# INSTITUTE OF REMOTE SENSING

## ANNA UNIVERSITY, CHENNAI - 600 025.

# LAB MANUAL

## SURVEYING 1 LABORATORY

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| Expt No. 1 | FINDING PACE VALUE OF SURVEYOR USING CHAINING AND RANGING | Date of Expt: |
|---|---|---|

**Aim**

To determine the Pace Value of the Surveyor using Chaining and Ranging.

**Apparatus Required**

- Chain
- Arrows
- Ranging Rods
- Offset Rods
- Cross staff or optical square,
- Plumb bob
- Pegs

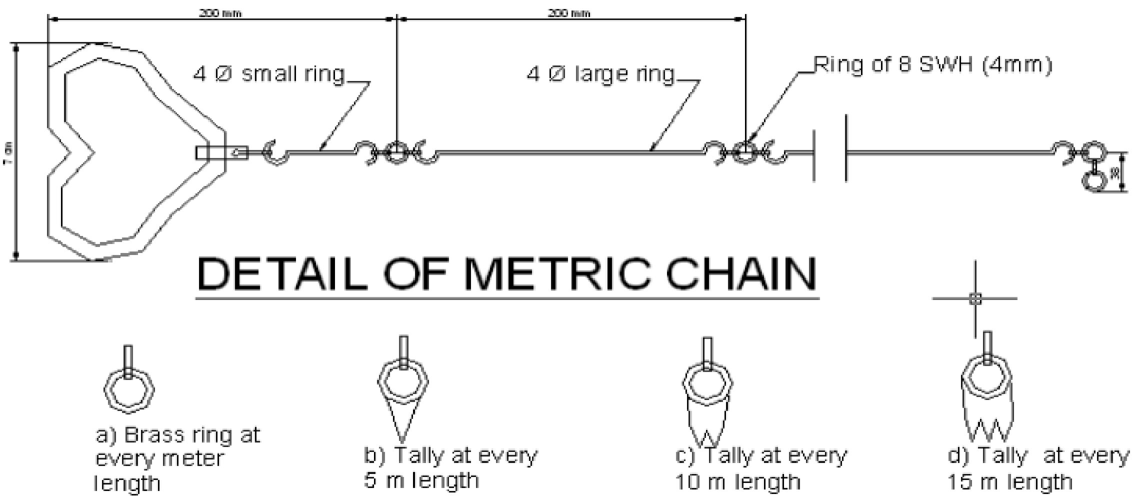



**Fig.1 Metric Chain**

**THEORY :**

Various methods of determining distance are available such as Chaining, Pacing, Odometer etc. Measurement of distance using chain is considered as one of the most accurate method. Depends upon the accuracy required the material of the tape is selected. Steel tapes or chains are used for highly precise work. Pacing is the simplest and easiest method for measuring distance.

Pacing is the process of walking the distance and counting the number of steps "paces" to cover the distance. Chaining means measurement of the given distance with the help of chain or tape. Two parties are involved in the chaining process. 1. The Leader (the surveyor) and 2. The follower (an assistant who helps to establish intermediate points)

**Duties of leader & follower**

**Leader:**

1) To put the chain forward

2) To fix arrows at the end of chain

3) To follow the instruction of the followers.

**Follower:**

1) To direct the leader to the line with the ranging rod.

2) To carry the rear end of the chain.

3) To pick up the arrows inserted by the leader.

**Procedure**

**Chaining**

1) The follower holds the zero handle of the chain against the peg &directs the leader to be in line of the ranging rod.

2) The leader usually with to arrows drags the chain alone the line.

3) Using code of signals the follower directs the leader as required to the exactly in the line.

4) The leader then fixes the arrows at the end of chain the process is repeated.

**Ranging**

1) Place ranging rods or poles vertically behind each point
2) Stand about 2m behind the ranging rod at the beginning of the line.
3) Direct the person to move the rod to right or left until the three ranging rods appear exactly in the straight line.
4) Sight only the lower portion of rod in order to avoid error in non-vertically.
5) After ascertaining that three rods are in a straight line, ask the person to fix up the rod.

**Pacing**

1) Walk the distance and count the number of steps "paces" to cover the distance.
2) Calculate the distance by multiplying the number of steps taken between two points by one's pace factor.

**RESULT :**

Total distance by chaining and ranging =

Number of Steps =

Pace Value of Surveyor =

| Expt No. 2 | MAPPING OF BUILDING WITH CROSS STAFF AND WITHOUT CROSS STAFF | Date of Expt: |
|---|---|---|

**AIM:**

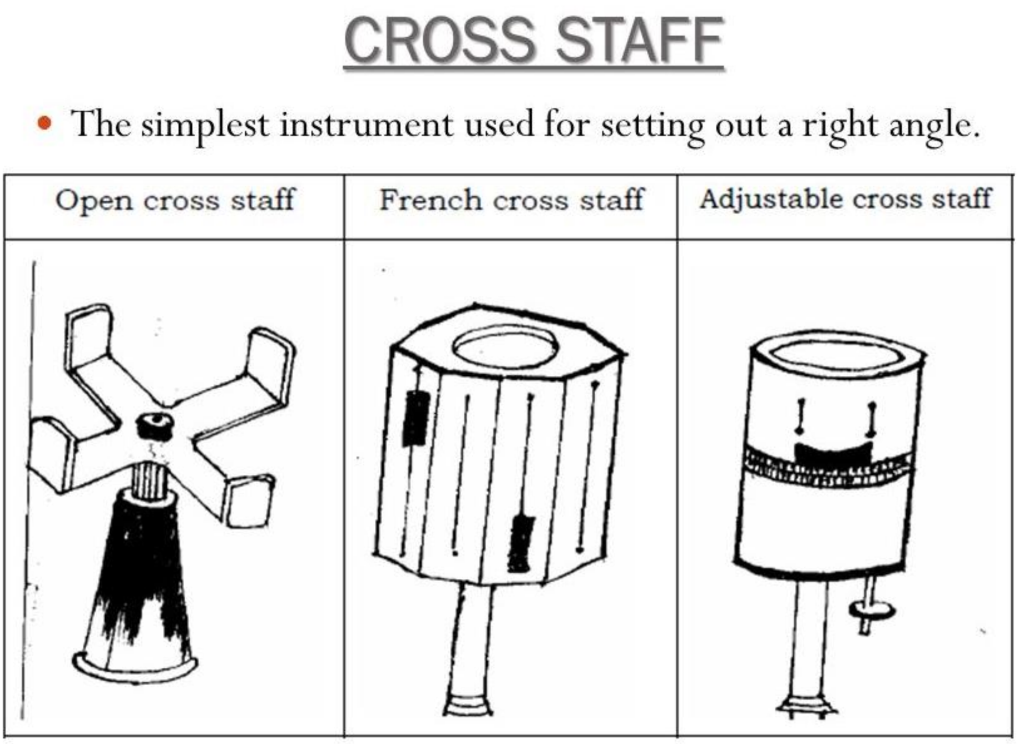
To map a building layout by using both traditional surveying methods with and without a cross staff.

**PART 1: MAPPING WITH CROSS STAFF**

**EQUIPMENT REQUIRED:**

- Cross staff
- Measuring tape (or chain)
- Surveyor's level (optional)
- Compass or theodolite (optional)
- Field notebook

**PROCEDURE:**




- **Setting Up the Surveying Station:**

Identify a starting point for your survey. This will typically be one corner of the building or a reference point in the surroundings.

Set up the cross staff at the chosen point.

Align the staff to a known reference direction (e.g., North).

- **Measuring Distances:**

Measure the distance from the starting point to the first corner of the building using a tape measure or a chain. Record this measurement in your field notebook.

- **Using the Cross Staff for Angle Measurement:**

Use the cross staff to measure the angles between different building corners. This is done by sighting the cross staff through the instrument while aligning the cross wires with the building corners.

Record the angles for each corner and direction.

- **Taking Multiple Measurements:**

Move from one corner to another, continuing to measure the distances and angles until the entire building outline has been surveyed.

Make sure all measurements are taken at right angles to ensure accuracy.

- **Plotting the Building Layout:**

Using the recorded distances and angles, plot the building on graph paper or a digital mapping tool.

Ensure that the angles and distances are accurately represented in the scale drawing.

**PART 2: MAPPING WITHOUT CROSS STAFF**

**EQUIPMENT REQUIRED:**

- Tape measure or chain
- Protractor (for angle measurement)
- Compass or theodolite (optional)
- Field notebook
- Stake markers (optional)

**PROCEDURE:**

- **Setting up the surveying station:**

As in the first part, choose a starting point for your survey. Mark this point clearly.

If available, use a compass to orient your survey to a cardinal direction (e.g., North).

- **Measuring distances:**

Use a tape measure or chain to measure the distances from the starting point to each corner of the building.

Record each measurement in the field notebook, ensuring precise distance measurement.

- **Measuring angles without the cross staff:**

To measure angles between building corners, use a protractor or an angle measuring device.

Position the protractor at each corner of the building and measure the angle to the adjacent corners.

Record the angles accurately.

Marking Points and Connecting Them:

Once all distances and angles are measured, mark the points corresponding to the building corners.

Use string or other markers to connect the points, forming the outline of the building.

- **Plotting the layout:**

As with the cross staff method, plot the building layout on graph paper or a digital tool.

Use the recorded distances and angles to ensure accuracy.

Comparison of Methods

**RESULT:**

This exercise demonstrates the importance of both traditional and modern surveying techniques. By practicing with both methods, we will better understand how to approach building layout mapping depending on the available tools, ensuring accurate and efficient surveying.

| Expt No. 3 | OVERCOMING OBSTACLES IN CHAINING | Date of Expt: |
| --- | --- | --- |

**AIM:**

To understand and overcome obstacles in the chaining process, a concept from behavior analysis and learning theory, where complex behaviors are learned by linking together simpler behaviors (or "links"). This experiment aims to explore common obstacles in chaining and test methods to overcome them.

**THEORY:**

Chaining is a method used to teach complex behaviors by breaking them down into smaller, manageable steps or links. There are two types of chaining:

- Forward chaining (starting with the first step and progressing forward)
- Backward chaining (starting with the last step and progressing backward).

However, there are several obstacles that can arise when attempting to chain behaviors, including incomplete linkages, improper reinforcement schedules, and the lack of motivation or clarity in the sequence.

