SURVEYING-I

Triangulation Surveying

Principles of Triangulation Surveying

Principle 1:

- A number of control points are fixed in the area concerned by adopting very accurate and precise methods.
- The lines joining these control points will be control lines.
- Other measurements are made to locate points inside these control lines.
- Thus, main triangles and traverses are formed first.

Principles of Triangulation Surveying

Principle 1:

- The main triangles and traverses are divided into smaller ones by using less rigorous methods.
- By doing so, accumulation of errors is avoided and any local error can be easily identified.
- If survey work is started from a part (smaller triangle or traverse) and proceeded to whole there are chances of errors getting multiplied at every stage.
- Hence any survey work should be from whole to part and not from part to whole.

Principles of Triangulation Surveying

Principle 2:

- New points should be fixed by at least two independent measurements.

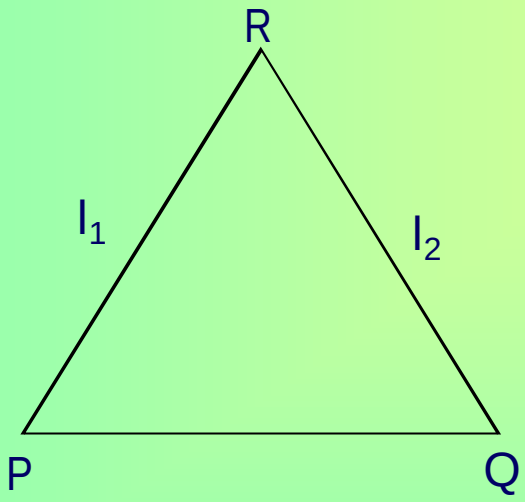


Figure 1

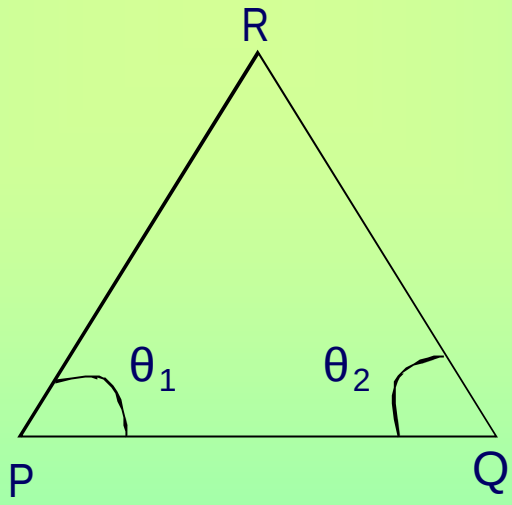


Figure 2

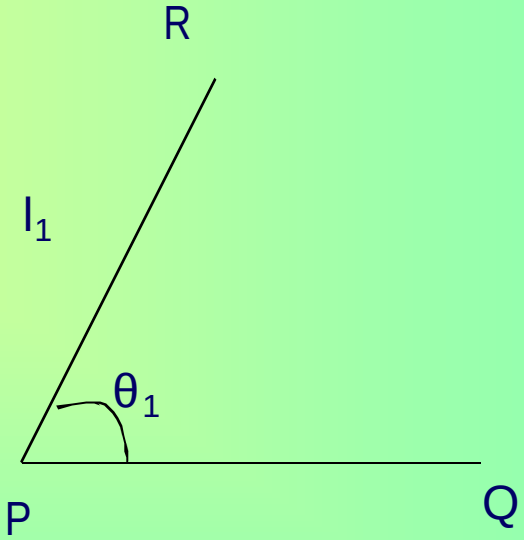


Figure 3

Principles of Triangulation Surveying

Principle 2:

- As per the Principle 2, the location of a new point involves one of the following.

(a) Measurement of two distances.

(b) Measurement of two angles

(c) Measurement one angle and one distance

Principles of Triangulation Surveying

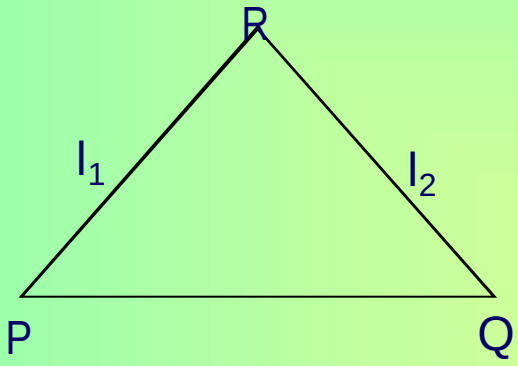


Figure 1

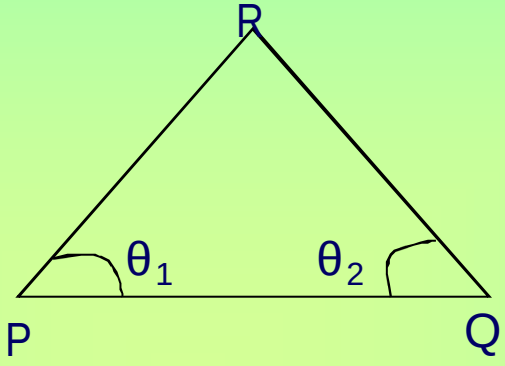


Figure 2

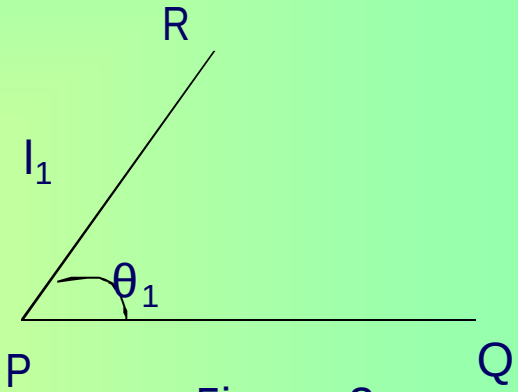


Figure 3

Fig 1: It shows the method of locating R with reference to known length PQ by using the known distances of PR (l_1) and QR (l_2)

Fig 2: It shows the method of locating R with reference to the length PQ by using the known angles QPR (θ_1) and PQR (θ_2)

Fig 3: It shows the method of locating R with reference to known length PQ by using the known distance of PR (l_1) and known angle QPR (θ_1)

Chain Surveying - Principle

- In chain surveying only linear distances on the field are measured.
- These distances are used to define the boundary of field and mark simple details.

Principle :

- It is to form a network of triangles by using the distances measured.
- Better accuracy will be obtained if the triangles thus formed are nearly equilateral in shape.

Classification of surveying

Classification of surveying:

- Chain Surveying
- Compass Surveying
- Theodolite surveying
- Plane Surveying
- Techeometric Surveying

Accessories used in Chain Surveying

The different accessories used in chain surveying are

(a) Metre Chain

(b) Chain Pins (arrows)

(c) Measuring Tape

(d) Ranging rod / Offset rod.

Accessories used in Chain Surveying

Metric surveying chain

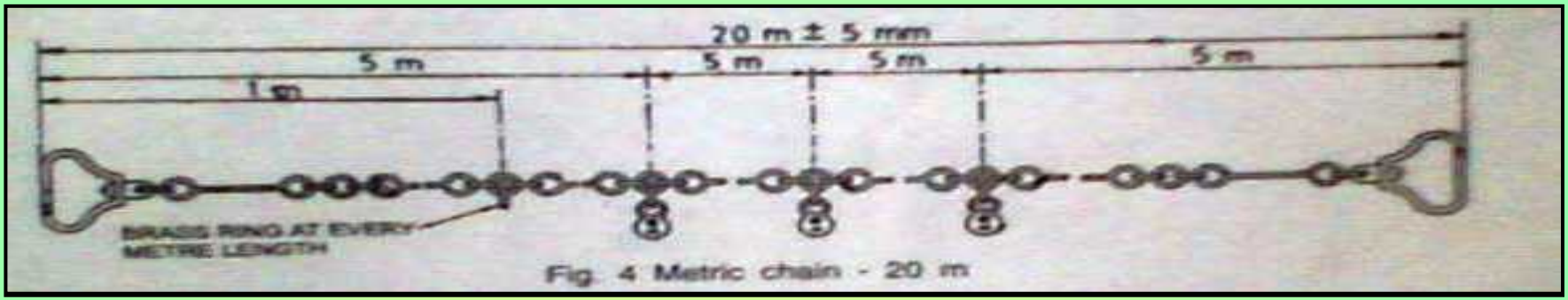


Fig. 4 Metric chain - 20 m

- A surveying chain is a device used to measure distance between two points on the ground.
- Metric chains are available in lengths of 5 m, 10m, 20m and 30 m.
- 20m – 30 m chain is normally used for the field of surveying.
- A surveying chain contains brass handles with brass eyebolt and collar, galvanized mild steel links and wire rings.
- In the case of 20 m and 30 m chains, brass tallies are provided at every 5 m length and indicating brass wire rings are attached at every meter length except where tallies are provided.

Accessories used in Chain Surveying

Metric surveying chain

- The distance between the outside faces of handles of a fully stretched out chain is the length of the chain.
- The length of the chain, like 20m is engraved on the handles.
- While measuring the long distance, the chain will have to be used a number of times.
- Arrows are driven at the end of every chain length.
- For holding the arrows in position, grooves are cut in the outside face of the handles.

Accessories used in Chain Surveying

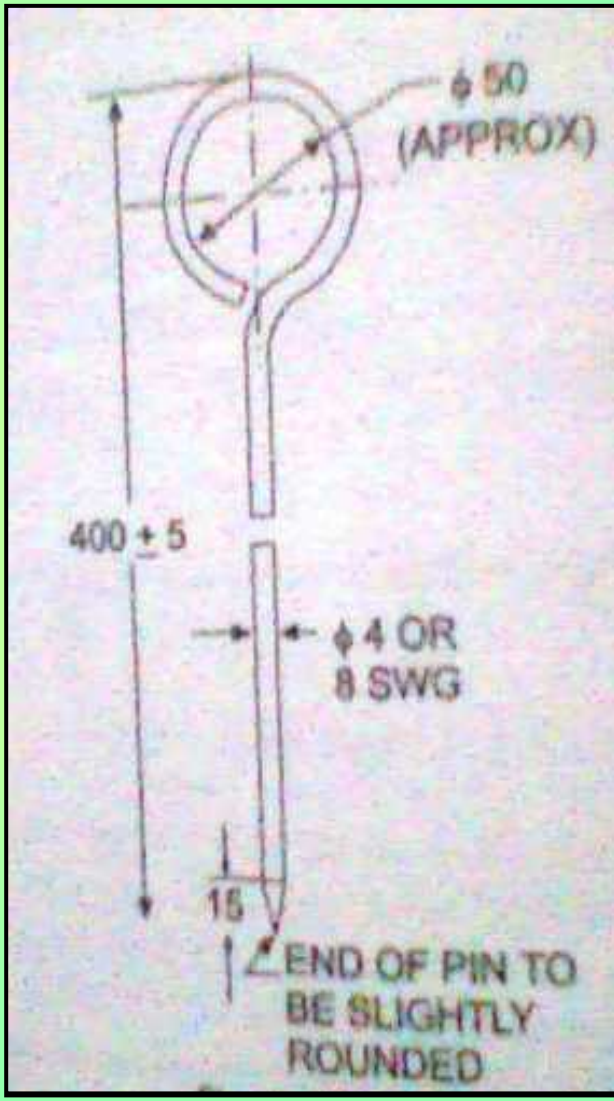
Metric surveying chain

- The radius of the groove is the same as that the arrows.
- For convenient handling of the chain, the handle joint is made flexible so that it is possible to swivel to handle round the eye bolt.

