 00' = 79° 30'

Interior ∠B = BB of AB − FB of BC

= 330° 00' − 230° 30' = 99° 30'

Interior ∠C = BB of BC + (360° − FB of CD)

$\angle A = 48^\circ 00' + (360^\circ - 306^\circ 15') = 101^\circ 45'$

Interior $\angle D$ = BB of CD + (360° − FB of DE)

$= 127^\circ 45' + (360^\circ - 298^\circ 00') = 189^\circ 45'$

Interior $\angle E$ = BB of DE − FB of EA

$= 120^\circ 00' - 49^\circ 30' = 70^\circ 30'$

Check, Sum of calculated interior angle

$= \angle A + \angle B + \angle C + \angle D + \angle E$

$= 79^\circ 30' + 99^\circ 30' + 101^\circ 45' + 189^\circ 45' + 70^\circ 30'$

$= 541^\circ 00'$

But the sum of angles should be

$(2N - 4) \times 90^\circ = (2 \times 5 - 4) \times 90^\circ = 540^\circ$

Here, Error = $541^\circ - 540^\circ = 1^\circ$

Correction per angle = $\frac{1^\circ}{5} = \frac{60'}{5} = -12'$

The error should be equally distributed among all the angles.

Corrected table

Angle	Calculated value	Correction	Corrected value
$\angle A$	$79^\circ 30'$	$-12'$	$79^\circ 18'$
$\angle B$	$99^\circ 30'$	$-12'$	$99^\circ 18'$
$\angle C$	$101^\circ 45'$	$-12'$	$101^\circ 33'$
$\angle D$	$189^\circ 45'$	$-12'$	$189^\circ 33'$
$\angle E$	$70^\circ 30'$	$-12'$	$70^\circ 18'$
Total =	541°	Total =	540°

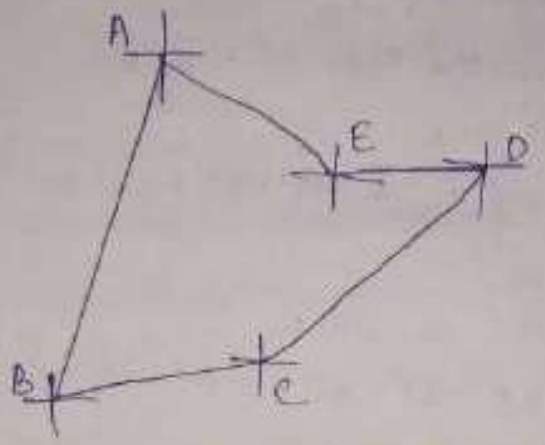
Q. The following are the observe bearings of the lines of a traverse ABCDEA with a compass in a place where local attraction was suspected.

Line	FB	BB
AB	$191^\circ 45'$	$13^\circ 0'$
BC	$39^\circ 30'$	$222^\circ 30'$

9

CD	22° 15'	200° 30'
DE	242° 45'	62° 45'
EF	330° 15'	147° 45'

Find the correct bearing of the line.



Interior $\angle A$ = FB of AB − BB of EA

= 191° 45' − 147° 45' = 44° 0'

Interior $\angle B$ = FB of BC − BB of AB

= 39° 30' − 13° 01' = 26° 30'

Interior $\angle C$ = FB of CD + (360° − BB of BC)

= 22° 15' + (360° − 222° 30')

= 159° 45'

Interior $\angle D$ = FB of DE − BB of CD

= 242° 45' − 200° 30' = 42° 15'

Interior $\angle E$ = FB of AEA − BB of DE

= 330° 15' − 62° 45' = 267° 30'

Sum of the calculated interior angle =

= $\angle A + \angle B + \angle C + \angle D + \angle E$ =

= 44° 0' + 26° 30' + 159° 45' + 42° 15' + 267° 30'

= 540°

Method of application of correction :-

(1) 1st method :- The interior angles of a traverse are calculated from the observe bearings. Then an angular check is applied. The sum of the interior angles should be equal to $(2N-4) \times 90°$. If it is, not so, the total error is equally distributed among all the angles of the traverse.

(a) 2nd method :- In this method the interior angles are not calculated., From the given table the unaffected line is 1st detected. Then commencing from the unaffected line, the bearing of the other effected lines are corrected by finding the amount of correction at each station.

→ This is an easy method & ~~one~~ which is generally employed.

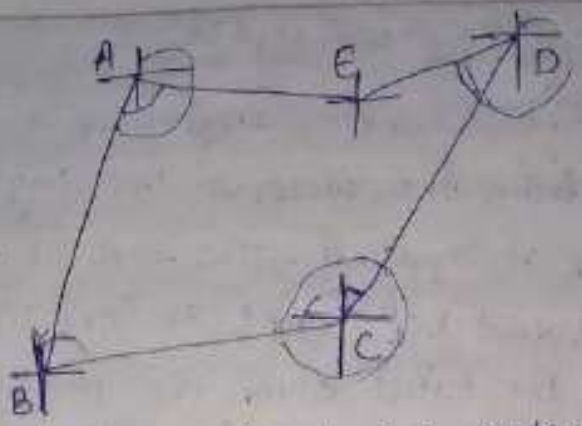
Problems on local attraction :-

- The following are the observe bearing of the lines of a traverse ABCDEA with a compass in a place where local attraction was suspected.

Line	FB	BB
AB	191° 45'	13° 0'
BC	39° 30'	222° 30'
CD	22° 15'	200° 30'
DE	242° 45'	62° 45' ← free from local attraction
EA	330° 15'	147° 45' ←

Find the correct bearings of the line.

Ans- 1st method → By calculating interior angles.



(a) Calculation of interior angles.

Interior $\angle A$ = FB of AB − BB of EA

= 191° 45′ − 147° 45′ = 44° 00′

Interior $\angle B$ = FB of BC − BB of AB

= 39° 30′ − 13° 00′ = 26° 30′

Interior $\angle C$ = FB of CD + (360° − BB of BC)

= 22° 15′ + (360° − 222° 30′) = 159° 45′

Interior $\angle D$ = FB of DE − BB of CD

= 242° 45′ − 220° 30′ = 42° 15′

Interior $\angle E$ = FB of EA − BB of DE

= 330° 15′ − 62° 45′ = 267° 30′

Sum of interior angles = $\angle A + \angle B + \angle C + \angle D + \angle E$

= 44° 0′ + 26° 30′ + 159° 45′ + 42° 15′ + 267° 30′

= 540° 00′

Which is equal to $(2N-4) \times 90°$ = 540° 00′

So, the calculated angles are correct.

(b) Calculation of corrected bearing

- The line DE is free from local attraction.

So FB of DE = 242° 45′ (Correct)

FB of EA = 330° 15′ Correct

FB of AB = BB of EA + $\angle A$ = (330° 15′ − 180°) + 44° 00′

= 150° 15′ + 44° 00′ = 194° 15′

FB of BC = BB of AB + ∠B

$= (194° 15' - 180°) + 26° 30' = 40° 45'$

FB of CD = BB of BC - Exterior ∠C

$= (40° 45' + 180°) - (BB \text{ of } BC - FB \text{ of } CD)$

$= 220° 45' - (222° 30' - 22° 15') = 20° 30'$

FB of DE = BB of CD + ∠D

$= (FB \text{ of } CD + 180°) + CD$

$= (20° 30' + 180°) + 42° 15' = 242° 45'$

The result is tabulated as below.

Line	Corrected FB	Corrected BB
AB	194° 15'	14° 15'
BC	40° 45'	220° 45'
CD	20° 30'	200° 30'
DE	242° 45'	62° 45'
EA	330° 15'	150° 15'

Second method → Direct applying correction:-

→ On varifying the observe bearing, it is found that the FB & BB of line DE differ by exactly 180°. So the stations D & E are free from local attraction & the observe FB & BB of DE are correct.

→ The observe FB of EA is also correct.

→ The actual back bearing of EA = FB of EA - 180°

~~$= 330° - 180° = 150° 180$~~

$= 330° 15' - 180° = 150° 15'$

But the observe back bearing of EA = 147° 45'.

So a correction = 150° 45' - 147° 45' + 2° 30'

+2° 30' should be applied at A°.

→ Correct FB of AB = 191° 45' + 2° 30' = 194° 15'

The actual BB of AB = 194° 15' − 180° = 14° 15'

But observe bearing = 13° 00'.

So a correction = 14° 15' − 13° 00' = +1° 15'

1° 15' should be applied at B.

→ Correct FB of BC = 39° 30' + 1° 15' = 40° 45'

The actual BB of BC = 40° 45' + 180° = 220° 45'

But observe bearing of BC = 222° 30'

So correction = ~~222° 30' − 220° 30'~~

220° 45' − 222° 30' = ~~−2°~~ −1° 45'

−1° 45' should be applied at C.

→ Correct FB of CD = 22° 15' − 1° 45' = 20° 30'

The actual BB of BCD = 20° 30' + 180° = 200° 30'

Station D & E is free from local attraction when Fore bearing & back bearing of DE & Fore bearing of EA is correct.

The result is tabulated as follows :-

Line	Observed FB	Observed BB	Correction	Correct FB	Correct BB	Remark
AB	191° 45'	13° 00'	+2° 30' at A	194° 15'	14° 15'	
BC	39° 30'	222° 30'	+1° 15' at B	40° 45'	220° 45'	
CD	22° 15'	200° 30'	−1° 45' at C	20° 30'	200° 30'	
DE	242° 45'	62° 45'	0° at D	242° 45'	62° 45'	Station D is free from local attraction
EA	330° 15'	147° 45'	0° at E	330° 15'	150° 45'	

Station E is also free from local attraction

10)

Q. The following bearing where observe at a place where local attraction was suspected. Find the corrected bearings of the lines.

Line	FB	BB
AB	S 45° 30' E	N 45° 30' W
BC	S 60° 00' E	N 60° 40' W
CD	S 5° 30 E	N 3° 20' W
DA	N 83° 30' W	S 85° 00' E

Sol^n - The FB & BB of AB are numerically equal but their quadrants are just opposite. So stations A & B are free from local attraction. Hence the given FB & BB of AB are correct.

→ The observe FB of BC is also correct.

→ The actual BB of BC = N 60° 00' W

But the observe BB of BC = N 60 40' W

So a correction = 60° 00' − 60° 40' = − 0° 40'

− 0° 40' should be applied at C

→ Correct FB of CD = S 5° 30' E − 0° 40' = S 4° 50' E.

The actual BB of CD = N 4° 50' W

But Observe bearing = N 3° 20' W

So a correction = N 3° 20' W − N 4° 50' W = + 1° 30'

− 1° 30' should be applied at D

→ Correct FB of DA = 83° 30' − 1° 30' = N 82° 00' W

The actual BB of DA =

So a correction = N 4° 50' W − N 3° 20' W = + 1° 30'

+ 1° 30' should be applied at D

→ Correct FB of DA = 83° 30' + 1° 30' = N 85° 00' W

The actual BB of DA = S 85° 00' E

Station A & B are free from local attraction where

FB & BB of DE AB & FB of BC is correct.
The result is tabeled as follows.

Line	observed FB	observed BB	correction	Correct FB	Correct BB	Remark
AB	S 45°30'E	N 45°30'W	0° 00' A	S 45°30'E	N 45°30'W	Station A is free from local attraction
BC	S 60°00'E	N 60°40'W	0° at B	S 60°00'E	N 60°00'W	Station B is free from local attraction
CD	S 5°30'E	N 3°20'W	−0° 40' at C	S 4°50'E	N 4°50'W	
DA	N 85°30'W	S 85°00'E	+1° 30' at D	N 85°00'W	S 85°00'E	

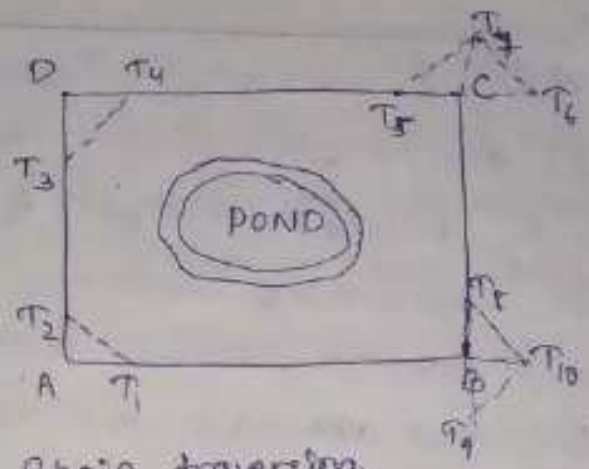
Methods of traversing :-

→ There are 4 types of methods of traversing.

(1) Chain traversing (By chain angle)
(2) Compass traversing (By free needle)
(3) Theodolite traversing (By fast needle)
(4) Plane table traversing (By plane table)

(1) Chain traversing (By chain angle) :-

→ Chain traversing is mainly conduct when it is no possible to adopt triangulation.
→ In this method the angles between adjacent sides are fixed by chain angle.
→ The entire survey is conducted by chain & tape only. & so angular measurements are taken.
→ When it is not possible to form triangles, as for example in a pond chain traversing is conducted as shown in figure.



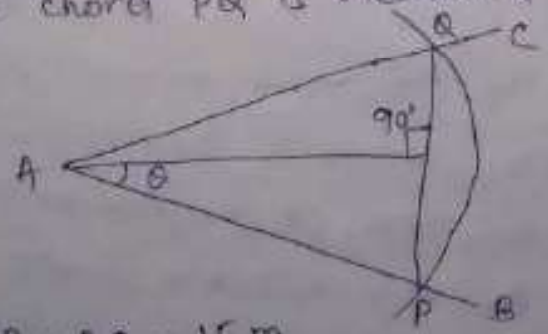
(a) Chain traversing

→ 1st method :-
Suppose a chain angle is to be form to fix the directions of AB & AD. The stations T_1 & T_2 are fixed on lying AB & AD. The distance AT_1, AT_2 & T_1T_2 are measured. Then the angle ~~$\angle T_1AT_2$~~ $\angle T_1AT_2$ is said to be chain angle. So the chain angle is fixed by the the line T_1, T_2.

(b) 2nd method

→ Some time the chain angle is fixed by a chord. Suppose the angle between the line AB & AC is to be fixed.

→ Taking A as the centre & a radius equal to one tape length 15 m & are intersecting the line AB & AC at points P & Q.
The chord PQ is measured & bisected at R.



AP

$AP = AQ = 15$ m

$\angle PAR = \theta°$

$\angle BAC = 2\theta$

In $\triangle PAR$ $= \frac{PR}{AP} = \sin\theta$

(2) Compass traversing :-

→ In this method the FB & BB of the traverse legs are measured by prismatic compass & the sides of the traverse measure by chain or tape. Then the observe bearings are verified & necessary correction for local attraction are applied. In this method closing error may occur when the traverse is plotted. This error is adjusted graphically by bowditch's rool.

(3) Theodolite traversing :-

→ In theodolite traversing the horizontal angle between the traverse legs are measured by a theodolite. The length of the legs are measured by chain or tape. The magnetic bearing of the starting leg is measured by a theodolite. Then the magnetic bearing of the other sides are calculated. This method is very accurate.

(4) Plane table surveying :-

→ In this method a plane table is set at every traverse station in the clock wise or anti clock wise direction & the circuit is finally closed. During traversing the sides of the traverse are plotted according to any suitable scale. At the end of the wall any closing error which may occur is adjusted practically.

Equipment required for compass survey:-

- The following equipment are required for conducting a compass survey.

(1) Prismatic compass with stand - 1 no
(2) Matric chain 20 m / 30 m - 1 no.
(3) Metallic tape 15 m - 1 no
(4) Arrows - 10 no.
(5) Ranging rods - 4 nos.
(6) Cross staff or optical square - 1 no.
(7) Plumb-bob - 1 no.
(8) Tri-square or wooden setsquare - 1 no.
(9) Wooden pegs - 10 nos.
(10) Mallet - 1 no.
(11) Field book - 1 no
(12) Eraser - 1 no.

Field procedure of compass traversing :-

(1) Reconnaissance
(2) Preparation of index sketch
(3) Marking the station on the ground
(4) Measurement of bearings of traverse legs

(1) Reconnaissance :-

- The area to be surveyed is examined thoroughly to select the traverse stations. These stations should be intervisible & should cover the whole area. It should be ensured that their is no magnetic substance near the selected stations. The traverse leg should run along fairly level ground.

(2) Preparation of index sketch :-

- After reconnaissance an index sketch should be prepare to showing the skeleton of the traverse.

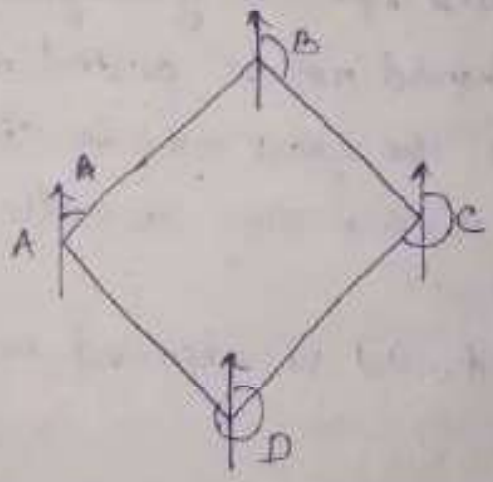
(3) Marking the stations on the ground :-

- The traverse stations are mark from the ground by wooden pegs. the pegs should be fixed on the station points in such a way that a height of about 8cm is always exposed above the ground surface
- Reference sketches should be prepare for all the traverse station by taking at least two measurements from some permanent points. These precaution is take so that the stations can be located accurately even if the pegs having removed by some body.