**MATERIALS:**

- A participant (human or animal subject)
- A task involving multiple steps (e.g., a puzzle or action sequence)
- Reinforcers (treats, verbal praise, tokens, etc.)
- A stopwatch or timing device
- Data collection sheet or software
- Experimenter assistant (optional)

**PROCEDURE:**

1. **Task Selection:** Choose a task with at least 4-6 individual steps (links). For example, training a participant to assemble a toy, complete a puzzle, or engage in a multi-step motor sequence (e.g., pressing a series of buttons in a particular order).
2. **Training with Forward Chaining:** a. Introduce the first step of the task to the participant. b. Provide immediate reinforcement for completing the first step. c. Gradually introduce subsequent steps, reinforcing the participant for completing each step in sequence. d. Ensure that each link is mastered before moving to the next.
3. **Training with Backward Chaining:** a. Start with the last step of the task. b. Reinforce the participant for completing the final step and then progress backward to the first step, reinforcing each step as they become part of the chain.

4. **Testing for Obstacles:** During the task, observe and note any instances of failure in mastering a link, interruptions in the sequence, or unclear completion of steps. Common issues might include:

    - The participant failing to execute a specific link correctly.
    - Missing reinforcement at an appropriate time.
    - Inconsistent execution of links.

5. **Intervention Strategies:** Based on the obstacles encountered, apply different strategies such as:

    - **Shaping:** Reinforce closer approximations of the correct behavior when a link is not performed correctly.
    - **Task Modifications:** Simplify steps if the chain is too difficult or overwhelming.
    - **Increased Reinforcement:** Increase the frequency or intensity of reinforcement for successfully completing each link.

6. **Data Collection:** Record the following:

    - The time it takes to complete the chain with and without interventions.
    - The number of errors made at each step of the chain.
    - The number of successful completions of each link.
    - The types of reinforcement used and the participant's response.

7. **Analysis:** After completing the experiment, analyze the data to determine which strategies were most effective in overcoming the obstacles. Look for patterns in errors and how specific interventions (e.g., reinforcement schedules, shaping, task modifications) impacted the learning process.
8. **Conclusion:** Summarize the findings and discuss how overcoming obstacles in chaining can be applied to both animal and human learning contexts. Evaluate the importance of stepwise learning, reinforcement, and motivation in facilitating complex behaviour acquisition.

**RESULTS:**

- The experiment can be modified to test different types of chaining (e.g., total task presentation, mixed chaining).
- Further research can explore the role of reinforcement schedules and timing in overcoming chaining obstacles.

| Expt No. 4 | COMPUTATION OF INCLUDED ANGLE AFTER ADJUSTMENT OF LOCAL ATTRACTION | Date of Expt: |
|---|---|---|

**Aim**

To survey an area (Closed Traverse) by Compass Survey and to plot the area after correcting the local attraction

**Apparatus Required**

- Tape or Chain
- Arrows
- Ranging Rods
- Compass
- Tripod

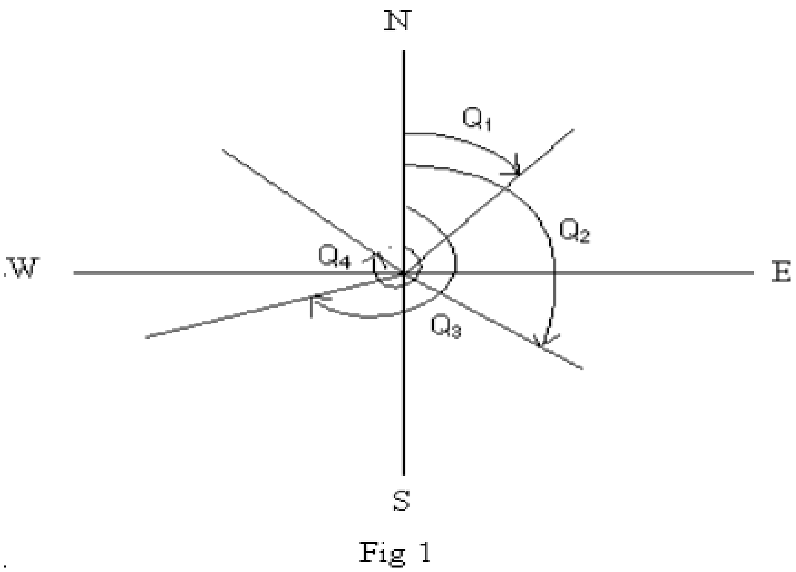



**Fig.1 Whole Circle Bearing**

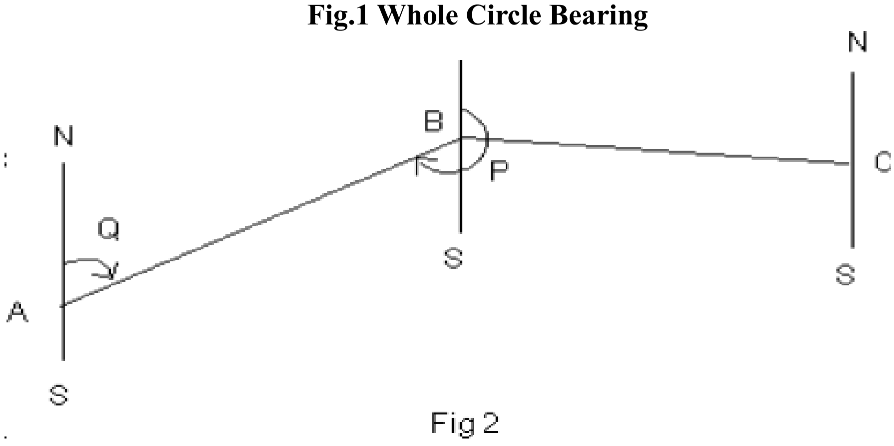



**Fig.1 Fore Bearing and Back Bearing line of AB**

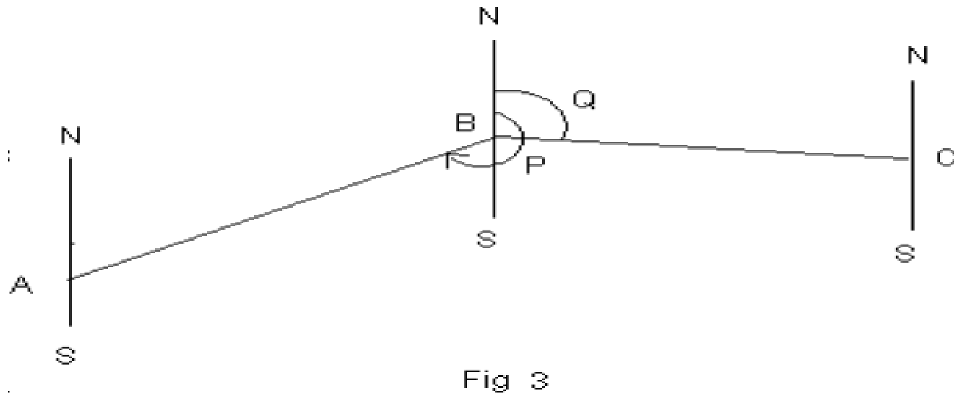



**Fig.1 Included Angle**

**THEORY**

**WHOLE CIRCLE BEARING (WCB):**

A bearing that defines the direction of a survey line by its horizontal angle measured clockwise from true north (WCB). The values of WCB will vary from $0^o$ and $360^o$. Fig 1 represents the WCB.

**Fore or Forward Bearing (FB) (WCB System):**

The bearing of line in the forward direction of progress of the survey is called Fore or Forward Bearing.

**Back or Reverse Bearing (BB) (WCB System):**

The bearing of a line in the opposite direction of progress of the survey is known as Back or Reverse Bearing.

Fig.2 shows the fore bearing of line AB i.e. Q and the back bearing of line AB i.e. P

**CALCULATION OF INCLUDED ANGLES FROM FORE BEARING AND BACK BEARING:**

- The horizontal angle between two lines is known as included angle. It may be interior or exterior.
- Included angle between two lines is obtained by the following formula,
- Included Angle = Fore Bearing of Next Line – Back Bearing of Previous Line
- In Fig 3 the included angle between line AB and line BC is, = FB of line BC – BB of line AB . If the calculated included angle comes out as a negative value, $360^o$ is added to it.

**PROCEDURE.**

1. Keep the compass over the starting point of the line while running from clockwise direction in the traverse.
2. Keep the line of sight along N – S direction such that the bearing under the prism should read $0^{o}$.
3. Turn the compass in clockwise direction only until the line of sight coincides with the ranging rod placed at the end point of line.
4. Shift the compass to the end point of the line for taking Back Bearing of that line and same procedure is followed as it is followed while taking Fore Bearing.
5. Repeat the same procedure till completing the Fore Bearing and Back Bearing of all lines of closed traverse (Fig.4).
6. Measure the distances of all lines of closed traverse with chain or tape.

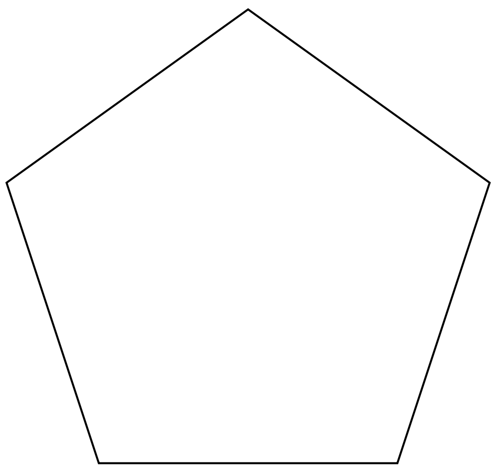


**Fig.4 . Closed Traverse**

Theoretical Included angles = **(2n - 4) X 90°**

Where n = Number of sides of closed traverse.

**Error = (Theoretical Sum of Included Angles – Total Actual Included Angles) / n**

Where n = Number of sides of closed traverse.

If the Error is positive, add this error to each actual included angle and if the Error is negative, deduct this error from each actual included angle.

Therefore, **Corrected Included Angle = Actual Included Angle + Error, if positive.**

**Corrected Included Angle = Actual Included Angle – Error, if negative.**

**Check:**

Sum of Corrected Included Angles = Sum of actual Included Angles.

**Calculation of internal included angles:**

Internal Included Angle between two lines can be calculated by,

Internal Included Angle = 360°– External Included Angle

**TABULATION**

| Line | Observed | | Difference (FB of Next Line – BB of Previous Line) | Included Angle | Theoretical Sum of Included Angles | Error | Corrected Included Angle | Distance | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | FB | BB | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| Total | | | | | | | | | |

**RESULT:**

Distances :

Included Angles :

Area of the given closed traverse :

5. Determination of Inaccessible Distance using compass

6. Mapping of Building with Compass including traverse adjustment

| Expt No. 5 | DETERMINATION OF INACCESSIBLE DISTANCE USING COMPASS | Date of Expt: |
|---|---|---|

**AIM:**

To learn how to determine the distance to an inaccessible point using a compass. This method involves measuring angles from a known reference point, applying basic trigonometry, and using the compass to find the distance to an inaccessible object or point.