Accessories used in Chain Surveying

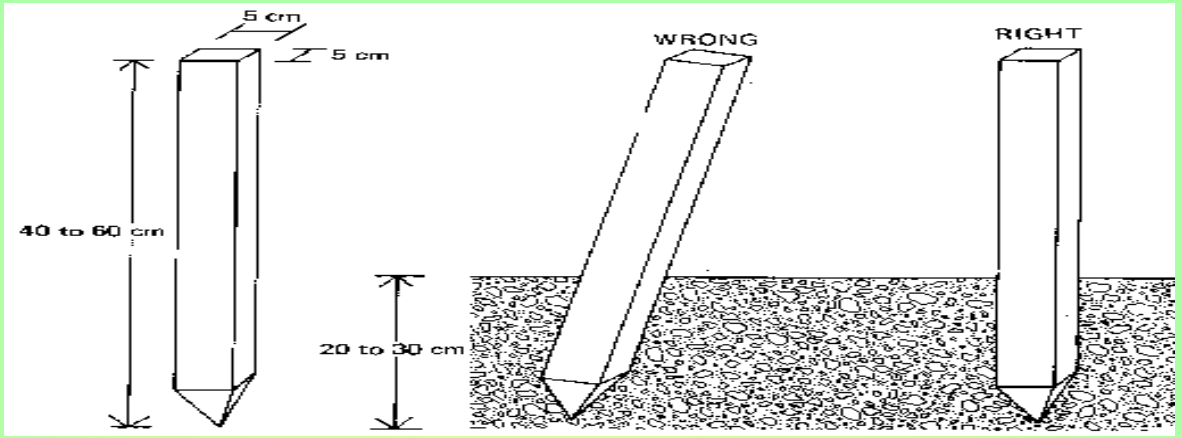
Chain Pins

- Chain pins or arrows are used with the chain for marking each chain length on the ground.
- The arrow is driven into the ground at the end of each chain length is measured.
- Chain pins the arrow should be made of good quality hardened and tempered steel wire of minimum tensile strength of 70 kg/mm^2.
- The overall length is 400 mm and thickness is 4mm.
- The wire should be black enameled.
- The arrow has a circular eye at the one end is pointed at the other end .



Accessories used in Chain Surveying

Pegs



- Wooden pegs of 15cm length and 3 cm square in section are used to establish the station points or the end points of a line on the ground.
- They are tapered one end and are driven into the ground by using a wooden hammer.
- About 4 cm is left projecting above the ground.

Accessories used in Chain Surveying

Measuring Tape

- There are different types of tapes are used. They are

(a) Cloth or linen type

(b) Metallic Tape

(c) Steel Tape

(d) Invar Tube.

Metallic tape and steel tapes are most commonly used.

Accessories used in Chain Surveying

Measuring Tape

- Metallic Tape is made of varnished waterproof linen.
- It is reinforced with fine brass copper or bronze wires.
- Tapes are available in lengths of 10, 15, 20, 30 or 50 metres.
- In metallic tapes every metre is divided into 100 divisions (cms).
- In steel tapes, the centimetre division are also subdivided.

Accessories used in Chain Surveying
Ranging Rod

Ranging Rod:

- It is also known as ranging pole or picket.
- Ranging rod is used for ranging or aligning long lines on the ground in field surveying.
- Ranging is a straight line means fixing a series of pegs or other marks such that they all lie on a straight line.
- Ranging rods are used marking points on the ground so that the positions of the points are distinctly visible from some distant way.

Accessories used in Chain Surveying
Ranging Rod

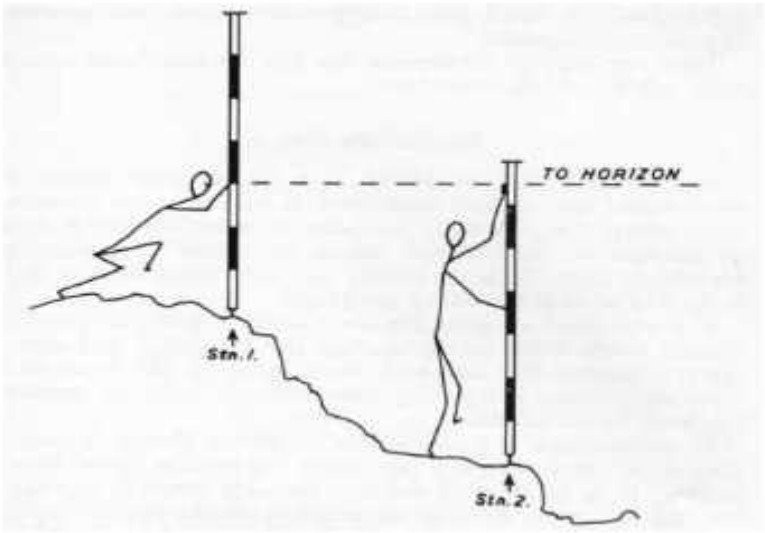
Ranging Rod:

- The length of ranging rod may be 2 m and 3 m and its diameter is 30 mm.
- Ranging rod made of steel tube has an internal diameter of 32 mm.
- The ranging rods are made of well seasoned, straight grained timber of circular cross section.

Accessories used in Chain Surveying

Ranging Rod

- Ranging rods should be straight and free from warps.
- The deviation in straightness should not exceed 5mm in a 2 m length.
- The ranging rod is painted in red and white in alternate band lengths of 200 mm each.
- The bottom end of the rod is fitted with a pointed, hollow, cast iron shoe or steel shoe of 15 cm length.



Accessories used in Chain Surveying

Offset Rod

- It is a ranging rod with two short, narrow, vertical sighting slots passing through the centre of the section.
- A hook is fitted of a groove is cut at the top to enable pulling or pushing of the chain through obstruction like hedges.
- Offset rods are meant for setting outlines approximately at right angles to the main line.

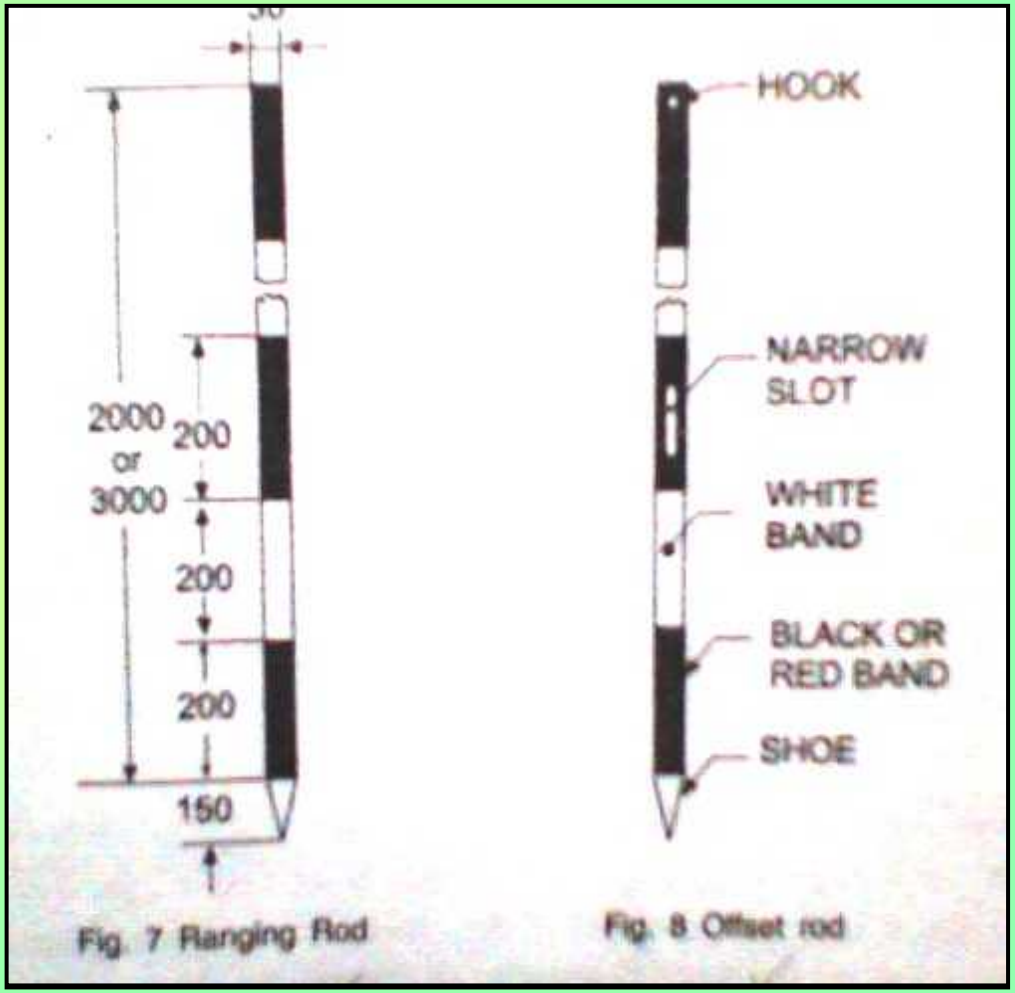


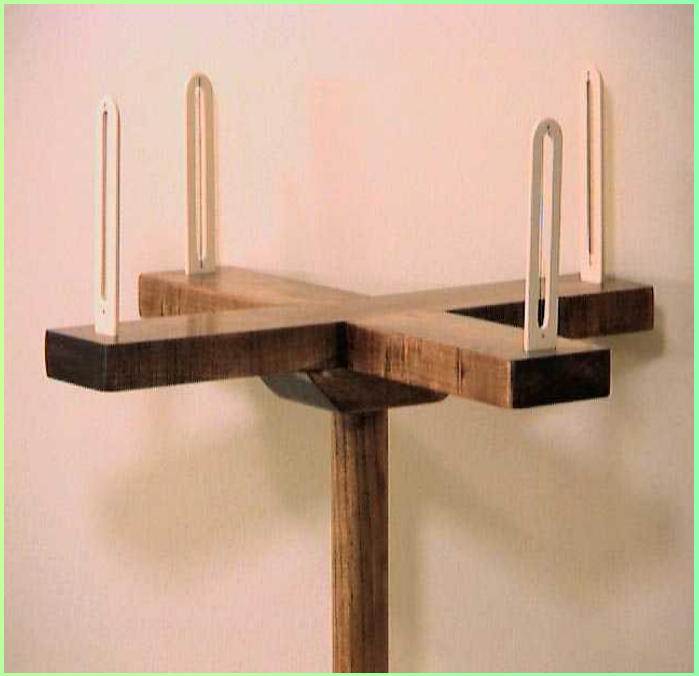
Fig. 7 Ranging Rod

Fig. 8 Offset rod

Accessories used in Chain Surveying

Cross Staff

- It is used to set out right angles in chain surveying
- It consists of four metal arms vertical slits mounted on a pole.
- Two opposite slits are positioned along the length of a line (Main Line)
- A line perpendicular to the main line is formed or sighted through the other two slits



Accessories used in Chain Surveying

Plumb Bob

- It consists of a solid conical piece and a string attached to it at its centre.
- When in use, the solid piece is at the bottom.
- It is used to test the verticality of the ranging rods and to transfer the points to the ground.
- Plumb bob is used while doing chain surveying on sloping ground.