(4) Measurement of bearings of traverse leg :-

- The traverse station may be selected clockwise or anticlockwise order. But the direction of the traverse should be indicated in the index sketch
- Suppose 4 traverse station A, B, C & D are selected to enclose an area.
- The prismatic compass is centred & levelled at the starting station A.
- The FB of 'AB' & BB of 'DA' are taken from this station.
- The distance 'AB' is measure & offsets are taken along the line 'AB' & recorded in the field book
- The compass is then shifted & centred over the

station B.
- Then the FB of 'BC' & BB of 'AB' are taken.
- Here the FB & BB of the line should be differ by exactly 180°.
- Now the line 'BC' is measure & offsets are taken & noted in the field book. similarly all the traverse legs are measured & noted in the field book.
- After completion of the work the observation are tabulated & necessary correction applied to eliminate the effect of local attraction.



(Bearing of traverse legs)

* Precautions to be taken in compass surveying :-

→ The following precautions should be taken while conducting a compass traverse.

(1) The centring should be done perfectly.

(2) To stop the rotation of the graduated ring, the break pin should be pressed very gently & not suddenly.

(3) Readings should be taken along the line of sight & not from any sight.

(4) When the compass has to be shifted from one stations to another the sight vane should be folded over the glass cover. This is done to lift the ring out of the pivot to avoid unnecessary wear of the pivot head.

(5) The compass box should be tapped gently before taking the reading. This is done to find out weather the needle rotates freely.

(6) The stations should not be selected near magnetic substance.

(7) The observer should not carry magnetic substance

(8) The glass cover should not be dusted with a handkerchief, because the glass may be charged with electricity & the needle may be deflected from its true directions.

(9) The glass cover should be cleaned moist finger

Procedure :-

(i) Suppose 'P' is a station on the ground from where the objects A, B, C & D are visible.

(ii) The plane table is set up over the station P. A drawing sheet is fixed on the table which is then levelled & centred. A point 'P' is selected on the sheet to represent the station 'P'.

(iii) The north line is marked from the right hand top corner of the sheet with trough compass or circular box compass.

(iv) With the alidade touching 'P', the ranging rods at A, B, C & D are bisected & the rays are dr

PLANE TABLE SURVEYING

Principle :- The principle of plane tabling is parallelism meaning that the rays drawn from stations to objects on the parallel to the lines from the stations to the objects on the ground.

* The relative position of the objects on the ground are represented by their plotted positions on the paper & lie on the respective rays.
* The table is always placed at each of the successive stations parallel to the position it occupied at the starting station.
* Plane table is a graphical method of surveying.
* Here, the field work & plotting are done simultaneously & such survey does not involve the use of a field book.
* Plane table survey is mainly suitable for filling interior details when traversing is done by theodolite.
* Traversing by plane table may also be done. But this survey is recomended for the work where great accuracy is not required.

Accessories of a plane table :-

(i) The Plane Table
(ii) The Alidade - (a) Plain Alidade
(b) Telescopic Alidaole
(iii) The spirit level
(iv) The compass - (a) The Trough compass
(b) The circular Box compass
(v) U-fork or Plumbing fork with plumb-bob.

- Plane table surveying is a graphical method of survey in which the field observations & plot are done simultaneously.

Use of Alidade :-

In use, a plane table is set over a point & brought to precise horizontal level. A drawing sheet is attached to the surface & an alidade is used to sight objects of interest.

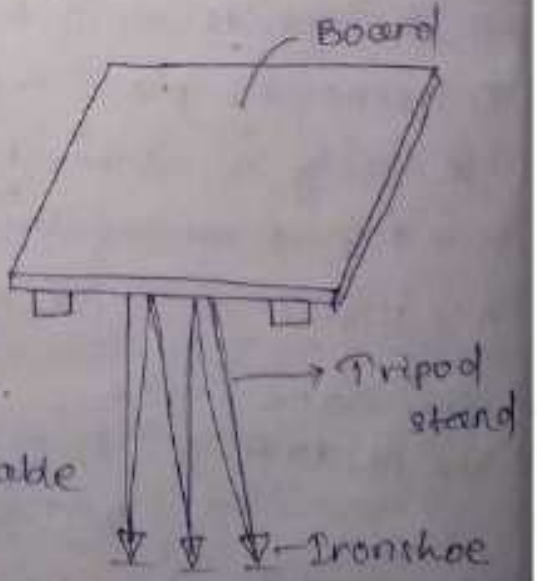
By using the alidade as a surveying level information on the tropography of the site can be directly recorded on the drawing as elevation

bevelled :- reduce to a sloping edge
(a square edge on an object)

Accessories of a Plane table :-

(1) The plane table :-

* The plane table is a drawing board of 750 mm × 600 mm size made of well seasoned wood like 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.



(Plane table)

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* The plane table is meant for fixing a drawing sheet over it.
* The positions of the objects are located on this sheet by drawing rays & plotting to any suitable scale.

(2) The alidade :-

* There are two types of alidade -
  (i) Plain Alidade
  (ii) Telescopic Alidade

(i) Plain Alidade :-

→ The plain alidade consist of a metal or wooden ruler of length about 50 cm.
→ One of its edge is bevelled, & is known as fiducial edge.
→ It consists of two vanes at both ends which are hinged with the ruler. One is known as the object vane & carries a horse hair, the other is called sight vane & is provided with a narrow slit.

(ii) Telescopic alidade :-

→ The telescopic alidade consist of a telescope meant for inclined sight or sighting distant objects clearly.
→ This alidade has no vanes at the ends, but is provided with fiducial (bevelled) edge.
→ The function of the alidade is to sight objects.

The rays should be drawn along the fiducial edge.

(2) The spirit level :-

The spirit level is a small metal tube containing a small bubble of spirit. The bubble is visible on the top along a graduated glass tube.

The spirit level is meant for levelling the plane Table.

(4) The Compass :-

There are two kinds of compass :-

(a) The trough Compass

(b) The circular box compass

(a) The trough Compass :-

The trough compass is a rectangular box made of non-magnetic metal containing a magnetic needle pivoted at the centre. The compass consists of a 'O' mark at both ends to locate the N-S direction.

(b) The circular box compass :-

It carries a pivoted magnetic needle at the centre. The circular box is fitted on a square base plate.

Some times two bubble tubes are fixed at right angles to each other on the base plate. The compass is meant for making the north direction)

of the map.

(5) U-fork or plumbing fork with plumbbob :-

The U-fork is a metal strip bent in the shape of a 'U' having equal arm length. The top arm is pointed & the bottom arm carries a hook for suspending a plumb-bob.

This is meant for centring the table over a station.

Procedure of setting up a plane table over a station :-

(1) Fixing the table on the tripod stand :-

The tripod stand is placed over the required station with its legs well apart. Then the table is fixed on it by a wing nut at the bottom.

(2) Levelling the table :-

The table is levelled by placing the spirit level at different corners & various positions on the table. The bubble is brought to the centre of its run at every positions of the table by adjusting the legs.

(3) Centring the table :-

The drawing sheet is fixed on the table. A suitable point p is selected on the sheet to represent the station P on the ground. A pin is then fixed on this selected point. The upper pointed end of the U-fork is made in contact with

the station pin & the plumb-bob which is suspended from the hook at the lower end is brought just over the station P by turning the table clockwise or anticlockwise or slightly adjusting the legs. This operation is called centring. The table is then clamped.

(4) Marking the north line :-

The trough compass is placed on the right hand top corner with its north end approximately towards the north. Then the compass is turned clockwise or anticlockwise so that the needle coincides exactly with the 0-0 mark. Now a line representing the north line is drawn through the edge of the compass. It should be ensured that the table is not turned.

(5) Orientation :-

When plane table survey is to be conducted by connecting several stations, the orientation must be performed at every successive station. It may be done by a magnetic needle or by the back sighting method. The back sighting process is always ~~prefer~~ preferred, because it is reliable.

During orientation, it should always be remembered that the requirements centring, levelling & orientation must be satisfied simultaneously.

Methods of plane Tabling :-

The following are the four methods of plane tabling :- ⇒ 1. Radiation
2. Intersection
3. Traversing
4. Resection

(1) The Radiation method :-

This method is suitable for locating the objects from a single station. In this method, rays are drawn from the station to the objects & the distance from the station to the objects are measured & plotted to any suitable scale along the respective rays.

Procedure :-

(a) Suppose P is a station on the ground from where the objects A, B, C & D are visible.

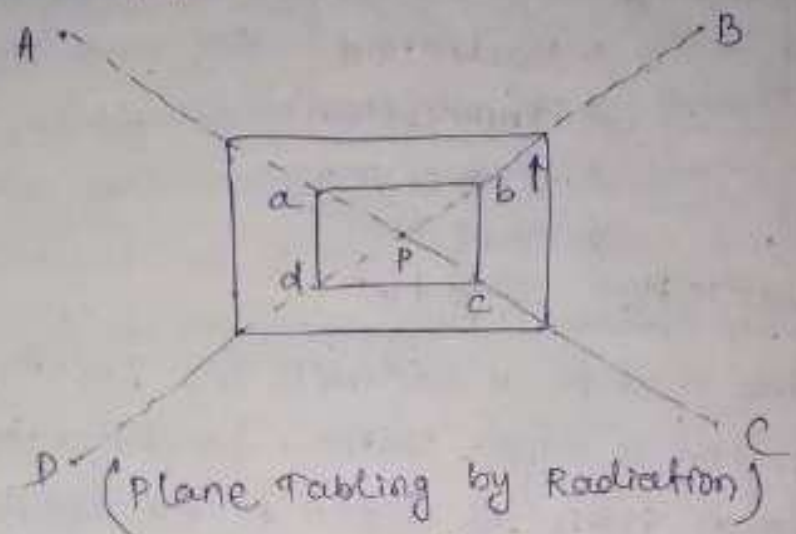
(b) The plane table is set up over the station 'P'. A drawing sheet is fixed on the table, which is then levelled & centred. A point 'p' is selected on the sheet to represent the station 'P'.

(c) The north line is marked on the right hand top corner of the sheet with trough compass or circular box compass.

(d) With the alidade touching p, the ranging rods at A, B, C & D are bisected & the rays drawn.

(e) The distance PA, PB, PC & PD are measured & plotted to any suitable scale to obtain the

points a, b, C & d, representing the objects A, B, C & D on paper.



(Plane Tabling by Radiation)

(2) The Intersection Method :-

This method is suitable for locating inaccessible points by the intersection of the rays drawn from two instrument stations.

Procedure :

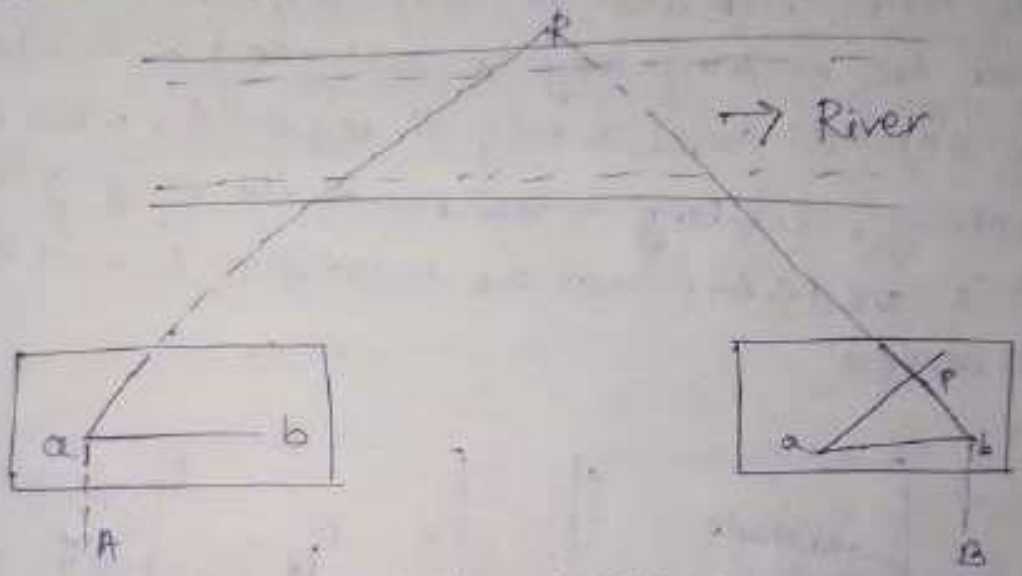
(a) Suppose A & B are two stations & P is an object on the far bank of a river. Now it is required to fix the position of P on the sheet by the intersection of rays, drawn from A & B.

(b) The table is set up at A. It is levelled & centred so that a point on the sheet is just over the station • A. The north line is marked on the right hand top corner. The table is then clamped.

(c) With the alidade touching a, the object P & the ranging rod at B are bisected, & rays are drawn through the fiducial edge of the alidade

(d) The distance AB is measured & plotted to any suitable scale to obtain the point b.

(e) The p Table is shifted & centred over B & levelled properly. Now the alidade is placed along the line 'ba' & orientation is done by backsighting. At this time, it should be remembered that the centring, levelling & orientation must be perfect simultaneously.



(2) Orientation by back sighting :-

→ This method is accurate & is always preferred.

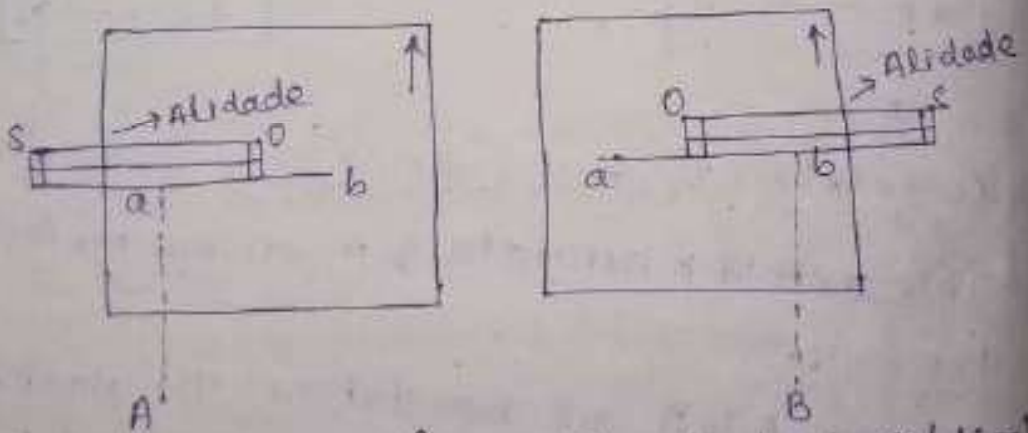
Procedure :-

(i) Suppose A & B are two stations. The plane table is set up over A. The table is levelled by spirit level & centred by U-fork. So that the point 'a' is just over station A. The north line is marked on the right hand top corner of the sheet by trough compass.

(ii) With the alidade touching 'a', the ranging rod at 'B' is bisected & a ray is drawn.

The distance AB is measured & plotted to any suitable scale. So the point 'b' represents station 'B'.

(iii) The table is shifted & set up over 'B'. It is levelled & centred so that 'b' is just over 'B'. Now the alidade is placed along the line 'ba' & the ranging rod at 'A' is bisected by turning the table clockwise or anticlockwise. At this time the centring may be disturbed & should be adjusted immediately if required. When the centring, levelling & bisection of the ranging rod at 'A' are perfect then the orientation is said to be perfect.



(Orientation by back sighting)

S - Sight vane

O = Object vane

Procedure of setting of a plane table over a station:

The following steps have to be performed in order to set up a plane table over a station.

(i) **Fixing the table on the tripod stand** :- The tripod stand is placed over the required station with

its legs well apart. Then the table is fixed on it by a wing nut at the bottom.

(2) Levelling the table :- The table is levelled by placing the spirit level at different corners & various positions on the table. The bubble is brought to the centre of its ~~drawn~~ run at every position of the table by adjusting the legs.

(3) Centring the table :-

→ The drawing sheet is fixed on the table a suitable point 'P' is selected on the sheet to represent ~~the~~ station 'P' on the ground. A pin is then fixed on this selected point. The upper pointed end of the U-fork is made in contact with the station pin & the plumb-bob which is suspended from the hook at the lower end is brought just over the station pin by turning the table clock wise anti clock wise or slidely adjusting the legs. This operation is called centring. The table is then clamped. Care should be taken not to disturb the levelling.

(4) Marking the north line :-

→ The trough compass is placed on the right hand top corner with its north end towards the north. Then the compass is turn clockwise or anticlock-wise so that the needle coincides exactly with the 0-0 mark. Now a line representing the north line is drawn through the edge of the compass. It should be ensured that the table is not turned.

(5) Orientation :-

→ When plane table survey is to be conducted by connecting several stations, the orientation must be perform at each every successive station by the It may be done by a magnetic needle or back sighting method. During orientation, it should always be remember that the requirement of centring, levelling & orientation must be satisfied.

Methods of plane tabling :-

→ Methods of plane tabling are

(1) Radiation
(2) Intersection
(3) Traversing
(4) Resection

(1) Radiation :-

→ This method is suitable for locating the objects from a single station. In this method rays are drawn from the station to the objects & the distance from the stations to the object are measured & plotted to any suitable scale along the respective rays.

(3) The traversing Method :-

→ This method is suitable for connecting the traverse station. This is similar to compass traversing or theodolite traversing. But here, fielding & plotting are done with the help of the radiation & intersection method.

Procedure :-

(1) Suppose A, B, C & D are the traverse stations.

(2) The table is set up at the station A. A suitable point a is selected on the sheet in such a way that whole area may be plotted in the sheet. The table is centred, levelled & clamped. The north line is marked on the right hand top corner of the sheet.