**THEORY:**

In many surveying and field operations, there are instances when certain points or objects are inaccessible for direct measurement, such as tall buildings, hills, or other obstacles. The **Compass Method** is commonly used in these situations. By taking measurements of angles from a known point to the target (inaccessible) point, we can use trigonometric calculations to determine the distance to the target.

This exercise involves using a **prismatic compass** to measure the angle between the observer and the target, and then applying simple trigonometry (usually the **law of sines** or **tan** rule) to calculate the inaccessible distance.

**MATERIALS:**

1. Prismatic Compass
2. Measuring Tape or Distance Measuring Instrument
3. Field Notebook
4. Protractor
5. Clinometer or Inclinometer (optional)
6. Reference Points (Two or More Known Points)
7. Ruler and Calculator

**PROCEDURE:**

**Step 1: Setup the Compass at the Reference Point**

1. **Position the Compass:**
   - Set up the prismatic compass at a known point (Point A) where you can clearly sight the inaccessible object or target (Point B). Ensure that the compass is level, and the sighting vane is aligned with the target point.
2. **Identify Two Known Points:**
   - Choose two known reference points on the ground (Point A and Point C) at a measurable distance apart, ensuring the target (Point B) is visible from both reference points.
3. **Record the Distance:**

- Measure and record the distance between the two reference points (A to C). This will serve as the baseline for your measurements.

**Step 2: Measure Angles Using the Compass**

1. **Measure the Angle to the Target from Point A:**
   - Using the prismatic compass, measure the horizontal angle from Point A to the target (Point B). Record this angle as the **angle of sight** or **bearing** from Point A to Point B.
2. **Measure the Angle to the Target from Point C:**
   - Repeat the same process from Point C, measuring the angle from Point C to the target (Point B). This angle is also noted.
3. **Record the Angles:**
   - Record both angles, as well as the distance between Points A and C, in the field notebook.

**Step 3: Apply Trigonometry (Law of Sines or Tangent Method)**

1. **Using the Law of Sines:**
   - If the angles measured are $\theta_1$ (from Point A) and $\theta_2$ (from Point C), and the distance between Points A and C is **d**, you can use the law of sines to determine the distance to the target (Point B).

   **Law of Sines:**

$$\frac{d}{\sin(\theta_3)} = \frac{AB}{\sin(\theta_2)} = \frac{CB}{\sin(\theta_1)}$$

Where:

- $\theta 3=180°-(\theta 1+\theta 2)$ is the angle at the target.
- AB is the distance from Point A to the target (Point B), which is the value you are solving for.

2. **Alternatively, Using the Tangent Method (for Elevation Angles):**
   - If the target is elevated, you can use the **tangent method**

$$AB = \frac{h}{\tan(\theta)}$$

Where:

- h is the height difference between the target and observer.
- θ is the angle of elevation or depression.

**Step 4: Perform the Calculations**

1. **Calculate the Distance:**
   - Using the angles recorded and applying either the Law of Sines or the Tangent Method, calculate the distance to the target point (Point B).
2. **Repeat for Verification:**
   - If necessary, repeat the process from a different location to ensure consistency in measurements and improve accuracy.

**Step 5: Final Check**

1. **Verify Calculations:**
   - Double-check your angle measurements and trigonometric calculations to ensure they are accurate. Small errors in angle measurement can lead to significant errors in distance calculation.
2. **Plot the Target Location:**
   - If this distance is part of a survey or map, plot the target location based on the calculated distance and bearings.

**DATA COLLECTION:**

1. **Angle Measurements:**
   - Record the angles measured from both reference points (Point A and Point C) to the target (Point B).
2. **Baseline Distance:**
   - Measure and record the distance between the two reference points (Point A to Point C).
3. **Calculated Distance:**
   - After applying trigonometry, record the calculated distance to the target (Point B).

**CALCULATIONS AND ANALYSIS:**

1. **Trigonometric Accuracy:**
   - Evaluate the precision of the calculated distance by checking for consistency in angle measurements and ensuring the applied trigonometric methods are correct.
2. **Error Analysis:**
   - Consider possible sources of error, such as misalignment of the compass, incorrect angle measurements, or inaccurate distance readings. Discuss how

these errors might affect the accuracy of the calculated distance and how they could be minimized.

3. **Verification:**
    - If possible, compare the calculated distance with a known or measured distance (from GPS, tape measure, or other instruments) to verify the accuracy of the compass-based method.

**RESUT:**

- The calculated distance to the inaccessible point will be close to the actual distance, assuming accurate angle measurements and correct application of trigonometric formulas.
- This laboratory exercise helps students understand how to apply trigonometry with compass measurements to determine distances to inaccessible points, a valuable skill in both field surveying and practical outdoor navigation.

| Expt No. 6 | MAPPING OF BUILDING WITH COMPASS INCLUDING TRAVERSE ADJUSTMENT | Date of Expt: |
|---|---|---|

**AIM:**

To learn and apply the procedure for mapping a building or structure using a compass for direction measurements and performing a traverse adjustment to improve the accuracy of the final map. This exercise will teach students how to use the compass in field mapping, determine relative positions of points, and correct for errors through traverse adjustment.

**THEORY:**

In surveying, **compass surveying** is a method that uses a magnetic compass to measure the azimuths or bearings of lines between survey points. **Traverse adjustment** is a procedure used to adjust the recorded angles and distances in a traverse survey to eliminate errors such as angular misclosures and length discrepancies.

The objective of this exercise is to map a building or structure, using the compass to measure the azimuths at various survey points, and then to apply traverse adjustment techniques to ensure that the map is as accurate as possible. The corrected coordinates of the survey points will be used to finalize the building's layout.

**MATERIAL REQUIRED:**

1. **Compass (Prismatic or Surveying Compass):**
    - To measure the bearings or azimuths of survey lines between points.
2. **Measuring Tape or Distance Measuring Device:**
    - To measure the distances between survey points.
3. **Field Notebook:**
    - For recording azimuths, distances, and other necessary details.
4. **Plumb Bob (Optional):**
    - To help in ensuring that the measuring tape is straight.
5. **Theodolite (optional, if more precision is needed):**
    - For measuring angles with higher accuracy than a standard compass.
6. **Protractor:**
    - For measuring angles, especially when adjusting the traverse.
7. **Traverse Adjustment Software or Manual Calculations:**
    - If using software, it will help adjust angular misclosure and distance discrepancies. If performing manual adjustments, a calculator and formulas for **least squares adjustment** will be needed.
8. **Graph Paper or Map Sheet:**
    - For plotting the coordinates of the surveyed points.
9. **Ruler or Scale:**

- To draw lines representing survey points on the map.

**PROCEDURE:**

**Step 1: Prepare for Survey**

1. **Select the Survey Area:**
    - Choose a building or structure to map. Mark out the corners and significant features that will serve as survey points.
2. **Establish the Starting Point (Point A):**
    - Select a starting point outside the building or at a known reference location. This point will be used to measure bearings to other points.
3. **Set up a Compass:**
    - Position the compass at **Point A** (starting point) and ensure it is level. Use the sighting vane to ensure proper alignment of the compass.
4. **Record the Initial Bearing:**
    - Measure the bearing or azimuth from Point A to the first survey point (Point B). Record this angle in your notebook, along with the measured distance from Point A to Point B.

**Step 2: Survey the Building's Points**

1. **Measure Angles to Successive Points:**
    - From **Point B**, use the compass to measure the bearing to the next point in the survey (Point C). Record the bearing and distance to **Point C**.
    - Continue this process for each successive point around the building or structure, making sure to record both the bearing and the distance between each pair of points.
2. **Close the Traverse:**
    - After surveying all relevant points, return to the starting point (**Point A**) to close the traverse loop. Measure the final bearing and distance between the last survey point and **Point A**.
3. **Double-check for Completeness:**
    - Ensure that all necessary corners, edges, and features of the building are included in your survey. If any additional points are required, go back and survey them.

**Step 3: Traverse Adjustment**

1. **Calculate the Angular Misclosure:**
    - After completing the survey, compare the sum of all the angles in the traverse with the expected value (usually 360° for a closed loop, or a multiple of 360°).
    - The misclosure angle is the difference between the expected sum and the sum of your recorded angles.

2. **Distribute the Angular Misclosure:**
   - Using the **Method of Equal Distribution** or the **Least Squares Method**, distribute the angular misclosure proportionally among the angles in the traverse.
   - The angular misclosure can be corrected by adding or subtracting a portion of the error to each angle. The adjustment ensures that the corrected angles add up to the expected total.
3. **Correct the Recorded Distances:**
   - If there is a discrepancy between the expected total length and the actual length of the traverse (i.e., there is a **distance misclosure**), apply **proportional adjustment** to each measured distance.
   - This means adjusting each individual distance by a constant factor to make the total distance equal to the expected total.
4. **Apply the Adjustments:**
   - After applying the necessary corrections to the bearings and distances, the final traverse will be the adjusted map of the building or structure.

**Step 4: Plot the Map**

1. **Plot Survey Points:**
   - Using the corrected bearings and distances, plot each survey point on the map. You can do this manually using graph paper, or by using software that can take the adjusted coordinates and plot the points.
2. **Connect the Points:**
   - Once all points are plotted, connect them in the order in which they were surveyed to form the boundary of the building. You can also add interior features, walls, or rooms as necessary.
3. **Label Points:**
   - Label each point with its corresponding name or number for easy reference.

**Step 5: Final Adjustments and Checks**

1. **Verify the Map:**
   - After plotting the points and making adjustments, double-check the map for accuracy. Ensure that all measurements align correctly and that the overall shape of the building is accurate.
2. **Check for Consistency:**
   - Check the consistency of the distances and angles by re-measuring some known distances on the map. Any significant discrepancies should be corrected.
3. **Document Errors:**
   - If there are any errors that cannot be resolved through adjustment, document them in the field notebook, noting the potential causes of error (e.g., instrument error, measurement error, human error).

## DATA COLLECTION:

1. **Angle Measurements:**
   - Record the measured bearings or azimuths for each leg of the traverse.
2. **Distance Measurements:**
   - Record the distances between each pair of consecutive points.
3. **Traverse Closure Information:**
   - Calculate the angular and distance misclosures for the entire traverse and note the adjustments applied.
4. **Final Adjustments:**
   - Record the corrected bearings, distances, and final positions of the survey points after adjustments.