Accessories used in Chain Surveying

Unfolding and folding of chain

- Both the handles of the chain are held in the left hand and the other portions in the right hand.
- The portion held in the right hand is thrown forward;
- The person throwing moving backward himself.
- The leader takes one handle of the chain and moves forward himself.
- The leader takes one handle of the chain and moves forward till the chain is stretched to its full length.
- The chain should be free from any kinks or bends.
- After the completion of the work, the two handles are brought together and the chain is folded started with the middle pair.
- The links are placed obliquely across each pair.
- The folded chain is securely tied with a rope

Ranging a line

- It means fixing a series of pegs or other marks such that they all lie on a straight line.
- Suppose P and Q are the two ends of a survey line.
- One ranging rod is driven Q.
- The surveyor holds another ranging rod at P and stands at about 30 cm behind ranging rod.
- The assistant goes with another ranging rod along the survey line and positions himself approximately in line with PQ at a distance less than a chain length from P.

Ranging a line

- The surveyor at P keeps his eye in line with PQ and signals to the assistant by way of adjusting the position of the ranging rod held by the assistant traversely.
- This adjustment is continued till the intermediate ranging rod is truly in line with P and Q.
- Other intermediate points along the survey line are also fixed in the same manner.

Outline of Chain surveying

- A base line which is a chain line is fixed.
- The base line is aligned by ranging.
- The length of the line is measured by chaining.
- For this follower holds the zero end of the chain and the leader drags the chain to an intermediate point on the line
- The leader straightens the chain by jerking till the chain lies exactly over the line.
- The leader marks the end of the chain by driving the chain pin (arrow)
- The follower holds the zero end of the chain at the chain pin point again
- Thus the chaining is continued till the entire length is covered.

Outline of Chain surveying

- For locating the details, lateral measurements are taken to the objects.
- These lateral measurements are called offsets.
- If the offset is at right angles to the base line, it is called perpendicular offset.
- If it is inclined to the base line, it is called oblique offset.
- Depending upon the situation, perpendicular or oblique offsets are taken
- The length are measured are entered.

Advantages and disadvantages of chain surveying

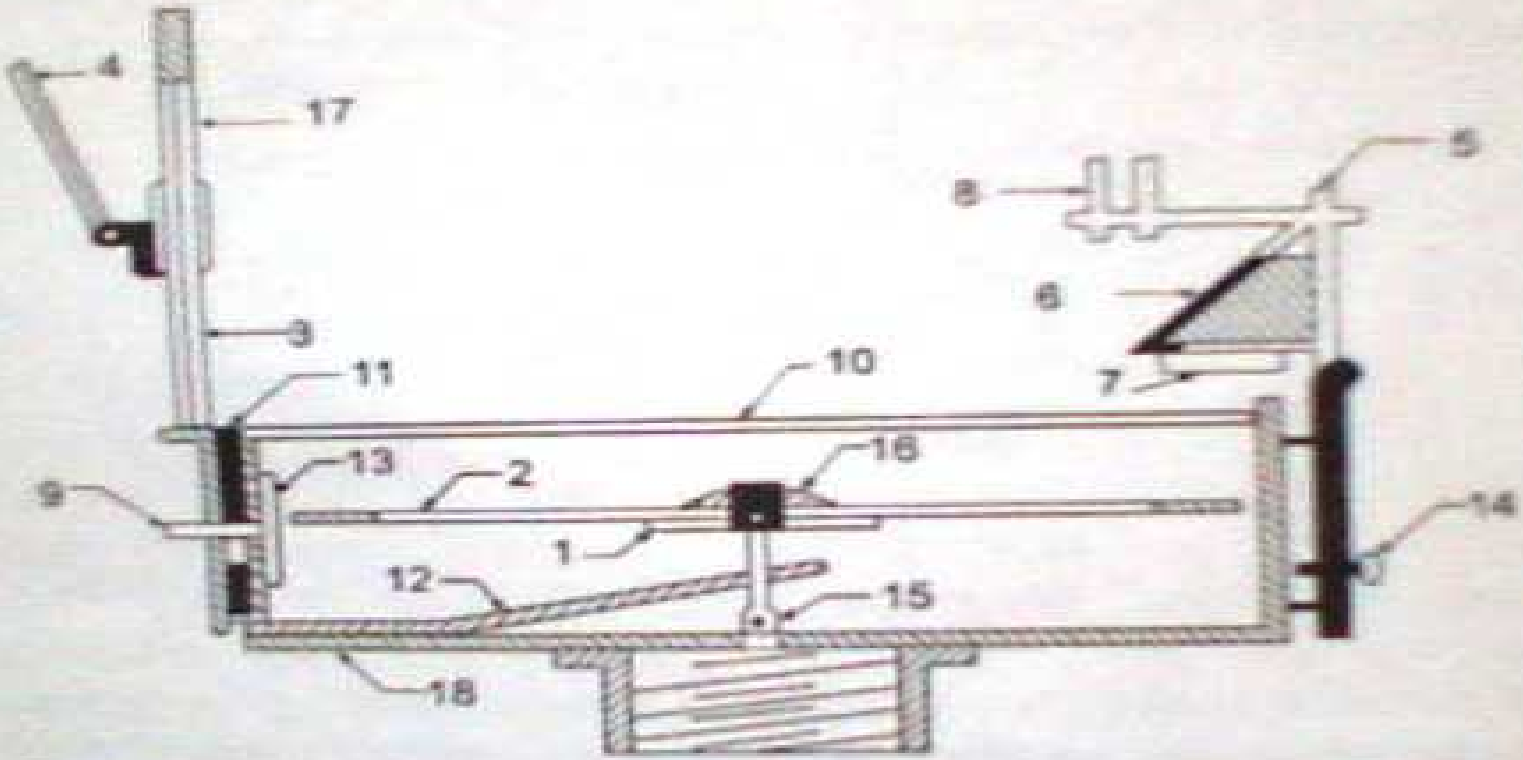
Advantages:

- It is simple
- It does not require any costly equipment
- It is adopted for preparing plans for small area

Disadvantages:

- It cannot be used for large areas
- It cannot be used in thick bushy areas with ups and downs.
- Chain surveying is not always accurate.

Compass Surveying – Prismatic Compass

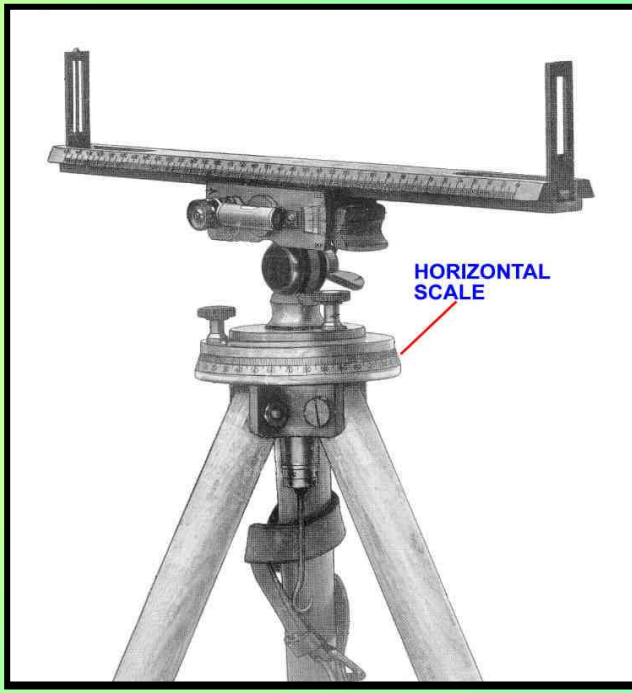


1. Magnetic needle 2. Circular ring 3. Object vane 4. Mirror
5. Eye vane 6. Prism 7. Prism dust cap 8. Sun glasses
9. Brake pin 10. Glass lid 11. Lifting pin 12. Lifting lever
13. Spring brake 14. Focussing stud 15. Pivot 16. Agate cap
17. Sighting hair line 18. Compass box

Fig. 11 Prismatic compass

Compass Surveying

- Whenever a number of base lines are to be run for obtaining the details as in traversing, just linear measurements made by chain surveying will not be sufficient.
- The angles included between the adjacent lines should also be measured
- Compass is one of the instruments used to measure the angles.



Prismatic Compass

Description:

- A magnetic needle is balanced over a pivot in a circular box of 85 mm to 110 mm in diameter.
- A graduated aluminium ring is attached to the magnetic needle.
- An agate cap keeps the aluminium ring stable.
- The box is covered by a glass lid.
- Object vane and eye vane are provided at diametrically opposite ends.
- Eye vane caries a reflecting prism which can be raised or lowered as desired.
- A vertical horse hair or fine wire is provided at the middle of the object vane.
- The graduations in the aluminium ring are made in the clockwise direction starting with 0^o at South and 180^o at North with inverted markings.

Prismatic Compass

Description:

- A triangular prism fitted below the eye slit enables magnification of readings to suit observer's eye.
- Based on this prism arrangement, the compass is named prismatic compass.
- Compass is fixed over a tripod with ball and socket arrangement.
- A braked pin is provided below the object vane to damp the oscillations of the magnetic needle while taking readings.

Prismatic Compass

Working Principle:

- The magnetic field aligns itself with the magnetic meridian (N-S direction)
- The line of sight is actually the line joining the object vane and eye vane
- The angle between the N-S direction and the line of sight is observed in the compass
- This angle is actually the angle between N-S direction and the line on the ground
- This angle made by the line with the N-S direction is called the bearing of the line.
- Compass is used to measure the bearing of the different lines from which the angles included between the adjacent lines are computed.

How to take reading using compass

- The compass is centered over the station by dropping a small piece of stone from the centre of the bottom of the compass.
- A plumb bob is used for centering.
- The compass is levelled by adjusting the ball and socket till the top of the box is horizontal.
- The graduated ring should move freely after having levelled the instrument.
- Suppose the bearing of a line PQ is to be observed.
- The compass is centered over P.
- It is levelled.
- The prism and the object vane are kept in vertical position.
- The compass is turned slowly till the ranging rod already erected at Q is bisected.