(3) With the alidade touching the point 'a', the ranging rod at B is bisected & a ray is drawn. The distance AB is measured & plotted to any suitable scale. The table is shifted & centred over B. It is then levelled, oriented by back sighting & clamped.

(4) With the alidade touching the point 'b', the ranging rod at 'C' is bisected & a ray is drawn. The distance BC is measured & plotted to the same scale.

(5) The table is shifted & set up at 'C' & the table is centred, levelled & clamped.

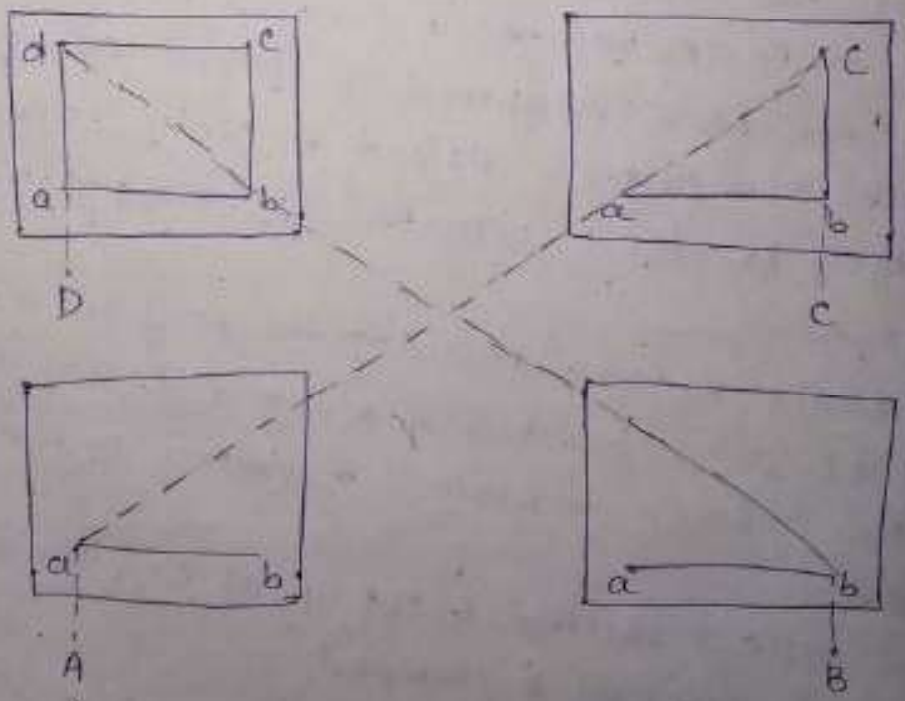
(6) With the alidade touching the point 'c' the ranging rod at D is bisected & a ray is drawn. The distance CD is measured & plotted to the same scale.

(7) In this manner all stations of the traverse are connected.

(8) At the end, the finishing point may not coincide with the starting point & their may be some closing error. This error is adjusted graphically by Bowditch's rule.

(9) After making the correction for closing error, the table is again set up at A. After centring, levelling & orientation the surrounding details are located by radiation.

(10) The table is then shifted & set up at all the stations of the traverse & after proper adjustment the details are located by the radiation & intersection method.



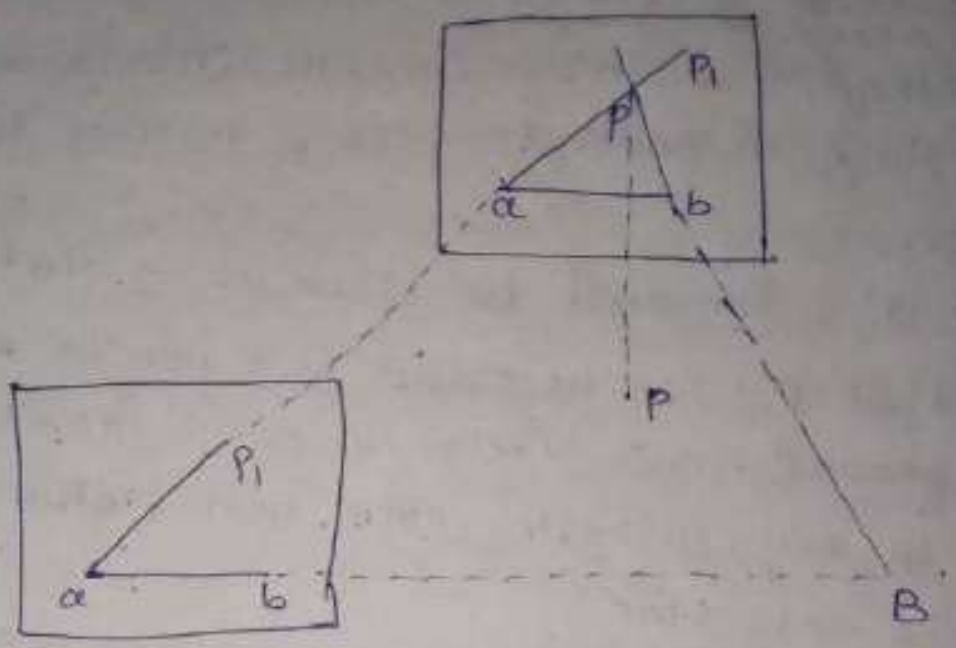
(Plain Tabling by Traversing)

(4) The Resection Method :-

→ This method is suitable for establishing new station at the place in order to locate missing details.

Procedure :-

- Suppose it is required to establish a station at the position P. Let us select two points A & B on the ground. The distance AB is measured & plotted to any suitable scale. This line AB is known the base line.
- The table is set of at A. It is levelled, centred & oriented by bisecting the ranging rod at B. The table is then clamped.
- With the alidade touching the point 'a', the ranging rod at P is bisected & a ray is drawn.
- Then a point P_1 is marked on the ray by estimating with the eye.
- The table is shifted & centred in such a way the P_1 is just over P.
- It is then oriented by back sighting the ranging rod at A.
- With the alidade touching the point P the ranging rod at B is bisected & a ray is drawn. Suppose this ray intersects the previous ray at a point P.
- This point represents the position of the station P on the sheet. Then the actual position 'P' is marked on the ground by U-fork & plumb-bob.



(Plain tabling by Resection)

~~Three point problem~~ :-

Procedure of plane table traversing :-

Equipment required :-

(1) Plane table with tripod stand - 1 no.
(2) Alidade (Plain or telescopic) - 1 no.
(3) Trough compass or Circular box compass - 1 no.
(4) Spirit level - 1 no.
(5) U-fork with plumbob - 1 set
(6) Metric chain - (20 m) - 1 no.
(7) Metallic tape (15 m) - 1 no.
(8) Arrows - 10 nos.
(9) Ranging rods - 3 nos
(10) Wooden pegs - 10 nos
(11) Mallet - 1 nos
(12) Drawing sheet (Good quality) - 1 no.
(13) Board pins or clasp - 4 nos.
(14) Good pencil - 1 no
(15) Eraser - 1 no.
(16) Set square (45°, 60°) - 2 nos

Procedure of field work :-

(1) Reconnaissance :- The area to be surveyed is thoroughly examined through find the best possible way for traversing. The traverse station should cover the whole area & should be intervisible. The provisions for check line should be kept in mind.

(2) Marking the stations :- The selected stations are marked on the ground by wooden pegs. Reference sketches should be prepared for the stations so that they can be easily located in case the station pegs are removed.

(3) Connecting the traverse legs & marking details:-

→ The three point problem :- In this problem three well defined points are selected whose positions have already been plotted on the map. They by perfectly bisecting these three well defined points a new station is established at the required position.

The table is directly placed at the required positi

The problem may be solved by three methods.

(1) The graphical of bessel's method

(2) The mechanical method

(3) The trial & Error method

(1) The graphical method :-

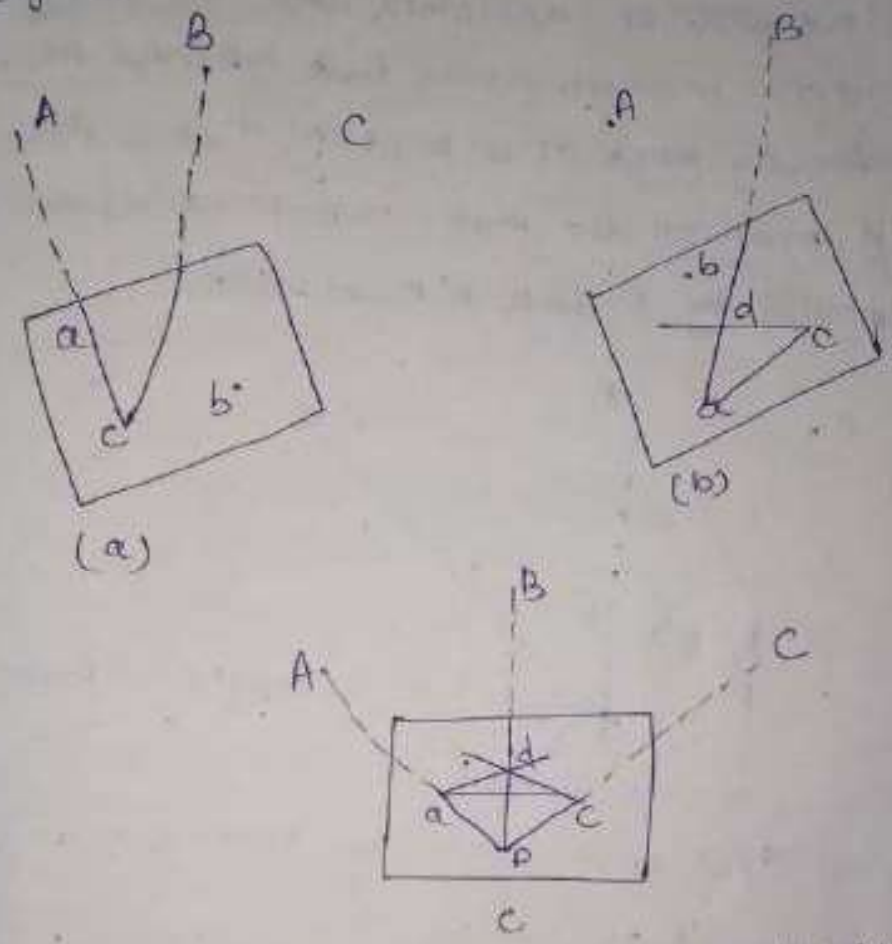
→ Suppose A, B & C are three well defined points which have been plotted as a, b & c. Now it is required to Locate a station at P.

→ The table is placed at the required ~~position~~ station P & levelled The alidade is placed along the line ca & the point A is bisected. The table is clamped. With the alidade centre done C, the point B is bisected & ray is drawn. (Fig- a).

→ Again the alidade is placed along the line BC & the point 'C' is bisected & the table is clamped. With the alidade touching 'a' the point 'B' is bisected & a ray is drawn. Suppose this ray intersect the previous ray at a point 'd'. (Fig- b).

→ The alidade is placed along the line 'db' & the point 'B' is bisected. At this position the table is said to be perfectly oriented. Now the rays Aa, Bb & Cc are drawn. These three rays must meet at a point 'p'.

which is the required point on the map. This point is transferred to the ground by a U-fork & plumb-bob. (Fig-C).



(Solving three point problem graphically)

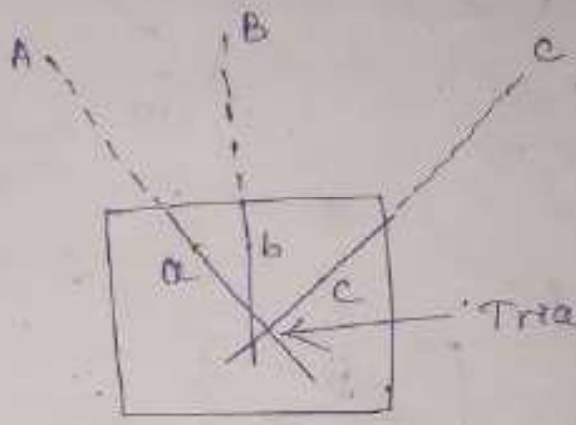
(b) ~~Mechanical~~ The Method of Trial & Error :-

(i) Suppose A, B & C are three well defined points which have been plotted as a, b, & c on the map. Now it is required to establish a station at 'P'.

(ii) The table is set of at P & levelled. Orientation is done by eye estimation.

(iii) With the alidade, rays a Aa, Bb, Cc are drawn. As the orientation is approximate, the rays may not be intersect at a point, But may form a small triangle - the triangle of error.

(iv) To get the actual point, the triangle of error is to be eliminated. By repeatedly turning the table clock wise or anticlock wise the triangle is eliminated in such a way that the rays Aa, Bb & Cc finally meet at a point 'p'. This is the required point on the map. This point is transferred to the ground by U-fork & plumb-bob.



(Solving three point problem by trial & error)

(b) The mechanical method :-

(i) Suppose A, B & C are three well defined points which have been plotted on the mape as a, b & c. It is required to locate a station at 'P'.

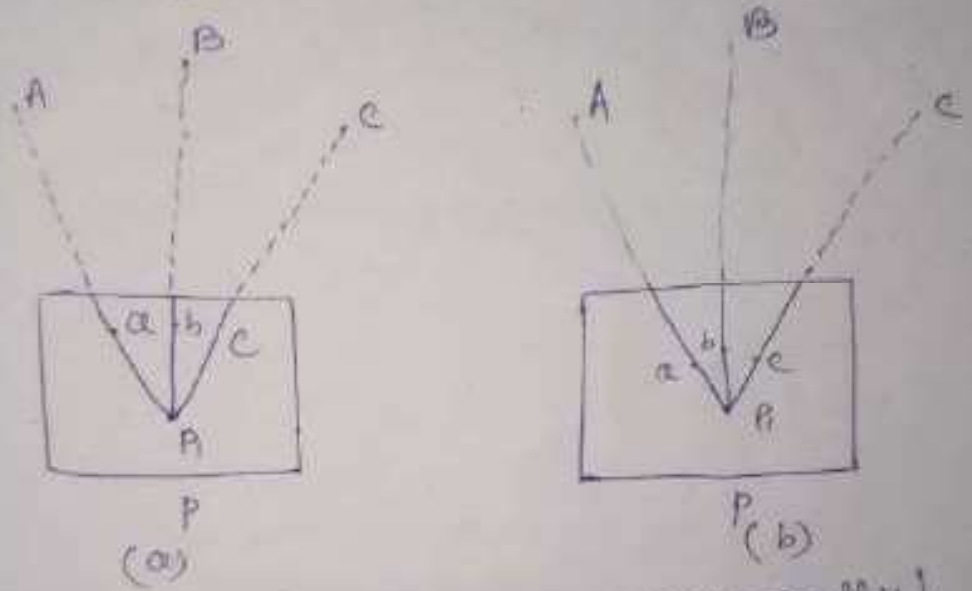
(ii) The table is placed at 'P' & levelled. A tracing paper is fixed on the map & a point 'p' is marked on it.

(iii) With the alidade centre done 'p', the points A, B & C are bisected & rays are drawn. These rays may not pass through the points a, b & c as the orientation is done approximately

(iv) Now the tracing paper untastened & moved about over the map in such a way that three rays

pass through the plotted position a, b & c. Then the point 'p' is pricked with a pin to give an impression 'p' on the map. 'p' is required point on the map. The tracing paper is then removed.

(v) Then the alidade is centre done 'p' & the rays are drawn towards A, B & C. These rays must pass through the point a, b & c.



(Solving three point Problem Mechanically)

LEVELLING

Levelling is the branch of surveying which deals with determination of position of the point (height or depth) with respect to a datum line using levelling instruments.

Some definations:-

Level surface :-

→ A level surface is defined as curved surface which at each point is perpendicular to the direction of gravity at the point.

Example :- The surface of a still water is truely a level surface.

Level line :-

→ A level line is a line which lies on the level surface.

Horizontal plane :-

→ It is a plane through a point tangential to the level surface at that point.

Horizontal line :-

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

Vertical line :-

→ It is the line normal to the level line at a point.

Datum :-

→ Datum is any surface whose elevations are known. The mean sea level (MSL) is a convenient datum world over & elevations are commonly given as so much above or below sea level.

Elevation :-

→ The elevation of a point on or near the surface of earth is its vertical distance above or below an arbitrarily assume level surface or datum.

Vertical angle :-

→ It is an angle between two intersecting lines in a vertical plane.

Mean sea Level (MSL) :-

→ MSL is the average height of the sea for all stages of tides. At a perticular place it is derived by averaging the hourly tide heights over a long period of 19 years.

Bench mark :-

→ It is a relatively permanent point of reference whose elevation with respect to assume datum is known. It is generally the starting point or the end point for levelling to check the correctness.

Methods of levelling :-

There are mainly three types of levelling.

(1) Barometric levelling.
(2) Trigonometric levelling
(3) Spirit levelling

(1) Barometric levelling :-

→ It makes the use of phenomenon that the difference in elevations between two points is proportional to the difference in atmospheric pressure at these two points.

→ A barometer is generally used for taking observations.

→ This method is relatively inaccurate hence is little used in surveying work. Except on reconnaissance or exploratory surveying.

(2) Trigonometric levelling (Indirect levelling)

→ It is the process of levelling in which the elevations of points are computed from the vertical angles & the horizontal distance measured in the field using proper trigonometric relations.

(3) Spirit levelling or direct levelling :-

→ It is a type of levelling in which the vertical distances with respect to a horizontal line may be used to determine the difference in elevation between two adjascent point.

→ Here a spirit level & a sighting device (telescope) are combined & vertical distances are measured by observing on a graduated rod placed on that point. This is known as direct levelling.

