LABORATORY MANUAL
FOR **Geomatics Engineering**
Subject Code: **CEP 1403**

DEPARTMENT OF CIVIL ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY MIZORAM

LIST OF EXPERIMENTS

EXPERIMENT NO. I

Problem I: Measurement of distance by ranging and chaining

AIM: To measure the horizontal distance between two points using the method of ranging and chaining.

THEORY: Chain surveying is a simple and fundamental method of surveying where measurements are taken using chains or tapes. It is particularly effective for small and medium-sized areas with clear and relatively level terrain. Ranging is the process of ensuring a straight line between two points, and chaining is the measurement of distances using a chain or tape. Accurate distance measurement is crucial for creating detailed maps and plans. The precision of chaining, for ordinary work, ranges from 1/1000 to 1/30,000 and precise measurement such as Baseline may be of the order of 1000000.

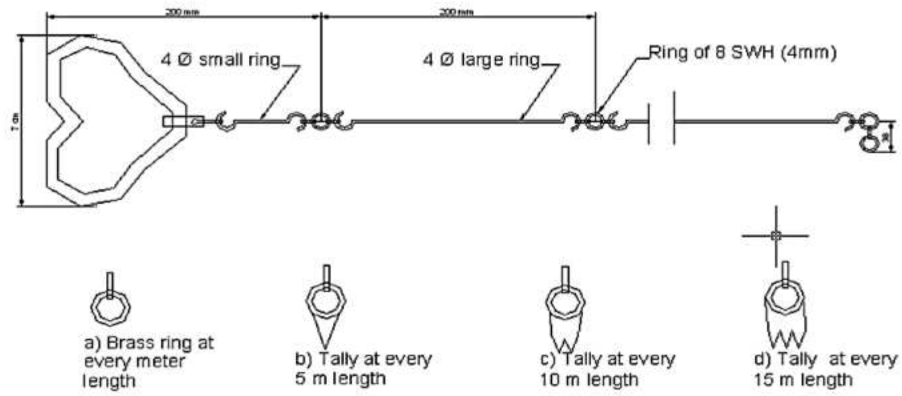


Figure 1.1. Details of metric chain

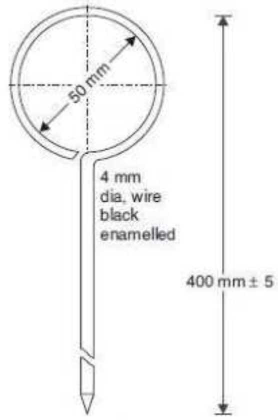


Figure 1.2. Arrow

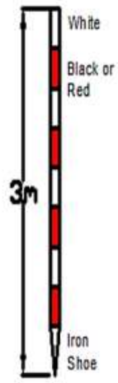


Figure 1.3. Ranging rod

APPARATUS:

a) Chain/Tape: For measuring distances.
b) Arrows: Used to mark chain lengths.
c) Ranging Rods: For establishing straight lines.
d) Cross Staff: For setting out right angles.
e) Pegs: To mark the start and end points.
f) Measuring Tape: For precise measurement over short distances.
g) Plumb Bob: For ensuring verticality.

PROCEDURE:

1. Gather all the required equipment.
2. Identify and mark the start point and end point using pegs.
3. Place a ranging rod at start point and another at end point. If the distance is long, place additional ranging rods at intermediate points to help maintain a straight line. Align these intermediate rods visually to ensure they are in a straight line with start and end point.
4. Move to the intermediate ranging rods and adjust their positions until they form a straight line with the end points, ensuring the line of measurement is straight.
5. Position the cross staff at intervals along the line to verify that right angles are being maintained as needed.
6. Starting from first point, stretch the chain or tape along the ground towards end point. The leader pulls the chain while the follower holds the end at first point.
7. As the leader reaches the end of each full chain length, insert an arrow into the ground at that point to mark the full chain length.

8. If an obstacle is encountered, such as a tree or building, use the following indirect chaining method. The obstacles may be divided into two classes. Those which do not obstruct the ranging (view) like ponds, rivers etc. fall in the category of obstacles to measurement. The others are those which we cannot see across, i.e., both the chaining and ranging are obstructed, e.g., houses, haystacks, etc., and are known as obstacles to alignment.

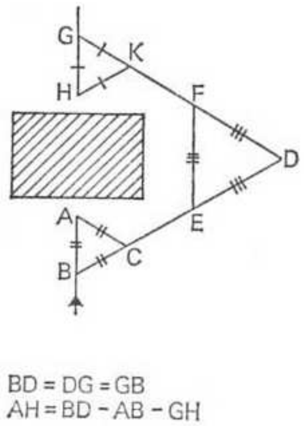


Figure 1.4. Survey line which is obstructed by a building

It is required to range a survey line which is obstructed by a building. The ranged line as shown in figure proceeds as far as A and can go no farther.

- Mark a point B on the survey line at a convenient distance such that AB forms a base. 2. From the base AB set out a point C on the ground such that AB = AC = BC. This results in the equilateral triangle ABC.
- Produce the line BC to set out point D on the ground such that it is clear of the obstacle.
- On the line BD thus formed set out a point E on the ground at a convenient distance such that DE forms a base.
- From the base DE set out a point F on the ground such that DE = EF = DF. This results in the equilateral triangle DEF.
- Produce the line DF to set out point G on the ground such that BD = DG, so that the triangle BDG is also equilateral. (G now lies on the extension of AB. But the direction of the line cannot be established until the third equilateral triangle GHK is set out.)
- On the line DG thus formed set out a point K on the ground at a convenient distance such that GK forms a base.
- From the base GK set out a point H on the ground such that GK = GH = KH. This results in the equilateral triangle GHK.

- Produce HG forward to continue the survey. (HG Produced provides the extension of the survey line AB on the other side of the building)

9. Record the number of full chains, partial chains, and any necessary corrections for obstacles.
10. Verify the straightness of the line and accuracy of the measurements by checking the alignment of the ranging rods and ensuring the chain is fully extended without any sagging or twisting.
11. After completing the chaining, remove the arrows and gather all the equipment. Record the final distance measured, including any adjustments for terrain or obstacles.

OBSERVATIONS:

- Total distance measured: ______
- Number of chains and additional links: ________
- Corrections needed: _________

CALCULATION:

- Total distance measured by chain survey =

RESULTS:

Final distance between the two points after corrections =

Using the data recorded in the field-book prepare a plan to a suitable scale.

PRECAUTIONS:

- Ensure the chain is fully extended and not twisted during measurement.
- Verify that the line is straight before recording the measurement.
- Avoid chaining on rough or uneven surfaces to reduce measurement errors.

QUESTIONS:

1. What is the purpose of ranging in chain surveying?
2. How would you handle an obstacle during chaining?
3. Why is it important to correct for slope when measuring distances?
4. What are the common errors that can occur during chaining and how can they be minimized?

Problem II: Determination of the area - Closed Traverse

AIM: To determine the area of a polygon by conducting a chain and cross staff survey.

THEORY: The chain and cross staff survey method is used to measure areas by dividing a polygon into simpler shapes, such as triangles or trapezoids, which can be measured more easily. A chain is used to measure the distances, while a cross staff is used to measure offsets and perpendiculars to the main survey lines.

APPARATUS:

a) Chain: For measuring distances.
b) Cross Staff: For setting out perpendicular lines.
c) Arrows: To mark chain lengths.
d) Ranging Rods: For establishing straight lines.
e) Pegs: To mark vertices of the polygon.
f) Measuring Tape: For precise short-distance measurements.
g) Plumb Bob: For ensuring verticality.

PROCEDURE:

1. Select the required closed traverse open field to be surveyed for calculating the area. Mark the polygon as ABCDEF as shown in Figure 1.5.

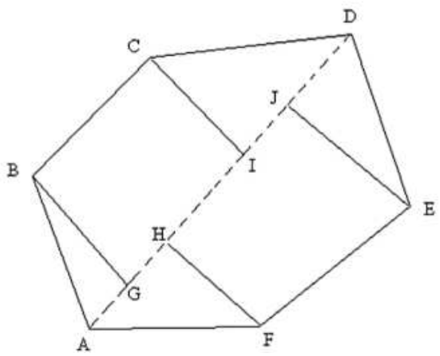


Figure 1.5. Survey of an open field (Closed Traverse)

2. From the station A the length of all the opposite corners such as AC, AD and AE are measured with a chain and the longest distance is considered for laying off the main chain line. In this case AD is the longest and a chain line running from A to D is laid.
3. Offsets to corner points B, C, E and F are now laid from the chain line AD either by tape or cross-staff and their foot of offsets are G, I, J, H respectively.

4. All the offset lengths GB, HF, IC and JE are measured either by chain or tape depending on the length of offsets.
5. The distances between all the points AG, GH, HI, IJ and JD are also measured along the chain line.

OBSERVATIONS:

Distances measured:

CALCULATION:

Calculate the area of each simpler shape using the recorded measurements.

For triangles, use the formula: $Area = \frac{1}{2} \times base \ \times height$

For trapezoids, use the formula: $Area = \frac{1}{2} \times (sum\ of\ parallel\ sides) \times height$

RESULTS:

Area of the open field as determined by the chain and cross staff survey = ___ m^2

Using the data recorded in the field-book prepare a sketch of the area to scale.

PRECAUTIONS:

- Ensure the chain is fully extended and not twisted or sagging during measurement. Make sure the chain is fully extended and not twisted during measurement.
- Verify that all lines are straight and perpendicular offsets are accurate.
- Avoid measuring on uneven ground to reduce errors in distance measurements.

QUESTIONS:

1. What is the purpose of using a cross staff in this survey?
2. How do you determine the area of irregular polygons using chain and cross staff survey?
3. What are the common sources of error in chain and cross staff surveys and how can they be minimized?
4. Why is it important to record all measurements accurately in your notebook?

Problem III: Distance between two points across a sloping ground

AIM: To measure the distance between two points by chaining across a sloping ground using the stepping method.

THEORY: The sloping ground is divided into many horizontal and vertical strips, like steps. So, this method is known as the stepping method. The length of the horizontal portions is measured and added to get the total horizontal distance between the points. The steps may not be uniform and would depend on the nature of the ground.