How to take reading using compass

- In this position, the ranging rod, the object and the eye vane all lie in the same line.
- The focusing prism is raised or lowered till the readings were clear and sharp.
- The reading in the ring cut by the object hair line is taken after damping the oscillations of the ring by pressing the brake pin.

Definitions

Magnetic Bearing:

- It is the angle between the magnetic meridian and the line.
- The angle is always measured in the clockwise direction
- It is the direction shown by a freely suspended magnetic needle
- The magnetic meridian is also called bearing.

True Bearing:

- True bearing of a line is the angle between the true meridian and the line.
- The angle is always measured in the anticlockwise direction.
- The true meridian is the line joining the geographical north and south bearings.

Definitions

Whole Circle Bearing:

- The bearing of lines measured from the North is called Whole Circle Bearing.
- The angle is reckoned in the clockwise direction from 0^o coinciding with the north.

Quadrant Bearing:

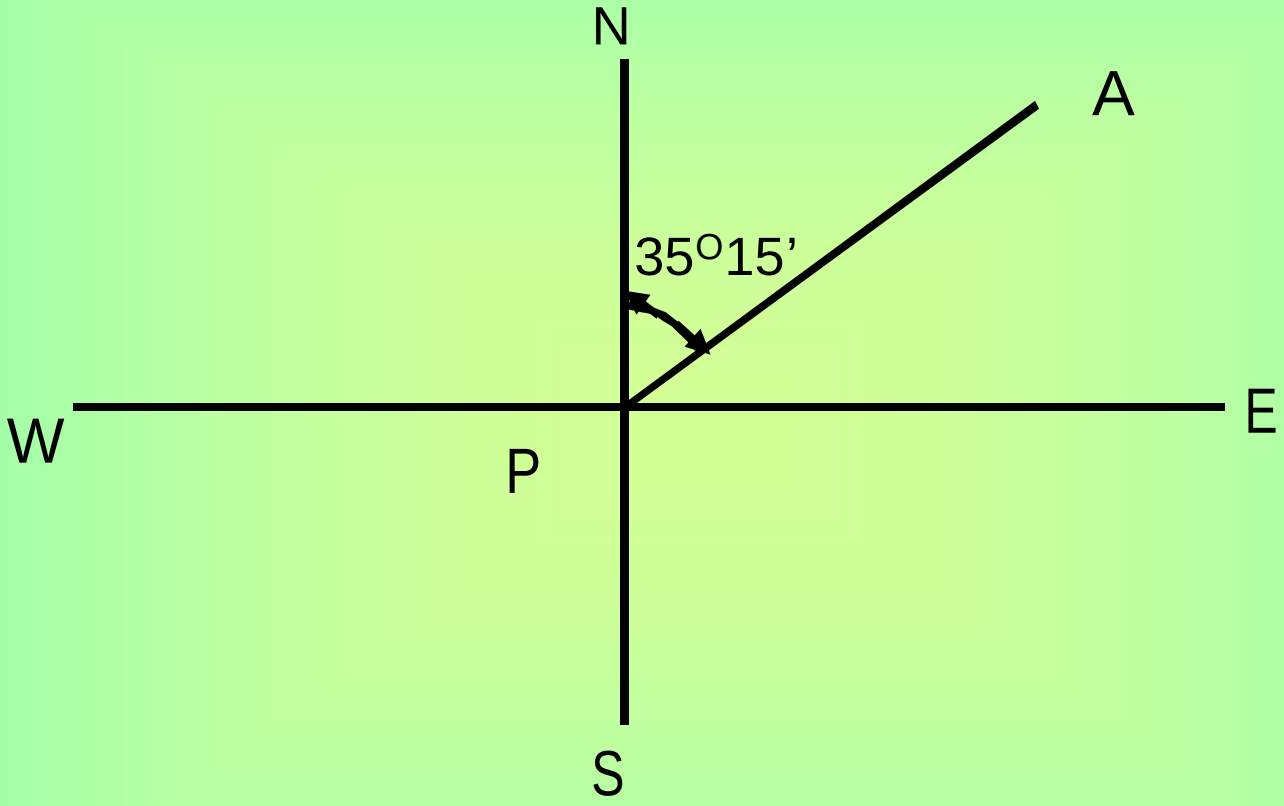
- The whole circle is divided into four quadrants.
- The bearing is expressed with N or S as prefix and E or W as suffix.
- Quadrant Bearing is also known as Reduced Bearing.

Definitions

Fore Bearing and Back bearing:

- Every line has two bearing namely fore bearing and back bearing
- Fore bearing is the bearing taken in the direction of surveying and Back bearing is the bearing taken in the reverse direction.
- The difference between the fore bearing and the back bearing should be 180^{o}.
- It means that one or both stations of the line are subjected to local attraction.
- Thus, local attraction is the influence caused on the measured bearings of lines due to the presence of materials like railway track, current carrying wires or cables, etc.,

To find QB from WCB

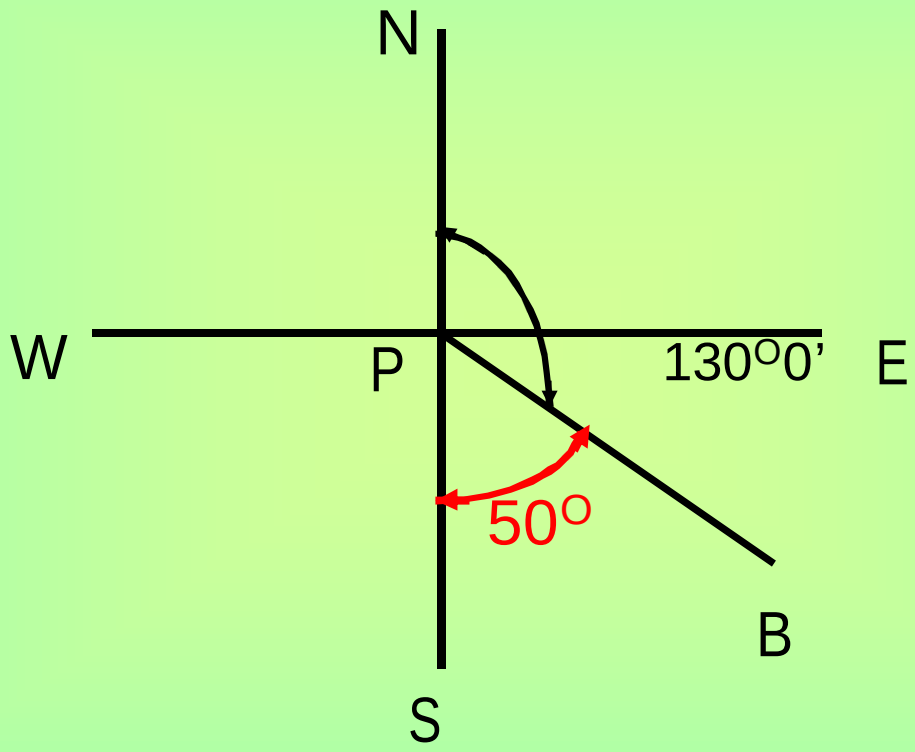


Solution :

Line PA lies in 1st quadrant.

Quadrant Bearing bearing of PA = N 35o 15’ E

To find QB from WCB

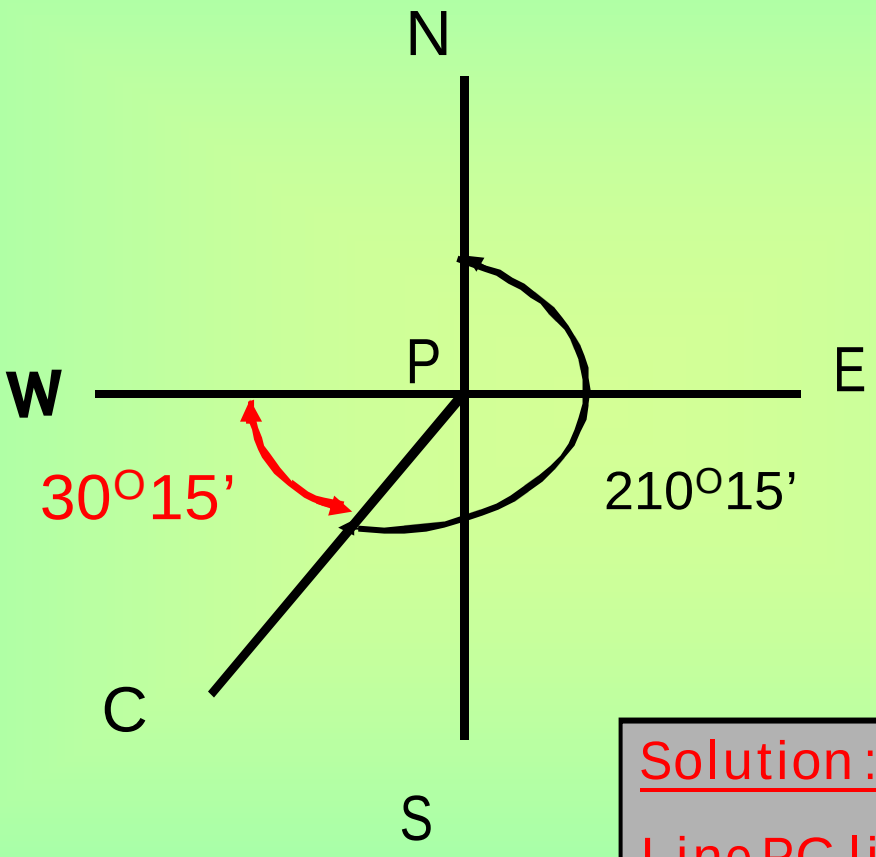


Solution :

Line PB lies in 2nd quadrant.

Quadrant Bearing of PB = S 50° 00' E

To find QB from WCB

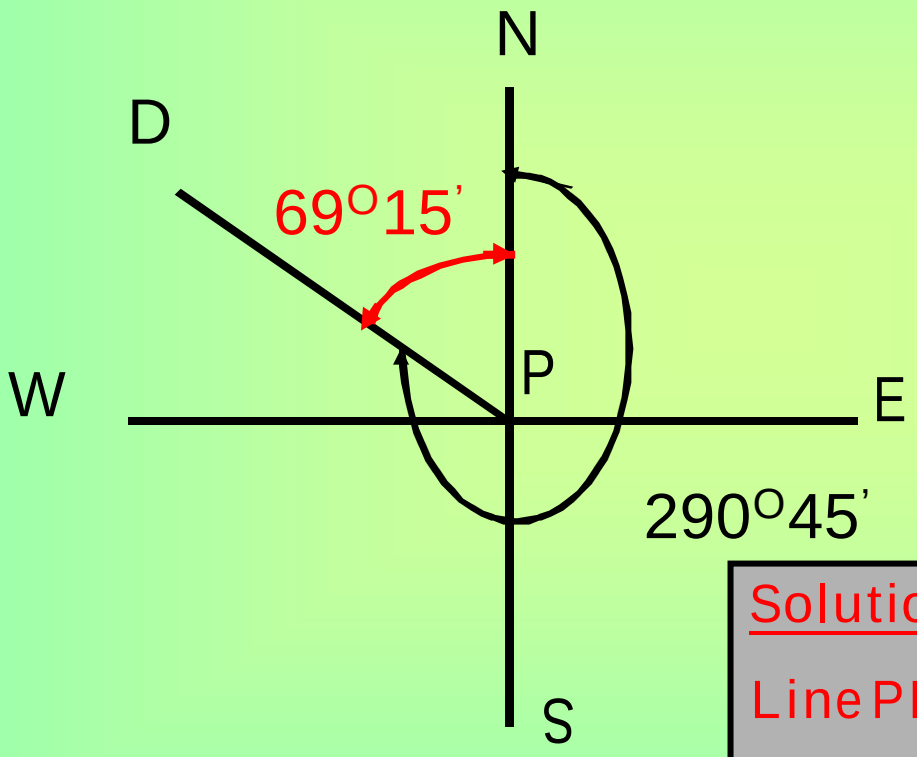


Solution :

Line PC lies in 3rd quadrant.