Levelling instruments :-

→ The levelling instruments is commonly used are

(1) A level
(2) A levelling staff

(1) A level :-

→ The purpose of a level is to provide a

horizontal line of sight. A level consists of following parts.

(i) A telescope to provide a line of sight.

(ii) A level tube to make the line of sight horizontal.

(iii) A levelling head (tribrach & trivet) to bring the bubble in the centre of the run.

(iv) A tripot to support the instrument.

Their are mainly four types of levels.

(i) Dumpy level

(ii) Wye level

(iii) Reverseble level

(iv) Tilting level.

(i) Dumpy level :-

→ The dumpy level originally designed by gravatt.

→ It consist of a telescope tube firmly secured in two collars fixed by adjusting screws to the stage carried by vertical spindle.

→ The modern corn of dumpy level as the telescope tube & the vertical spindle cast in one piece & the long bubble tube is attached to the top of the telescope. This form is known as solid dumpy.

→ The name dumpy level originated form the fact that formorly this level was equipet with inverting eye piece & was shorter than the wye level of the same magnifying power.

→ In some of the instrument a clamp screw is provided to control the movement of the spindle about the vertical axis. For the precise moment a slow motion screw or the tangent screw is also provided.

→ The levelling head consist of two parallel plates with either 3- foot screws & four - screws. The upper plate is called tribrach & the lower plate is called trivet which can be screw on to a trivet.

Advantages :-

→ Simpler construction with fewer movable parts.

→ Fewer adjustment to be made.

→ Longer life of the adjustment.

(ii) Wye level (Y) :-

→ The difference between dumpy level & Wye level is that in case of dumpy level the telescope is fixed to the spindle while

in case of wye level the telescope is carried in two vertical wye supports.

→ The wye supports consist of curved clips.

→ If the clips are raised the telescope can be rotated in the wyes & turn end to end.

→ If clips are fastand the telescope is held from turning about its axis by a lug from one of the clips.

→ The bubble tube may be attached to the telescope curve to the stage carrying the wyes.

→ Advantages :-

→ Adjustment can be tested with greater rapidity & ease.

→ Adjustment do not have longer life & are disturbed more frequently due to large no. of movable parts.

(iii) Reversible level :-

→ It combines the features of both dumpy level & wye level.

→ The telescope is supported by two rigid sockets into which telescope can be introduced from either end & then fixed in position by a screw.

→ The sockets are rigidly connected to the spindle through a stage. Once the telescope is pushed into the sockets & screw is tightened the level acts as a dumpy level.

→ For testing & making the adjustment, the screw is slackened & the telescope can be taken off & reversed end for end.

→ The telescope can also be turned with in the sockets about the longitudinal axis.

(iv) Tilting level :-

→ The line of sight can be tilted slightly without tilting the vertical axis.

→ The line of sight & the vertical axis need not be exactly perpendicular to each other.

→ The instrument is level roughly by three foot screws with respect to the bubble tube or a two a small circular bubble, thus making the vertical axis approximately vertical.

→ While taking the sight to a staff the line of sight is made exactly horizontal by centering the bubble by means of a fine pitched tilting screw which tilts the telescope with respect to the vertical axis.

→ It is mainly designed fre pre-size levelling.

Advantages :-

→ Levelling can be much quicker.

→ Many readings can be taken with one instrument setting.

(2) Levelling staff :-

→ Levelling staff is a straight rectangular rod having graduations, the foot of the staff representing zero reading.

→ The purpose of a level is to establish a horizontal line of sight.

→ The purpose of levelling staff is to determine the amount by which the station is above or below the line of sight.

→ Levelling staff is divided into two types.

(1) Target staff

(2) Self reading staff

(2) Self reading staff :-

→ This is one which can be read directly by the instrument men through the telescope.

→ There are three types of self reading staff.

(i) Solid staff

(ii) Folding staff

(iii) Telescopic staff

→ The solid staff is in english units or in metric units having the smallest division is 0.01 ft or 5mm

→ The staff is generally made of seasoned wood having a length of 10 ft or 3 mtrs.
→ The folding staff is usually 10 ft long having a hing at the middle of its length.
→ When not in use, the rod can be folded about the hing. So that it becomes convenient to carry it to the one place to another place.
→ Since a ~~bed~~ self reading staff is always seen through telescope all readings appear to be inverted. So reading are taken from above downwards.
→ The levelling staff graduated in english units generally have whole no. of feet, marked in red to the left ~~sight~~ of the staff.
→ The odd length of the ft are marked in black to the right hand ~~right~~ sight.
→ In case of telescopic staff the central box slides into lower box. In the 5 m staff, the three corresponding lens are usually 1.5 m, 1.5 mm & 2 m.

(1) Target staff :-

→ It consist of two sliding length of approximately 7 ft. & 6 ft.
→ The rod is graduated in ft. 10th & 100th & the vernier of the target enables the readings to

be taken up to 1000th ~~part~~ part of a feet.

→ For readings below 7ft the target is slided to lower part & for readings above that the target is fix to the 7ft mark of the upper length.

→ For taking the readings the level man directs the staff man to raise or lower the target till it is bisected by the line of sight.

→ The staff man then clamps the target & takes the reading.

→ The upper part of the staff is graduated from to down words.

Self reading staff	Target staff
(i) Reading can be taken ~~bo~~ quicker.	(i) Readings can be taken slower.
(ii) Ordinary man can hold the staff by just keeping the staff in plumb.	(ii) The duties of staffman & level man requires more training.
(iii) Readings can be taken with lower accuracy.	(iii) Readings can be taken with greater accuracy.

Temporary adjustment of level :-

→ Each surveying instruments needs two type of adjustment.

(i) Temporary adjustment

(ii) Permanent adjustment

→ Tempory adjustments are those which are made at each instrument setting & preparatory to take

Observation with the instrument.

→ Temporary adjustment of a level consists of the following steps.

(i) Setting of the level

(ii) Levelling off

(iii) Elimination of parallax.

(i) Setting of the level :-

→ The operation of setting off includes fixing the instrument over the tripod stand & levelling the instrument approximately by leg adjustment.

→ To fix the level on the tripod, the clamp is released, instrument is held in the right hand & is fixed on the tripod by turning round the lower part with the left hand.

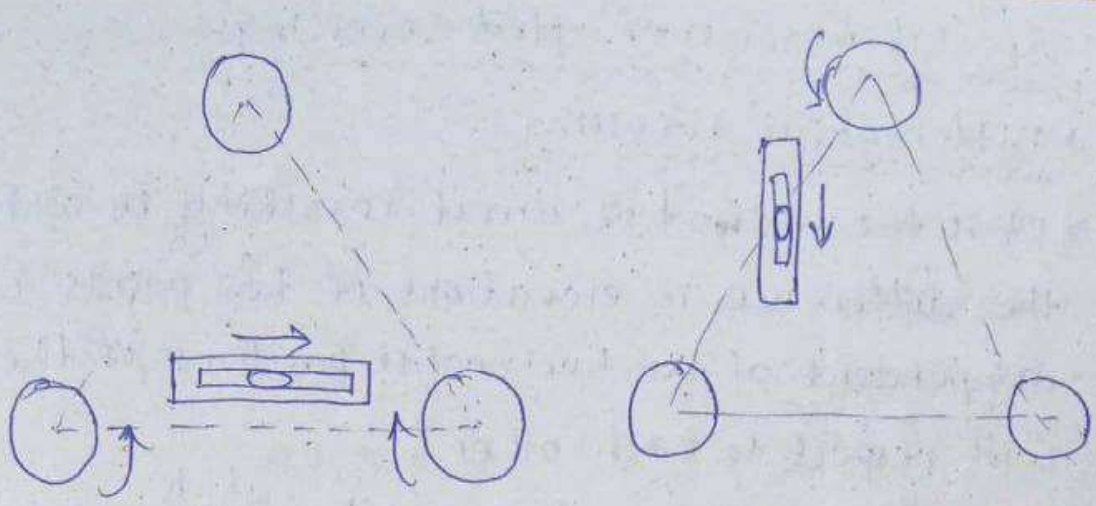
→ The tripod legs are so adjusted that the instrument is at a convenient height & the tribrach is approximately horizontal.

(ii) Levelling off :-

→ After setting off the instrument accurate levelling is done with the help of foot screws & with reference to the plate levels.

→ The purpose of levelling is to make the vertical axis truely vertical.

→ The levelling of the instrument can be done either with three foot screws or four foot screws



Step - I

Step - II

Elemination of parallax:-

→ Parallax is a condition arises when the image form by the objective is not in the plane of cross hairs.

→ Unless parallax is eliminated, accurate sighting is impossible.

→ This can be eliminated by focusing the eye piece for distinct vision of the cross hairs & by focusing the objective to bring the image of object in the plane of cross hairs.

Spirit levelling:-

→ A level provides horizontal line of sight that means a line tangential to the level surface at the point where the instrument stands.

→ The difference in elevation between two stations is the vertical distance between two level lines. This is called the theory of direct levelling or spirit levelling.

Special methods of spirit levelling:-

(1) Differential levelling:-

→ It is the method of direct levelling in which the difference in elevations of two points is independent of the horizontal positions of the points with respect to each other.

→ When the points are far apart, ~~with~~ which may be necessary to set up the instrument several times. This is known as fly levelling.

(2) Profile levelling:-

→ It is a method of direct levelling in which determination of elevations of points at major intervals along a given line in order to obtain a profile of the surface along that line.

(3) Cross sectioning:-

→ It is also known as cross levelling.

→ It is the process of taking levels on each sight of the main line at right angles to that lines. In order to determine the vertical cross section of the surface of the ground or under line strata.

(4) Reciprocal levelling:-

→ It is the method of levelling in which the difference in elevations between two points

is accurately determined by two sets of reciprocal observations when it is not possible to set up the level between the two points.

(5) Precise levelling:-

→ It is the levelling in which the degree of precision required is too great to be attained by ordinary methods & in which special improvement or special precautions or both are necessary to eliminate as far as possible.

Station:-

→ Station is a point where the levelling staff is held.

Height of the instrument (HI):-

→ For any set of level the HI is the elevation of the plain of sight with respect to assume datum.

Back Sight (BS):-

→ It is the sight taken ~~from~~ on the staff held at a point of known elevations to ascertain the amount by which the line of sight is above that point & to determine the HI.

→ It is also called plus sight. Because the BS is always added to the level of the datum to get the HI.

Fore sight (FS) :-

→ It is the sight taken on the staff held at a point of unknown elevation to determine the amount by which the point is below the line of sight & to obtain the elevation of the station.

→ It is also called the minus sight, because FS is always subtracted from the HI to get the elevation of that point.

Turning point (TP) / change point (CP) :-

→ It is a point on which both minus sight & plus sight are taken on the line of direct levels.

Intermediate stations (IS) :-

→ It is a point or points intermediate between two turning points on which only one sight is taken to determine the elevation of the stations.

~~Differential levelling :-~~

Booking of the levels :-

→ There are two methods of booking of the levels from the observe staff readings.

(i) Collimation or Height of instrument method

(ii) Rise & fall method.

(i) Height of instrument method :-

Proforma (HI method) :-

Station	BS	IS	FS	HI	RL	Remark

This table is correct if sum of BS - sum of FS = Last RL - ~~first~~ First RL.

(ii) Raise & fall method :-

Station	BS	IS	FS	Rise	Fall	RL	Remark

This is correct if sum BS - sum FS = sum Rise - Sum of fall = Last RL - First RL.

Comparison of the two methods :-

→ The HI method is more rapid, less tedious & simple. However the raise & fall method is more tedious but provides a full check in calculation for all sights.

Q. The following staff readings where observed successively with a level, the instrument have been moved after 3rd, 6th, 8th readings. The readings are 2.228, ~~0.602, 1.982, 1.044~~, ~~2.684 m~~. 1.606, 0.988, 2.090, 2.864, 1.262, 0.602, 1.982, 1.044, 2.684 m. Enter the above readings in a page of level book & calculate the RL of points if the 1st reading was taken with a staff held on a benchmark of 432.384 m.

Ans- HI method :-

Station	BS	IS	FS	HI	RL	Remark
A	2.228			434.612	432.384	TBM
B		1.606		434.612	433.006	
C	2.090		0.988	435.714	433.624	TP-1
D		2.864		435.714	432.85	
E	0.602		1.262	435.054	434.452	TP2
F	1.044		1.982	434.116	433.072	TP-3
G			2.684	434.116	431.432	
ΣBS = 5.964		ΣFS =	6.916			

ΣBS - ΣFS = Last RL - First RL

⇒ 5.964 - 6.916 = 431.432 - 432.384

⇒ - 0.952 = 0.952

RL + BS = HI

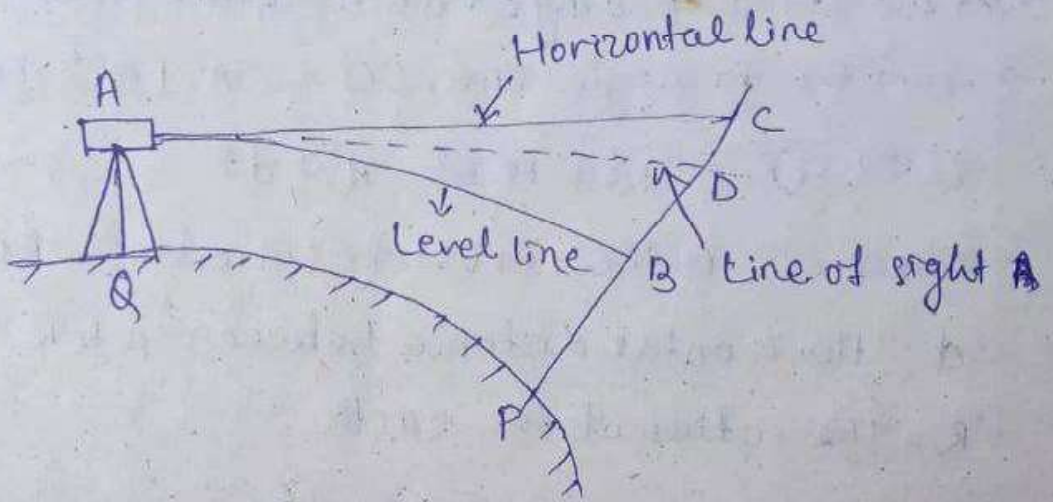
Raise & fall method :-

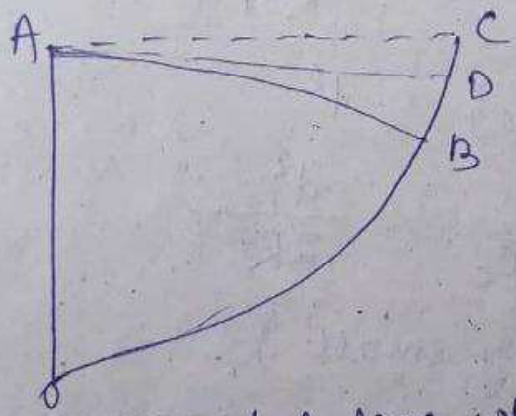
Station	BS	IS	FS	Rise	Fall	RL(m)	Remark
A	2.228					432.384	TBM
B		1.606		0.622		433.006	
C	2.090		0.988	0.618		433.624	
D		2.864			0.774	432.85	
E	0.602		1.262	1.602		434.452	
F	1.044		1.982		1.38	433.072	
G			2.684		1.64	431.432	
	5.964		6.916	2.842	3.794		

Curvature & refraction :-

→ The horizontal line departs from the ~~table~~ level surface due to curvature of the earth. For long sights, the horizontal line of sight does not remain straight but it slightly bends downwards having concavity towards the earth surface due to refraction.

Curvature correction (Cc) :-





→ AC is the horizontal line which deflects from the level line AB by an amount BC. AD is the actual line of sight. BC is called departure from the level line.

→ Actually the staff reading at B, where the level line cuts the staff. But since the level provides only the horizontal line of sight, the staff reading is taken at C. in the absence of refraction.

→ Thus the apparent staff reading is more & therefore the object appear to be lower then it really is.

→ The correction for curvature is thus -ve as applied to the staff reading which is equal to BC.

→ From the triangle OAC, $OC^2 = OA^2 + AC^2$

$\Rightarrow (R + C_c)^2 = R^2 + d^2$

where C_c is the curvature correction = BC

d = Horizontal distance between A & B.

R = The radius of the earth.

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

$\Rightarrow C_c(2R + C_c) = d^2$

$\Rightarrow C_c = \frac{d^2}{2R + C_c} = \frac{d^2}{2R}$

(∵ C_c is very small).

If d is in Km & R = 6370 Km then

$$\boxed{C_c = 0.07857\, d^2 \text{ m}}$$

Refraction correction (C_R) :-

→ The effect of refraction is the same as if the line of sight was curved downward or concave towards the earth surface & hence the staff reading is decreased.

→ So the effect of refraction is to make the object appear higher then they really are.

→ So the correction applied to the staff reading is +ve.

→ The C_R is irregular because of the atmospheric condition. Hence the refraction curve is assume to have a diameter about 7 times then that of the earth.

Mathematically,

$$C_R = \frac{1}{7} \times C_c = 0.01122\, d^2 \text{ m}$$

where d is in KM.