APPARATUS:

a) Chain
b) Tape
c) Ranging rod
d) Peg
e) Plumb bob
f) Mallet

PROCEDURE:

1. Suppose the horizontal distance between points A and B is to be measured.

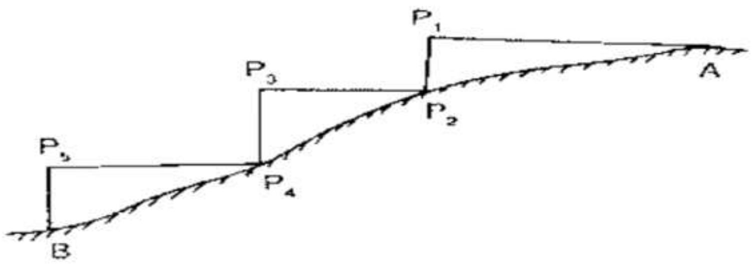


Figure 1.6. Survey points on a slopped ground

2. The line AB is first ranged properly.
3. Then, the follower holds the zero end of the tape at A.
4. The leader selects a suitable length AP1 so that P1 is at chest height and AP1 is just horizontal.
5. The horizontal is maintained by eye estimation, by tri-square, or by wooden set-square.
6. The point P2 is marked on the ground by plumb-bob so that P1 is just over P2.
7. The horizontal length AP1 is noted then the follower moves to position P2 and holds the zero end of the tape at that point.

8. Again, the leader selects a suitable length of P2P3 in such a way that P2P3 is horizontal and P3P4 vertical.
9. Then the horizontal lengths P2P3 and P4P5 are measured.
10. So, the total horizontal length, AB = AP1 + P2P3 + P4P5

OBSERVATIONS:

Sl No	Points	Step length	Total length

CALCULATION:

Total distance between points A and B = (calculation)

RESULTS:

The distance between two points as determined by the chain survey =

Using the data recorded in the field book prepare a sketch to scale.

PRECAUTIONS:

- The verticality of points should be rechecked and confirmed to avoid erroneous measurements.

QUESTIONS:

1. What is the purpose of using ranging rods and plumb bob in this survey?
2. Why is the direct distance between A and B not considered in this experiment?

EXPERIMENT NO. II

Problem I: Compass Survey: Distance between two inaccessible points

AIM: To determine the distance between two inaccessible points using a compass survey: It is required find the distance between two points P and Q. Both P and Q are inaccessible.

THEORY: The Compass surveying is used to measure angles and distances when the terrain makes direct measurement difficult or impossible. This method is especially useful for determining the distance between points that are separated by obstacles such as water bodies or inaccessible terrain. The compass provides bearings which, in conjunction with known distances and angles, allow for the calculation of distances between points using trigonometric methods.

Prismatic compass is an instrument based on the principle that a freely suspended or pivoted magnetic needle point in the direction of magnetic meridian. The bearings of lines are obtained in the WCB system. A prismatic compass consists of a circular box of about 100 mm diameter. A magnetic needle is attached to a light circular aluminium ring balanced on a hard steel pointed pivot. The ring is graduated to degree and half degree with 0° mark at the south end of the needle and 180° mark at its north end. The graduations run clockwise; therefore, 90° mark is towards west and 270° mark is towards east as shown in Figure 4.2.

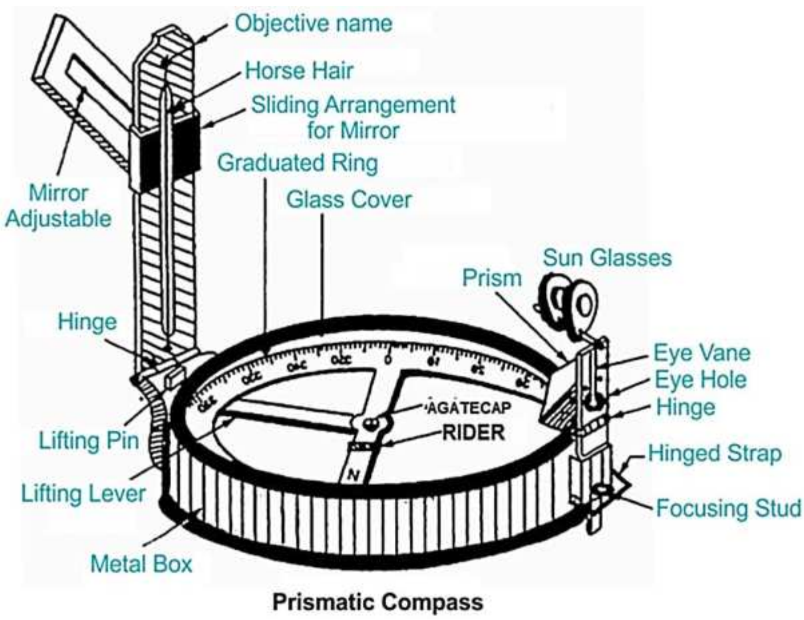


Figure 2.1. Parts of a prismatic compass

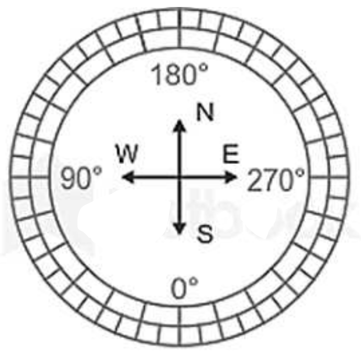


Figure 2.2. Graduations in prismatic compass

The figures on the ring are written inverted. When these are read using a prism, they are erected and magnified. The object vane carries a vertical hair attached to a suitable frame. Sight vane or eye slit consists of a vertical slit cut into the upper assembly of the prism. The object vane and sight vane are hinged to the box, diagonally opposite at the top. To sight an object, the sight vane is rotated with respect to N-S ends of the ring through an angle which the line makes with the magnetic meridian. The angle read is the whole-circle bearing of the line at the compass station.

APPARATUS:

a) Compass: For measuring angles and bearings.
b) Chain/Tape: For measuring distances between accessible points.
c) Ranging Rods: For sighting and marking points.
d) Pegs: To mark reference points.
e) Tripod: To stabilize the compass for accurate readings.

PROCEDURE:

1. Suppose it is required find the distance between two points P and Q. Both P and Q are inaccessible.
2. Select two stations A and B on the ground such that line AB is nearly parallel to line PQ.
3. Measure the distance AB.
4. Centre the prismatic compass over station A and observe the bearings of lines AP, AQ and AB and record them as θ1, θ2 and θ3. Thus, angles α and β can be obtained.

5. Centre the prismatic compass over station B and observe the bearings of lines BA, BP and BQ and record them as θ4, θ5 and θ6. Thus, angles γ and δ can be obtained.

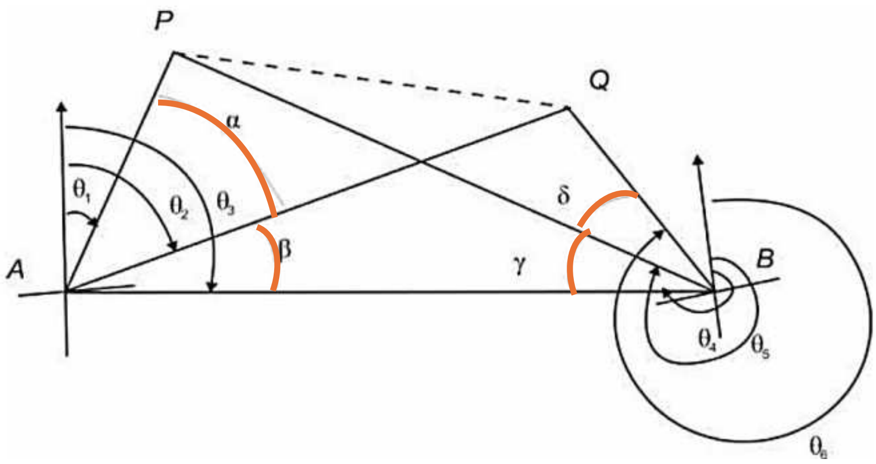


Figure 2.3. Distance between two inaccessible points – compass survey

OBSERVATIONS:

Angles	Measurement
θ1	
θ2	
θ3	
θ4	
θ5	
θ6	

CALCULATION:

$$\alpha = \theta 2 - \theta 1$$

$$\beta = \theta 3 - \theta 2$$

$$\gamma = \theta 5 - \theta 4$$

$$\delta = \theta 6 - \theta 5$$

$$PB = \frac{AB}{\text{Sin}(180) - (\alpha + \beta + \gamma)} \times Sin\ (\alpha + \beta)$$

$$QB = \frac{AB}{\text{Sin}(180) - (\beta + \gamma + \delta)} \times Sin\ (\beta)$$

$$PQ = (PB^2 + QB^2 - 2 \times PB \times QB \times Cos\ (\delta))^{\frac{1}{2}}$$

RESULTS:

The distance between two inaccessible points P and Q = ____m

PRECAUTIONS:

- Ensure the compass is properly levelled and stabilized on the tripod to avoid errors in bearing measurements.
- Double-check all measurements and calculations to prevent errors due to incorrect data recording.
- Avoid magnetic interference when taking bearings to ensure accurate compass readings

QUESTIONS:

1. What is the significance of using a compass in this survey method?
2. How can you minimize errors while taking bearings with a compass?
3. How would you handle magnetic interferences that affect compass readings?
4. State the difference between (i) bearing, true bearing, and magnetic bearing and (ii) true meridian, magnetic meridian, and arbitrary meridian.

Problem II: Compass Survey: Closed traverse

AIM: To plot the plan of a given area by compass traversing.

THEORY: Traverse is the framework of survey lines connecting the control points. A series of control points (stations), each one being intervisible with its adjacent stations are chosen. The survey lines joining the control points are called traverse lines. In this method of traversing linear measurements are taken with either chain or tape and every bearing is observed directly from the magnetic meridian established at each station by the floating needle of prismatic compass. Both fore and back bearings of lines are observed at each station. The offsets necessary to locate the details are taken along the traverse lines in the usual way and recorded in the field- book.

APPARATUS:

a) Prismatic compass
b) Stand
c) Chain/tape
d) Ranging rods
e) Pegs
f) Plumb bob
g) Hammer
h) Field-book, pencils, eraser, etc.

PROCEDURE:

1. Select the traverse stations A, B, C, D & E (as shown in figure given below) along the boundary of the given area. Traverse stations must be chosen such a way that the preceding and succeeding traverse stations must be visible from any traverse station.
2. Set up the prismatic compass on a tripod over station 'A' and level it to allow the needle to swing freely.
3. Rotate the case until the back station E is sighted and observe the WCB of line AE and record it in the table give in Observations.
4. Rotate the case until the forward station B is sighted and observe the WCB of line AB and record it in the table.
5. Measure the distance AB and record it in the table.