Quadrant Bearing of PC = S 30° 15’ W

To find QB from WCB



Solution :

Line PD lies in 4th quadrant.

Quadrant Bearing bearing of PD = N 69º 15’ W

To find Whole Circle Bearing from QB

(i) WCB = PA –N 15^{o} E

(ii) WCB = PB – S 25^{o} 45’ E

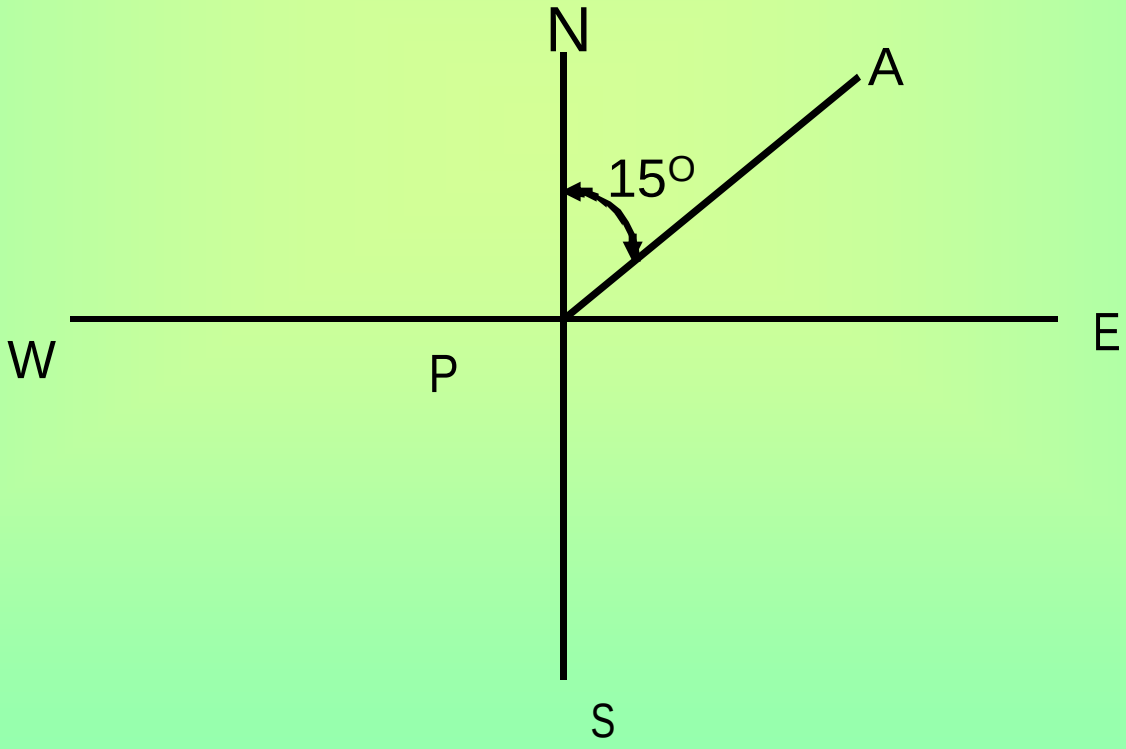
(iii) WCB = PC – S 45^{o} 30’ W

(iv) WCB = PD – N 10^{o} W

To find Whole Circle Bearing from QB

Qn: PA – N 15^{o} E

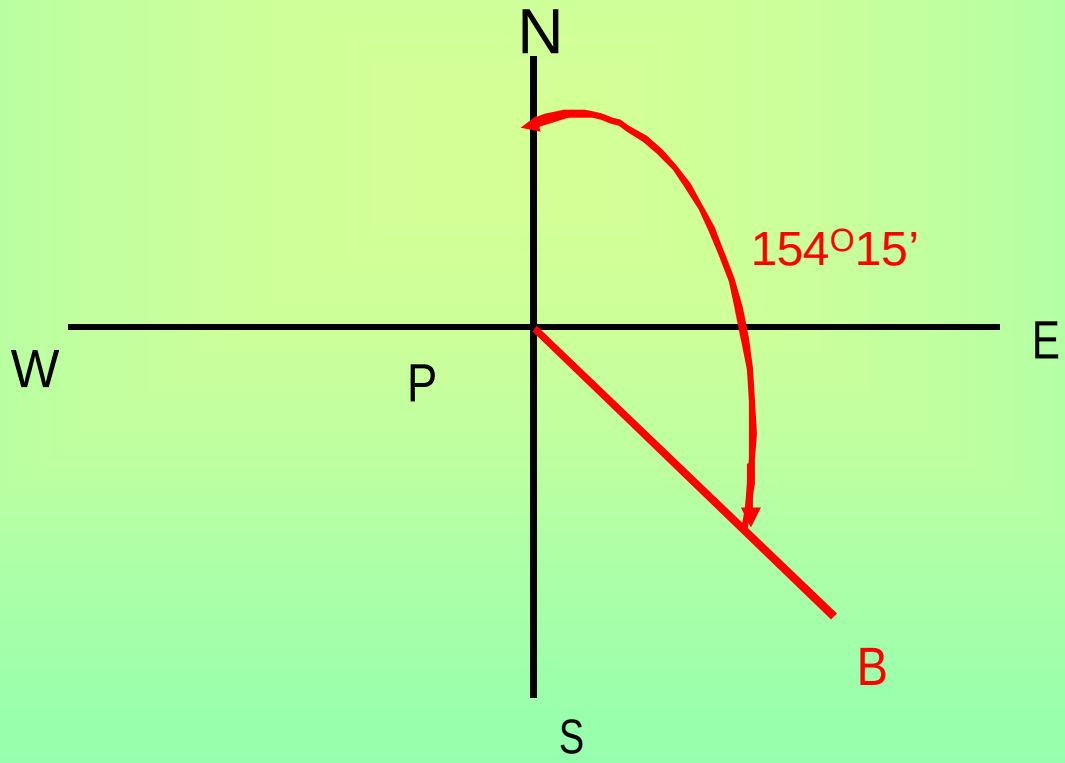
Ans: Line PA is in the first quadrant. Its WCB is 15^{o}



To find Whole Circle Bearing from QB

Qn: PB – S 25º 45’ E

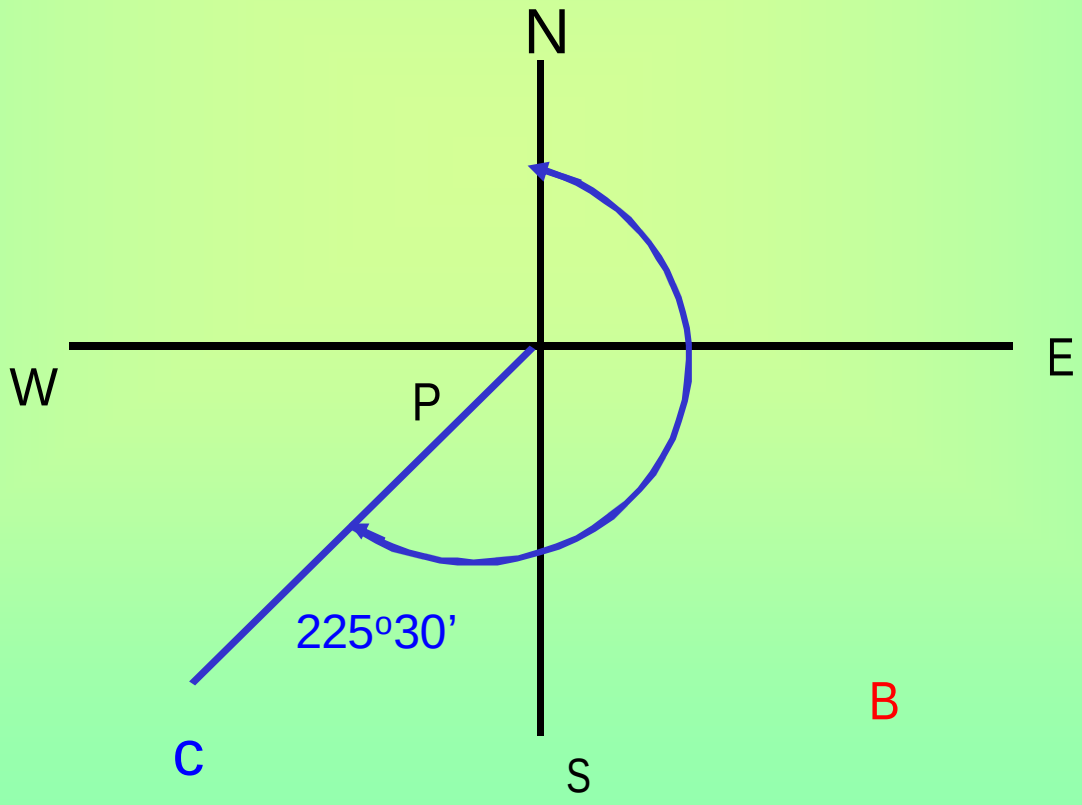
Line PB is in second quadrant. Its WCB is 180º00’-25º45’ = 154º15’



To find Whole Circle Bearing from QB

Qn: PC – S 45° 30'W

Line PC is third quadrant. Its WCB is 180°00'+45°30' = 225°30'