## CALCULATIONS AND ANALYSIS:

1. **Angular Misclosure:**
   - Sum the measured angles and compare them with the expected total (usually 360° for a closed loop).
2. **Distance Misclosure:**
   - Compare the measured traverse length with the expected length, applying proportional adjustments as necessary.
3. **Correction Factors:**
   - Apply correction factors for both angles and distances to ensure that the sum of the angles and total distance is accurate.
4. **Least Squares Adjustment (Optional):**
   - If a more rigorous approach is needed, use the **Least Squares Method** to adjust both the angular and distance measurements to minimize errors in all the survey points.

## RESULT:

This laboratory exercise offers students valuable experience in both **field survey techniques** and the **mathematical corrections** required for accurate mapping. It provides insight into how errors in measurements can be adjusted for better accuracy in practical surveying.

| Expt No. 7 | PLANIMETRIC MAPPING OF AN AREA USING PLANE TABLE SURVEYING (RADIATION, INTERSECTION) | Date of Expt: |
|---|---|---|

**AIM**

To plot a given area by Radiation and Intersection methods of Plane Table Survey

**APPARATUS REQUIRED**

- Tape
- Ranging Rods
- Arrows
- Plane Table with Tripod and its accessories
- Drawing sheet and drawing tools
- Paper clips or screws
  Plane table and its accessories are shown in below figure 1.

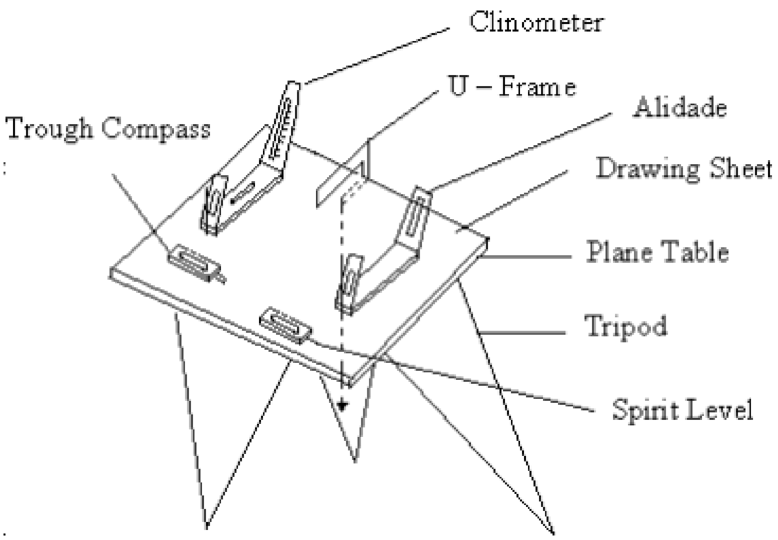



Fig.1 Plane Table and its accessories

**THEORY**

Plane table surveying is a graphical method of survey in which the field observations and plotting are done simultaneously.

**Methods of Plane Table Surveying**

- Radiation
- Intersection
- Traversing
- Resection

The first three methods are used to calculate the area or distance of the closed polygon where as the last method is used to located the unknown station point with the help of known field points.

**Arrangement of Plane Table**

1. **Fixing of Plane Table**
   Fix the plane table to the tripod stand. Arrange the drawing sheet on the plane table using paper clips or thumb screws. The sheet should be in one position from first to last.

2. **Leveling of Plane Table**

   Plane table should be leveled using spirit level.

3. **Centering of Plane Table**

   The table should be centered by using plumbing fork. By which we can arrange the plotted point exactly over the ground point.

4. **Orientation of Plane Table**

   Whenever we are using more than one instrument station, orientation is essential. It can be done by using compass or back sighting. In this case, the plane table is rotated such that plotted lines in the drawing sheet are parallel to corresponding lines on the ground.

**PROCEDURE**

**A. RADIATION METHOD**

1. Select a station O such that all other stations A, B, C and D are accessible and visible from O (Fig 2).

2. Plot the N – S direction in the top right corner of the drawing sheet.
3. Set the plane table at O.
4. Place the alidade at O and draw rays from O to the stations A, B, C, D and E.
5. Measure the distances of distances OA, OB, OC, OD and OE and mark the same in the drawing sheet with suitable scale as oa, ob, oc, od and oe.
6. Join a, b, c, d and e and compute the area.

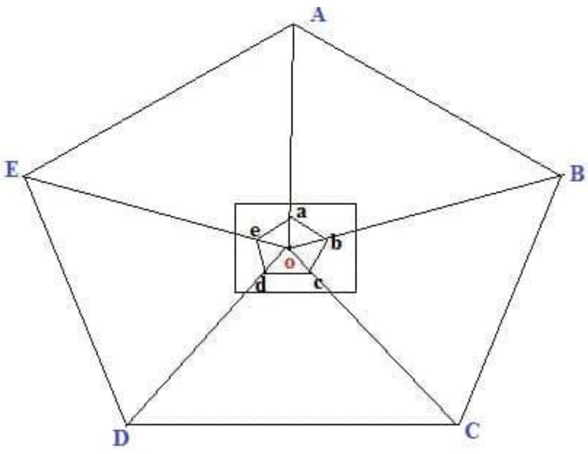



Fig. 2 Radiation Method

**B. INTERSECTION METHOD:**

1. Select P and Q be the two accessible stations (Fig 3)
2. Set the plane table at P. Plot N – S direction in the top right corner of the drawing sheet.
3. Transfer the ground station P as "p" onto the drawing sheet. With the alidade centered at "p‟, sight stationsA, B and Q.
4. With the alidade at 'p', draw rays"pA", 'pB' and 'pQ'.
5. Shift the equipment to station Q and orient the table to P by back orientation.
6. Plot the lines by sighting stations A, B and P. Finally, the intersection of A and B rays is the required location of point of intersection "a and b".
7. Join "a and b" and calculate the area pqab.

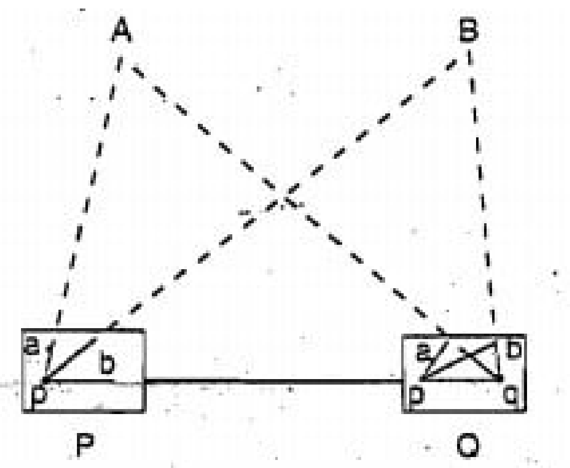



**Fig.3 Intersection Method**

**RESULT:**

Given area is plotted on paper by Radiation and Intersection methods of Plane Table Survey.

| Expt No. 8 | MAP UPDATION USING PLANE TABLE SURVEYING THROUGH RESECTION (GRAPHICAL METHOD) | Date of Expt: |
|---|---|---|

**AIM:**

To learn and apply the graphical method of resection in plane table surveying for updating an existing map. This method helps in determining the position of the plane table by sighting known points and graphically finding the intersection of lines of sight to update the map or plot new points accurately.

**THEORY:**

**Plane Table Surveying** is a direct method of surveying in which the surveyor records measurements and draws the map on the spot. The **Resection Method** is used to determine the position of the plane table by observing angles or directions to two or more known points. The graphical method of resection involves drawing lines of sight to known reference points on the map and finding their intersection, which gives the position of the survey instrument.

In the **Graphical Method of Resection**, the known points are marked on the map, and angles or bearings from the unknown point (the location of the plane table) to these known points are measured. The position of the unknown point is determined by plotting the lines of sight from the known points and finding their intersection on the map.

**MATERIALS:**

1. Plane Table
2. Alidade
3. Surveying Compass or Theodolite
4. Plumb Bob
5. Surveying Level (optional)
6. Measuring Tape or Distance Measurement Instrument
7. Pencil and Ruler
8. Protractor
9. Field Notebook
10. Known Reference Points (Two or More Points)

**PROCEDURE:**

**Step 1: Set Up the Plane Table**

1. **Position the Plane Table:**
    - Place the plane table at the unknown point where you want to update the map. Ensure the table is horizontal by using a plumb bob or levelling instrument.

2. **Mark Known Points on the Map:**
    - On the plane table sheet, plot the locations of at least two known points (Point A and Point B) that are visible from the current location. These points should already be marked on the map, and their coordinates should be known.

**Step 2: Measure the Angles or Bearings**

1. **Measure the Angle to the First Known Point (Point A):**

    - Using the alidade or a theodolite/compass, sight the first known point (Point A) and measure the angle or bearing between the plane table and Point A.
    - Record the angle in your field notebook.

2. **Measure the Angle to the Second Known Point (Point B):**

    - Next, sight the second known point (Point B) and measure the angle or bearing from the plane table to Point B.
    - Record this angle as well.

3. **Repeat for Additional Points (Optional):**

    - If more known points are available and visible, repeat the process for additional points. More points can increase the accuracy of the intersection, but two points are generally sufficient for basic resection.

**Step 3: Graphically Plot the Resection**

1. **Plot Known Points on the Map:**

    - On the plane table map, plot the locations of the known points (Point A and Point B) using their coordinates. These points should be accurately positioned on the map.

2. **Transfer Angles to the Map:**

    - Using the protractor, measure and transfer the angle (or bearing) measured to Point A from the plane table onto the map. Draw a line from Point A in the direction corresponding to the measured angle. This line represents the line of sight from the plane table to Point A.
    - Similarly, transfer the angle measured to Point B onto the map and draw the corresponding line of sight from Point B.

3. **Find the Intersection:**

   - The lines of sight drawn from the known points (Point A and Point B) should intersect at a single point. The point of intersection represents the location of the plane table in the field.
   - Mark this intersection as the position of the plane table on the map.

**Step 4: Verify and Adjust**

1. **Check the Accuracy:**

   - If the lines from both known points (Point A and Point B) do not intersect at a common point or if the intersection seems off, recheck the angles or bearings for accuracy.
   - If necessary, adjust the plane table's position and repeat the process of sighting the known points and transferring the angles to the map.

2. **Repeat with More Points (Optional):**

   - If required, repeat the process with additional known points to increase accuracy. With three or more known points, the accuracy of the resection improves.