6. Set up the prismatic compass on a tripod over station B and level it to allow the needle to swing freely.
7. Rotate the compass case until the back station A is sighted. Observe the WCB of line BA and record it in the table.
8. Rotate the compass case until the forward station C is sighted. Observe the WCB of line BC and record it in the table.
9. Measure the distance BC and record it in the table.
10. Shift the prismatic compass to the forward station C and carry out similar measurements and recordings as done previously.
11. Shift the prismatic compass to the forward station D and carry out similar measurements and recordings as done previously.
12. Shift the prismatic compass to the forward station E and carry out similar measurements and recordings as done previously.

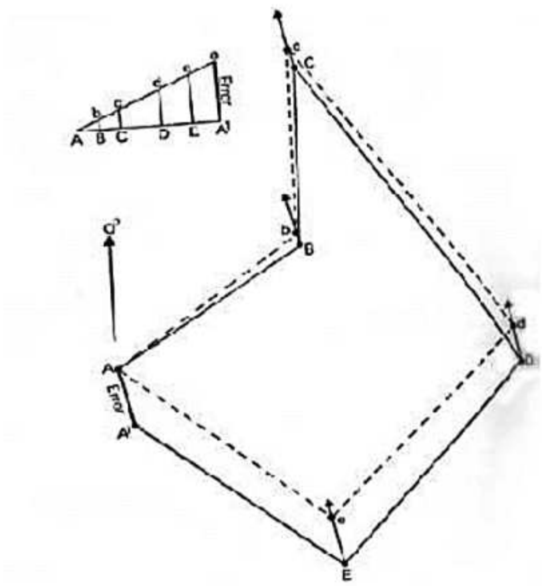


Figure 2.4. Compass traversing

13. Using the observations recorded in the table obtain the corrected bearings in order to eliminate the local attraction.
14. Draw a line up the drawing sheet to represent the reference direction of the magnetic meridian and mark the starting point A.
15. Place the circular protractor with its centre at A and zero lined up with the reference direction. Mark on the paper against the protractor edge the corrected bearing of line AB.

16. Remove the protractor, draw the direction of the line AB, scale the distance and plot the position of B.
17. The direction of BC is plotted by placing the centre of the protractor at B and orienting it by rotating it until its zero direction is parallel to the reference direction as before. This is achieved when the line BA cuts the protractor at the corrected bearing of BA.
18. Mark the bearing BC and plot C in the same way as B was plotted before.
19. Continue the process for all remaining stations. And thus obtain the figure ABCDEA'.
20. The figure ABCDEA' as now plotted does not truly represent the actual figure on the ground because the plotted figure gives two positions for A, whereas only on exist on the ground. This apparent displacement of A is due to the build-up of error in surveying and plotting around the traverse. The total error in the figure indicated by the line AA' may be distributed back around the figure graphically in the following way:
    a. A' should be at a and must be moved the distance AA' in the direction shown. The effect of this movement will be to move the plotted position of the other points proportionally along the parallel directions.
    b. Draw lines parallel to the direction of the closing error through the other plotted points.
    c. Draw a straight line and scale off the lengths of the traverse legs along it. The scale of this construction need not be the same as for the original traverse plot and is more conveniently drawn to a smaller scale.
    d. Erect perpendiculars at each point along the line. Pick off the length of the closing error on the plot with a pair of dividers and mark it on the perpendicular erected at A'. Join aA
    e. The intersection of aA with the perpendiculars indicates the extent of adjustment needed for each station, illustrating also the proportional build-up or error from nothing at A to the maximum amount of A'.
    f. The amount of error at E, being eE, is picked off the diagram and transferred to the line drawn through E on the plot parallel to the closing error, giving the adjusted position e. The other errors at each station are transferred to the plot in the same way.
    g. Join up the positions of the adjusted points giving the figure AbcdeA, which now forms the graphically adjusted traverse. This figure represents more closely the actual layout on the ground than the original plot did prior to adjustment.

OBSERVATIONS AND CALCULATIONS:

S. No	Station	Line	Length (m)	Observed WCB	Correction	Corrected WCB
1	A	AE				
		AB				
2	B	BA				
		BC				
3	C	CB				
		CD				
4	D	DC				
		DE				
5	E	ED				
		EA				

RESULTS:

Plan of the given area is shown on the drawing sheet.

PRECAUTIONS:

1. Ensure the compass is correctly leveled and stabilized on the tripod to avoid errors in bearing measurements.
2. Take bearings multiple times and average them to minimize errors due to compass needle fluctuations.
3. Avoid taking measurements near magnetic objects or sources of magnetic interference to ensure accurate compass readings.

QUESTIONS:

1. What are the advantages of using a prismatic compass over other types of compasses in surveying?
2. How can local attraction affect compass readings, and how can it be corrected?
3. Why is it important to take both fore and back bearings during a compass survey?
4. Explain the process of graphically adjusting the traverse to correct for accumulated survey errors.

EXPERIMENT NO. III - Plane Table Survey I: Radiation method and intersection method

AIM: To draw the position in plan of the given points by radiation method and intersection method.

THEORY:

Radiation method: Plane table is a surveying instrument that can be used to prepare a map or plan of an area directly in the field without the direct measurement of any angles. Plane table is a surveying instrument that can be used to prepare a map or plan of an area directly in the field without the direct measurement of any angles. Radiation is one of the methods employed in plane table survey. This method is generally employed for locating the details. In this method, a ray is drawn from the instrument station towards the point. The distance is measured between the instrument station and the point. The point is located by plotting to some scale the distance so measured. This method is more suitable for small distances. One instrument station can cover several points to be detailed.

Intersection method: Intersection is one of the methods employed in plane table survey. This method is generally employed for locating the details. In this method the location of an object is determined by sighting at the object from two plane table stations and drawing the rays. The intersection of these rays will give the position of the object. Therefore, in this method it is essential to have at least two plane table stations. The distance between the two plane table stations is measured and plotted on the sheet to some scale. The line joining the two plane table stations is known as the base line. No linear measurement other than that of the base line is made in this method of surveying. This method is preferred when the distance between the point and the plane table station is either too large or cannot be measured accurately due to some field conditions.

APPARATUS:

a) Plane table and its accessories (tripod, alidade, trough compass, plumbing fork, spirit level, drawing sheet, cello- tape, pencil, eraser and dusting cloth)
b) Chain/tape
c) Ranging rods
d) Pegs

e) Hammer

f) Field-book.

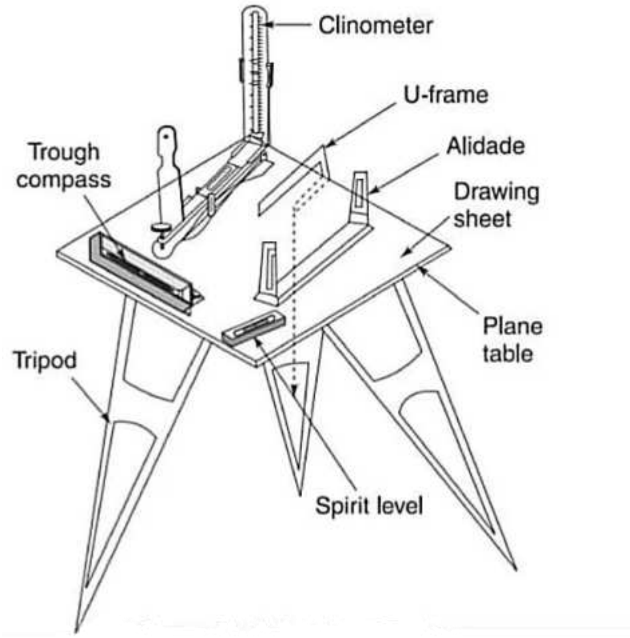


Figure 3.1. Plane table and its accessories

PROCEDURE:

<u>Radiation method:</u>

1. Select a point 'T' on the ground so that all points to be located are visible from it.
2. Set up the table at 'T', level it, and do centering.
3. Transfer the point 'T' on to the drawing sheet by means of plumbing fork so that it is exactly over station 'T' on the ground and name it 't'.
4. Mark the direction of the magnetic meridian on the drawing sheet by means of trough compass.
5. Centering the alidade on 't' BISECT the points A, B, C, D, E and F one after the other and draw the rays along the fiducial edge.
6. Measure the distances TA, TB, TC, TD, TE and TF on the ground and plot their distances to some scale along the corresponding rays and thus get the position of points a, b, c, d, e, and f on the drawing sheet. (upper case letters are used to represent stations on ground and lower-case letters are used to represent stations on drawing sheet)
7. Join a,b,c,d,e and f on the drawing sheet.

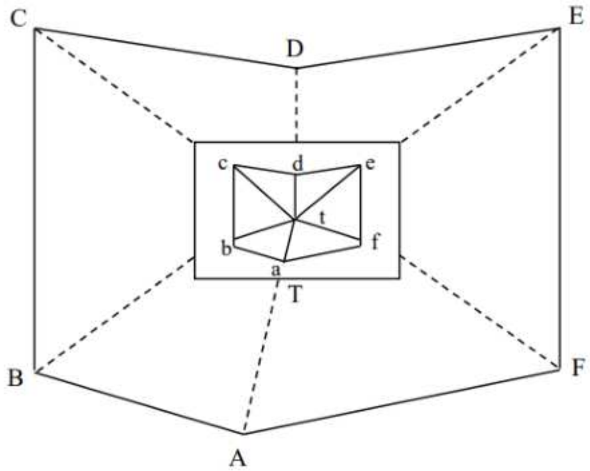


Figure 3.2. Radiation method

Intersection method:

1. It is required to plot the position of ground points PQRS (shown in figure given below) on the drawing sheet. The line AB is a base line measured on the ground. It is represented by the line ab on the board drawn to scale. The position of the base line AB is chosen such that it is in the middle of the boundary formed by PQRS.
2. Set up the plane table over A and orient the plane table by laying the alidade along the drawn line ab and rotate the board until B is sighted from A through the alidade (Now the line ab is aligned with line AB on the ground).
3. Pivot the alidade at 'a' and sight to the points P, Q, R & S and draw the rays. These rays represent the lines of sight to these features.
4. Shift the table to B. Plumb point b on the board over B on the ground.
5. By laying the alidade along the drawn line ba rotate the board until A is sighted and clamp the board (Now the line ab is aligned with line AB on the ground)
6. Mark the direction of the magnetic meridian on the drawing sheet by means of trough compass.
7. Pivot the alidade at 'b' and sight to the points P, Q, R & S and draw the rays (The rays from B will intersect those drawn from A, thus establishing the positions p, q, r and s on the board).
8. Join the points p, q, r & s on the drawing sheet.