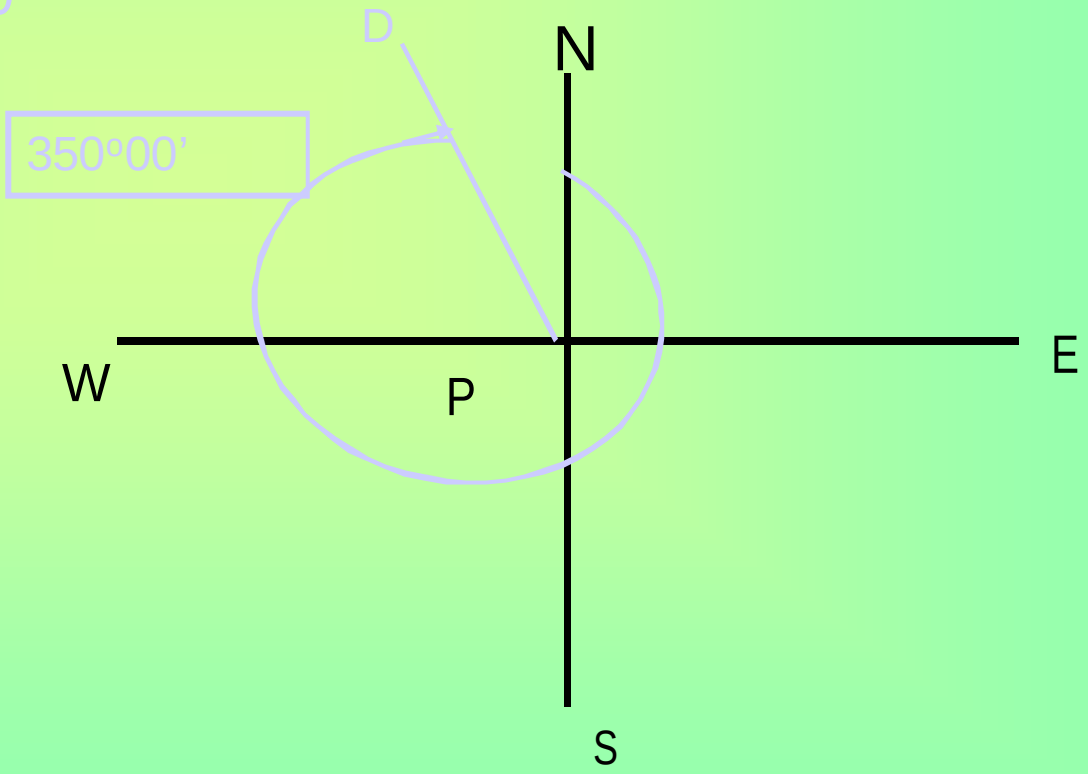


To find Whole Circle Bearing from QB

Qn: PD – N 10° W

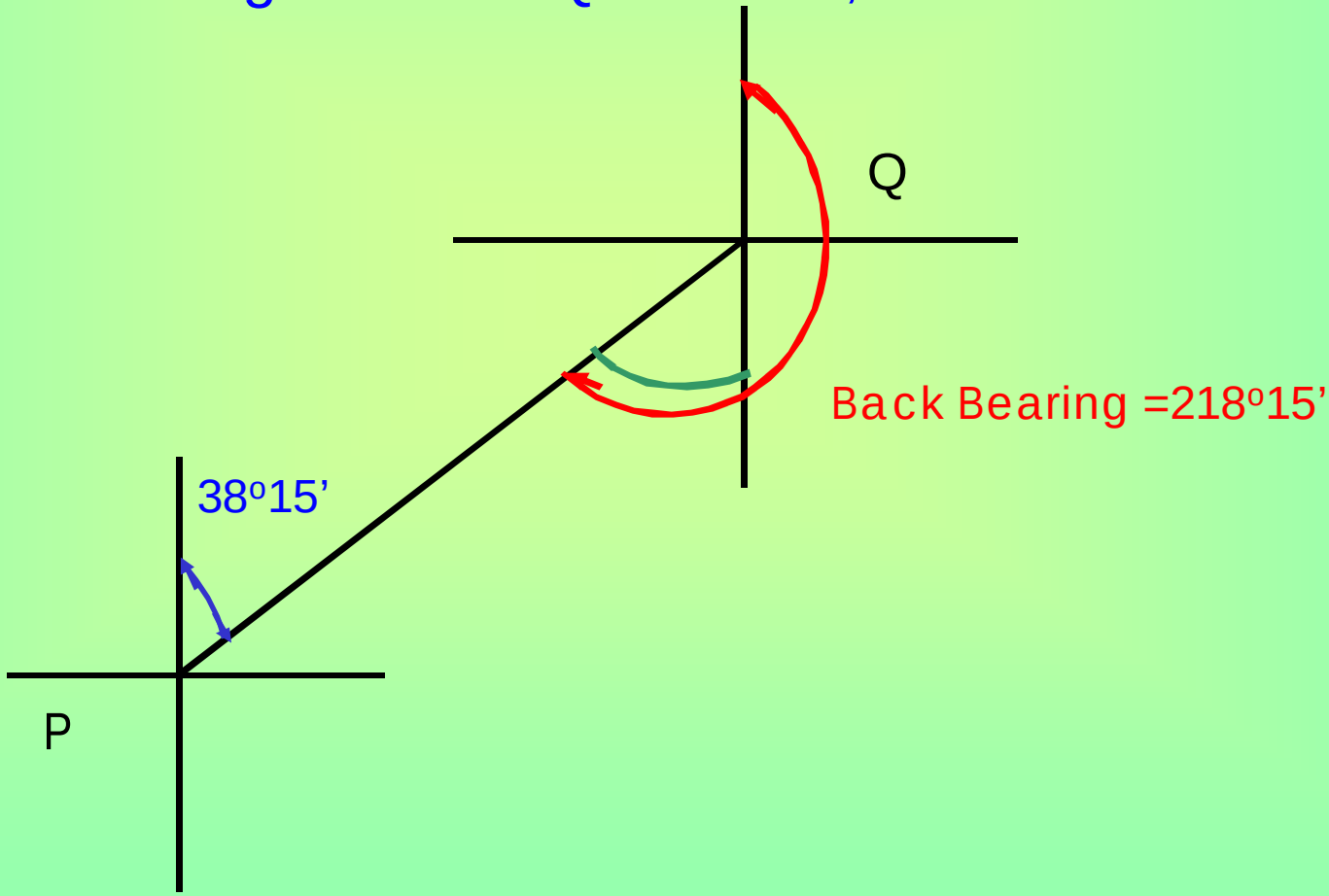
Line PD is in fourth quadrant. Its WCB is

360°00’-10°00’= 350°00’



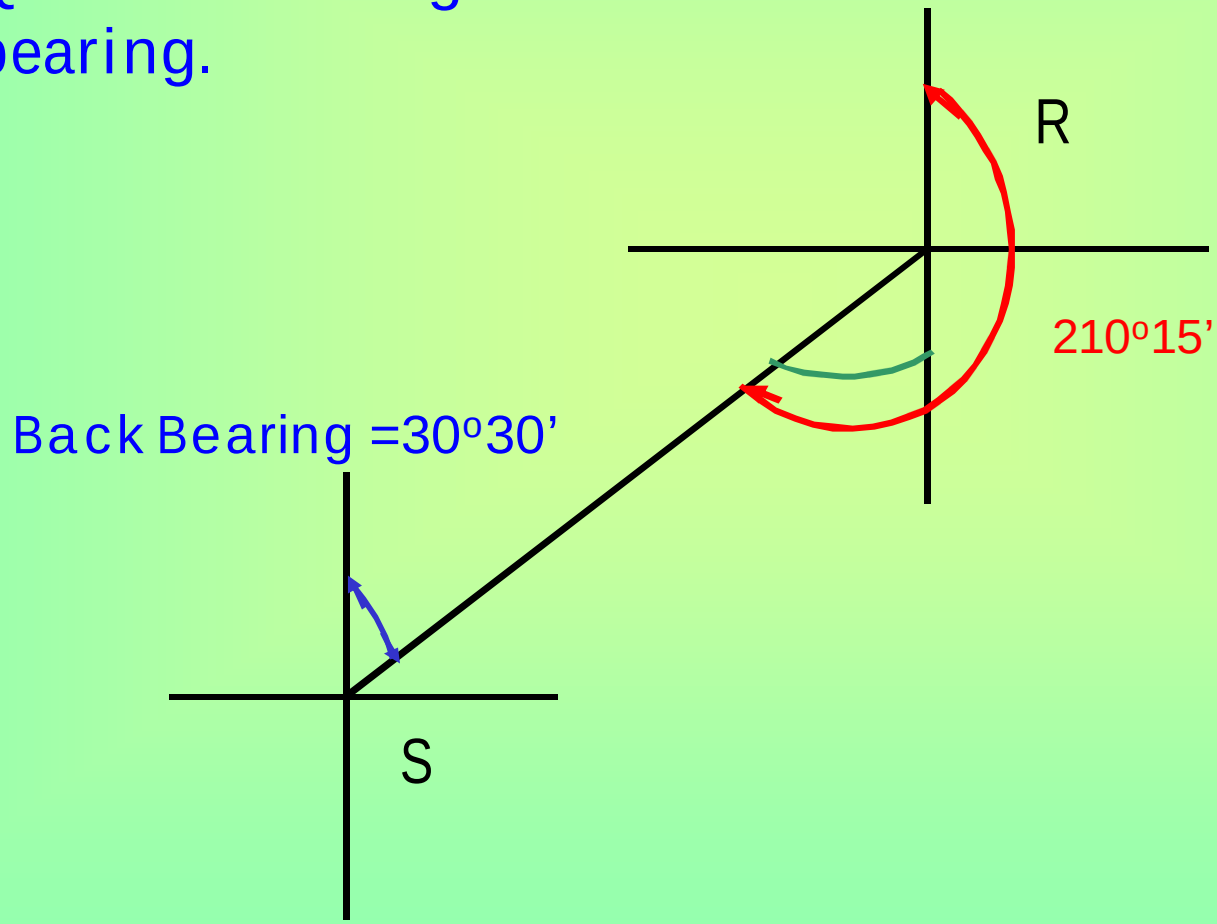
To find Back Bearing from Fore Bearing

Qn: Fore bearing of Line PQ is 38°15', find Back bearing.



To find Back Bearing from Fore Bearing

Qn: Fore bearing of Line RS is 210°15' find the back bearing.



Levelling

- It is a surveying method used to determine the level of points / objects with reference to the selected datum.
- It is also used to set out engineering works.

Uses of Levelling:

- To determine the difference in levels of points / Objects
- To obtain contour map of an area
- To obtain cross section of roads, canals etc.,
- To determine the depth cutting and filling in engineering works.
- To establish points or erect machinery or construct a building component at a predetermined level.

Important Terms

Bench Mark: It is surveyor's mark cut on a stone/ rock or any reference point used to indicate a level in a levelling survey.

Reduced Level:

- Reduced level of a point is the level of the point with respect to the level of permanent feature or bench mark.
- It indicates whether the point is above or below the reference point (datum).