- Combined correction for due to curvature & Refraction.

$$C = \frac{d^2}{2R} - \frac{1}{7} \times \frac{d^2}{2R} = \frac{6}{7} \times \frac{d^2}{2R}$$

$$= 0.068735\, d^2$$

where d is in KM. (subtractive)

Q. Find the C_c & C_R for a distance of 1200 m. Also find the combined correction.

Soln :- $d = 1200 \text{ m} = 1.2 \text{ KM}$

$C_c = 0.07857\, d^2 = 0.07857 \times 1.2^2 = 0.094 \text{ m}$

$C_c = 0.07857 \times d^2$

$= 0.07857 \times (1.2)^2$

$= 0.113$ m

$C_e = 0.01122 \times d^2$

$= 0.01122 \times (1.2)^2$

$= 0.016$ m

$C = 0.06735 \times (1.2)^2$

$= 0.096$ m

Q. In order to find the difference in elevation between two points P & Q, a level was setup on the line PQ, 60 m from P & 1280 m from Q. The readings obtained on the staff kept at P & Q where 0.545 m & 3.920 m. Find the true difference in elevation between P & Q.

Sol^n:- For Point P, $d = 60$ m

For Point Q, $d = 1280$ m

Combined correction for Q

$C_c = 0.06735 \times (1.28)^2$

$= 0.11$ m

The correct staff reading at Q $= 3.92 - 0.11$

$= 3.81$ m

So the difference in elevation between P & Q

$= 3.81 - 0.545$ m $= 3.265$ m

Q being lower.

Q. A light house is visible just above the horizon at a certain station at the sea level. The distance between the station & the light house is 50 KM. Find the height of the light house.

Sol^{n} $d = 50$ KM

$C = 0.06735 \times 50^2 = 168.375$ m

Reciprocal Levelling :-

→ When it is necessary to carrying levelling across a river or any obstacle requiring a long sight between two points so situated that no place for the level can be found from which the length of fore sight & back sight will be approximately equal. In that case a special method called reciprocal levelling must be used to obtain accuracy & to eliminate the following.

(i) Error in instrument adjustment

(ii) Combined effect of curvature & retraction of the atmosphere &

(iii) variation in average retraction

Mathematical formula :-

Let A & B be the points & observations being made with a level, the line of sight of which is inclined upward. when the bubble is in the centre of the run.

→ The level is set up at a point near A & staff readings are taken on A & B.

→ Then the level is shifted to the other bank of the river & the level is set up on a point near B & the readings are taken on the staff held at B & A.

→ Let h_a & h_b be the corresponding staff readings on A & B for the 1st set of level & $h_{a'}$ & $h_{b'}$ be the readings for 2nd set. Then the true difference in elevation of the levels between A & B is equal to $H = \frac{1}{2}[$

$$H = \frac{1}{2}\left[\{h_a - h_b\} + \{h_{a'} - h_{b'}\}\right]$$

Q. In levelling between two points A & B on the opposite banks of a river, the level was setup near 'A', the staff reading on A & B were 1.285 & 2.860 m respectively. The level was then moved to be at respective readings on A & B were 0.860 & 2.220 m. Find the true difference of level between A & B.

Sol^n = For level near A,

$h_a = 1.285$ m (A being higher)

$h_b = 2.860$ m

For level near B,

$h_{a'} = 0.860$ m (A being heigher)

$h_{b'} = 2.220$ m

True difference in level = $\frac{1}{2}\{(h_a - h_b) + (h_{a'} - h_{b'})\}$

~~$= \frac{1}{2}\{1.285 - 2.860$~~

$= \frac{1}{2}\{(h_b - h_a) + (h_{b'} - h_{a'})\}$

$= \frac{1}{2}\{(2.860 - 1.285) + (2.220 - 0.860)\}$

$= 1.467$ m (A being higher)

Profile levelling or longitudional sectioning :-

→ It is the process of determining the elevations of points at short measure interval along a fixed line such as the centre of the railway, roadway, canal or sewer.

→ The fixed line may be a single straight line or may be composed of succession of straight line or a series of straight lines connected by curves which is called as longitudional sectioning.

→ From the profile levelling, the field engineer is able to study the relationship between the existing ground surface & the levels of the proposed construction in the direction of its length

Plotting the profile :-

→ The profile is usually plotted on a specially prepared profile paper.

→ On this paper the vertical scale is much

higher than the horizontal scale.

→ The horizontal distances are plotted along the horizontal axis with some convenient scale & the distances are also marked.

→ The elevations are plotted along the vertical axis.

→ Each ground point is plotted by two coordinates, one is horizontal other is vertical.

→ The various point so obtained are joint by straight lines to get the profile.

Cross-sectioning :-

→ Cross-sections are ren at right angles to the longitudional profile & on either sides of it for the purpose of lateral outline of the ground surface.

→ They provide the data for estimating quantities of earthwork & for other purposes.

→ The cross sections are numbered consecutively from the commencement of the centre line & are set out at right angles to the main line of the section with the chain & tape.

→ The length of the cross-section depends upon the nature of the work.

→ The left & the right of the centreline, the levels are taken for the cross-section at equal spacing.

Plotting the cross-section :-

→ Cross-sections are plotted almost the same manner as Longitudional section (Ls) except in this case both the scales are kept equals.

→ The points on the longitudional section the Ls is plotted at the centre of the horizontal axis.

→ The points to the left of the centre are plotted to the left & those to the right are plotted to the right. The point so obtained are joint by straight lines.

Levelling problems :-

→ Following are some of the difficulties are commonly faced in levelling.

(i) Levelling on steep slope
(ii) Levelling on summits & hollows
(iii) Taking level of an over head point.
(iv) Levelling across ponds & lakes
(v) Too wide to be sighted across
(vi) Levelling across river
(vii) Levelling passed high wall

→ ~~When~~ levelling passed high wall :-

→ When the height of the wall above the line of collimation or line of sight is more than the length of the staff, a suitable mark is made at

the height where the line of sight intersects the face of the wall.

→ The vertical distance between the mark & the top of the wall is measured.

→ Hence the RL of the top of the wall is known.

→ The instrument is then set on the other side of the wall & a similar mark at the collimation level is made on the wall.

→ The vertical height of the top of the wall is measured from the mark & the HI of the instrument is calculated.

Errors in levelling:-

→ All the levelling instruments & measurements are subjected to three principal sources of errors

1) Instrumental errors
2) Natural errors.
3) Personal errors.

1) Instrumental errors :-

→ It includes errors due to imperfect adjustment.
→ Errors due to sluggish bubble.
→ Error due to moment of objective slide.
→ Staff not of standard length.
→ Error due to defective joint.

2) Natural Error :-

→ It includes earths curvature.
→ Refraction.

→ Variation of temperature.
→ Settlement of the tripod on turning point.
→ Wind vibrations.

3) Personal error :-

→ It includes
(i) Mistake in manipulation.
(ii) Rod handling.
(iii) Mistake in reading the staff
(iv) Errors in sighting.
(v) Mistake in recording.

The level tube or the bubble tube :-

→ The bubble tube gives the direction of horizontal plane because the surface of a steel liquid at all points is at right angles to the direction of gravity.
→ Hence the liquid will alone provide a level surface.
→ The bubble tube consists of a glass partially filled with a low viscosity liquid like alcohol, chloroform or sulphuric either, the inner surface of which is carefully ground so that a longitudional section of it by a vertical plane through the axis of the tube is part of circular arc.
→ The tube is graduated on its upper surface &

is enclosed by a metal casing.

Sensitiveness of bubble tube :-

→ It is defined as the angular value of one division of the bubble tube.

→ The linear value of one division is generally 2mm.

→ Sensitiveness is otherwise called sensitivity.

Mathematically,

$$S = \frac{n l D}{R}$$

Where, D = Distance bet^n the staff & instrument.

S is the difference of staff readings.

$\frac{nl}{R}$ = α = sensitivity of the bubble tube

l = Length of the 1 division of bubble tube

R = Radius of curvature of the bubble tube

n = No. of divisions deviated by the bubble

Again $\alpha = \frac{s}{nD} \times 206265$ second

→ The sensitivity depends upon Radius of curvature diameter of the ab tube, Length of the bubble & viscosity & surface tension of the liquid of the bubble tube.

→ Larger the radius, larger the diameter, larger is the sensitivity. Lower the viscosity & surface tension of the liquid greater A is the sensitivity

→ A very smooth internal surface of the bubble tube increases sensitivity.

Q. The reading taken on a staff 100 m from the instrument with the bubble central was 1.872m The bubble is then moved 5 divisions out of the centre & the staff reading is observed to be 1.90 m. Find the angular value of one division of the bubble & radius of curvature of bubble tube. The length of one division of bubble is 2 mm.

Sol^{n}

$$S = \frac{nlD}{R}$$

$$S = 1.906 - 1.872 = 0.034 \text{ m}$$

$$n = 5$$

$$l = 2\text{mm} = \frac{2}{1000} \text{ m}$$

$$D = 100 \text{ m}$$

$$S = \frac{nlD}{R}$$

$$\Rightarrow R = \frac{nlD}{S} = \frac{5 \times 0.002 \times 100}{0.034}$$

$$= 29.41 \text{ m}$$

~~$\alpha = \frac{S}{nD} \times 206265$~~

Angular value of one division of bubble tube = sensitivity.

$$\alpha = \frac{S}{nD} \times 206265 = \frac{0.034}{5 \times 100} \times 206265$$

$$= 14.02 \text{ second}.$$

Chapter-2 CONTOURING

Contour :-

→ Contour is an imaginary line on the ground joining points of equal elevation.

Contour interval :-

→ The vertical distance between any two consecutive contours is called contour intervals.

→ The contour interval is kept constant for a contour plan. Otherwise the general appearance of the map will be misleading.

Horizontal equivalent :-

→ The horizontal distance between two consecutive contours is called horizontal equivalent.

→ It depends upon the steepness of the ground.

Factors affecting contour interval :-

1) Nature of the ground :-

→ For flat ground a smaller interval is require

→ If the ground is mostly undulated then highe contour interval may be used otherwise contou will come close to each other.

2) Scale of the map :-

→ If the scale of the map is small, contour

interval will be large & vice versa.

3) Purpose & extent of survey :-

→ If the survey is intended for detailed design works, a smaller contour interval may be used.

→ In case of location surveys, for lines of communications, for reservoirs & drainage works, where the extent of survey is large a large contour interval is used.

4) Time & expense :-

→ If the time available is less greater contour interval is taken.

→ If time & money is not a factor then smaller contour interval is used.

IMP Characteristics of contour :-

→ The following characteristics features may be used while plotting or reading a contour plan.

(i) Two contour lines of different elevations never cross each other. They intersect only in case of over hanging cliff.

(ii) Contour lines of different elevation can unite to form one line only in the case of a vertical cliff.

(iii) Contour lines close together indicate steep slope. If ~~for~~ they are far apart it indicates

a gentle slope. If there equally spaced it indicates uniform slope. A series of straight parallel & equally spaced contours represent a plaine surface.

(iv) A contour passing through any point is perpendicular to the line of steepest slope at that point.

(v) Two contour lines having same elevations can not unite & continue as one line. Similarly a single contour can not split into two lines.

(vi) A contour line must close upon itself, not necessarily within the limits of the map.

(vii) Contour lines cross a watershed or ridge line at right angles. They form curves of v-shape round it with concave sight of the curve towards the higher ground.

(viii) Contour lines cross a valley line at right angles. They form sharp curve of V shape across it with convex sight of the curve towards the higher ground.

(ix) The same contour appears on either sight of a ridge or valley for the highest horizontal plane that intersects the ridge must cut it on both sites.

(x) A closed contour line with one or more higher ones inside it represented a hills. similarly a closed contour lines with one or more lower ones inside its indicates a dipression without any outlet.

Methods of locating contour :-

1) Direct method
2) Indirect method

→ The location of a point in topography survey involves both horizontal & vertical control.
→ The field method may be divided into two classes. 1) Direct method 2) Indirect method

1) Direct method :-

→ In this method contours are actually plotted on the ground.
→ Here only those points are surveyed, which happened to be plotted.
→ It involves two fold field work
(i) Vertical control
(ii) Horizontal control

(i) Vertical control :-

→ The points on the contour are fressed either with the help of a level & staff or with the help of a hand level.

→ In the former case, the level is set at a point to command as much area as possible & is levelled.

→ The staff is kept on the bench mark & HI is determined.

→ Having known HI, the staff reading is calculated so that the bottom of the staff is at an elevation equal to the value of the contour.

(ii) Horizo

→ The staff man should be inserted to insert a twig at the point thus located.

→ The twig must be split to receive a piece of paper on which RL of the contour should be written.

(iii) Horizontal control :-

→ After having locating the points on various contours, they are to be surveyed using chain surveying, theodolite traversing or plane tabling.

→ In this case for small areas & from the nature of the works suitable control system is use.

2) Indirect method :-

→ In this method, some guide points are selected along a system of straight line & their

elevations are found.
→ The points are then plotted & contours are then drawn by interpolation.
→ While interpolating it is assume that the slope between any two adjacent guide point use uniform.
→ For locating the ground points, the area to be surveyed is divided into no.s of squares or nos of rectangles.
→ The size of the square or rectangle depends upon the nature of the contour & contour interval.
→ The elevations of the corners of the square or rectangle are determined with the help of level & staff.
→ The contour lines may then be drawn by interpolation.
→ When there are appreciable breaks in the surface between corners additional guide points may also be used. This method is also known as spot levelling.
→ Contours can also be plotted by using cross-sections that are run transverse to the centre line of a road, railway or canal.
→ The spacing of the cross section depends upon the character of the terrain, contour interval

& purpose of survey.

→ The cross sections & the points can be plotted & the elevation of each point is mark.

→ The contour lines are interpolated on the assumption that there is uniform slope bet^n two points on two adjacent contour.

→ In case of hilly terrain the tacheometric meth may be used.

Interpolation of contour :-

→ It is the process of spacing of contour proportionately between plotted ground points establish by indirect method.

→ The methods of interpolation is based on the assumption that the slope of ground between the two points is uniform.

→ There are three main methods for interpolation

(i) By estimation (Extreamly rough & used for small work).

(ii) Arithmetic calculation (More accurate but time consuming)

(iii) By graphical method (interpolation is done with the help of tressing paper or tressing cloth).

Contour gradient :-

→ It is a line lying through out on the surface of ground & preserving a constant inclination to the horizontal.

→ If the inclination of such line is given, its direction from a point may be easily located either in the map or in the ground.

→ To locate a contour gradient in the field, clenometer, a theodolite or a level may be used.

Uses of contour map :-

→ Following are some of the uses of contour maps.

(i) Drawing of sections → Gives idea about general shape of the ground & it is used for earthwork calculation.

(ii) Determination of intervisibility ~~of~~ between two points - determine the intervisibility of trangulation stations.

(iii) Tressing of contour gradient & location of roude - useful in locating the roude of highway, railway, canal or any communication line.

(iv) Measurement of drainage area -

(v) Calculation of reservoir capacity - using

trapezoidal rule or prismoidal rule.

$$V = \frac{h}{2}(A_1 + 2(A_2 + A_3 + \cdots + A_{n-1}) + A_n) \quad \text{(Trapezoidal)}$$

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

(Prismoidal rule)

(vi) Intersection of surface & measurement of earth work.

Where,

A_1, A_2, A_3 are the area enclosed by a single contour of perticular RL.

h is the contour interval.

v is the volume of the reservoir.

Chapter-3 THE THEODOLITE

Introduction :-

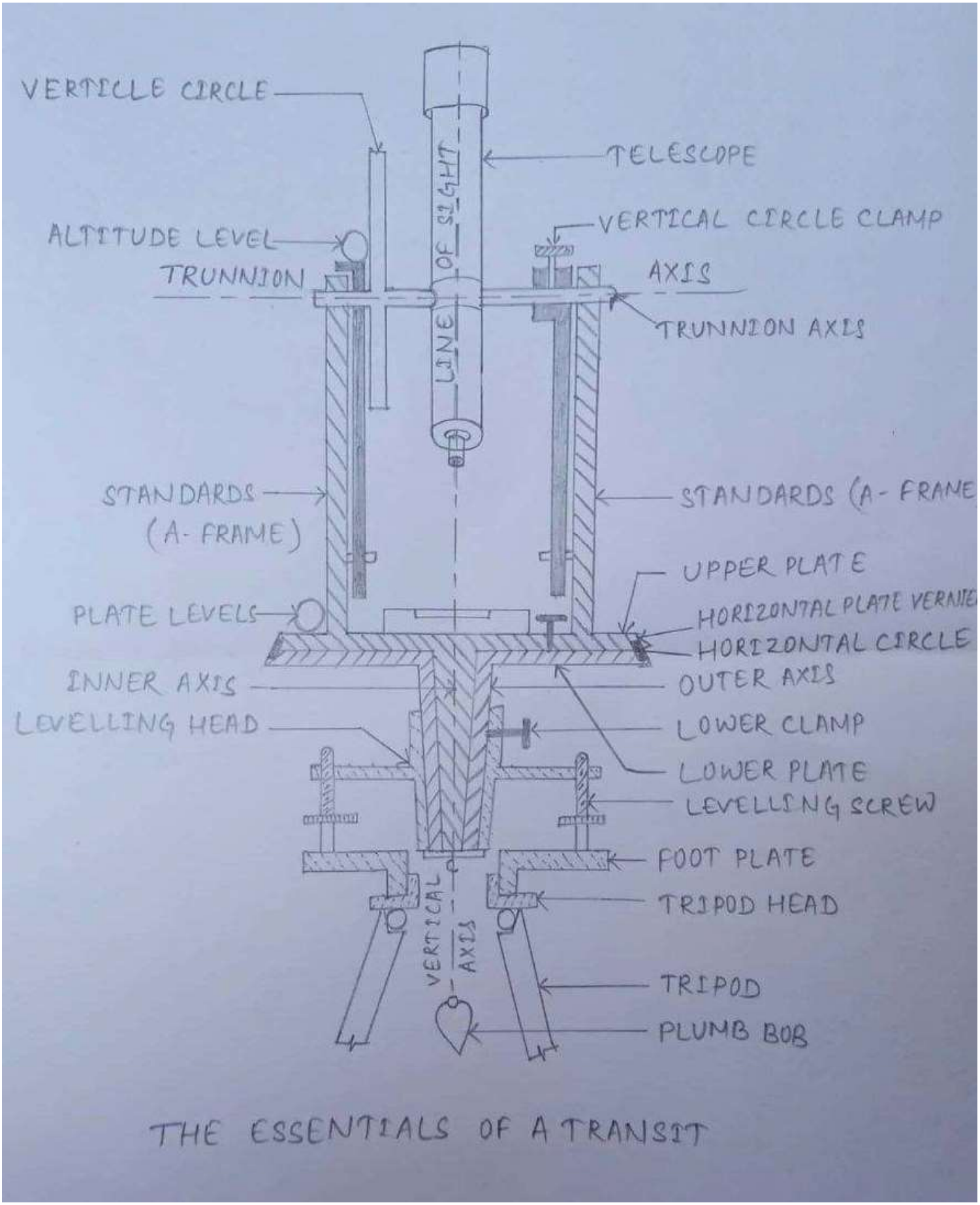
→ The theodolite is the most precise instrument designed for the measurement of horizontal & vertical angle & has wide applicability in surveying such as laying of horizontal angle, locating points on line, prolongation of survey lines, establishing grades, determining elevation difference & setting out of curves.