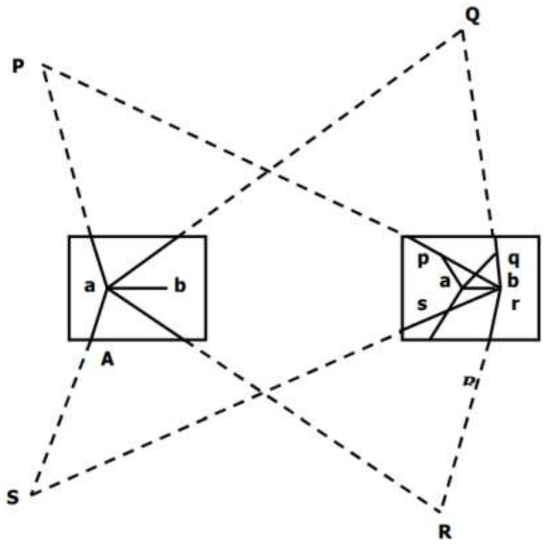


Figure 3.3. intersection method

OBSERVATIONS AND CALCULATIONS:

Radiation method:

- Measure the distance AB, BC, CD, DE, EF and FA on the ground.
- Scale the distance ab, bc, cd, de, ef and fa on the drawing sheet.

Intersection method:

- Measure the distance PQ, QR, RS and SP on the ground.
- Scale the distance pq, qr, rs and sp on the drawing sheet

RESULTS:

Radiation method: Compare the ground and plan distances between the stations A, B, C, D, E and F.

Intersection method: Compare the ground and plan distances between the stations P, Q, R and S.

PRECAUTIONS:

1. Ensure the plane table is properly leveled to avoid inaccuracies in plotting.
2. Avoid setting up the plane table near magnetic objects or metallic surfaces to prevent interference with the compass readings.
3. Secure the drawing sheet firmly on the plane table to prevent any movement while plotting.

QUESTIONS:

1. What are the advantages of the radiation method in plane table surveying?
2. How does the intersection method help in locating points that are difficult to measure directly?
3. Why is it important to orient the plane table using the magnetic meridian?
4. Explain how errors in levelling the plane table can affect the accuracy of the survey.
5. What are some common sources of errors in plane table surveying, and how can they be minimized?

EXPERIMENT NO. IV - Plane Table Survey II: Two-point and three-point problems

AIMS:

1. To Locate the position on the plan, of the station occupied by the plane table by means of observations to two well defined points whose positions have been previously plotted on the plan.
2. To Locate the position on the plan, of the station occupied by the plane table by means of observations to three well defined points whose positions have been previously plotted on the plan.

THEORY: Plane table is a surveying instrument that can be used to prepare a map or plan of an area directly in the field without the direct measurement of any angles. In the process sometimes a technique called 'resection' is employed. Resection is the process of determining the plotted position of the station occupied by the plane table, by means of sights taken towards known points, location of which have been plotted. In two-point problem the position of occupied station on the drawing sheet is obtained by means of observations to two well defined points whose positions have been previously plotted on the plan. In three-point problem the position of occupied station on the drawing sheet is obtained by means of observations to three well defined points whose positions have been previously plotted on the plan.

APPARATUS:

a) Plane table and its accessories (tripod, alidade, trough compass, plumbing fork, spirit level, drawing sheet, cello- tape, pencil, eraser and dusting cloth)
b) Chain/tape
c) ranging rods
d) pegs
e) hammer
f) field-book.

PROCEDURE:

<u>Two-point problem</u>

Let us take two points A and B, the plotted positions of which are known (a, b). Let C be the point to be plotted. Therefore, the whole problem is to orient the table at C.

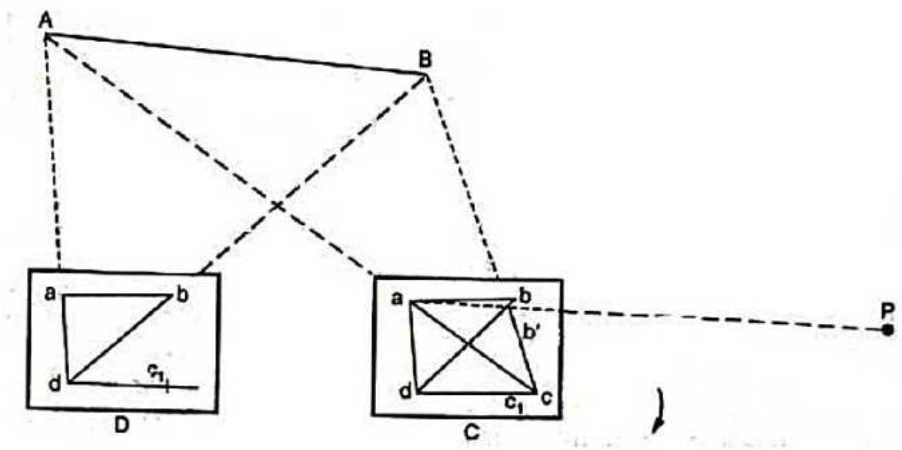


Figure 4.1. Two-point problem using plane table

1. Choose an auxiliary point D near C. While choosing D take care that angle CAD and angle CBD are not very acute.
2. Place the table at D. By eye judgment orient the table at D such that ab is nearly parallel to AB. Clamp the table.
3. Keep the alidade at a and sight A and draw back a resector. Similarly keep the alidade at b and sight B and draw back a resector. The two rays resect at d1. (Here we are not naming it as d because it is not exactly d, since the orientation is by eye judgment and therefore not a correct orientation).
4. Transfer the point d1 to the ground and drive a peg.
5. Keep the alidade at d1 and sight C. Draw the ray. Mark a point c1 on the ray by estimation to represent the distance DC.
6. Shift the table to C, orient it by taking backsight to D and centre it with reference to c1. (Thus, the orientation is same as it was at D).
7. Keep the alidade pivoted at a and sight it to A. Draw the ray to intersect with the previously drawn d1c1 in c2. (Thus, c2 is the point representing the station C with reference to the approximate orientation made at D).
8. Pivot the alidade about c2 and sight B. Draw the ray to intersect with the ray d1b in b1. (Thus, b1 is the approximate representation of B with reference to the approximate orientation made at D)

9. The angle between ab and ab1 is the error in orientation and must be corrected for. Keep the alidade along ab1 and fix a pole at P on the ground in line with ab1 at a great distance.
10. Keep the alidade along ab, rotate the table till P is bisected. Clamp the table. The table is thus correctly oriented.
11. Draw a resector from a to A and another from b to B, the intersection of which will give the position C occupied by the table. Thus name the point as c.

<u>Three-point problem</u>

Let us take three points A, B and C the plotted positions of which are known (a, b and c). Let P be the point to be plotted. Therefore, the whole problem is to orient the table at P.

1. After having set the table at station P, keep the alidade on ba and rotate the table so that A is bisected. Clamp the table.
2. Pivot the alidade about b, sight to C and draw the ray x y along the edge of the alidade.
3. Keep the alidade along ab and rotate the table till B is bisected. Clamp the table.
4. Pivot the alidade about a, sight to C. Draw the ray along the edge of the alidade to intersect the ray x y in c′. Join c c′.
5. Keep the alidade along c′c and rotate the table till C is bisected. Clamp the table. Now the table is correctly oriented.
6. Pivot the alidade about b, sight to B. Draw the ray to intersect c c′ in p. Similarly, if alidade is pivoted about a and A is sighted, the ray will pass through p if the work is accurate.

Note: The points a, b, c′ and p form a quadrilateral and all the four points lie along the circumference of a circle. Hence this method is known as "Bessel's Method of Inscribed Quadrilateral".

OBSERVATIONS AND CALCULATION:

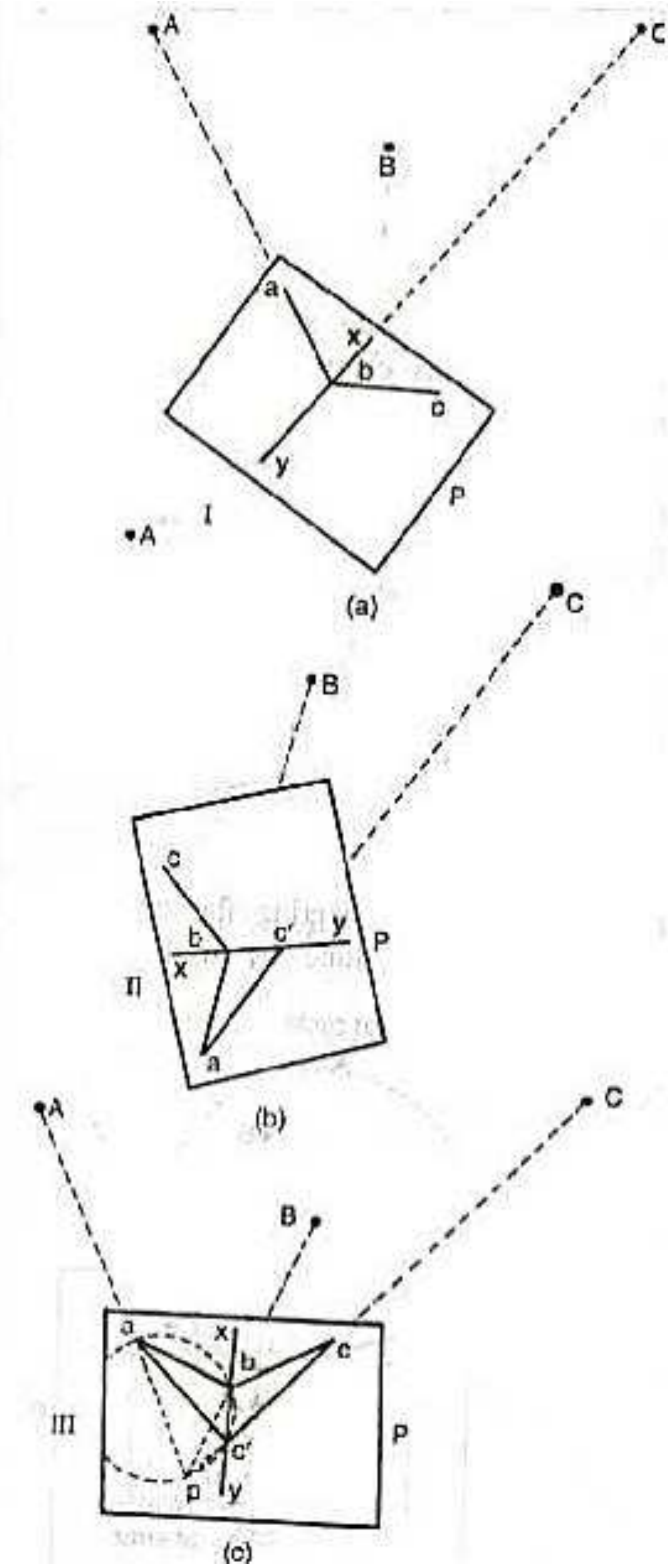
Two-point problem:

- Measure the distance CA and CB on the ground.
- Scale the distance ca and cb on the drawing sheet.