Instruments used in levelling

Instruments used in levelling are,

(i) Levelling instrument

(ii) Levelling staff

Leveling Instrument :

- Simplest form of levelling instrument is dumpy level.
- The different parts of levelling instrument are,

(a) Telescope (b) Eye-piece (c) focusing knob (d) level tube (e) cross bubble (f) foot screws (g) levelling head (h) diaphragm (i) ray shade

Dumpy Level

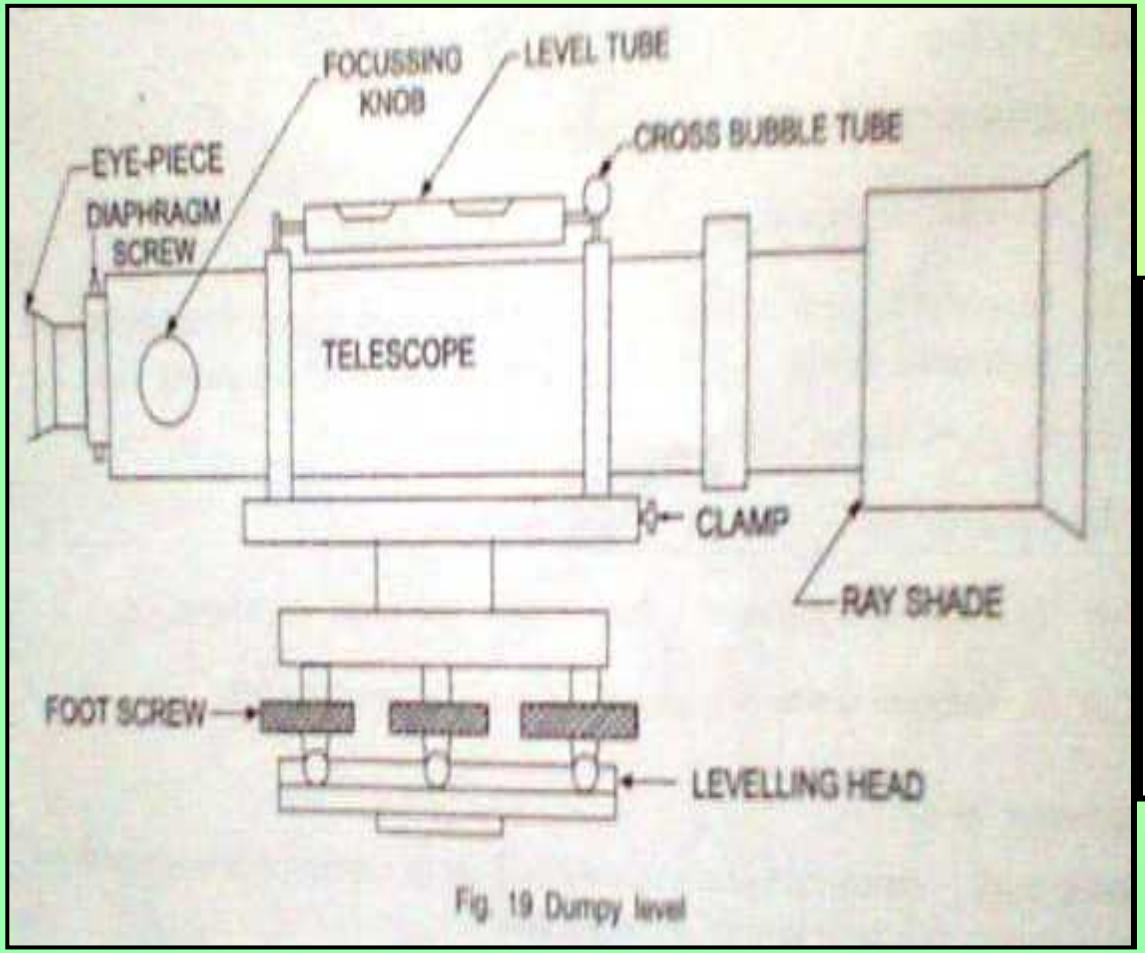
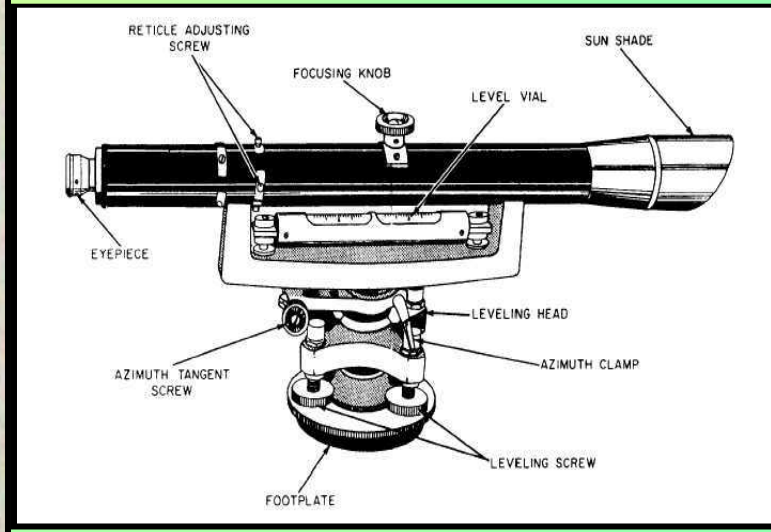


Fig. 19 Dumpy level



Levelling Staff

- It is an important accessory used with levelling instrument at the time of conducting levelling survey.
- Reading is taken on the levelling staff held properly at the point concerned by viewing through the telescope of the levelling instrument.
- Usually 4 m levelling staff may be used of folding type or telescopic type
- Aluminium levelling staff foldable at every metre length has also came to the market.
- The levelling staff consists of three pieces.
- The topmost one slides into the middle one and the middle portion slides into the bottom one.
- When the staff is fully pulled, it will read exactly 40 decimeters (4m) from the bottom shoe.

Levelling Staff

Graduation in levelling staff:

- Every metre length is divided into 200 divisions.
- The divisions are painted in black and white alternately of thickness 5 mm each.
- The graduation figures are marked at every decimeter length.
- The number indicating metre is in red and the decimeter number is in black.
- Thus, a graduation figure of 24 indicates 2 meters and 4 decimeters.

Levelling Staff

Graduation in levelling staff:

- The graduation are made continuously one above the other in the same line.
- The division lines should be parallel to the base of the bottom shoe and perpendicular to the length of the staff.
- The edges of the division lines should be straight sharply defined.
- They should be clear and made distinctly visible by properly contrasting.
- The graduation colour paints used should not crack or blister when exposed to adverse or atmospheric conditions.

Important Terms in levelling

- Station : In Levelling, the term station always refers to the point where the levelling staff is held and not the instrument station.

- Height of Instrument : It is the elevation of the line of sight with reference to the assumed datum.

- Back Sight (B.S) : It is the reading taken on the staff held at a point, the elevation of which is known already. It is useful to know the new height of the instrument.

Important Terms in levelling

- Foresight (F.S): It is the reading taken on the staff held at a point of unknown elevation. From, F.S., the height of the line of instrument above the point can be obtained. It is useful to find the elevation of the point.
-
- Change Point : It is the point at which the fore sight is taken from one instrument station and back sight is taken from the next instrument station.

- Intermediate station : A point between two change points is known as intermediate station. Only one reading is taken on the intermediate station.

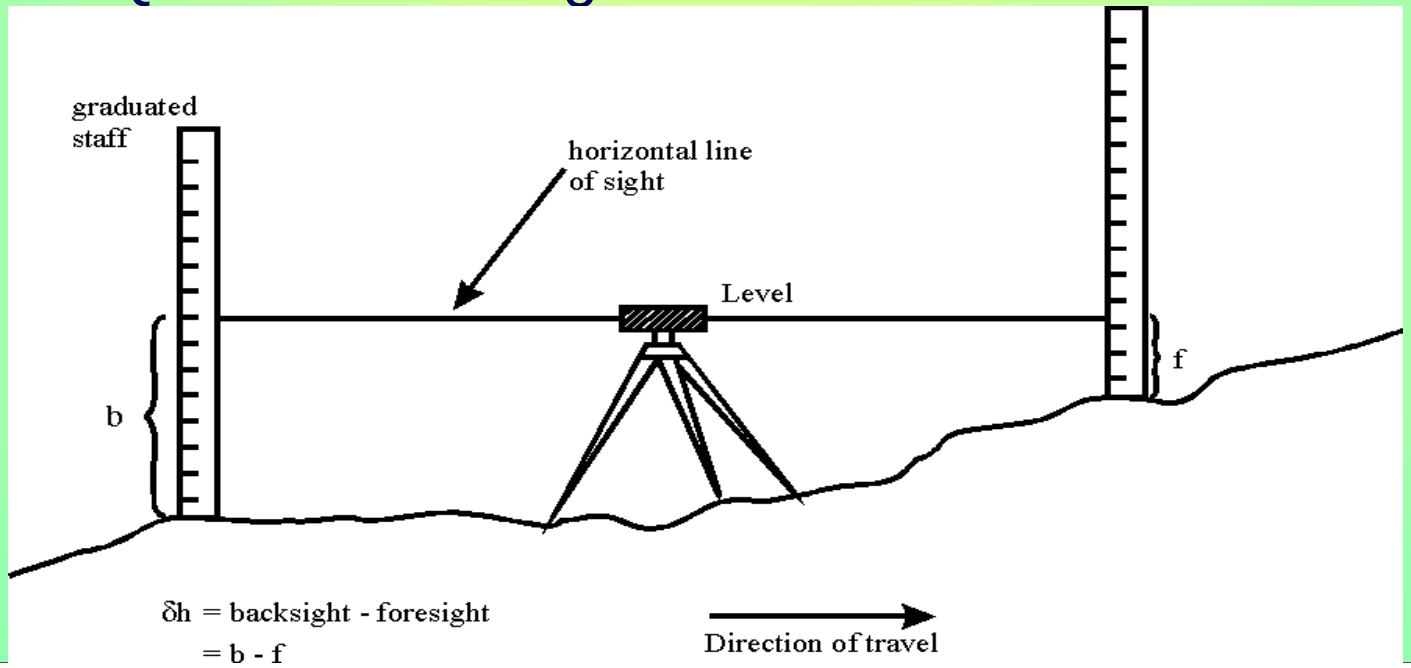
Methods of Levelling

- Method 1 : It is done with only one setting of the instrument.

- Method 2: When the two station points are wide apart and the instrument is set up at more than one point and the levelling is carried out.

Method 1
With only one setting of the instrument

- The instrument is set up at a point between P and Q and the temporary adjustments carried out.
- The levelling staff is held at P, the elevation of which is known already.
- A back sight is taken on the staff held at P. The staff is then held at Q and the foresight is taken.