**Step 5: Update the Map**

1. **Plot Additional Features:**

   - Once the position of the plane table has been accurately determined, use it to plot new points or features in the area. Connect the newly located points and features to complete the updated map.

2. **Final Check:**

   - Perform a final check of the updated map to ensure that all points are correctly plotted and aligned with the known points. Any discrepancies should be addressed, and corrections made.

**DATA COLLECTION:**

1. **Angle Measurements:**

   - Record the angles or bearings between the alidade (or compass/theodolite) and the known reference points (Point A, Point B, etc.).

2. **Position Adjustments:**

    - Document any adjustments made to the plane table's position during the graphical resection process to ensure an accurate intersection of the sightlines.

3. **Coordinates:**

    - Record the coordinates or reference points for the known locations (Point A, Point B, etc.) to ensure correct positioning on the map.

**CALCULATIONS AND ANALYSIS:**

1. **Accuracy of the Resection:**

    - Evaluate the precision of the resection by comparing the intersection point with known coordinates or the position of the plane table. If the intersection is far off, assess the potential causes of error, such as incorrect angle measurements or improper leveling of the plane table.

2. **Error Analysis:**

    - Identify possible sources of error, including parallax errors in sighting, inaccuracies in measuring angles, or difficulties in aligning the alidade.

    - Discuss how these errors might affect the accuracy of the final map and suggest methods to minimize them (e.g., using more known points, rechecking angles, or improving leveling).

3. **Comparison with Other Methods:**

    - If available, compare the results of the graphical resection method with other methods, such as the trial and error resection or modern GPS-based methods, to assess the effectiveness and accuracy of plane table surveying.

**RESULT:**

- The graphical method of resection should allow you to determine the position of the plane table with a high degree of accuracy, as the lines of sight from known points will intersect at the location of the plane table.
- The updated map will include the new point locations, and the process should demonstrate how plane table surveying can be used for efficient map updation.
- This laboratory exercise provides hands-on experience in using the graphical method of resection for plane table surveying, helping students understand how to update maps efficiently and accurately through basic surveying techniques.

| Expt No. 9 | MAP UPDATION USING PLANE TABLE SURVEYING THROUGH RESECTION (TRIAL & ERROR METHOD) | Date of Expt: |
|---|---|---|

**AIM:**

To update an existing map or survey using plane table surveying through the resection method (Trial & Error Method). The goal is to determine the position of the plane table by sighting known points from the field, and adjusting the position of the plane table iteratively until the map is accurately updated.

**THEORY:**

**Plane Table Surveying** is a method of direct surveying in which the surveyor draws the map or survey on a drawing sheet while observing angles or distances to various points in the field. In the **Resection Method**, the position of the plane table is determined by observing angles or bearings from the plane table to at least two known points. The method is iterative, adjusting the plane table's position until the observed angles match those of the known points, updating the map or survey accordingly.

In the **Trial & Error Method** of resection, the surveyor repeatedly adjusts the plane table based on observed angles until the drawing on the map aligns with the known points in the field. This technique is particularly useful in small-scale surveys or when mapping additional features on an existing map.

**MATERIALS:**

- Plane Table
- Alidade
- Surveying Compass or Theodolite
- Plumb Bob
- Surveying Level (optional)
- Reference Points (Two or More Known Points)
- Measuring Tape or Distance Measurement Instrument
- Protractor or Angle Measuring Tool
- Pencil and Ruler
- Field Notebook

**PROCEDURE:**

**Step 1: Setup the Plane Table**

1. **Level the Plane Table:**

    - Position the plane table at the point where you wish to update the map.
    - Use the plumb bob or leveling instrument to ensure the plane table is perfectly horizontal.

2. **Mark Known Points on the Plane Table:**

    - On the plane table sheet, mark the positions of at least two known reference points (Point A and Point B) that are visible from the survey location. These points should be visible from the plane table's location and their coordinates should be known or pre-marked on the map.

**Step 2: Perform the Resection (Trial & Error) Process**

1. **Align the Alidade to the First Known Point (Point A):**

    - Using the alidade, sight along the line to the first known point (Point A). Align the alidade with Point A and draw a line on the map in the direction of Point A from the position of the plane table.
    - This is the first trial position of the plane table.

2. **Sight the Second Known Point (Point B):**

    - Next, using the alidade, sight the second known point (Point B) from the plane table location.
    - Draw a second line on the map in the direction of Point B, based on the sighting.

3. **Check the Intersection:**

    - Where the two lines (from Points A and B) intersect will give you the position of the plane table. This is the point where the plane table should be placed on the map.
    - If the lines do not intersect at a common point or are misaligned, you need to adjust the position of the plane table.

4. **Adjust the Position:**

    - Based on the misalignment of the lines, shift the plane table slightly to a new position and repeat the sighting process. Move the table in such a way that both lines of sight (to Point A and Point B) intersect more accurately.
    - This is the "trial and error" part of the method. You will need to adjust the plane table's position iteratively, making small corrections to the position and drawing lines from the known points.

5. **Repeat the Process:**

    - Continue the resection process by adjusting the plane table position, sighting the known points, and redrawing the lines. After several adjustments, the lines from the known points should converge accurately at a single point, which represents the true position of the plane table.

**Step 3: Update the Map**

1. **Plot the Corrected Position:**

    - Once the lines from both known points (or more, if applicable) converge accurately, plot the final position of the plane table on the map.
    - You can now use this location to plot additional details or features relative to the known points.

2. **Check for Accuracy:**

    - Verify the accuracy of the updated map by cross-checking the plotted position with any known coordinates or distances. Adjust if necessary to ensure the map aligns correctly with the existing reference points.

3. **Record Measurements:**

    - Take note of the adjustments made to the plane table's position and record any relevant measurements in your field notebook.

**Step 4: Final Adjustments and Map Completion**

1. **Complete the Map:**

    - After updating the position, you can continue with the survey, plotting new points or features, or connecting surveyed points with lines.

2. **Final Check:**

    - Perform a final check of the map to ensure that all points align correctly and that the updated features are accurately plotted according to the known reference points.

**DATA COLLECTION:**

1. **Angle Measurements:**

    - Record the angles between the alidade and the known reference points during each trial. These measurements will help assess how close the sighting lines are and guide adjustments.

2. **Position Adjustments:**

    - Document each adjustment made to the plane table's position during the trial and error process, along with any distances or changes in angle.

3. **Map Coordinates:**

    - Note the final position of the plane table and the newly updated map coordinates.

**RESULT:**

This laboratory exercise helps students understand the basics of map updation using plane table surveying, specifically the resection method, and provides practical experience in applying this method in the field.

| Expt No. 10 | PLANE TABLE SURVEYING – TWO POINT PROBLEM | Date of Expt: |
|---|---|---|

**AIM:**

To learn and apply the plane table surveying technique for solving the two-point problem. The two-point problem involves determining the location of an unknown point by using two known points and taking sight measurements with a plane table.

**THEORY:**

Plane table surveying is a simple and effective method of surveying where the surveyor directly plots the features of the land onto a drawing sheet. It involves using a plane table, an alidade, and a level to measure angles and distances to create accurate maps of the terrain. The **two-point problem** is a classic method used in plane table surveying to locate an unknown point by sighting two known points.

In this problem, the two known points are observed from a third, unknown point. By drawing lines of sight from the known points to the unknown point, and applying geometry, the position of the unknown point can be determined.

**EQUIPMENTS REQUIRED:**

- Plane Table
- Alidade
- Surveying Compass or Theodolite (optional)
- Plumb Bob
- Surveying Level (optional)
- Protractor
- Measuring Tape or Distance Measurement Instrument
- Field Notebook
- Pencil and Ruler
- Reference Points (Two Known Points)

**PROCEDURE:**

1. **Setup:**

  - Place the plane table on the ground at the unknown point from where you will make observations.
  - Ensure the table is level using the plumb bob or leveling instrument.
  - Position the alidade on the plane table and align it with the known points.

2. **Mark Known Points:**

    - On the plane table, mark the locations of the two known points (Point A and Point B) on the drawing sheet.
    - Ensure that the known points are well defined on the map or survey sheet, and their coordinates (or directions) are noted.

3. **Sight the First Point:**

    - Using the alidade, sight the first known point (Point A) from the unknown position (the location of the plane table).
    - Adjust the alidade until it lines up with Point A, and then draw a line from the unknown point toward Point A on the drawing sheet. This line represents the line of sight to Point A.

4. **Sight the Second Point:**

    - Next, sight the second known point (Point B) in the same manner, using the alidade. Draw a line from the unknown point to Point B on the drawing sheet.

5. **Intersection of Lines:**

    - The two lines drawn from the unknown point toward Points A and B will intersect at the unknown point (Point C).
    - The intersection point represents the location of the unknown point, which can now be transferred to the map.

6. **Adjustments:**

    - Double-check the accuracy of the drawn lines to ensure that they intersect exactly where the unknown point is located.
    - If additional accuracy is needed, repeat the procedure or use a third known point for a more refined calculation (though this experiment focuses on the two-point method).

7. **Distance and Angle Measurement (if required):**

    - Measure the horizontal distance between Point A and Point B.
    - If precise angle measurements are needed, use a theodolite or a compass to measure the angles between the known points and the unknown point, which can further refine the location.

8. **Record the Data:**

- Record all observations, including the sighting angles, distances, and any adjustments made.
- Document the location of the unknown point on the survey sheet.

**DATA COLLECTION:**

1. **Coordinates and Measurements:**

- Write down the coordinates (or azimuths, bearings, or angles) of the known points (Point A and Point B).
- Record the angle between the two sightlines and the distances between the points.

2. **Observation Accuracy:**

- Note any errors or discrepancies that might arise from misalignment, inaccuracies in the alidade, or difficulty in identifying the correct sightlines.

3. **Mapping the Unknown Point:**

- Draw the final intersection of the two sightlines on the plane table map and identify the location of the unknown point.

**RESULT:**

1. **Interpretation of Results:**
   - Review the final location of the unknown point and the accuracy of its plotted position.
   - Discuss how this method can be applied in real-world surveying scenarios, such as mapping terrain or establishing boundaries.
2. **Application of the Two-Point Problem:**
   - This technique is particularly useful in situations where only limited surveying equipment is available, and quick or preliminary measurements are needed for plotting unknown points.
3. **Possible Extensions:**
   - Apply this method to different terrain types or more complex surveying scenarios.
   - Compare the results of the two-point problem with other triangulation or GPS-based methods to assess accuracy.

| Expt No. 11 | FLY LEVELING USING DUMPY LEVEL | Date of Expt: |
|---|---|---|

**AIM:**

To find the level difference between two given points using dumpy level.