→ Theodolite is classified into two types.

(1) Transit theodolite

(2) Non-transit theodolite

A transit theodolite consist of following essential parts.



THE ESSENTIALS OF A TRANSIT

(1) The telescope:-

→ The telescope is an integral part of the theodolite & is mounted on a spindle known as the horizontal axis or the trunnion axis.

→ The telescope may be internal focusing type or external focusing type.

(2) Vertical circle:-

→ The vertical circle is a circular graduated arc attached to the trunnion axis of the telescope.

→ The graduated are rotates with the telescope when it is rotated about the horizontal axis.

→ By means of the vertical circle clamp screw & its corresponding slow motion or tangent screw, the telescope can be set accurately at any desired position in the vertical plane.

→ The circle is graduated continuously from 0° to 360° in the clockwise direction or may be divided into four quadrants.

3) The index frame / T-frame / Vernier frame:-

→ The index frame is a T-shape frame consisting of a vertical leg called clipping arm, & a horizontal bar called vernier arm or index arm.

bubble is placed on the top of index frame.

(4) The standards or A-frame :-

→ Two standards resembling the letter A are mounted on the upper plates.

→ The trunnion axis of the telescope is supported on these.

→ The T-frame & the arm of vertical circle clamp are also attached to A-frame.

(5) The levelling head :-

→ The levelling head consists of two parallel triangular plates known as tribrach plates.

→ The upper tribrach has three arms each carrying a levelling screw.

→ The lower tribrach or foot plate has a circular hole through which a plumb bob may be suspended.

→ The levelling head supports the main parts of the instrument, attached the theodolite

with tripod & provide a mean for levelling the theodolite.

(6) The two spindles :-

→ The inner spindle is solid & conical & fits into the outer spindle which is hollow & ground conical in the interior.

→ The inner spindle is called the upper plate & the outer spindle is called the lower plate.

(7) The lower plate :-

→ The lower plate is attached to the outer spindle, which carries a horizontal circle at its levelled edge called scale plate.

→ The lower plate carries a lower clamp screw & a corresponding slow motion tangent screw.

→ When the clamp screw is tightened, the lower plate is fixed to the upper tribrach of the levelling head.

→ On turning the tangent screw the lower plate can be rotated ~~slightly~~ slidely.

→ Usually the size of the theodolite is represented by the scale plate ie- 10 cm theodolite or 12 cm theodolite.

→ The upper plate is attached to the inner axis & carries two verniers with magnifiers at two extremities diametrically.
→ The upper plate supports the standards.
→ It carries an upper clamp screw & a corresponding tangent screw for purpose of accurately fixing it to the lower plate.
→ On clamping the upper & unclamping the lower clamp the instrument can rotate on its outer axis without any relative motion between the two plates.
→ If lower clamp is clamped & upper clamp unclamped the upper plate & the instrument can rotate on the inner axis with a relative motion between the vernier & the scale.

(9) The plate levels :-

→ The upper plate carries two plate levels right angles to each other.
→ One is kept parallel to trunnion axis & other is kept at right angles to it.
→ It can be centred with the help of foot screws.

Tripod :-

→ When in use, the theodolite is supported on the tripod which consist of three solid legs.
→ At the ends, the legs are provided with pointed steel shoes.

of the inner axis to centre the instrument exactly over the station mark.

The compass :-

→ Some theodolite are provided with the compass.
→ The compass is generally fitted with the standards

Striding level :-

→ Some theodolites are fitted with a striding level.
→ It is used to test the horizontality of trunnion axis.

Some definitions :-

The vertical axis :-

→ It is the axis about which the instrument can be rotated in a horizontal plane.

Horizontal axis :-

→ The trunnion or horizontal axis is the axis about which the telescope & the vertical circle rotate in vertical plane.

The line of collimation or sight :-

→ It is the line passing through the intersection of horizontal & vertical cross hairs & the optical centr of the object glass & its continuation.

Axis of the level tube :-

→ It is a straight line tangential to the longitudinal curve of the level tube at its centre.

centring :-

→ It is the process of setting the theodolite exactly over the station mark.

→ It is the process of turning the telescope in the vertical plane through 180° about trunnion axis.

→ It is also known as plunging or reversing.

Swinging the telescope :-

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

→ It may be right swing or left swing depending upon clockwise or anti clockwise rotation.

Face left observation :-

→ If the face of the vertical circle is to the left of the observer, the observation of angle is called face left observation.

Face right observation :-

→ If the face of the vertical circle is to right to the observer, the observation of angle is called face right

Telescope normal :-

→ A telescope is said to be normal or direct when the face of the vertical circle is to the left & the bubble is up.

Telescope inverted :-

→ A telescope is said to be inverted or reversed when the face of the vertical circle is to the right & the bubble is down.

Changing face :-

→ It is an operation of bringing the face of the telescope from left to right & vice versa.

Temporary adjustment :-

→ Temporary adjustment are those which are made at every instrument station & preparatory to take observation with the instrument.

→ It includes (i) setting over the station, l.

(ii) Levelling off.

(iii) Elemination of parallax.

Measurement of horizontal angle by repeatition method :-

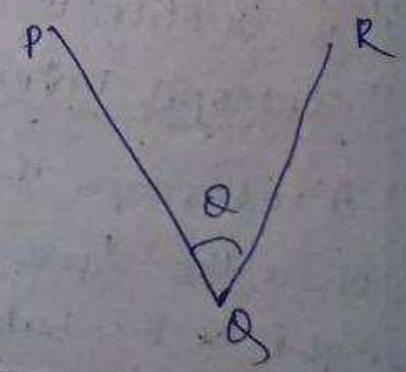
→ The method of repeatition is use to measure horizontal angle to a finer degree of accuracy.

→ In this method, an angle is measured two or more times by allowing the vernier to remain clam each time at the end of each measurement.

→ An angle reading is mechanically added several times depending upon the no. of repeatitions.

→ The avg. horizontal angle is then obtain by dividing the final reading by the no. of repeatition.

→ To measure an angle PQR following steps should be follows.



(i) Set the instrument at Q & level it. with the help of upper clamp & tangent screw set zero reading on vernier A. Note the reading of vernier B.

(ii) Loose the lower clamp & directs the telescope towards point 'P'. Clamp the lower clamp & bisect point 'P' accurately with lower tangent screw.

(iii) Unclamp the upper clamp & turn the instrument clock wise towards R. clamp the upper clamp & bisect an accurately with the help of upper tangent screw. Note the reading of vernier A & B to get the ∠PQR.

(iv) Unclamp the lower clamp & turn the telescope clock wise to sight 'P' again. Bisect 'P' accurately It is seen that the vernier reading will not be changed. Since the upper plate is clamped to the lower.

(v) Unclamp the upper clamp, turn the telescope clockwise to see R.

(vi) Repeat the process until the angle is repeated the required no of times i.e. 3 times. The average angle with the face left will be equal to final reading divided by 3.

(vii) Change the face to right & make three more

repeatition as described above to get the averag angle with face right.

(viii) The avg. horizontal angle is then obtained by taking the avg. of the face left & face right observations.

Advantages of repeatition method :-

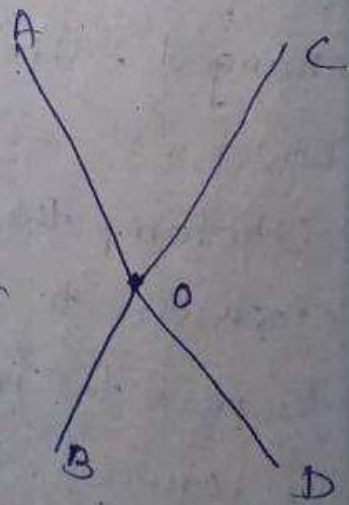
→ Errors due to essentricity of verniers & centres are eliminated by taking both vernier readings.

→ Errors due to inadjustment of line of collimation trunnion axis, inaccurate graduations & inaccurate bisection of object are eliminated.

• Measurement of horizontal angle by reiteration method :-

→ This method is also known as direction method or method of series suitable for measurement of angle of a group having a common vertex point.

→ To measure angle following steps are to be followed.



(i) Set the instrument over O & level it. Set one vernier to zero & bisect point A accurately.

(ii) Loose the upper clamp & turn the telescope clock wise to point C & bisecting accurately. Read both the verniers. The mean of the vernie

reading will be the angle AOC.

(iii) Similarly bisect successively D & B. Read both the verniers at each bisection.

(iv) On final sight to 'A', the reading of the vernier should be same as original setting.

(v) Repeat the ~~the~~ steps from 2-4 with the other face.

(vi) The avg. of the two readings will be the required angle.

Measurement of vertical angle:

→ Vertical angle is the angle which the inclined line of sight to one object makes with the horizontal.

→ It may be angle of elevation or angle of depression depending upon the object is above or below the horizontal plane passing through the trunnion axis.

→ To measure a vertical angle, the instrument should be levelled with respect to the altitude bubbles.

→ To measure a vertical angle following steps shall be followed.

(i) Level the instrument with respect to plate levels.

(ii) Loose the vertical circle clamp & rotate the telescope in the vertical plane to sight the object. Use vertical circle tanget screw for accurate bisection.

(iii) Read both the verniers C & D of the vertical circle.

(iv) The mean of the two gives the vertical angle. Similar observation may be made with another face. The average of two face readings will give

→ The fundamental line of a transit theodolite are -

(i) The vertical axis

(ii) The horizontal or Trunnion axis

(iii) The line of collimation or line of sight.

(iv) The axis of the plate level

(v) Axis of altitude level

(vi) Axis of striding level.

Desired relationship :-

→ The axis of the plate level must lie in a plane perpendicular to the vertical axis.

→ The line of collimation must be perpendicular to the trunnion axis at its intersection.

→ The horizontal axis must be perpendicular to the vertical axis.

→ The axis of the altitude level must be parallel to the line of collimation.

→ The vertical circle vernier must read zero when the line of collimation is horizontal.

Miscellaneous operation with theodolite :-

(1) Measurement of magnetic bearing of a line.

(2) Measurement of direct angles.

(3) Measurement of deflection angles.

(4) To prolong a straight line.

(5) To run a straight line between two points.

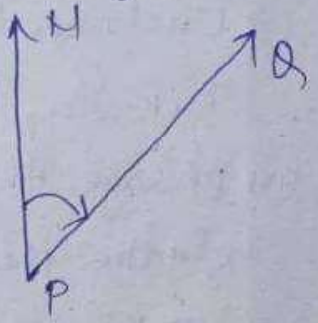
(6) To locate the point of intersection of two straight lines.

(7) To layout a horizontal angle.

(1) Measurement of magnetic bearing of a line :-

→ To measure the magnetic bearing of a line, the theodolite should be provided with a compass.

→ To measure the magnetic bearing of a line PQ, set the instrument at P & level it accurately.



→ Set the vernier A to 0.

→ Loose the lower clamp. Release the needle of the compass. Rotate the instrument about its outer axis till the needle roughly point to North. Clamp the lower clamp.

→ Using the lower tangent screw being the needle exactly against the mark so that it is in magnetic meridian. The line of sight will also be in the magnetic meridian.

→ Loose the upper clamp & point the telescope towards Q. Bisect Q accurately with the upper tangent screw. Read vernier A & B.

→ Change the face & repeat all the steps. The average of the two will give the correct bearing of the line PQ.

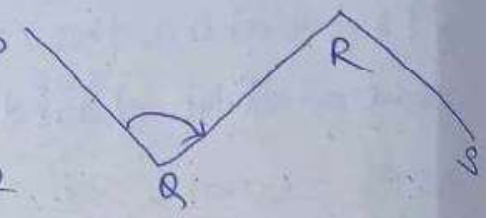
(2) Measurement of direct angles :-

→ Direct angles are the angles measure clockwise from preceeding line to the following line.

→ To measure an angle PQR, following steps should be followed.

(i) Set the theodolite at Q & levelled it accurately We the face left set the reading on vernier A to 0

(ii) Unclamped the lower clamp & direct the telescope to P. Bisect it accurately using the lower tangent screw.



(iii) Unclamped the lower clamp swing the telescope clock wise to see R. Read both the verniers.

(iv) Plunge the telescope, unclamped the lower clamp & take the back sight on P. Reading on the vernier will be the same as in step 3.

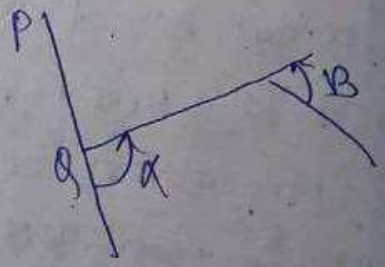
(v) Unclamp the upper clamp & bisect R again. Read the verniers, the angle PQR will be obtained by dividing the final reading by 2.

Measurement of deflection angle :-

→ To measure the deflection angle at Q following steps shall be followed.

(i) Set the instrument at Q & levelled it.

(ii) With both plate clamp at 0° takes back sight on P.



(iii) Plunge the telescope thus the line of sight is in the direction of PQ produced.

(iv) Unclamp the upper clamp & turn the telescope anti

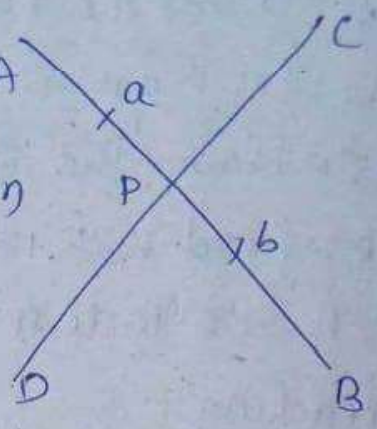
clockwise to see R. Read both the verniers.

(v) Unclamp the lower clamp & turn the telescope to see P again. Plunge the telescope.

(vi) Un clamp the upper clamp & turn the telescope to see R. Read both the verniers.

(vii) The deflection angle at Q will be half the final reading.

→ To locate the point of intersection of two straight lines.



(i) Let it be required to locate the point of intersection P of two straight line AB & CD.

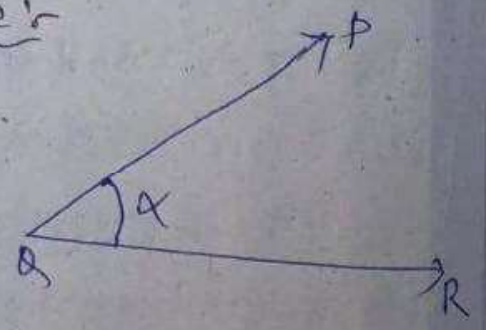
(ii) Set the instrument at A, sight B & set two stakes a & b, a short distance apart on either sight of estimated position of point P.

(iii) Set the instrument at C & sight D.

(iv) Stretch a thread or string between AB & locate P, where the line of sight cuts the string.

~~(v) To lay off~~

To Lay off horizontal angle:-



Let it be required to lack off the angle PQR of α°.

→ Set the instrument at Q & level it.

→ Using upper clamp & upper tangent screw, set the reading on vernier A to 0°.

→ Loose the lower clamp & sight P. Using lower tangent screw bisect P accurately.

→ Loose upper clamp & turned the telescope till the reading is approximately equal to th

angle PQR, which is α.
→ Depressed the telescope & establish R in the line of sight.

Errors in theodolite measurement :-

→ The sources of error in transit work are
(i) Instrumental errors
(ii) Personal errors
(iii) Natural errors.

(i) Instrumental errors :-

→ These errors include the following.
(a) Imperfect adjustment of the instrument like adjustment of plate level, line of collimation not being perpendicular to the horizontal axis, horizontal axis not being perpendicular to the vertical axis, non parallelism of the axis of the telescope level & line of collivation, imperfect adjustment of vertical circle vernier, imperfect graduations & eccentricity of vernier.
(b) Structural defect in the instruments.
(c) Imperfections due to wear.

(ii) Personal errors :-

→ These include
(a) Errors in manipulation like inaccurate centring Inaccurate levelling, slip, manipulating wrong tangent screw,

(b) Errors in sighting & reading - they include inaccurate bisection of points observe, parall & mistakes.

(iii) Natural errors :-

→ Sources of natural errors are

(a) Unequal atmospheric refraction due to high temperature.

(b) Unequal expansion of the parts of the telesco & circles.

(c) Unequal settlement of tripod.

(d) Wind producing vibrations.