Method 1
With only one setting of the instrument

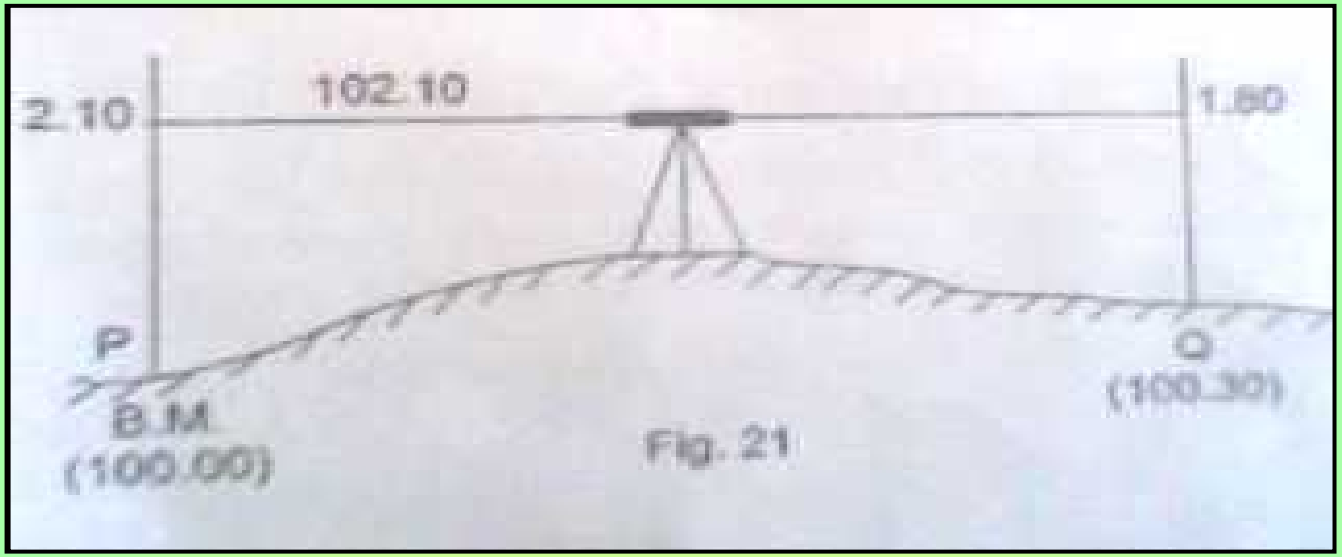


Fig. 21

Height of the instrument = Known elevation of P + the staff reading at P

= 100.00 + 2.10 = 102.10 m

Elevation of Q = Height of the instrument – the staff reading at Q

= 102.10 – 1.80 = 100.30 m

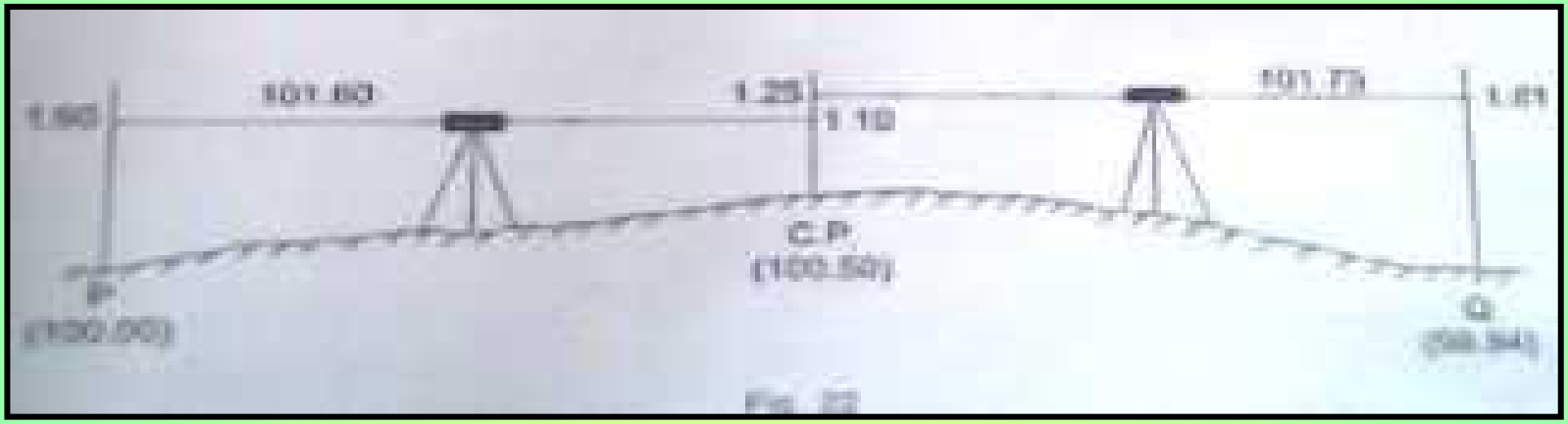
Method II

When the station points are wide apart, the instrument is setup for at more than one point and levelling is done (Height of Collimation Method)

- A change point (C.P) is established in between P and Q.
- A back sight is taken at P and a fore sight is taken at the change point.
- The instrument is shifted to another point between the change point and Q.
- A back sight is taken at the change point and a fore sight is taken at Q.
- Any number of change points are established as required.
- This method is known as Height of Collimation method.

Method II

When the station points are wide apart, the instrument is setup for at more than one point and levelling is done (Height of Collimation Method)



The elevation of change point = Elevation of P + Back sight at P – Fore sight at change point (C.P)

= 100.00+1.60-1.10 = 100.50 m

The second height of the instrument = The elevation of change point+ Back Sight at change point

= 100.50+1.25 = 101.75 m

The elevation of Q = The second height of instrument – foresight at Q

= 101.75 – 1.81 = 99.94 m

Rise and Fall Method of calculating the level

- The staff readings of the points observed from the same setting of the instrument are compared.
- It is found whether a point is above or below the preceding point.
- If the point is above, the staff reading will be less than the preceding point. The difference between the staff readings is called rise.
- If the point is below the preceding point, the staff reading will be greater than that at the preceding point. The difference between the staff readings is termed fall.

Rise and Fall Method

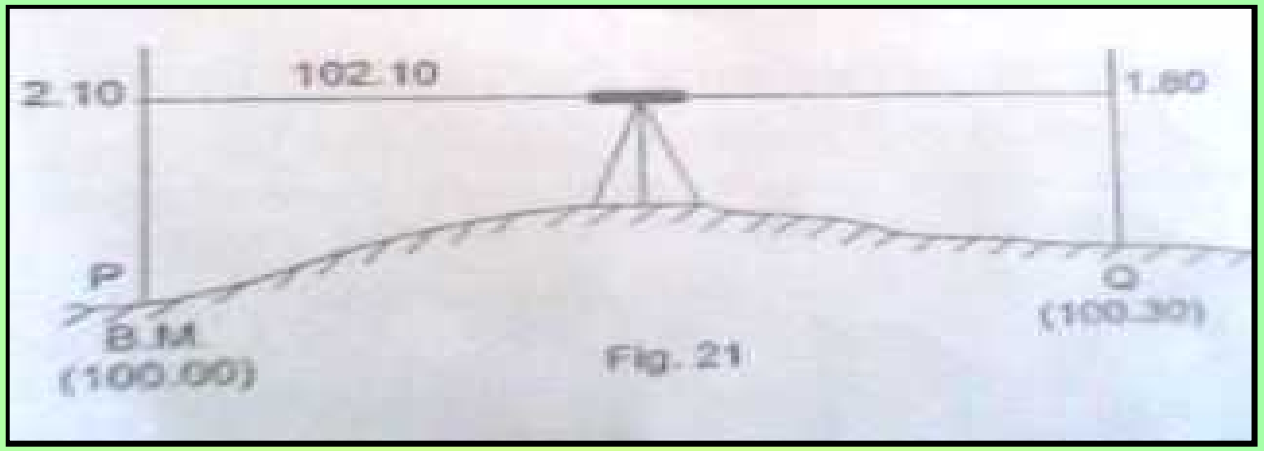


Fig. 21

The difference between the staff readings

at P and Q = 2.10 – 1.80 = 0.30 (rise)

Hence, level of Q = Elevation of P + Rise

= 100.00+0.30 = 100.30 m

Rise and Fall Method

Back sight	Intermediate station	Fore sight	Rise	Fall	Reduced Level	Remarks
1.245					100.00	BM
	2.100			0.855	99.145	
2.425		0.810	1.290		100.435	STATION A
		0.480	1.945		102.380	STATION B
? BS 3.670		? FS 1.290	? RISE 3.235	? FALL 0.855		

Arithmetical Check of Rise and Fall method

? B.S - ? F.S = ? Rise - ? Fall = Last R.L – First R.L.

3.670 – 1.290 = 3.235 – 0.855 = 102.380 – 100.00

2.380 = 2.380 = 2.380

Fly Levelling

- Any number of change points are established as required during levelling. This method is known as fly levelling.

- It is adopted to find the difference in level between two points, when

  (i) The two points are too far away

  (ii) the difference in level between two points is large

  (iii) there are no obstructions in between the two points concerned.

Calculation of Areas

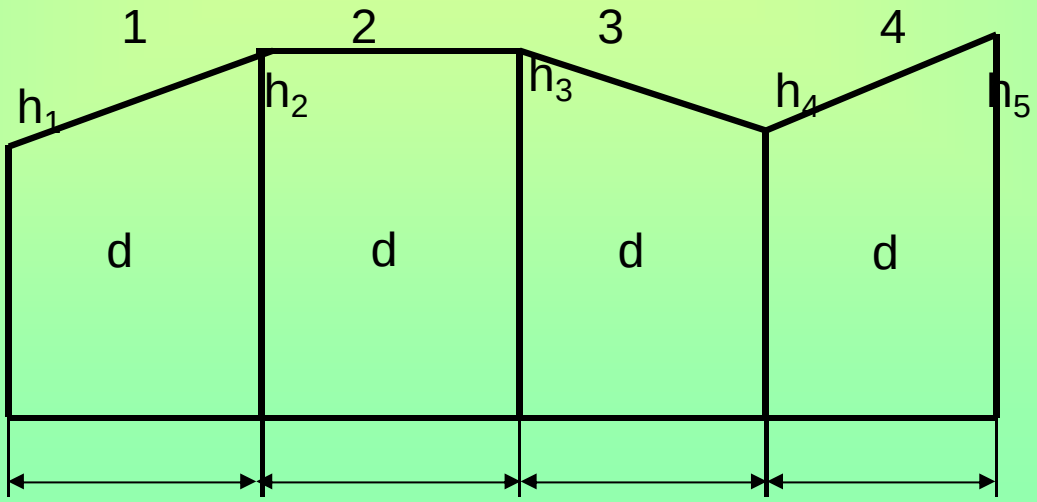
- One of the purposes of surveying is to determine the area to be surveyed.

- The area of the land obtained by surveying actually refers to the area as projected on a horizontal plane.

- There are different methods of computing the area of land using the data obtained by surveying.

Calculation of area by Trapezoidal Rule

- In trapezoidal, a convenient base line is established.
- Perpendicular distances from the base line to the boundary of the land concerned are measured at regular (equal) intervals along the base line.
- These perpendicular distances are called ordinates.



Trapezoidal rule

Total Area,

$$A = d/2\,(h_1 + h_n + 2(h_2 + h_3 + \ldots\ldots + h_{n-1}))$$

Simpson's Rule

- This rule is applicable only if the number of ordinates is odd.

$$A = d/3 \{(\text{First Ordinate} + \text{Last Ordinate} + 2(\text{sum of odd ordinates}) + 4(\text{sum of even ordinates})\}$$

$$\text{i. e. } A = d/3\{(h_1+h_n+2(h_3+h_5+h_7+\ldots..+h_{n-2})+4(h_2+h_4+\ldots.+h_{n-1})\}$$

- If the number of ordinates is even, the area of the last trapezoid is calculated separately and added to the result.

Thanks