Terna Public Charitable Trust's
College of Engineering, Osmanabad
Dept. of Civil Engineering

Class:- S.Y.B Tech **Sub:-** Surveying-I

INDEX

Expt. No.	Name of Experiment	Page No.
1	Differential and Reciprocal Leveling with dumpy, tilting and auto level	2-11
2	Sensitivity of bubble tube	12-18
3	Permanent adjustments of dumpy and tilting levels	19-24
4	Area measurements by mechanical Planimeter and digital planimeter.	25-34
5	Methods of plane table survey: Radiation Method & Intersection Method	35-40
6	Measurement of horizontal angles by theodolite.	41-47
7	Measurement of vertical angles by theodolite.	48-51
8	Measurement of bearing, deflection angle, and prolonging of line by theodolite.	52-56
9	Trigonometrically leveling – both planes by theodolite.	57-61
10	Usage of minor instruments	62-69

Subject In-charge **HOD**

EXPERIMENT No. 1

"DIFFERENTIAL AND RECIPROCAL LEVELLING WITH DUMPY, TILTING AND AUTO LEVEL"

Name of Equipment: Dumpy Level, Tilting Level and Auto level.

Title of Experiment: A) Differential Levelling With Dumpy, Tilting and Auto Level.

Aim of Experiment: Determination of elevation of various points with use of Dumpy level, Tilting Level, Auto Level by collimation plane method.

Experimental Setup: Dumpy level, Tilting level, Auto level, measuring staff, tripod stand.

Theory: Leveling - The art of determining and representing the relative height or elevation of different object/points on the surface of earth is called leveling. It deals with measurement in vertical plane. By leveling operation, the relative position of two points is known whether the points are near or far off. Similarly, the point at different elevation with respect to a given datum can be established by leveling.

Level: An instrument which is used for observing staff reading on leveling staff kept over different points after creating a line of sight is called a level.

The difference in elevation between the point then can worked out. A level essentially consists of the following points:

1) Leveling Heads

2) Limb plate

3) Telescope: Telescope consists of two tubes, one slide into the other and fitted with lens and diaphragm having cross hairs. it creates a line of sight by which the reading on the staff is taken.

The essential parts of a telescope are-

1) Body 2) Object glass 3) Eye-piece 4) Diaphragm 3) Focusing screw 4) Diaphragm screw.

4) Bubble tube

5) Tripod stand

1) Dumpy Level:

The dumpy level is simple, compact and stable instrument. The telescope is rigidly fixed to its supports. Hence it cannot be rotated about its longitudinal axis or cannot be removed from its support. The name dumpy is because of its compact and stable construction. The axis of telescope is perpendicular to the vertical axis of the level. The level tube is

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10)Tripod stand

2) Dumpy Level:

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Permanently placed so that its axis lies in the same vertical plane of the telescope but it is adjustable by means of captain head not at one end.

The ray shade is provided to protect the object glass. A clamp and slow motion screw are provided in modern level to control the movement of spindle, about the vertical axis. The telescope has magnifying power of about thirty diameters. The level tube is graduated to 2mm divisions and it has normally a sensitiveness of 20 seconds. The telescope may be internally focusing or external focusing type.

- **Use of Dumpy Level:**

Dumpy level is an important leveling instrument used in many engineering works such as roads, railways, dams, canals, water supply and sanitary schemes. It is used to find the difference in elevation between two or more points, to establish new bench marks, undulations of earth's surface for alignment of roads, railways, locating gradient lines of pipe lines, and sewers. It is used for layout and construction of buildings, bridges. It is used to prepare contour maps, to find catchment area, capacity of a proposed tank, reservoir, and earthwork quantities for roads, railways. The success of any engineering project entirely depends upon its accurate and complete leveling work.

- **Adjustment of the level:**

The level needs two type of adjustment-

1) Temporary adjustment and

2) Permanent adjustment

- **Temporary adjustments of dumpy level:**

  These adjustments are performed at each set-up the level before taking any observation.

A) Setting up the level: - This includes,

1) Fixing the instrument on the tripod: -The tripod legs are well spread on the ground with tripod head nearly level and at convenient height. Fix up the level on the tripod.

2) Leg adjustment: - Bring all the foot screws of the level in the center of their run .Fix any two legs firmly into the ground by pressing them with hand and move the third leg to leg to right or left until the main bubble is roughly in the center. Finally the legs are fixed after centering approximately both bubbles. This operation will save the time required for leveling.