Three-point problem:

- Measure the distance PA, PB and PC on the ground.

- Scale the distance pa, pb and pc on the drawing sheet.



(a) (b) (c)

RESULTS:

Two-point problem: Compare the ground distances *CA* and *CB* with corresponding plan distances *ca* and *cb*.

Three-point problem: Compare the ground distances *PA, PB* and *PC* with corresponding plan distances *pa pb* and *pc*.

PRECAUTIONS:

1. Ensure the plane table is properly leveled to avoid inaccuracies in plotting.
2. Avoid setting up the plane table near magnetic objects or metallic surfaces to prevent interference with the compass readings.
3. Take measurements and observations multiple times to minimize errors due to observational mistakes.

QUESTIONS:

1. What is the resection method in plane table surveying, and how is it used?
2. Why is it important to avoid acute angles when choosing an auxiliary point in the two-point problem?
3. How does the Bessel's Method of Inscribed Quadrilateral help in the three-point problem?

EXPERIMENT NO. V - Plane Table Survey III: Traversing

AIM: To survey a small piece of land by closed traverse technique using plane table.

THEORY: Traversing is that of survey in which a number of connected survey lines form a framework. The directions and lengths of the survey lines are measured with the help of an angle (or direction) measuring instrument and a tape respectively. If the framework formed by the lines closes at the starting station, that is, if they form a closed polygon, it is called closed traverse. In plane table traversing, at each successive station the table is set, a foresight is taken to the following station and its location is plotted by measuring the distance between the two stations as in the radiation method.

APPARATUS:

a) Plane table and its accessories (tripod, alidade, trough compass, plumbing fork, spirit level, drawing sheet, cello- tape, pencil, eraser and dusting cloth)
b) Chain/tape
c) ranging rods
d) pegs
e) hammer
f) field-book.

PROCEDURE:

1. Select the traverse stations A,B,C,D and E on the ground.
2. Set the table at A. Use plumbing fork and transfer A on to the sheet and name it ‘a’. On the top right corner of the sheet mark the direction of magnetic north with the help of trough compass.
3. With the alidade pivoted about a, sight it to B and draw the ray. Measure AB and scale of ab to a suitable scale. Similarly draw a ray towards E, measure AE and mark ‘e’.
4. Shift the table to B and set it. Orient the table accurately by back sighting A. Clamp the table.
5. Pivoting the alidade about b, sight to C. Measure BC and plot it on the drawn ray to the same scale. Similarly, the table can be set at other stations and the traverse is completed.

Note: While being at each station, take measurements by radiation to any details that are to be included in the plan.

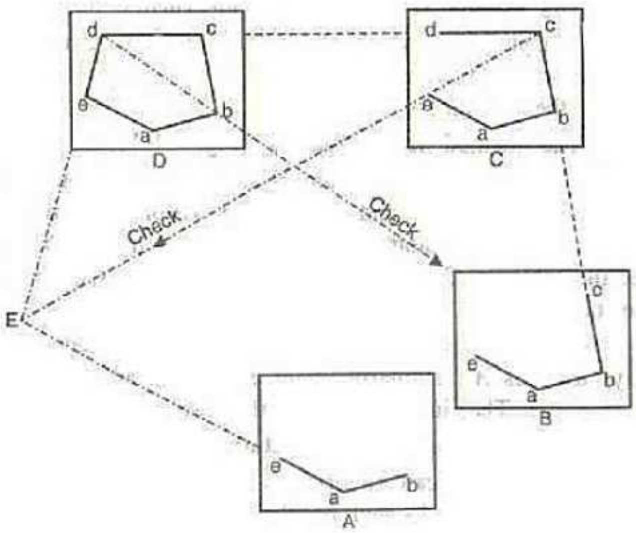


Figure 5.1. Plane Table traversing

OBSERVATIONS AND CALCULATIONS:

- Measure the distance *DB* and *EC* on the ground.
- Scale the distance *db* and *ec* on the drawing sheet.

RESULTS:

Compare the ground distances *DB* and *EC* with corresponding plan distances *db* and *ec*.

PRECAUTIONS:

- Ensure the plane table is properly leveled to avoid inaccuracies in plotting.
- Avoid setting up the plane table near magnetic objects or metallic surfaces to prevent interference with the compass readings.
- Take measurements and observations multiple times to minimize errors due to observational mistakes.

QUESTIONS:

- What is the purpose of orienting the plane table at each station in a traverse survey?
- How does back sighting help in maintaining accuracy during plane table traversing?
- Why is it important to mark the direction of magnetic north on the drawing sheet before starting the survey?

EXPERIMENT NO. VI - Levelling I: Differential levelling

AIM: To find the reduced levels of the given stations by differential levelling.

THEORY: To find difference of level between two points on the ground, it is necessary to establish a level surface above the two points and measure the vertical distance from it to the points. The difference between these measurements will give the difference in level between the points. It is possible to get a horizontal surface from the line of sight of a telescope adjusted into the horizontal position. This is done by any Levelling instrument. Therefore, by setting up a Levelling instrument at a suitable location on the ground it is possible to obtain difference between levels of two points. Automatic level is a very convenient Levelling instrument. When the difference in level between two points cannot be obtained by one set-up of Levelling instrument, it is necessary to repeat the process. This process of using a series of several set-ups of Levelling instrument to find the level difference between two distantly placed points is called fly Levelling.

APPARATUS:

a) Automatic Level
b) Levelling staff
c) Levelling book, pencil and eraser.

PROCEDURE:

1. Set-up the automatic level at point ‘P’ near to the Benchmark (BM) (the R.L of BM is 100.000 m) as shown in figure and level the instrument.
2. Focus the telescope on BM and bisect the staff correctly and take the back sight (BS) on it and record the reading in the Levelling book.
3. Keep the levelling staff at a convenient intermediate point(s) and take the intermediate sight (IS) and enter the reading.
4. Before shifting the instrument to the next station enter the last staff reading in the FS column.
5. Shift the instrument to the next station ‘Q’ and follow the steps from 3 to 4.
6. Calculate the Reduced levels by Height of Instrument Method and also by Rise and Fall Method which can be shown in Tables below.

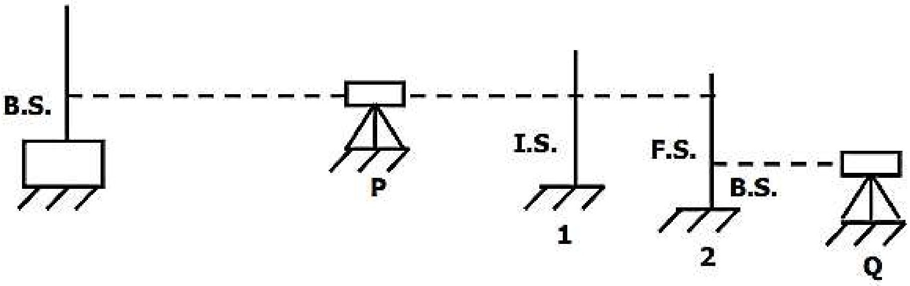


Figure 6.1. Differential levelling

OBSERVATIONS:

Table 6.1: Height of Instrument Method

S. no	Station	Sigh to	B.S (m)	I.S (m)	F.S (m)	H.I (m)	R.L (m)	Remarks

Table 6.2: Rise and Fall Method

S. no	Station	Sigh to	B.S (m)	I.S (m)	F.S (m)	Rise (m)	Fall (m)	R.L (m)	Remarks

CALCULATION:

a) Height of Instrument Method:

- Height of Instrument (H.I.) = R.L. of A.B.M. + B.S.
- R.L. of a station = H.I. – I.S. or F.S.
- Height of Instrument at C.P. (H.I.) = R.L. of C.P. + B.S.
- R.L. of a station = R.L. of C.P. – I.S. or F.S.
- CHECK: Sum of B.S. – Sum of F.S. = First R.L. – Last R.L.

b) Rise and Fall Method:

- If the difference of successive observations is +ve, it indicates fall, otherwise it indicate rise.
- R.L. of a station = R.L. of B.M. + Rise or (– Fall)

- CHECK: Sum of B.S. – Sum of F.S. = Sum of Rise – Sum of Fall
  = First R.L. – Last R.L.

RESULTS:

Reduced level of the given station =

PRECAUTIONS:

1. Ensure the automatic level is properly set up and leveled to avoid inaccuracies in measurements.
2. Keep the leveling staff vertical while taking readings to ensure accurate measurements.
3. Take multiple readings at each station and average them to minimize errors due to staff movements or instrument instability.
4. Avoid taking measurements in areas with heavy traffic or vibrations that might affect the leveling instrument.

QUESTIONS:

1. What is the purpose of using an automatic level in differential leveling?
2. How do you calculate the reduced level (RL) of a point using the height of instrument (HI) method?
3. What is the difference between back sight (BS) and fore sight (FS) readings in leveling?
4. Why is it important to establish a benchmark (BM) before starting the leveling process?

EXPERIMENT NO. VII - Levelling II: Longitudinal and cross-sectioning levelling

AIM: To plot the longitudinal section and cross section along a proposed alignment of a highway.

THEORY: Profile Levelling is an operation to determine elevations of points spaced apart at known distances along a given line. The purpose of profile Levelling is to provide data from which a vertical section of the ground surface along a surveyed line can be plotted. Longitudinal sectioning and cross sectioning are examples of profile Levelling.

a) Longitudinal sectioning: to find out the elevations of the points on the ground at fixed intervals along the centre line of proposed sewer lines, pipelines, highways, railways, canals, etc.
b) Cross sectioning: to find out the elevations of the points on the ground at fixed intervals on either side and perpendicular to centre line of proposed highways, canals, etc.

APPARATUS:

a) Automatic level
b) Tripod,
c) Levelling staff
d) Chain/tape
e) Cross staff
f) Arrows
g) Ranging rods
h) Pegs
i) Hammer
j) Levelling book, pencil and eraser.