**APPARATUS REQUIRED:**

- Leveling staff
- Tripod
- Dumpy level

**THEORY:**

The dumpy level (Fig.1) is an optical instrument used for surveying and levelling operations. It comprises of a telescope tube, firmly held between two collars and adjusting screws. The complete instrument is staged by the vertical spindle. The telescope placed on the dumpy level can be rotated amongst the horizontal plane. Relative elevation of survey points on the land can be determined through the dumpy level.

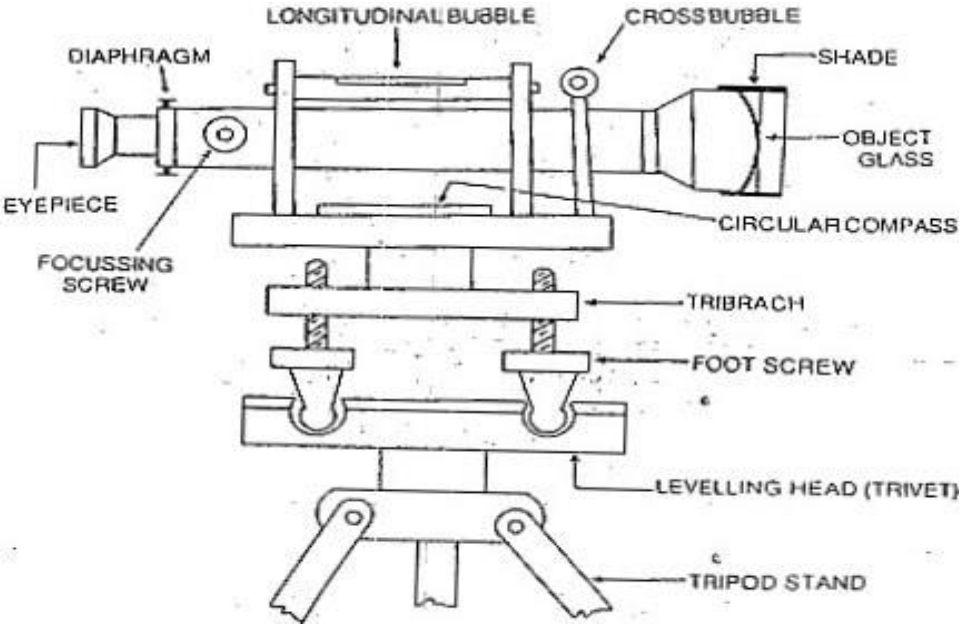



**Fig.1 Dumpy Level**

The dumpy level operates on the principle by establishing a visual relationship between two or more points, through an inbuilt telescope and a bubble level. The desirable level of accuracy can be achieved through steps. It is also called through various names such as Surveyors levels, Builders level, Dumpy level or even its pre-historic version "Y(Wye) Level".

**FLY LEVELLING**

Differential leveling is the method of direct leveling the object ive of which is to determine difference in elevations of two points regardless of horizontal position of point with respect to each Other, when points are apart it may be necessary to setup the instrument several times. This type of Leveling is also known as "FLY- LEVELLING".

**Temporary adjustment**

The temporary adjustments have been made at every instrument setting and preparatory to taking observations with the instrument.

The following steps have been followed:-

1. **Setting up the level: -** This operation includes the fixing the instrument on the tripod and levelling the instrument approximately by the leg adjustment.
2. **Levelling up: -** In this step, accurate levelling (Fig.2) has been done with the help of foot screws and with reference to the plate levels. The purpose is to make the vertical axis truly vertical or perpendicular to the line of sight. The manner of levelling the instrument with three levelling screw are following: -

a) Loose the clamp. Turn the instrument until the longitudinal axis of the plate level is roughly parallel to a line joining any two of the levelling screws.

b) Hold these two levelling screws ('A' and 'B') between the thumb and first finger of each hand and turn them simultaneously so that the thumbs move either towards each other or away from each other until the bubble comes in central area. (The bubble will move in the direction of movement of the left thumb.)

c) Turn the instrument by $90^o$ and then turn the third levelling screw 'C'. The third levelling screw 'C' should be turn in such a way that the bubble comes in the centre.

d) Turn the instrument again and repeat the above procedure. The instrument must be level in any direction means the bubble must be in centre.

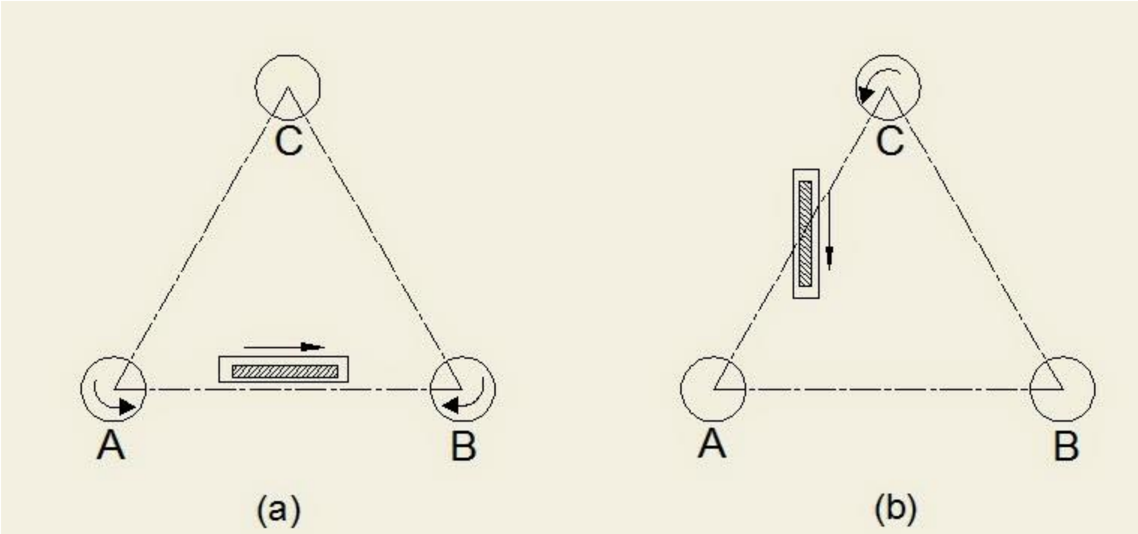



**Fig. 2. Levelling-up with three foot screws**

**3. Elimination of parallax: -** Parallax is a condition arising when the image formed by the objective is not in the plane of the cross hairs. It has been done by rotating the eye-piece for clear cross hairs and by rotating focusing screw provided for objective focus.

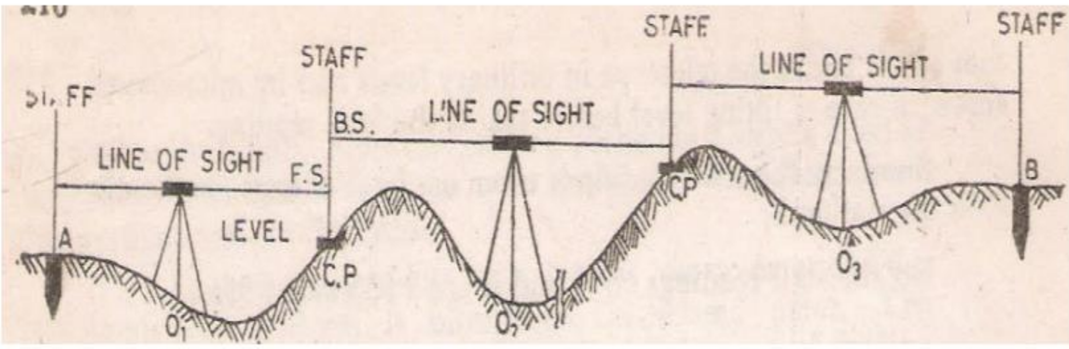



**Fig.3 Levelling**

**PROCEDURE:**

1. Set the dumpy level at convenient positions near first point A (say O1)(fig.3).
2. Perform the temporary adjustments, (setting up, leveling up, elimination of a parallox).
3. Sight the B.M (point of known elevation) and enter the staff reading in the back Sight column of field book.

4. Sight the unknown point and enter the staff reading in the back sight column of field book.
5. Select the convenient change point or turning point if distance is large and shift the instrument to the first turning point (or)changing point (C.P1).
6. Set the instrument at new position (O2) and perform temporary adjustment.
7. Take back sight atC.P.1. Thus turning point will have both back sight and fore sight readings.
8. Repeat the process till last point (say B) whose level difference has to be found with respect to A (B.M) is reached.
9. Calculate the reduced level either by height of instrument method (or) rise and fall method.
10. Complete the remakes column also. Apply the arithmetical check

**CALCULATION;**

**Rise:** Difference of two consecutive readings is positive it is said to be rise

**Fall:** Difference of two consecutive readings is negative it is said to be fall

**a) RISE AND FALL METHOD**

| BS (m) | FS (m) | Rise (m) | Fall (m) | RL (m) | Remarks |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| ∑ = | ∑ = | ∑ = | ∑ = | | |

∑BS - ∑ FS = Last RL – First RL

**b) HI METHOD**

| BS (m) | FS (m) | HI (m) =(RL+BS) | RL (m) = (HI-FS/IS) | Remarks |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

∑BS - ∑ FS = - ∑Rise - ∑Fall = Last RL – First RL RL

**RESULT:**

Difference of level between the given points ----

| Expt No. 12 | FLY LEVELING USING TILTING LEVEL | Date of Expt: |
|---|---|---|

**AIM:**

To find the level difference between two given points using tilting level.

**APPARATUS REQUIRED;**

- Levelling staff
- Tripod
- Tilting level

**THEORY**

- A surveying instrument with sighting telescope so mounted that it can be raised or lowered through a limited arc without impairing accuracy of reading, though axis of rotation is not precisely horizontal. The bubble tube is usually mounted alongside the telescope and is viewed from the eyepiece and through an optical sighting arrangement, which either brings opposite halves of the bubble image into coincidence or the end of the bubble to a reference line. Tilting levels are commonly used for precision work.
- Tilting level (fig.1) consist a telescope which enabled for the horizontal rotation as well as rotation about 4 degree in its vertical plane. Centering of bubble can be easily done in this type of level. But, for every setup bubble is to be centered with the help of tilting screw. The main advantage of tilting level is it is useful when the few observations are to be taken with one setup of level.