B) Levelling: - Levelling is done with the help of foot screws and bubbles. The purpose of levelling is to make the vertical axis truly vertical. The method of leveling the instrument

Depends upon whether there are three foot screws or four foot screws. In all modern instruments three foot screws are provided and this method only is described.

) Place the telescope parallel to pair of foot screws.

2) Hold these two foot screw between the thumb and first finger of each hand and turn them uniformly so that the thumbs move either toward each other until the bubble is in center.

3) Turn the telescope through 90°so that it lies over the third foot screw.

4) Turn this foot screw only until the bubble is centered.

5) Bring the telescope back to its original position without reversing the eye piece and object glass ends.

6) Again bring the bubble to the center of its run and repeat these operation until the bubble remains in the center of its run in both position which are at right angle to each other.

7) Now rotate the instrument through 180°, the bubble should remain in center provided the instrument is in adjustment: if not, it needs permanent adjustment.

C) Focusing the eye piece: - To focus the eye piece, hold a white paper in front of the object glass, and move the eye piece in or out till the cross hairs are distinctly seen. Care should be taken that the eye piece is not wholly taken out, sometimes graduation are provided at the eye piece and that one can always remember the particular graduation position to suit his eyes. This will save much time of focusing them eye piece.

D) Focusing the object glass: - Direct the telescope to the leveling staff and on looking through the telescope, turn the focusing screw until the image appears clears and sharp. The image is thus formed inside the plane of cross hairs, Parallax, if any is removed by exact focusing. It may be noted that parallax is completely eliminated when there is no change in staff reading after moving the eye up and down.

2) Tilting Level:

The tilting level is a later addition to the family of levels. In tilting level, The fundamental conditions that the vertical axis should be vertical and the line of collimation perpendicular to it are done away with . This is made possible by making provision to tilt the telescope about the horizontal axis with a fine pitched screw. Even if the vertical axis is not vertical, the line of collimation can be made horizontal with this screw. Leveling takes less time, as only approximate leveling of the instrument is required either with the circular bubble or with the telescope bubble. Whenever the reading is taken, the bubble is centered to make the line of collimation horizontal .if many readings are to be taken from one station, the advantage is not apparent. However, the operation can be completed speedily when precise leveling is required to transfer the benchmarks or to determine the reduced level of a point by fly leveling.

3) Auto Level:

Auto levels though similar to dumpy levels in construction, eliminate the need for the manual adjustment required in the case of dumpy levels to ensure accurate leveling. These instruments use a compensator mechanism to keep the line of sight horizontal even if it is not perpendicular to the vertical axis. The compensator mechanism made of mirrors or prisms is built into the telescope tube and can be activated if the line of sight is horizontal within $15''$ to $30''$ of true horizontal. When the compensator is working, the action of tilting using the foot screws or the button brings the line of sight back to the same reading, after a momentary shift. Automatic level is very easy to operate. The circular level is brought approximately to the center of its run using the foot screws. Once the telescope is approximately level, the compensator is active and one has only to take readings on the staff kept at different points.

- **Determination of elevation using Dumpy level, Tilting Level, Auto Level:**
- **Reduced Levels**

The system of working out the reduced level of the points from staff reading taken in the field is called as reduced level (R.L) of points is the elevation of the point with reference to the same datum.

There are two systems of reduced levels,

1) The plane of collimation system (H.I. method)

2) The Rise and fall system

A) The plane of collimation system (H.I. method):

In this system, the R.L. of plane of collimation (H.I) is found out for every set-up of the level and then the reduced levels of the points are worked out with the respective plane of collimation as described below.

1) Determine the R.L. of plane of collimation for the first set up of the level by adding B.S. to the R.L. of B.M. i.e. (R.L of plane of collimation= R.L. of B.M.+B.S.)

2) Obtained the R.L. of the intermediate points and first change point by subtracting the staff readings (I.S. and F.S. from the R.L. of plane of collimation (H.I). (R.L. of a point=R.L of plane of collimation H.I. - I.S or F.S)

3) When the instrument is shifted and set up at new position a new plane of collimation is determined by addition of B.S. to the R.L of change point. Thus the levels from two set-ups of the instruments can be correlated by means of B.S. and F.S. taken on C.P.

4) Find out the R.L.s of the successive points and the second C.P. by subtracting their staff readings from this plane of collimation R.L.

5) Repeat the procedure until all the R.Ls are worked out.