PROCEDURE:

1. Establish points on the ground at fixed interval say 5 m along the proposed centre line of the highway by direct ranging and fix arrows as shown in figure given below.
2. Establish perpendicular lines on either side of the proposed centre line of the highway using cross staff as shown in figure given below.

3. Along the perpendicular lines that are established in the previous step fix arrows on the ground at a fixed interval say 2 m as shown in figure given below.
4. Carry out differential Levelling to find the R.Ls of every arrow point and enter the readings in table.
5. Calculate the R.Ls of all the points.
6. Draw the longitudinal section along the centre line of the proposed highway to a suitable scale.
7. Draw cross section in the transverse direction at each chainage point along the centre line of the proposed highway to a suitable scale.

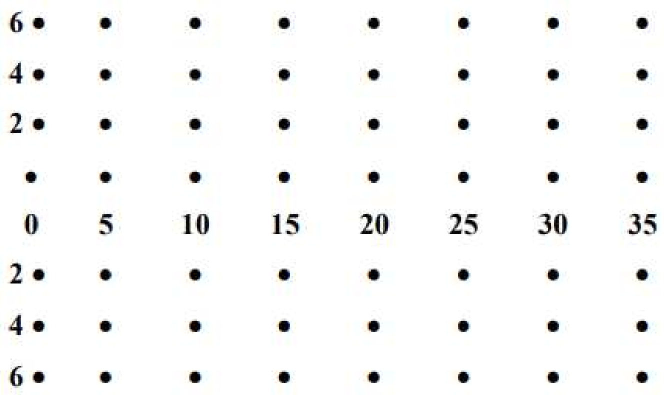


Figure 7.1. Longitudinal and cross sectioning

OBSERVATIONS:

Table:

S. no	Chainage of centre line	Chainage Left C.S.	Chainage Right C.S.	B.S (m)	I.S (m)	F.S (m)	H.I (m)	R.L (m)	Remarks

CALCULATION:

- Height of Instrument = R.L. of B.M. + B.S.
- R.L. of each arrow point = H.I. – I.S. or F.S.

RESULTS:

Profile of the centre line of the proposed highway and various cross sections along the centre line of the proposed highway are shown on the drawing sheet.

PRECAUTIONS:

1. Ensure the automatic level is properly calibrated and leveled before taking measurements.
2. Maintain a consistent and correct interval between the points along the center line and perpendicular lines to ensure accurate profile data.
3. Avoid taking readings during adverse weather conditions, such as strong winds or heavy rain, which can affect the accuracy of the leveling staff readings.
4. Double-check the placement of arrows and pegs to ensure they are aligned correctly with the proposed highway centerline and perpendicular lines.

QUESTIONS:

1. What is the main purpose of longitudinal sectioning in highway alignment?
2. How is cross-sectioning different from longitudinal sectioning in terms of data collection and usage?
3. Why is it important to establish fixed intervals for measuring points in profile levelling?
4. How do you calculate the reduced level (RL) of a point using the height of instrument (HI) method in longitudinal and cross-sectioning levelling?

EXPERIMENT NO. VIII - Contouring

AIM: To plot the contours of an area by method of squares (or gridding).

THEORY: The method of squares is also called coordinated method or gridding of locating contours. The entire area is divided into squares or rectangles forming a grid. The reduced levels of the corners are then determined by differential Levelling. The reduced levels are then plotted on the plan showing the same grid drawn to a suitable scale. After choosing suitable elevation values for contours to be drawn, the required contours are plotted by means of interpolation

APPARATUS:

a) Automatic level
b) Tripod
c) Levelling staff
d) Chain, tape
e) Cross staff
f) Arrows
g) Ranging rods
h) Pegs
i) Hammer
j) Levelling book, pencil and eraser.

PROCEDURE:

1. On the parcel of the ground for which contour map has to be made establish a square grid of points at a suitable interval (anywhere between 3m to 20m) by means of direct ranging and fix arrows as shown in figure given below.
2. Carry out differential Levelling to find the R.L.'s of every arrow point and enter the readings in table.
3. Draw the same grid that is established on the ground on the drawing sheet to a suitable scale.
4. Indicate on the drawn grid the reduced levels of each grid point.
5. Choose suitable values for elevations of contour lines.
6. Draw contour lines on the grid by interpolation.

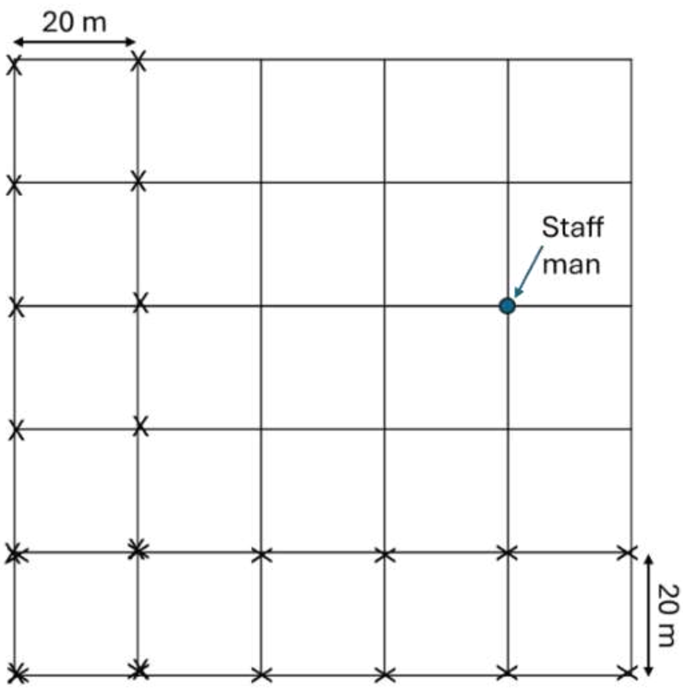


Figure 8.1. Contouring

OBSERVATIONS AND CALCULATIONS:

Table:

S. No	Grid point	B.S (m)	I.S (m)	F.S (m)	H.I (m)	R.L (m)	Remarks

RESULTS:

Contours of the given area are plotted on sheet.

PRECAUTIONS:

1. Ensure the automatic level is properly calibrated and set up on a stable surface.
2. Maintain consistent grid intervals throughout the survey area to ensure accurate and uniform contour plotting.
3. Verify all equipment, such as leveling staff and ranging rods, are in good condition and accurately marked.
4. Avoid taking readings during extreme weather conditions to prevent errors in measurements.

QUESTIONS:

1. What is the method of squares (or gridding) in contouring, and why is it used?
2. How do you determine the reduced levels of the grid points in the contouring process?
3. Explain the importance of choosing suitable values for contour elevations.
4. Describe the process of interpolation in drawing contour lines on a grid.

EXPERIMENT NO. IX - Theodolite Traversing: Measurements of horizontal angles by repetition method

AIMS: To measure the horizontal angle by Repetition method with the use of Theodolite.

THEORY: A theodolite is a precise optical instrument used in surveying to measure horizontal and vertical angles. It consists of a telescope mounted to move horizontally and vertically, an angular measurement scale, and leveling mechanisms to ensure the instrument is properly aligned. The telescope has two distinct motions: one in the horizontal plane and the other in the vertical plane. The former is measured on a graduated horizontal circle, and the latter on a vertical circle with two verniers. here are two main types of theodolites: transit and non-transit. In a transit theodolite, the telescope can be inverted to measure angles in both the direct and reverse positions. A non-transit theodolite has a fixed telescope that cannot be inverted. A theodolite is called a transit theodolite when its telescope can be revolved through a complete revolution about its horizontal axis in a vertical plane. The transit type is largely used.

Various parts of a transit theodolite include:

a) **Telescope**: An integral part mounted on a spindle known as the horizontal axis or trunnion axis. The telescope can be either internal or external focusing type.

b) **Leveling Head**: Consists of circular plates called upper and lower parallel plates. The lower parallel plate has a central aperture through which a plumb bob may be suspended. The upper parallel plate, or tribrach, is supported by four or three leveling screws by which the instrument may be leveled.

c) **Lower Plate (Screw Plate)**: Carries the horizontal circle and includes a lower clamp screw and tangent screw for fixing the instrument in a desired position.

d) **Upper Plate (Vernier Plate)**: Attached to the inner axis and carries two verniers at two extremities diametrically opposite.

e) **Compass**: May be either circular or trough type. The modern theodolite is often fitted with a tubular type compass.

f) **Vertical Circle**: Rigidly attached to the telescope, moves with it, and is usually divided into four quadrants.

g) **Index Arm**: Carries two verniers at the extremities of its horizontal arms and has a vertical leg called the clip or clipping screw at its lower extremity. The index arm and the clipping arm together are known as the T-frame.

h) **Plumb Bob**: Used to center the instrument exactly over a station mark, suspended from a hook fitted to the bottom of the central vertical axis.

Repetition Method of Measuring Horizontal Angles: When it is required to measure horizontal angles with great accuracy, such as in traversing, the repetition method may be adopted. The repetition method increases measurement accuracy by averaging out small errors that may occur due to instrument imperfections, observer inaccuracies, and external factors. In this method, the same angle is added several times by keeping the vernier clamped each time at the end of each measurement instead of setting it back to zero. The corrected horizontal angle is obtained by dividing the final reading by the number of repetitions. Usually, six readings—three with face left and three with face right—are taken. The average horizontal angle is then calculated. The repeated measurements are summed, and the total is divided by the number of repetitions to obtain the mean angle, which is considered more accurate than any single measurement.