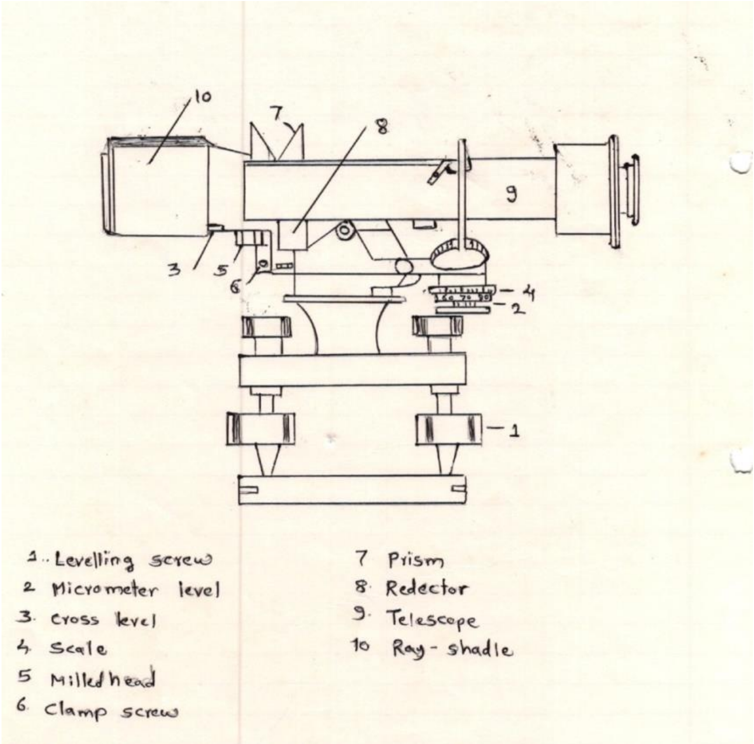



Fig.1 Tilting Level

**FLY LEVELLING**

Differential leveling is the method of direct leveling the object ive of which is to determine difference in elevations of two points regardless of horizontal position of point with respect to each Other, when points are apart it may be necessary to setup the instrument several times. This type of Leveling is also known as "FLY- LEVELLING".

**TEMPORARY ADJUSTMENT**

The temporary adjustments have been made at every instrument setting and preparatory to taking observations with the instrument.

The following steps have been followed:-

1. **Setting up the level: -** This operation includes the fixing the instrument on the tripod and levelling the instrument approximately by the leg adjustment.
2. **Centering : -** Set up the level on firm ground and bring the two small bubble to the centre of their run by means of foot screw in the usual way. If there is a circular level instead of two cross levels bring it to the centre of its run. The vertical axis is thus brought approximately vertical.

**3. Elimination of parallax: -** Parallax is a condition arising when the image formed by the objective is not in the plane of the cross hairs. It has been done by rotating the eye-piece for clear cross hairs and by rotating focusing screw provided for objective focus.

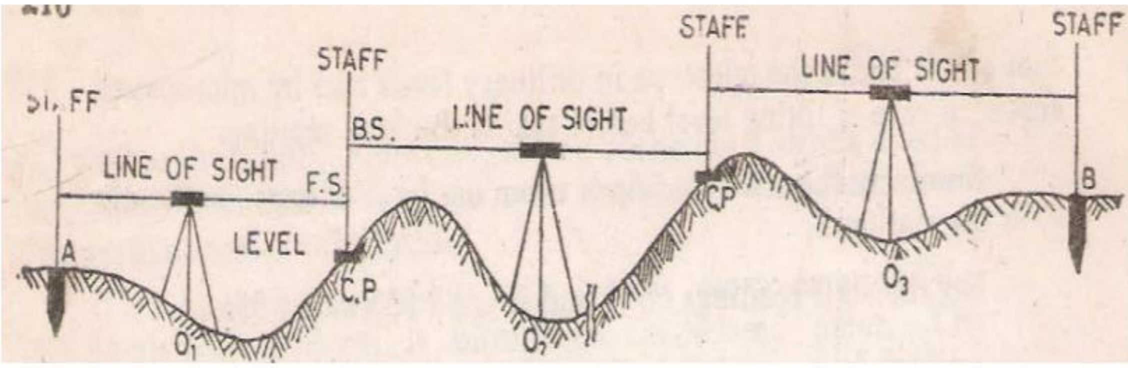



**Fig.3 Levelling**

**PROCEDURE:**

1. Set the dumpy level at convenient positions near first point A (say O1) (fig.3).
2. Perform the temporary adjustments, (setting up, centering, elimination of a parallox).
3. Sight the B.M (point of known elevation) and enter the staff reading in the back Sight column of field book. Before every reading centre the bubble with the help of tilting screw
4. Sight the unknown point and enter the staff reading in the back sight column of field book.
5. Select the convenient change point or turning point if distance is large and shift the instrument to the first turning point (or) changing point (C.P1).
6. Set the instrument at new position (O2) and perform temporary adjustment.
7. Take back sight at C.P.1. Thus turning point will have both back sight and fore sight readings.
8. Repeat the process till last point (say B) whose level difference has to be found with respect to A (B.M) is reached.
9. Calculate the reduced level either by height of instrument method (or) rise and fall method.
10. Complete the remakes column also. Apply the arithmetical check

**CALCULATION;**

**Rise:** Difference of two consecutive readings is positive it is said to be rise

**Fall:** Difference of two consecutive readings is negative it is said to be fall

**A. RISE AND FALL METHOD**

| BS (m) | FS (m) | Rise (m) | Fall (m) | RL (m) | Remarks |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| ∑ = | ∑ = | ∑ = | ∑ = | | |

∑BS - ∑ FS = Last RL – First RL

**B. HI METHOD**

| BS (m) | FS (m) | HI (m) = (RL+BS) | RL (m) = (HI-FS/IS) | Remarks |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

∑BS - ∑ FS = - ∑Rise - ∑Fall = Last RL – First RL RL

**RESULT:**

Difference of level between the given points__________.

| Expt No. 13 | TRANSFER OF BENCH MARK USING CHECK LEVELLING | Date of Expt: |
|---|---|---|

**AIM:**

Fixing bench mark with respect to temporary bench mark with dumpy level by

check levelling

**APPARATUS REQUIRED:**

- Tripod
- Dumpy level
- Levelling staff

**THEORY:**

**Check levelling:**

The main purpose of this type of leveling is to check the values of the reduced levels of the bench marks already fixed. In this method only back sight and foresight are taken. There is no need of intermediate sights. However great care has to be taken for selecting the change points and for taking reading on the change points because the accuracy of leveling depends upon these.

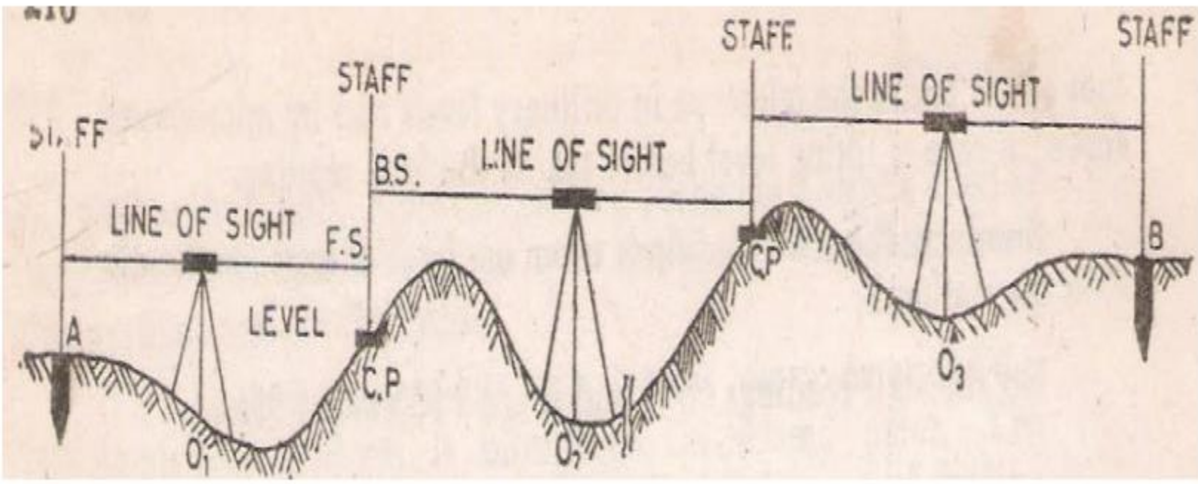



**Fig.1 Levelling**

**PROCEDURE:**

1. Take two instrument and surveyor. The following procedure has to be done by both the surveyors simultaneously and the R.L of each change point has to be check.
2. Let A is the known bench mark (B.M). R.L of B has to be found with respect to A. The two points are too far apart as shown in figure.1
3. Let O1, O2, O3 be the positions of the level to be setup. Choose the change points (C.P.)1,2 etc. on a stable ground so that the position of the level should be midway between the two staff to avoid error due to imperfect adjustment of the level.
4. Setup the level at O1, take the reading on the staff kept vertically on A with bubble at centre. This will be a back sight and R.L of A is known. Record these values in the same line in the level book.
5. Select the position of C.P1 in such a way that the distance of O1A is approximately equal to that of O1C.P.1
6. With the bubble in the centre take the reading of the staff held vertically over the change point 1. This will be a fore sight and book this value in the level book on the next line in the column provided.
7. Shift the level to O2 and set up it there carefully, with the bubble in the centre take reading on the staff kept vertically as the fore sight over C.P(1). This will be a back sight, book it in the same line as the fore sight already recorded in the column provided.
8. Select another C.P(2) on the stable ground as before so that station O2 is approximately midway between C.P (1) and C.P(2).
9. With the bubble centre, take the reading on the staffkept vertically over C.P2.This will be fore sight and book it in the level book page in next line.
10. Repeat the process until reach the point B.The last reading will be a foresight
11. Find out the reduced levels by height of instrument method or by rise and fall method.
12. Complete the remakes column also. Apply the arithmetical check

**CALCULATION:**

**A. RISE AND FALL METHOD**

| BS (m) | FS (m) | Rise (m) | Fall (m) | RL (m) | Remarks |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| ∑ = | ∑ = | ∑ = | ∑ = | | |

∑BS - ∑ FS = Last RL – First RL

**B. HI METHOD**

| BS (m) | FS (m) | HI (m) = (RL+BS) | RL (m) = (HI-FS/IS) | Remarks |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

∑BS - ∑ FS = - ∑Rise - ∑Fall = Last RL – First RL

**RESULT:**

Thus the B.M. is transferred to B.

| Expt No. 14 | CUT AND FILL VOLUME CALCULATION USING PROFILE LEVELLING | Date of Expt: |
|---|---|---|

**AIM:**

To determine the cut and fill volumes of a terrain by applying profile levelling techniques, commonly used for construction projects involving earthwork (e.g., road construction, embankments, or landscaping). The experiment will focus on calculating the volumes of soil to be removed (cut) or added (fill) based on a given design surface and the natural ground profile.