—— o ——

Chapter-4 THEODULITE TRAVERSING

Traverse :-

→ It is a type of survey in which a no. of connected survey lines form the frame work & the directions & length of survey line are measu with the help of angle measuring instrument & a tape respectively.

→ Traverse may be closed or opened.

Closed traverse :-

→ When the lines form a circuit which ends at the starting point it is called a closed

COMPUTATION OF AREA

→ The term area in the surveying refers to the area of a land projected upon the horizontal plane & not to the actual area on the land surface.

→ Area may be expressed in the following units.

(i) Sq. meter

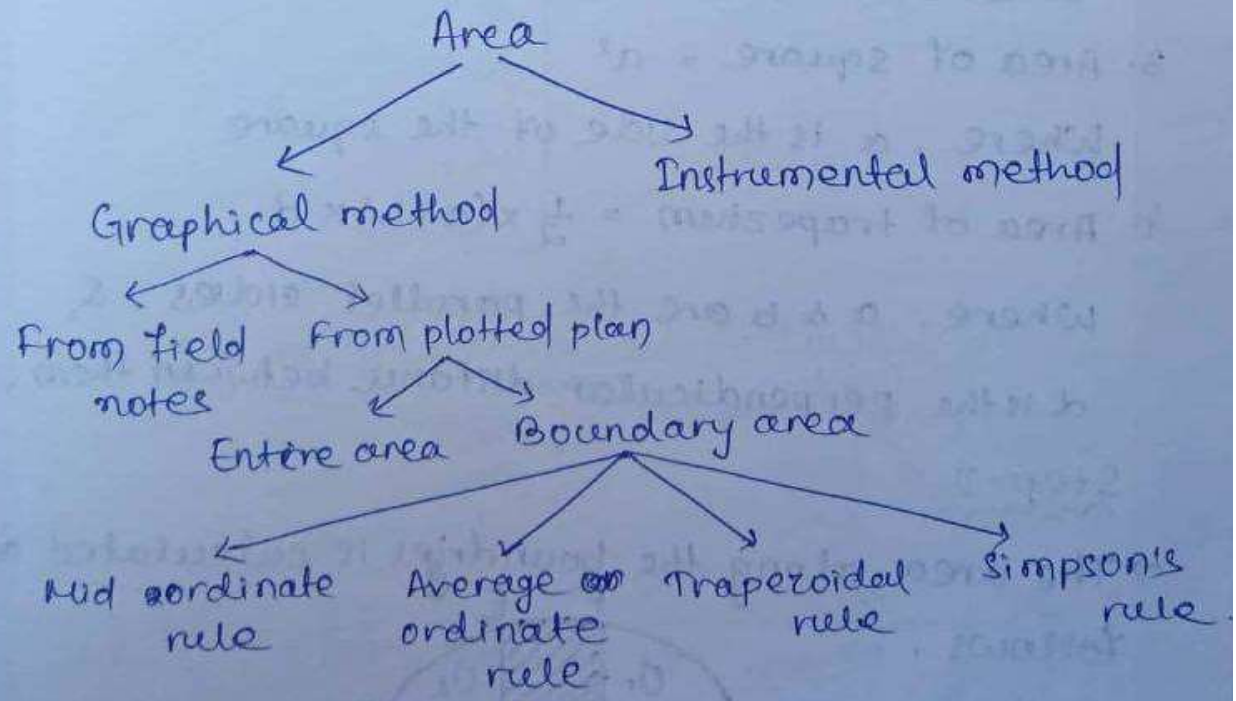
~~(ii) Feet~~

(ii) Hecter (1 Hecter = 10000 m^2)

(iii) Sq. feet

(iv) Acres (1 Acres = 4840 square yard
= 43.560 sq. feet)

→ The following is a representation of the various methods of computation of area.



Computation of area from field notes :-

Step-1

→ In cross staff survey the area of field can

be directly calculated from field notes. During survey work, the whole area is divided into some geometrical figures. Such as triangles, rectangles & trapezions & then the area is calculated as follows.

1. Area of triangle = $\sqrt{s(s-a)(s-b)(s-c)}$

Where, a, b & c are sides

$$s = \frac{a+b+c}{2}$$

or area of triangle = $\frac{1}{2} \times b \times h$

Where, b = base

h = height

2. Area of rectangle = $a \times b$

Where, a & b are the sides.

3. Area of square = a^2

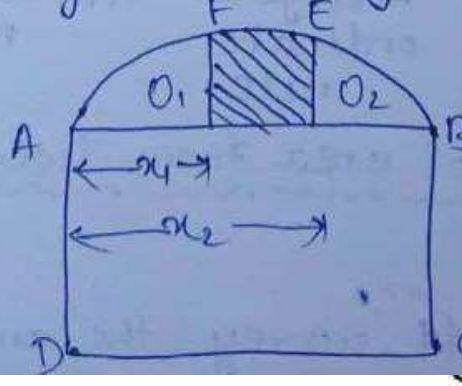
Where, a is the side of the square

4. Area of trapezium = $\frac{1}{2} \times (a+b) \times d$

Where, a & b are the parallel sides. & d is the perpendicular distance between them.

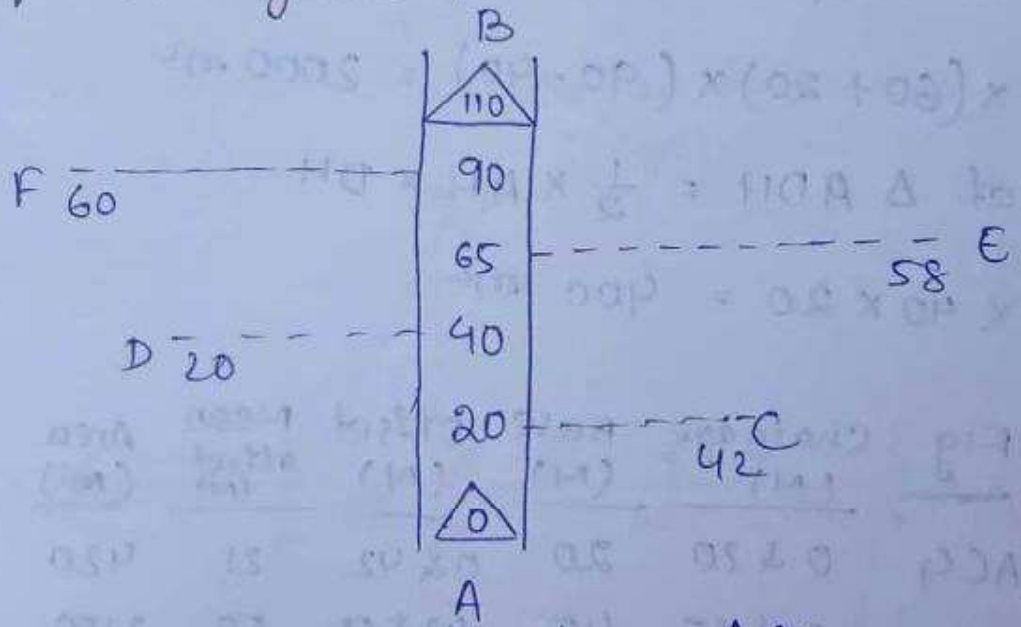
Step-II

→ The area along the boundries is calculated as follows.

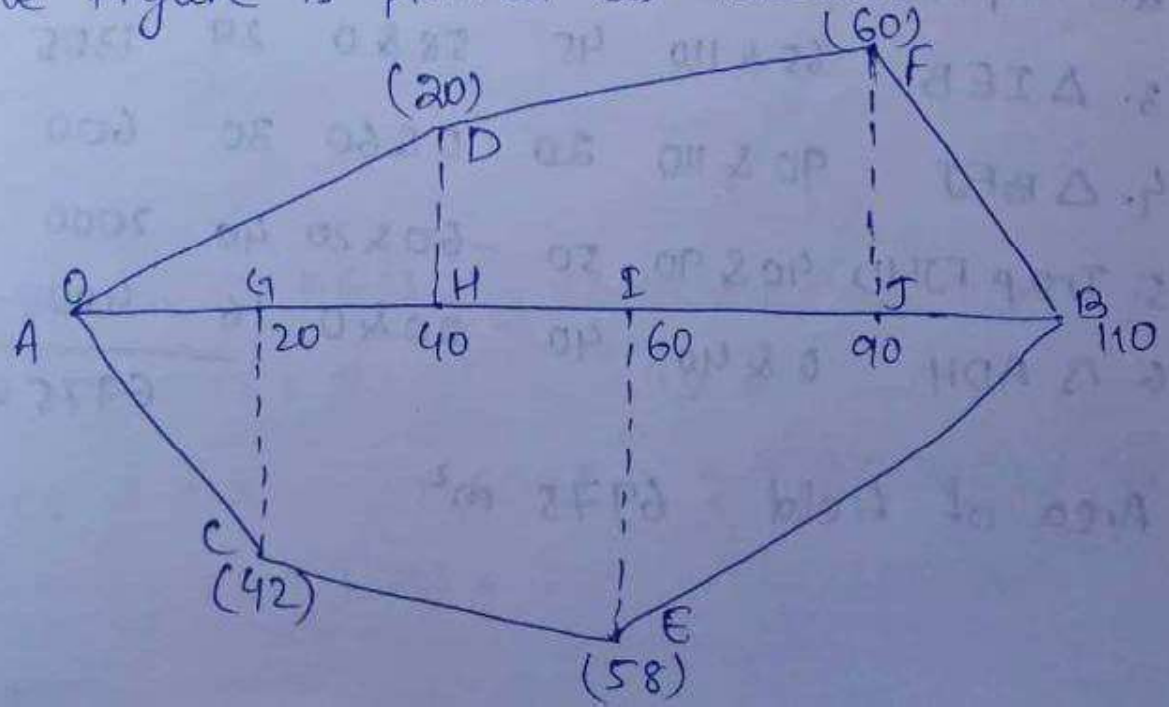


(Area calculation)

Problem-1 :- A page of the field book of a cross staff survey is given in figure. Plot the required figure & calculate the area.



The figure is plotted as follows.



Area of $\Delta ACG = \frac{1}{2} \times OG \times CG$

$= \frac{1}{2} \times 20 \times 42 = 420 \ m^2$

Area of trapezium $GCEI = \frac{1}{2} \times (CG + EI) \times GI$

$= \frac{1}{2} \times (42 + 58) \times (65 - 20) = 2250 \ m^2$

Area of $\Delta IEB = \frac{1}{2} \times IB \times EI$

$= \frac{1}{2} \times (110 - 65) \times 58 = 1305 \ m^2$

Area of $\Delta BFJ = \frac{1}{2} \times BJ \times FJ$

$= \frac{1}{2} \times (110 - 90) \times 60 = 600 \ m^2$

Area of trapezium $FJHD = \frac{1}{2} \times (FJ + HD) \times JH$

$= \frac{1}{2} \times (60 + 20) \times (90 - 40) = 2000 \ m^2$

Area of $\Delta ADH = \frac{1}{2} \times AH \times DH$

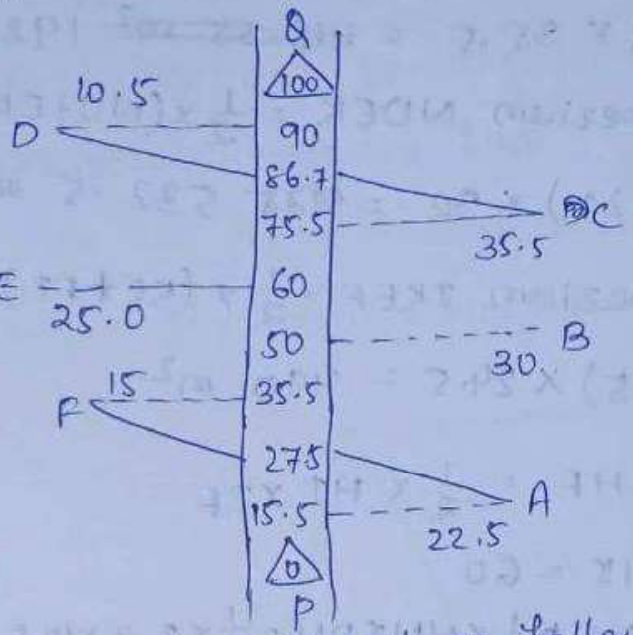
$= \frac{1}{2} \times 40 \times 20 = 400 \ m^2$

Sl. No.	Fig	Chainage (M)	Base (M)	offset (M)	Mean offset (M)	Area (m^2)	Remarks
1.	ΔACG	0 & 20	20	0 & 42	21	420	
2.	Trap GCEI	20 & 65	45	42 & 58	50	2250	
3.	ΔIEB	65 & 110	45	58 & 0	29	1305	
4.	ΔBFJ	90 & 110	20	0 & 60	30	600	
5.	Trap FJHD	40 & 90	50	-60 & 20	40	2000	
6.	ΔADH	0 & 40	40	20 & 0	16	400	
						6975 m^2	

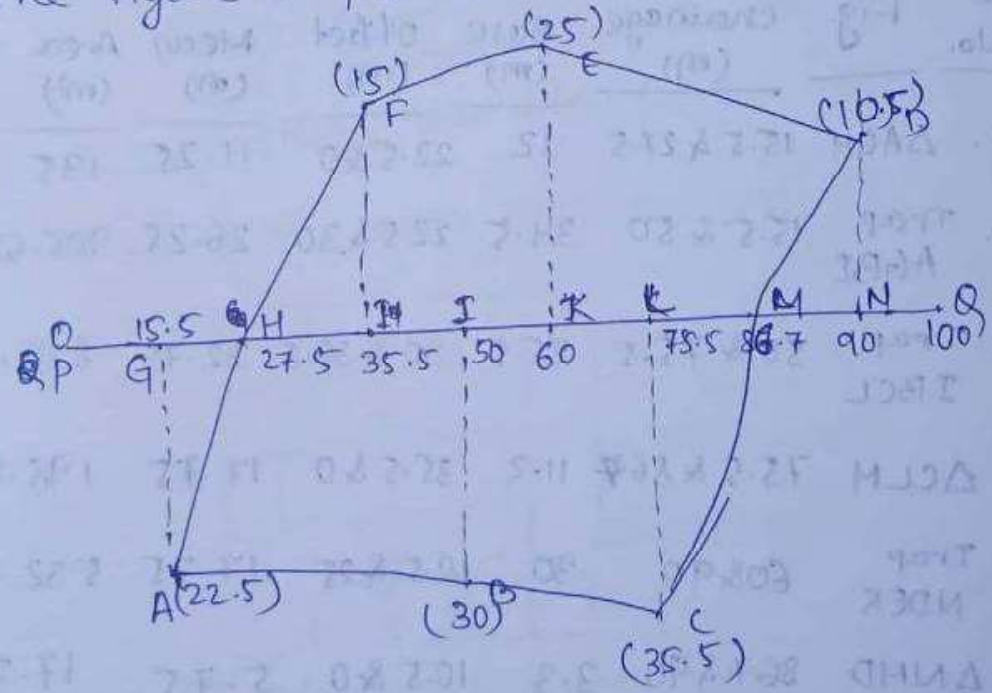
Area of field = 6975 m^2

Problem-2

The page of a field book shows a cross-staff survey plot the required figure & calculate the area of the trapezium ABCDEFA.



The figure is plotted as follows.



Area of $\Delta AGH = \frac{1}{2} \times GH \times AG$

$= \frac{1}{2} \times 12 \times 22.5 = 135 \text{ m}^2$

Area of trapezium $AGBI = \frac{1}{2} \times (AG + BI) \times GI$

$= \frac{1}{2} \times (22.5 + 30) \times 34.5 = 905.625 \text{ m}^2$

Area of trapezium IBCL = $\frac{1}{2} \times (IB + CL) \times IL$

$= \frac{1}{2} \times (30 + 35.5) \times 25.5 = 835.125 \text{ m}^2$

Area of $\Delta CLM = \frac{1}{2} \times ML \times CL$

$= \frac{1}{2} \times 112.2 \times 35.5 = 198.8 \text{ m}^2$

Area of trapezium NDEK = $\frac{1}{2} \times (ND + EK) \times NK$

$= \frac{1}{2} \times (10.5 + 25) \times 30 = 532.5 \text{ m}^2$

Area of trapezium IKEF = $\frac{1}{2} \times (KE * FI) \times KI$

$= \frac{1}{2} \times (25 + 15) \times 24.5 = 490 \text{ m}^2$

Area of $\Delta IHF = \frac{1}{2} \times HI \times IF$

$= \frac{1}{2} \times 8 \times 15 = 60$

Area of $\Delta NMD = \frac{1}{2} \times MN \times DN = \frac{1}{2} \times 3.3 \times 10.5 = 17.325$ m

Sl. No.	Fig	Chainage (m)	Base (m)	offset (m)	Mean (m)	Area (m^2)	Remark
1.	ΔAGH	15.5 & 27.5	12	22.5 & 0	11.25	135	
2.	Trap AGBI	15.5 & 50	34.5	22.5 & 30	26.25	905.625	
3.	Trap IBCL	50 & 75.5	25.5	30 & 35.5	32.75	835.125	
4.	ΔCLM	75.5 & 86.7	11.2	35.5 & 0	17.75	198.8	
5.	Trap NDEK	60 & 90	30	10.5 & 25	17.75	532.5	
6.	ΔNMD	86.7 & 90	3.3	10.5 & 0	5.75	17.325	
7.	Trap IKEF	35.5 & 60	24.5	25 & 15	20	490	
8.	ΔIHF	27.5 & 35.5	8	15 & 0	7.5	60	

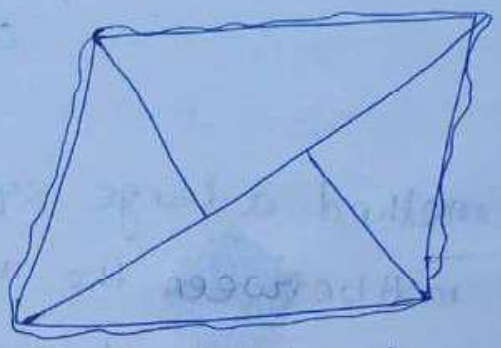
Computation of Area from plotted plan :-

Case - 1 :- Considering the entire area :-

(1) By dividing the area into triangles :-

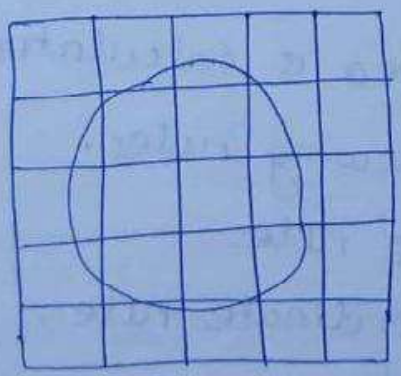
→ The triangles are so drawn as to equalise the irregular boundry line.