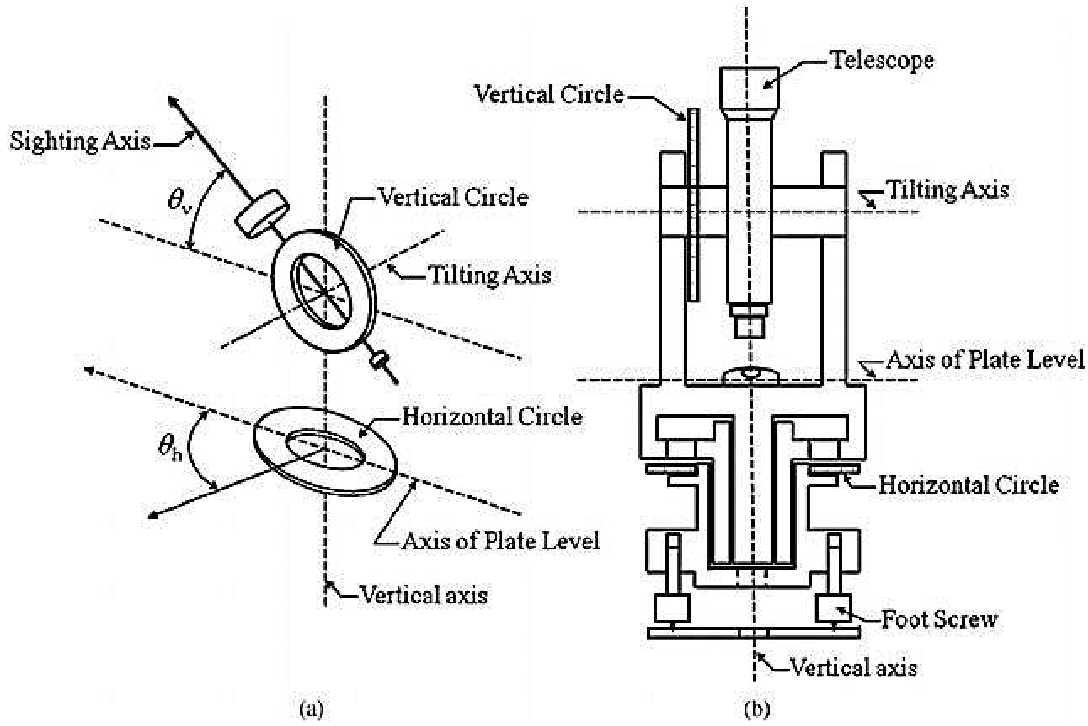


Figure 9.1. Typical structure of a theodolite: (a) a view of vertical circle and horizontal circle; (b) front view

APPARATUS:

a) Theodolite
b) Ranging rods,
c) Pegs or Arrows.

PROCEDURE:

1. Theodolite is set over an instrument station (O) exactly, and all the temporary adjustments are done. The vertical circle is placed to the left of the observer (face left observation).
2. Vernier A is set to zero with the help of the upper clamp screw and tangent screws. Readings of Vernier A and B are noted.
3. The upper clamp is clamped. The lower clamp is loosened, and the telescope is turned towards point "A." The lower clamp is then clamped, and point "A" is bisected exactly using the tangent screws.
4. Both Vernier A and B are read and noted (should be 0° and 180°, respectively). The upper clamp is unclamped, and the telescope is turned clockwise to bisect point "B."
5. The upper clamp is clamped, and "B" is bisected exactly using the tangent screws. Both verniers are read. The mean of the readings provides an approximate included angle of AOB.
6. The reading of Vernier A directly gives the angle AOB, and 180° is subtracted from the reading of Vernier B. The mean value of the two readings gives the angle AOB with one face.
7. The lower clamp is unclamped, and the telescope is turned anticlockwise to sight point A again. The lower clamp is clamped, and point A is bisected exactly using the tangent screws.
8. The upper clamp is loosened, and the telescope is turned clockwise to bisect point B. The upper clamp is clamped, and point B is bisected exactly using the tangent screws. The verniers now read twice the value of angle AOB.
9. Steps 7 and 8 are repeated once again to get three times the value of angle AOB.
10. The final obtained reading is divided by 3 to get the mean value of angle AOB.
11. The face is changed, and the entire process is repeated (face right observations).
12. The average value of the two horizontal angles obtained with face left and face right observations is determined.

OBSERVATIONS AND CALCULATION:

Table

Measurement of Horizontal Angle (Reiteration Method)																												
Instrument Station	Sight to	Face: Swing:												Face: Swing:												Average Horizontal angle		
		A			B			Mean			Horizontal angle			A			B			Mean			Horizontal angle					
		0	′	″	0	′	″	0	′	″	0	′	″	0	′	″	0	′	″	0	′	″	0	′	″	0	′	″

RESULTS:

The horizontal angle measured at O between A and B. i.e AOB

a) With face left:

b) With face right:

c) Average:

PRECAUTIONS:

1. Ensure the theodolite is properly leveled before starting any measurements to avoid inaccuracies.
2. Verify that all screws and clamps are securely tightened to maintain the instrument's stability.
3. Always sight objects accurately through the telescope to avoid parallax errors.
4. Repeat the measurements carefully and consistently to ensure accurate averaging.
5. Avoid touching the instrument during measurements to prevent any movement or disturbance.
6. Regularly check and calibrate the theodolite to ensure it is functioning correctly.

QUESTIONS:

1. How does the repetition method improve the accuracy of angle measurements?
2. What are the main differences between a transit theodolite and a non-transit theodolite?
3. Why is it necessary to take readings with both face left and face right observations?
4. How do you calculate the mean value of the angle AOB using the repetition method?
5. What are the possible sources of error in theodolite traversing, and how can they be minimized?
6. Explain the significance of using tangent screws for precise bisection of points.

EXPERIMENT NO. X - Theodolite Traversing: Determination of elevation of an object

AIM: To determine the reduced level and height of given object by trigonometric levelling.

THEORY: Theodolite traversing is a method used in surveying to determine the positions of points relative to one another by measuring angles and distances. The theodolite is a precision instrument designed for measuring horizontal and vertical angles. This technique is essential in various applications such as mapping, construction, and topographic surveys. In the context of determining the elevation of an object, trigonometric levelling is employed.

Trigonometric levelling involves calculating the difference in elevation between points by using trigonometric relationships. This method is particularly useful for determining the height of an object or a point that is not easily accessible for direct levelling, such as the top of a building or a distant hill. The process involves setting up the theodolite at a known station point and measuring the angle of elevation or depression to the top of the object whose height is to be determined. The horizontal distance between the theodolite and the object is also measured. Using these measurements, the height difference between the instrument station and the object can be calculated using trigonometric functions. The basic trigonometric relationship used in this method is given by the tangent function in a right-angled triangle:

$$tan\ (\theta) = \frac{Opposite}{Adjacent}$$

Where:

θ is the angle of elevation or depression.

The "Opposite" side is the vertical height difference between the instrument station and the object.

The "Adjacent" side is the horizontal distance between the instrument station and the object.

From the tangent function, the height differences can be calculated:

- Elevation height h2 = D tan $\alpha1$
- Depression height h3 = D tan $\alpha2$
- Total height H = h2 + h3

- Height of instrument (HI) = RL of BM + h1
- RL of the top of object = HI +h2

Where, h1: Staff reading on the BM

D: Distance between the object and instrument

α1 and α2: Top and bottom inclined angle of the object.

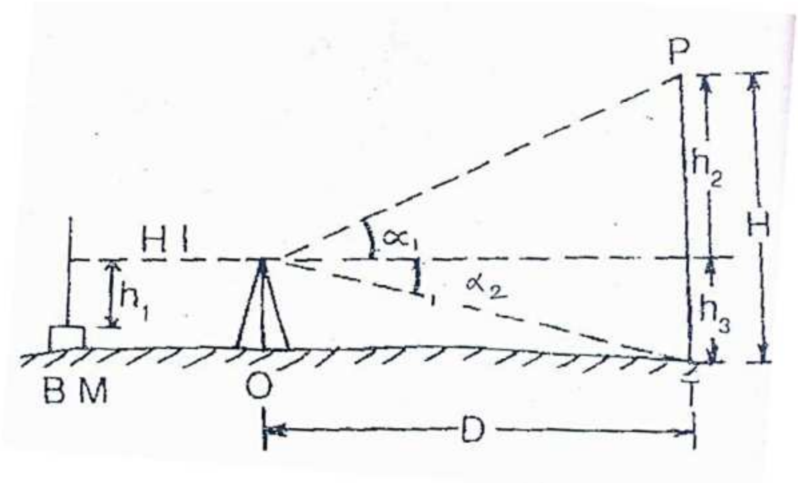


Figure 10.1. Trigonometric levelling

APPARATUS:

a) Theodolite with tripod
b) Ranging Rod
c) Arrows
d) Tape

PROCEDURE:

1. The instrument is set up at a convenient point from which the object is clearly visible.
2. Temporary adjustments are made, and the line of sight is set horizontal. The staff is held vertically over the benchmark, and the staff reading corresponding to the middle hair is taken. Let it be $h1$
3. The distance D is measured by chain or tape.
4. The top and bottom of the object are bisected, and the corresponding vertical angle of elevation $\alpha 1$and angle of depression $\alpha 2$ are noted.
5. Using the appropriate formula, the reduced level (R.L.) of the top of the object is calculated

OBSERVATIONS AND CALCULATION:

Table

Instrument Station	Object	Observation	Angle	Reading on vernier						Angle on vernier						Mean angle of vernier			Mean angle of observation			Distance
				C			D			C			D									
1	2	3	4	5			6			7			8			9			10			
				°	′	″	°	′	″	°	′	″	°	′	″	°	′	″	°	′	″	
O	A	Face : Left Swing : Right	AOC																			
	B		BOC																			
O	A	Face : Right Swing : Right	AOC																			
	B		BOC																			

RESULTS:

1. R.L. of B.M = ___________ m.
2. The height of the given object is _____________m.
3. The RL of the top of the object is ____________m.

PRECAUTIONS:

1. Ensure the instrument is precisely leveled and adjusted before taking any readings to avoid errors.
2. Verify that the staff is held vertically over the benchmark to ensure accurate readings.
3. Avoid parallax error by ensuring the observer's eye is directly in line with the telescope's crosshairs.
4. Double-check all measurements and recorded angles for consistency and accuracy.

QUESTIONS:

1. Why is it important to ensure the staff is held vertically during measurements?
2. How does the accuracy of the angle of elevation and depression affect the final calculated height of the object?
3. What potential errors can arise from improper leveling of the instrument, and how can they be mitigated?

EXPERIMENT NO. XI - Tacheometry: Determination of heights and distances by Tangential Tacheometry

AIM: To determine the reduced level of the object and horizontal distance by using tangential tacheometry.

THEORY: Tacheometry is a rapid surveying method that measures horizontal distances and elevations without the need for a chain or tape. It involves the use of a tacheometer, a specialized theodolite with an additional stadia diaphragm, which enables the determination of distance and elevation based on the angles and stadia readings observed through the telescope. In tangential tacheometry, the principle is based on the geometry of similar triangles. When the line of sight is inclined, the horizontal distance and elevation difference can be calculated using the vertical angles subtended by the top and bottom of the object, as well as the stadia intercept observed on the staff. To determine the horizontal distance and reduced level of an object, the tacheometer is set up at a known station, and the vertical angles of elevation and depression to the object are measured. The corresponding stadia readings are taken on a leveling staff held vertically at the object's base. Using these measurements, the horizontal distance and elevation difference are computed using trigonometric formulas. This method is particularly useful in hilly or difficult terrain where direct distance measurement is impractical. It allows surveyors to quickly obtain accurate data over long distances, making it an essential technique in topographic surveys, construction, and civil engineering projects.