**KEY CONCEPTS:**

- **Cut** refers to the material that needs to be removed from the ground to lower the surface to the design level, whereas **fill** refers to the material added to raise the surface.
- **Profile Levelling:** A surveying method that involves measuring the elevations along a line, which can be used to create a profile of the land surface.
- **Cross-Sections:** Cross-sectional views of the terrain at different intervals along the alignment.
- **Volume Calculation:** Using geometric methods (e.g., average end area method) to compute the volume of material to be cut or filled.

**MATERIALS:**

1. **Surveying Equipment:**
   - Levelling instrument (e.g., dumpy level or automatic level)
   - Levelling staff
   - Measuring tape or total station (optional for more advanced measurements)
   - Survey rods
   - Field notebook and pencil
2. **Design Surface Profile:**
   - Pre-determined design levels at key points along the survey line (typically provided by engineers or designers).
3. **Plotting Tools:**
   - Graph paper or CAD software for plotting cross-sections (if working manually, graph paper is sufficient).
   - Calculator or spreadsheet software for volume calculations.

**PROCEDURE:**

1. **Setup the Survey Line:**
    - Establish a survey line that represents the alignment of the road, embankment, or any other feature for which cut and fill volumes are to be calculated.
    - Set up the levelling instrument at a central point along the survey line.
2. **Conducting Profile Levelling:**
    - Use the levelling instrument and staff to measure the existing ground levels at multiple points along the survey line (typically at intervals of 10 meters, depending on the terrain).
    - Record the elevations of the natural ground at each surveyed point in a field notebook.
    - Repeat the process at several cross-sections if necessary to gather enough data for accurate volume calculations.
3. **Obtain the Design Surface Profile:**
    - Using the provided design surface levels (or those provided in the design documents), record the expected elevation at each point along the survey line or section.
4. **Plotting Cross-Sections:**
    - For each interval along the survey line, plot the existing ground elevation and the design surface elevation on a graph (cross-section).
    - Plot both the natural ground and the design profile along the same axis to easily identify areas where the design is above or below the existing ground.
5. **Calculate the Cut and Fill Volumes:**
    - Use the **average end area method** or **prismoidal method** for volume calculation:

**Average End Area Method:**

- Divide the cross-section into smaller segments (such as triangles or trapezoids).
- Calculate the area of each segment between the natural ground profile and the design surface profile.
- Average the areas at the two ends of the segment.
- Multiply the average area by the horizontal distance between the ends to get the volume of cut or fill in that segment.

**Formula for Average End Area Method:**

$$\boldsymbol{VOLUME = (A1 + A2)/2 * L}$$

Where:

- A1 = Area of the cross-section at the first point

- A2 = Area of the cross-section at the second point
- L= Length of the section

6. **Repeat for All Intervals:**

- Repeat the calculation for all cross-sections along the alignment of the survey.
- Sum the individual volumes to get the total cut or fill volume for the entire section or project area.

**CALCULATIONS AND ANALYSIS:**

1. **Cut and Fill Areas:**

- Identify segments where the design profile is higher than the existing ground (fill) and where the design is lower (cut).

2. **Volume Calculation:**

- Calculate the cut and fill volumes for each section using the average end area method or other applicable geometric methods.
- Add up the cut and fill volumes to determine the total volume of material to be excavated or added.

3. **Accuracy Check:**

- Ensure that the volume calculations are reasonable by reviewing cross-sectional areas and lengths.
- Compare volumes with known benchmarks or previous estimates if available.

**RESULTS:**

- The result will give you the total volume of material to be cut and filled in the specified area.
- A high degree of accuracy in levelling and profile plotting will lead to a reliable estimate of the required earthwork volume.

| Expt No. 15 | CONTOUR MAPPING USING GRID LEVELLING | Date of Expt: |
|---|---|---|

**AIM:**

To prepare the contour map for the given area by grid levelling.

**APPARATUS REQUIRED:**

- Tripod
- Dumpy level
- Levelling staff
- Prismatic compass
- Tape or Chain

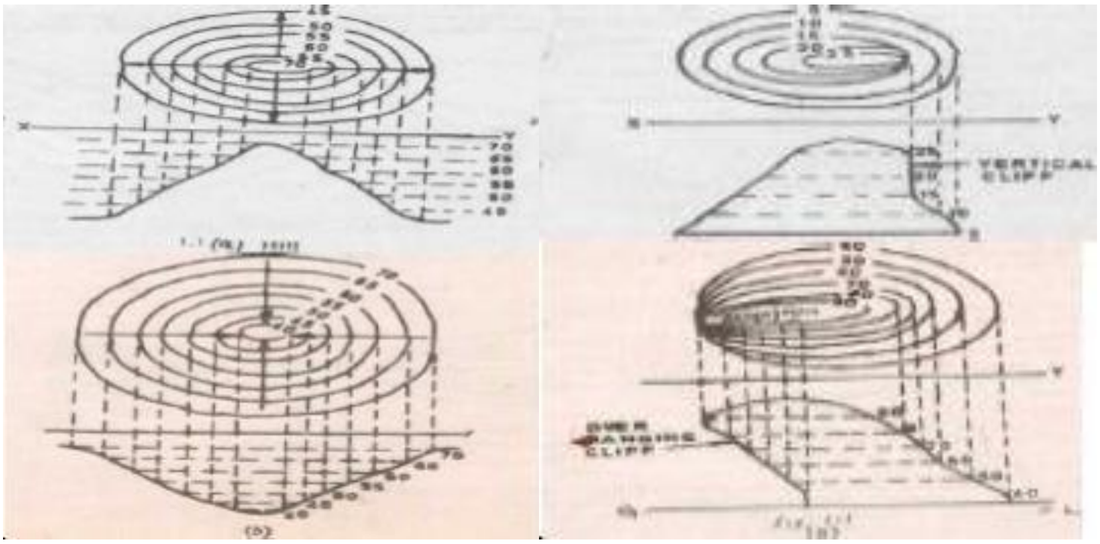



**Fig.1 Hill Contour**

**THEORY**

**Contouring**

The elevation and depression and the undulations of the surface of the ground are shown as map by interaction of level surface with by means of contour line. A contour may be defined as the line of intersection of a level surface with the surface of the ground.

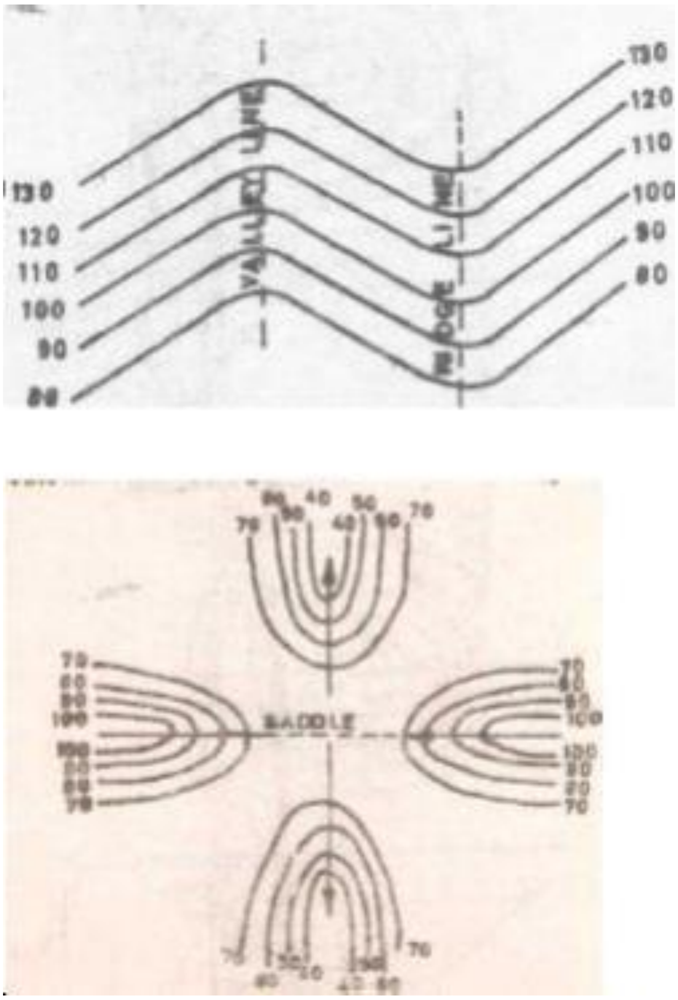



**Fig.2 Contour of Ridges**

**Characteristics of Counter Lines:**

The following are the Characteristics of the contours/ contour lines.

1) All points on the same contour line will have the same elevation.
2) Contour lines close together represent steep ground, while uniform slope is indicated when they are uniformly spaced. A series of straight, parallel and equally spaced contours show a plane or flat surface.
3) Contour lines of different elevation cannot merge or cross one another on the map, expect in the case of an overhanging cliff. A vertical cliff is indicated when several contours coincide.
4) A contour line must close upon itself either within or without the limits of the map.
5) Series of closed contour lines on the map either represent a hill or a depression

according as the higher or lower values are inside them as shown in fig.1.

6) A contour will not stop in the middle of the plan. It will either close or go out of the plan.

7) Ridge or water shed and valley lines are the lines joining the top most or the bottom most points of hill and valley respectively, cross the contours at right angles. A ridge line is shown when the higher values are inside the loop, while in the case of a valley line, the lower values are inside the loop as shown in figure 2.

**PROCEDURE**

1. Divide the area to be surveyed into a grid or series of squares with the size may vary from 5 m x 5 m to 25 m x 25 m depending upon the nature of the terrain, the contour interval required and the scale of the map desired. Also, the grids may not be of the same size throughout but may vary depending upon the requirement and field conditions.
2. Mark the grid corners on the ground and determine the spot levels of these corners by leveling.
3. Plot the grid to the scale of the map and enter the spot levels of the grid corners.
4. Locate the contours of desired values by interpolation.
5. Give special care to the spot levels to the salient features of the ground such as hilltops, deepest points of the depressions, and their measurements from respective corners of the grids, for correct depiction of the features.

**RESULT**

The contour of the given land is prepared.