→ The area of these triangles are calculated as area = $\frac{1}{2}$ x Base x Height



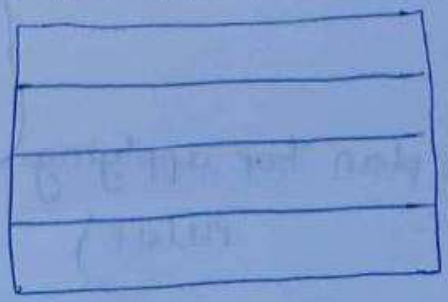
(Dividing into tricangles)

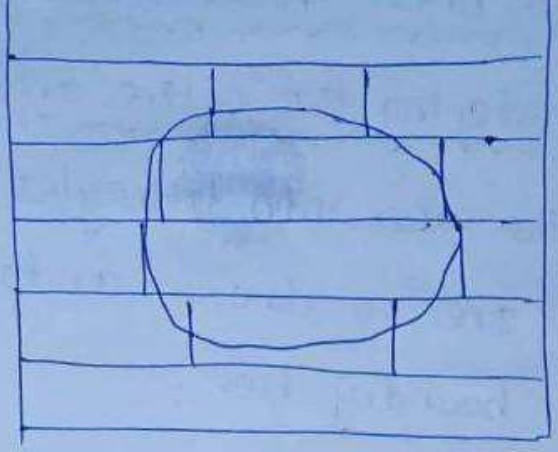
(2) By dividing the area into squares :-



(Dividing into squares)

(3) By drawing parallel lines & converting them into rectangles.

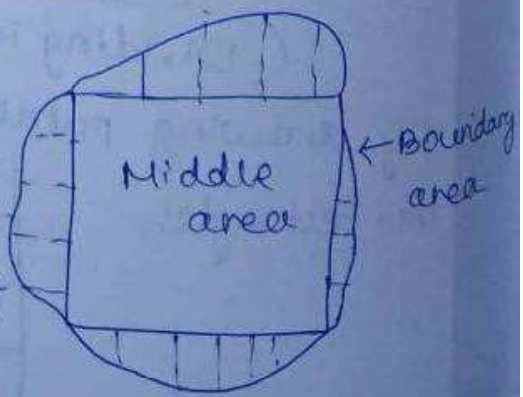




Required area = Σ Length of rectangles x constant distance

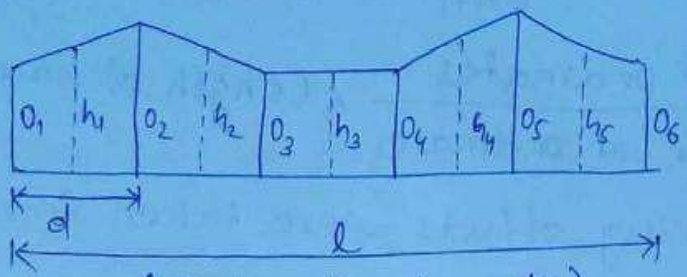
- In this method a large square or rectangle is form ~~mett~~ between the area . Then ordinates are drawn at regular intervals from the side of the square to the curved boundary.
- The middle area is calculated in the usual way. The boundary area is calculated according to one of the following rules.

1. The mid ordinate rule
2. The average - ordinate rule.
3. The trapezoidal rule
4. Simpson's rule



(Base plan for applying rules)

1. The mid-ordinate rule:-



(Mid ordinate rule)

Here,

$O_1, O_2, O_3, \ldots\ldots O_n$ = Ordinate at equal intervals

l = length of base line

d = common distance between ordinates

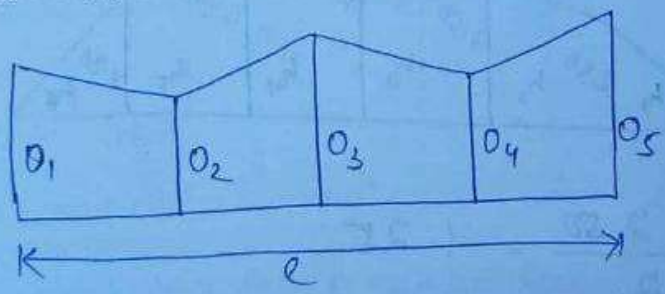
$h_1, h_2, h_3 \ldots\ldots h_n$ = Mid-ordinate

Area of plot = $h_1 \times d + h_2 \times d + \ldots\ldots + h_n \times d$

$= d(h_1 + h_2 + \ldots\ldots + h_n)$

Area = Common distance × sum of mid ordinates

2) Average ordinate rule:-



(Average ordinate rule)

$O_1, O_2, O_3 \ldots\ldots O_n$ = Ordinates or offsets at regular intervals

l = length of base line

n = No. of divisions

$n+1$ = Number of ordinates

$$\text{Area} = \frac{O_1 + O_2 + O_3 + \cdots + O_n}{O_{n+1}} \times l$$

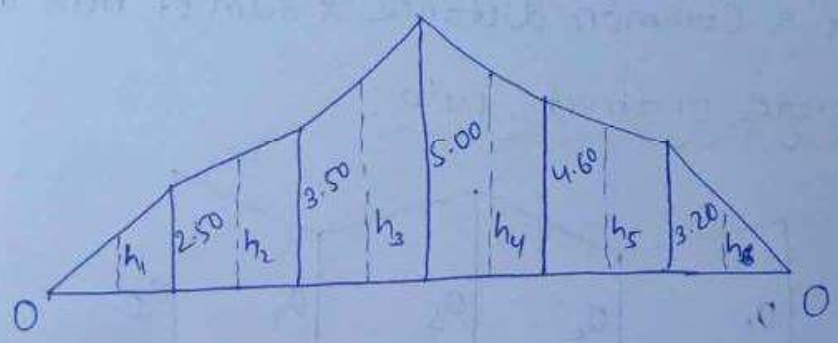
$$= \frac{\text{sum of ordinates}}{\text{Number of ordinates}} \times \text{Length of base line}$$

Q. The following offsets were taken from a chain line to an irregular boundry at an interval of 10 m.

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

Compute the area between the chain line, the irregular boundary line & the end offsets by (i) The mid ordinate rule

(ii) The average ordinate rule.



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

$$h_2 = \frac{2.50 + 3.50}{2} = 3.00$$

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

$$h_4 = \frac{5.00 + 4.60}{2} = 4.8$$

$$h_5 = \frac{4.60 + 3.20}{2} = 3.9$$

$$h_6 = \frac{3.20 + 0}{2} = 1.6$$

According to mid ordinate rule

Area = Common distance x sum of mid ordinates

$= d \times (h_1 + h_2 + \cdots + h_5)$

$= 10 \times (1.25 + 3.00 + 4.25 + 4.8 + 3.9 + 1.6)$

~~$= 172\ m^2$~~ $= 188\ m^2$

(ii) By average ordinate rule

$d = 10\ m$

$n = 6$

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

No. of ordinates = 7

$$\text{Area} = \frac{O_1 + O_2 + O_3 + \cdots + O_7}{O_7} \times l$$

~~$= 0 + 2.50 + 3.50 + 5.00$~~

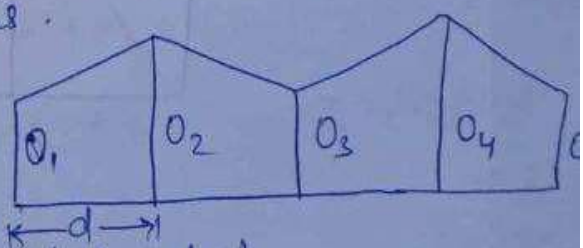
$$\text{Required area} = \frac{\text{sum of ordinates}}{\text{No. of ordinates}} \times \text{Length of baseline}$$

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

$= 161.14\ m^2$

(3) The trapezoidal rule :-

→ While applying the trapezoidal rule, boundries between the ends of ordinates are assume to be straight. Thus the area enclosed between the base line & irregular boundary line are considered as trapezoids.



(Trapezoidal rule)

$O_1, O_2, \ldots O_n$ = Ordinates at equal intervals.

d = common distance

First area = $\frac{O_1 + O_2}{2} \times d$

Second area = $\frac{O_2 + O_3}{2} \times d$

Third area = $\frac{O_3 + O_4}{2} \times d$

.....

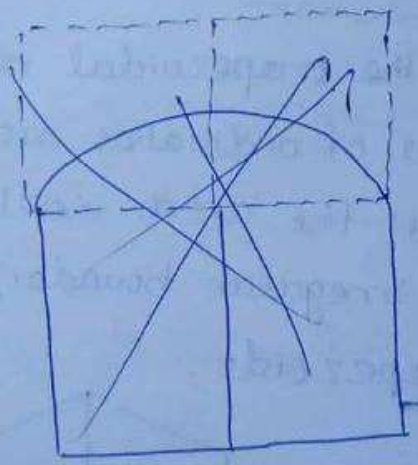
Last area = $\frac{O_{n-1} + O_n}{2} \times d$

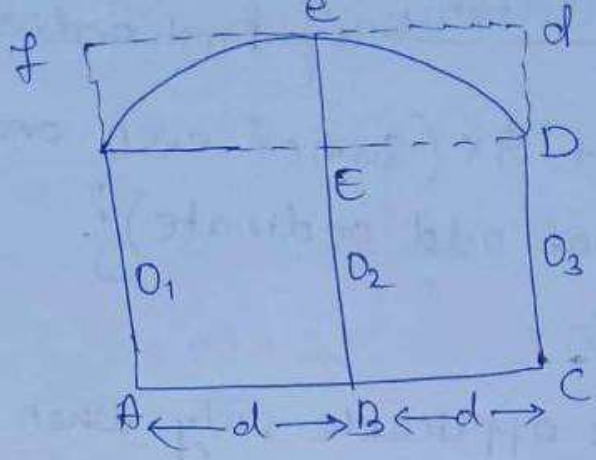
Total area = $\frac{d}{2}\{O_1 + 2O_2 + \ldots\ldots + 2O_{n-1} + O_n\}$

$= \frac{\text{common distance}}{2} \times \{(1\text{st ordinate} + \text{last ordinate}) + 2(\text{sum of other ordinate})\}$

(4) Simpson's rule :-

→ In this rule the boundries between the ends of ordinate are assumed to form an parc of a paraboka. Sympson's rule is sometimes called the parabolic rule.





O_1, O_2, O_3 = Three consecutive ordinate.

d = common distance between the ordinates

Area AFeDC = Area of trapezium AFDC + Area of sigment FeDEF

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

Area of sigment = $\frac{2}{3}$ 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 1st two divisions

$= \Delta 1 = \frac{O_1+O_3}{2} \times 2d + \frac{2}{3} \times \left\{ O_2 - \frac{O_1+O_3}{2} \right\} \times 2d$

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

Similarly the area between next two division

$= \Delta 2 = \frac{d}{3} \times \{ O_3 + 4O_4 + O_5 \}$

Total area $= \frac{d}{3} \times \{ O_1 + 4O_2 + 2O_3 + 4O_4 + \cdots + O_n \}$

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

$= \frac{\text{common distance}}{3} \times \{$ First ordinate + Last ordinate + 4x (Sum of even ordinate) + 2x (Sum of odd ordinate) $\}$.

Limitations :-

→ This rule is applicable only when the no. of division is even & the no. of ordinate is odd.

Comparison between trapezoidal rule & Simpson's rule :-

Trapezoidal rule	Simpson's rule
→ The boundary between the ordinates is consider straight.	→ The boundary between the ordinate is consider an arc of parabola.
→ Their is no limitation. It can be applied for any no. of ordinates.	→ To apply this rule the no. of ordinate must be odd. That is the no. of division must be even
→ It gives an approximate result.	→ It gives a more accurate result.

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

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

(i) Trapezoidal rule

(ii) Simpson's rule.

(i) Total Area = $\frac{d}{2}\{O_1 + 2O_2 + \cdots\cdots + 2O_{n-1} + O_n\}$

$= \frac{\text{common distance}}{2} \times \{(1\text{st ordinate} + \text{Last ordinate}) + 2(\text{sum of other ordinate})\}$

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

$= 188\ m^2$

(ii) By simpson's rule :-

Area = $\frac{\text{Common distance}}{3} \times \{(1\text{st ordinate} + \text{Last ordinate}) + 4\times(\text{sum of even ordinate}) + 2\times(\text{sum of odd ordinate})$

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

$= 196.66\ m^2$

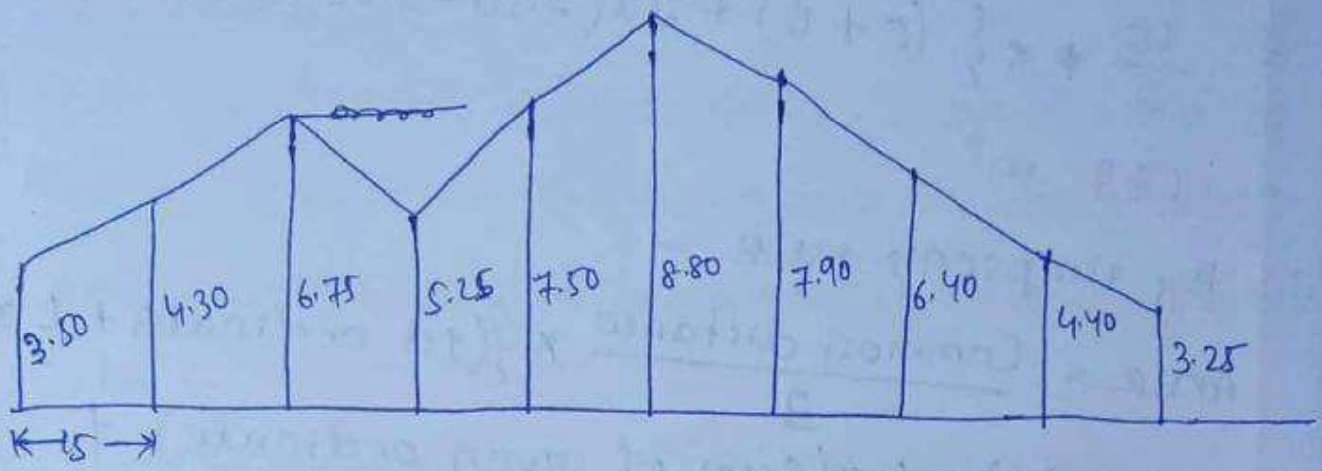
Q. The following offsets were taken at 15 m intervals from a survey line to an irregular boundary line.

3.50, 4.30, 6.75, 5.25, 7.50, 8.80, 7.90, 6.40, 4.40, 3.25 m

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

(i) The trapezoidal rule

(ii) Simpson's rule.



By 'd = 15 m

By trapezoidal rule

Area = $\frac{\text{common distance}}{2}$ {(1st ordinate + Last ordinate) + 2 (sum of other ordinate)}

= $\frac{15}{2}$ {(3.50 + 3.25) + 2(4.30 + 6.75 + 5.25 + 7.50 + 8.80 + 7.90 + 6.40 + 4.40)}

= 820.125 m^2

(ii) By simpson's rule

A_1 = $\frac{\text{common area}}{3}$ x {(1st ordinate + 9th ordinate) + 4 x (sum of even ordinate) + 2 x (sum of odd ordinate)}

= $\frac{15}{3}$ x {(3.50 + 4.40) + 4(4.30 + 5.25 + 8.80 + 6.40) + 2 x (~~3.50~~ + 6.75 + 7.50 + 7.90 + ~~4.40~~)}

= 756

$A_2 = \frac{\text{Common area}}{2} \times \frac{2}{2}(\text{1st ordinate} + \text{Last ordinate})$

$= \frac{15}{2} \times (4.40 + 3.25) \quad = 57.375 \ m^2$

Required area $= A_1 + A_2$

$= 756 + 57.375 = 813.375 \ m^2$

3) A series of offsets were taken from a chain line to an irregular boundary of a line at an interval of 30 m in the following order.

0, 6.8, 7.8, 5.4, 4.8, 7.0, 6.5, 0

Find the area between the chain line, the irregular boundary line & the offsets by

(a) Trapezoidal rule &

(b) Simpson's rule.

4) The following offsets are taken from a survey line to a curved boundary line.

Distance (m)	0,	5	10	15	20	30	40	60	80
Offset (m)	2.50	3.80	4.60	5.20	6.10	4.70	5.80	3.90	2.20

Find the area between the survey line, the curved boundary line, & the 1st & the last offsets by

(a) the trapezoidal rule,

(b) Simpson's rule.