<u>Formula:</u>

1. For Both angles of elevation
   - $D = S/(\tan \alpha 1 - \tan \alpha 2)$
   - $V = D \tan \alpha 2$
   - RL of Q = HI+ V-r
2. For both angles of depression
   - $D = S/(\tan \alpha 2 - \tan \alpha 1)$
   - $V = D \tan \alpha 2$
   - RL of Q = HI- V-r
3. For one angle of elevation and one depression
   - $D = S/(\tan \alpha 2 + \tan \alpha 1)$
   - $V = D \tan \alpha 2$
   - RL of Q = HI- V-r

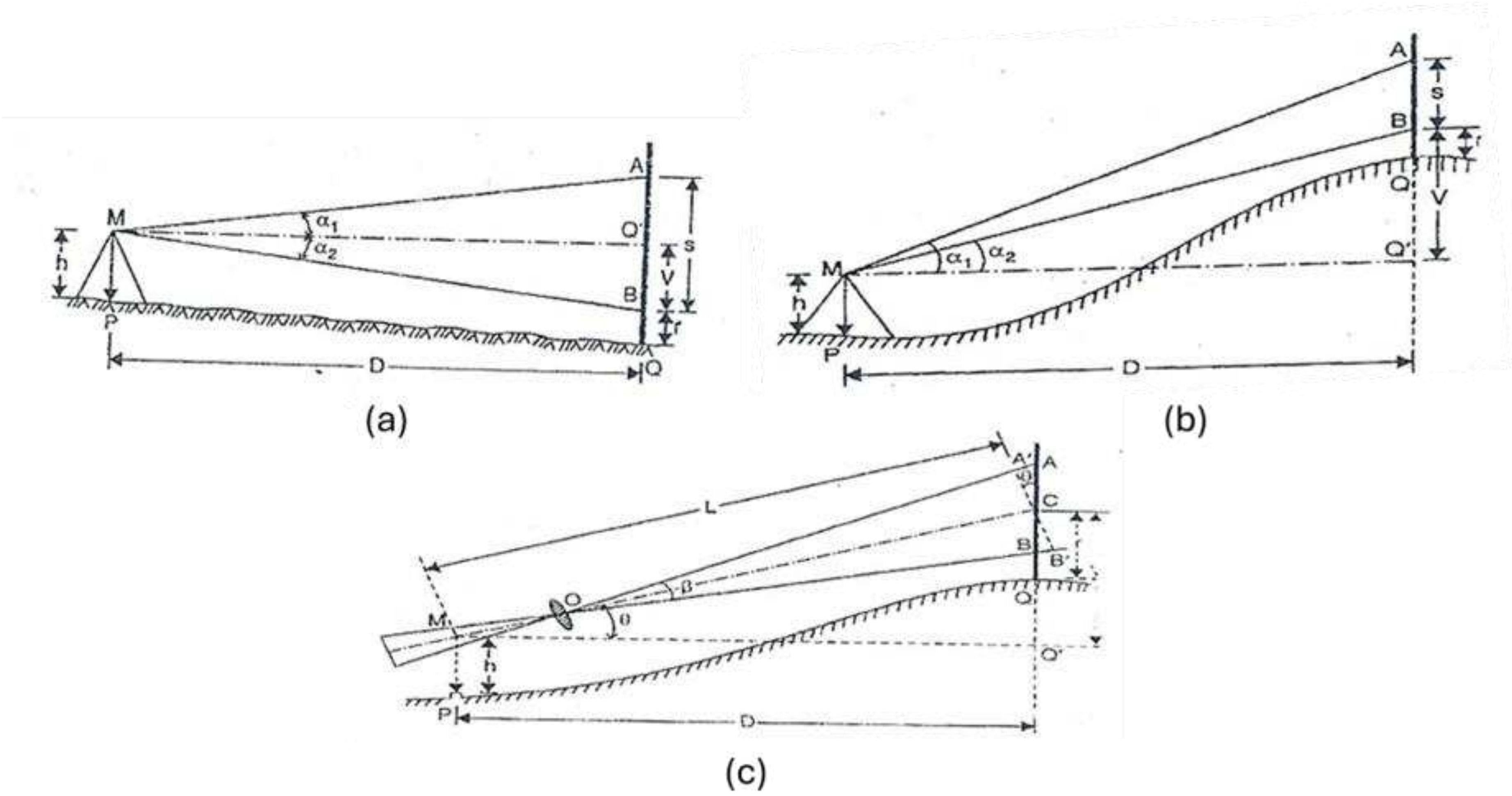


Figure 11.1. (a) One angle of elevation and one angle of depression; (b) both angles of elevation; (c) both angles of depression

OBSERVATIONS AND CALCULATION:

Table

Instrument Station	Object	Observation	Reading on vernier						Angle on vernier						Mean angle of vernier			Mean angle of observation			Stadia readings	Stadia Intercept	Height of instrument
			C			D			C			D											
1	2	3	4			5			6			7			8			9			10	11	12
			0	'	"	0	'	"	0	'	"	0	'	"	0	'	"	0	'	"	m	m	m
O	P Q	Face : Left Swing : Right																					
	P Q	Face : Right Swing : Right																					

RL of BM = ____________ m

APPARATUS:

a) Tacheometer with tripod
b) Levelling staff

PROCEDURE:

1. Set up the instrument at station P and make temporary adjustments.
2. Take a staff reading on the BM with a horizontal line of sight.
3. Transit the telescope and sight the upper tangent on the staff held at station Q, noting the angle of elevation $\alpha 1$.
4. Depress the telescope and sight the lower tangent on the same staff, noting the angle $\alpha 2$.
5. Record the staff intercept between the two tangents.
6. Use the relevant formula to calculate the RL of the given point.

RESULTS:

1. The RL of a given object = ____________ m
2. Distance between the instrument station and staff station = _______________m

PRECAUTIONS:

1. Ensure the instrument is set up on a stable and level surface to avoid errors in measurement.
2. Verify that the staff is held perfectly vertical to ensure accurate readings.
3. Double-check the angles of elevation and depression to avoid any miscalculations.
4. Make sure the line of sight is clear of any obstructions that could interfere with the measurements.

QUESTIONS:

1. What is the importance of transiting the telescope in tangential tacheometry?
2. How does the staff intercept method help in determining the reduced level of a point?
3. What are the potential sources of error in tangential tacheometry, and how can they be minimized

EXPERIMENT NO. XII - Total Station: Determination of distance and difference in elevation between two inaccessible points

AIM: To find the height of a remote point and distance using total station.

THEORY: In total station surveying, determining the distance and difference in elevation between two inaccessible points involves using a combination of electronic distance measurement (EDM) and angle measurements. A total station is a versatile and precise instrument that integrates the functions of a theodolite and an EDM device. It can measure horizontal and vertical angles as well as slant distances with high accuracy. The principle behind using a total station for this purpose involves the following steps. First, the total station is set up at a known point with coordinates that have been previously established. This point serves as the station point. The instrument is then aimed at the first inaccessible point, and the horizontal and vertical angles, as well as the slant distance to this point, are measured. Next, the total station is rotated to sight the second inaccessible point, and the same set of measurements (horizontal and vertical angles and slant distance) is taken. With these measurements, the coordinates of the two inaccessible points can be calculated using trigonometric formulas that relate the angles and distances. Once the coordinates of both points are known, the horizontal distance between them can be determined using the Pythagorean theorem. The difference in elevation between the two points is found by calculating the difference in their vertical coordinates.

The accuracy of this method relies on the precise calibration and setup of the total station, as well as the correct application of trigonometric principles. Total stations are equipped with data recording and processing capabilities, which help in minimizing errors and improving the reliability of the measurements. This technique is widely used in topographic surveys, construction projects, and any situation where direct measurement of distances and elevations is challenging due to obstructions or difficult terrain.

APPARATUS:

a) Total station
b) Prism
c) Tripod
d) Pegs

PROCEDURE:

1. Fix the total station over a station and level it.
2. Press the power button to switch on the instrument.
3. Select MODE B → S Function → File Management → Create (enter a name) → Accept.
4. Press ESC to go to the starting page.
5. Set zero by double-clicking on 0 Set (F3).
6. Go to S Function → Measure → Rectangular Coordinate → Station → Press Enter.
7. Here enter the point number or name, instrument height, and prism code.

PN.......................................
E..
N..
IH..
PC..

8. Press Accept (Fs).
9. Set up a reflector vertically beneath the point, the height of which is to be determined.
10. Enter the reflector height, target to it, and measure the distance.
11. Target the high point.
12. The height difference (H) between the ground point and the high point is now calculated and displayed at the touch of a button.

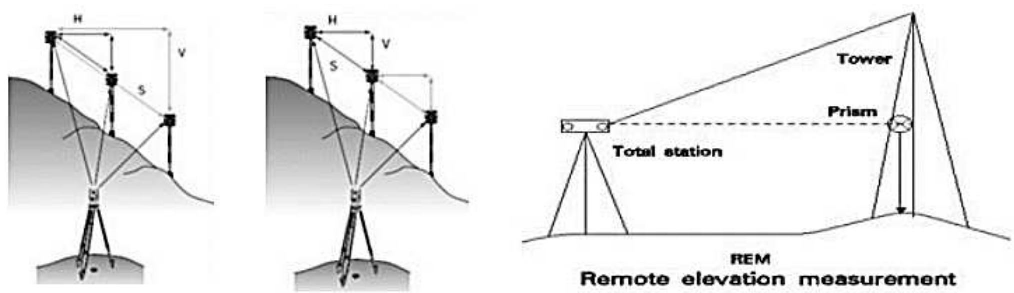


Figure 12.1. Total station measurement

OBSERVATIONS AND CALCULATION:

Select S function---> calculation---> 2D surface---->All------> accept

RESULTS:

Height of a remote point using total station is obtained.

PRECAUTIONS:

1. Ensure the total station is precisely leveled and securely fixed to avoid measurement errors.
2. Verify that the instrument height and prism height are correctly entered in the total station.
3. Make sure the reflector is accurately positioned vertically beneath the point to be measured.
4. Avoid obstructions and ensure a clear line of sight between the instrument and the reflector during measurements.

QUESTIONS:

1. How does incorrect leveling of the total station affect the accuracy of measurements?
2. What are the potential sources of error in measuring the height difference using a total station?
3. Why is it important to enter the correct prism code and height in the total station?
4. How can environmental conditions, such as temperature and humidity, impact the accuracy of distance measurements with a total station?