1. **Observation Table:**

A) Dumpy Level:

Station	Reading			R.L. of plane collimation (H.I)	Reduced Level	Remarks
	BS	IS	FS			

B) Tilting Level:

Station	Reading			R.L. of plane collimation (H.I)	Reduced Level	Remarks
	BS	IS	FS			

C) Auto Level:

Station	Reading			R.L. of plane collimation (H.I)	Reduced Level	Remarks
	BS	IS	FS			

- **Specimen Calculation: Arithmetical check:**

The difference between the sum of the back sights and the sum of the fore sights should be equal to the difference between the last and first reduced levels.

i.e. ∑B.S - ∑ F.S. = LAST R.L –FIRST R.L

- **Arithmetical check:**

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- **Arithmetical check:**

The difference between the sum of the back sights and the sum of the fore sights should be equal to the difference between the last and first reduced levels.

i.e. ∑B.S - ∑ F.S. = LAST R.L –FIRST R.L

Result: The various reduced levels are calculated by using height or the plane of collimation system (H.I. method**)** which is shown in observation table.

Title of Experiment: B) Reciprocal Levelling

Aim of Experiment: To determine the basic principle of Reciprocal Leveling

Apparatus: - Dumpy level, measuring staff, tripod stand.

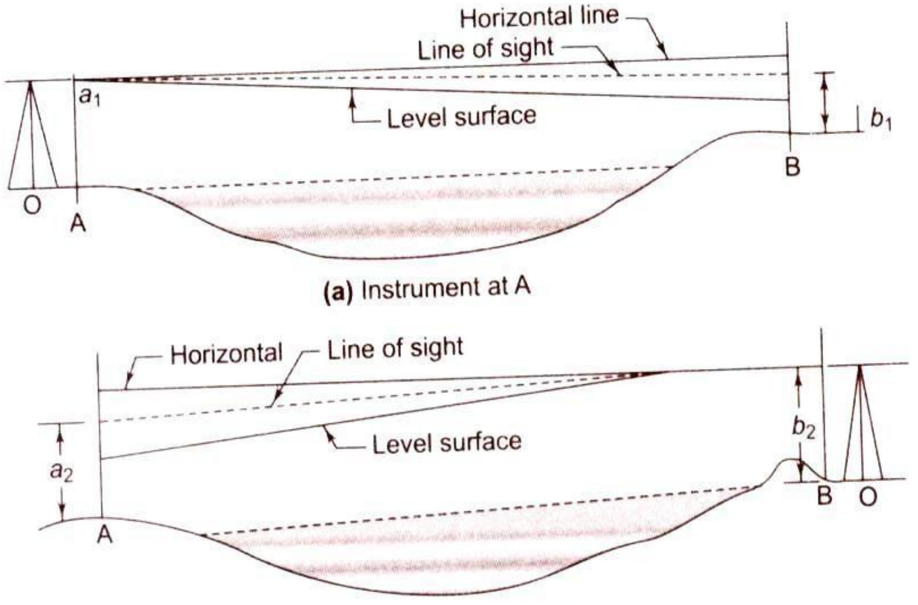
Theory:

Reciprocal leveling is the method of leveling to accurately determine the difference in elevation between two points that is considerable distance apart with an intervening in Obstacles, such as a river.

In Reciprocal Levelling, the level is set up on both banks of the river or valley and two sets of staff readings are taken by holding the staff on both banks. In this case, it is found that the errors are completely eliminated and the true difference of level is equal to the mean of the two apparent difference of level.

Procedure:

1. Take A & B the two points on the opposite banks of the river. The level is set up very near to A and after proper temporary adjustment, staff reading is taken at A and B. Suppose the reading is a1 & b1.
2. The level is shifted and set up very near to B and after proper adjustment, staff reading is taken at A and B. Suppose the reading is a2 & b2.



(a) Instrument at A

(b) Reciprocal levelling

Reciprocal levelling

Let,

h = true difference of level between A & B

e = error due to curvature, refraction and collimation

- In first case,

Corrected staff reading at A = a1

Corrected staff reading at B = b1 - e

So, true difference of level between A & B is,

$$h = a1 – (b1 – e) \text{ ----------------------(1)}$$

- In second case,

Corrected staff reading at B = b2

Corrected staff reading at A = a2 - e

So, true difference of level between A & B is,

$$h = (a2– e) – b2 \text{ ----------------------(2)}$$

From equation (1) & (2),

$$2h = a1 – (b1 - e) + (a2 – e) – b2$$

$$2h = a1 – b1 + e + a2 – e – b2$$

$$2h = (a1 – b1) + (a2 – b2)$$

$$\mathbf{h = [(a1 – b1) + (a2 – b2)] / 2}$$

Observation Table:

Sr.No.	**Instruments staff.**	**Reading on A**	**Reading on B**	**Remarks**
1				**Distance between AB = 30m** **RL of A = 525.500m**
2				

Result:

1. The true difference of level between A & B is = _________
2. The combined correction is = _______
3. The collimation error is = ______
4. The line of collimation is actually inclined ___________

Question Bank for Viva:

1. Explain Temporary adjustment of leveling instrument?
2. Explain Permanent adjustment of leveling instrument?
3. Identify the component parts of Auto, Tilting and Dumpy levels?
4. Methods of calculating RLs of different ground points?
5. Describe the reciprocal leveling with reference to purpose, Situation where it is preferred, field procedure & relevant equation?
6. What is Bench Mark and its types?

EXPERIMENT No. 2

"SENSITIVITY OF BUBBLE TUBE"

Name of Equipment: Dumpy level, Measuring staff, Tripod stand.
Title of Experiment: Sensitivity of Bubble Tube

Aim of Experiment: To determine the sensitivity of bubble tube using dumpy level.

Experimental Set up: Dumpy level, measuring staff, tripod stand.

- **Theory: Bubble Tube**: -

It is an imaginary line tangential to the longitudinal curve of the tube at its middle point. It is horizontal when the bubble is in the center of its run. It is also called as bubble line.

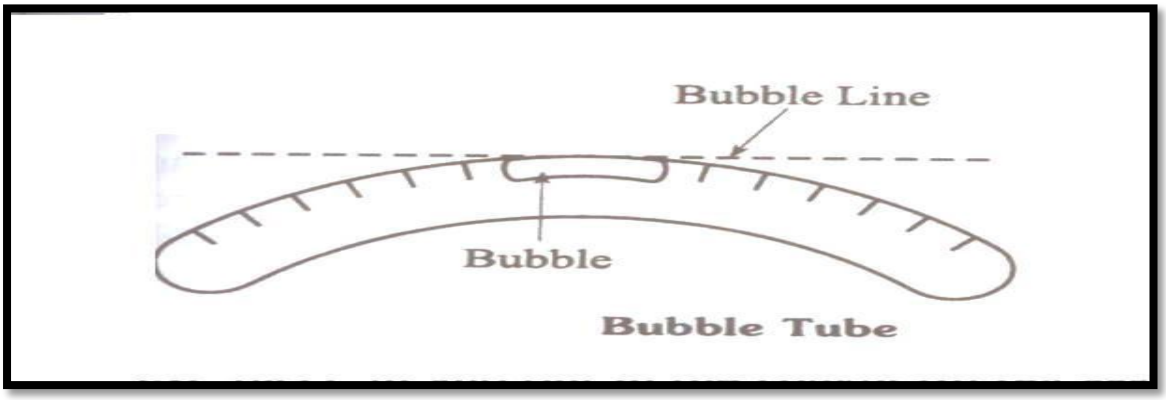
The telescope is fitted with a longitudinal bubble tube. The telescope can be made horizontal and the instrument can be leveled by bringing the bubble in the center of its run means of three foot screws. Capstan headed nuts or level tube nuts are used only during permanent adjustment of dumpy level. A cross bubble tube is provided on the top of the telescope. A ray shade is provided to slide it on the object glass to avoid glare while taking readings. A focusing screw is provided.

A spirit level, bubble level or simply a spirit is an instrument designed to indicate whether a surface is horizontal (level) or vertical (plumb). Different types of spirit levels may be used, by carpenters, stonemasons, bricklayers trades workers, surveyors, millwrights and other metalworkers, and in some photographic or video graphic work.

Early spirit levels had banana-shaped curved glass vials at each viewing point. These vials are incompletely filled with a liquid, usually a colored spirit or alcohol, leaving a bubble in the tube. They have a slight upward curve, so that the bubble naturally rests in the center, the highest point. At slight inclinations the bubble travels away from the marked center position. Where a spirit level must also be usable upside-down or on its side, the banana-shaped tube is replaced by a barrel-shaped tube.

Alcohols such as ethanol are often used rather than water. Alcohols have low viscosity and surface tension, which allows the bubble to travel the tube quickly and settle accurately with minimal interference with the glass surface. Alcohols also have a much wider liquid temperature range, and won't break the vial as water could due to ice expansion. A colorant such as fluorescein, typically yellow or green, may be added to increase the visibility of the bubble.

An extension of the spirit level is the bull's eye level: a circular, flat-bottomed device with the liquid under a slightly convex glass face with a circle at the center. It serves to level a surface across a plane, while the tubular level only does so in the direction of the tube.



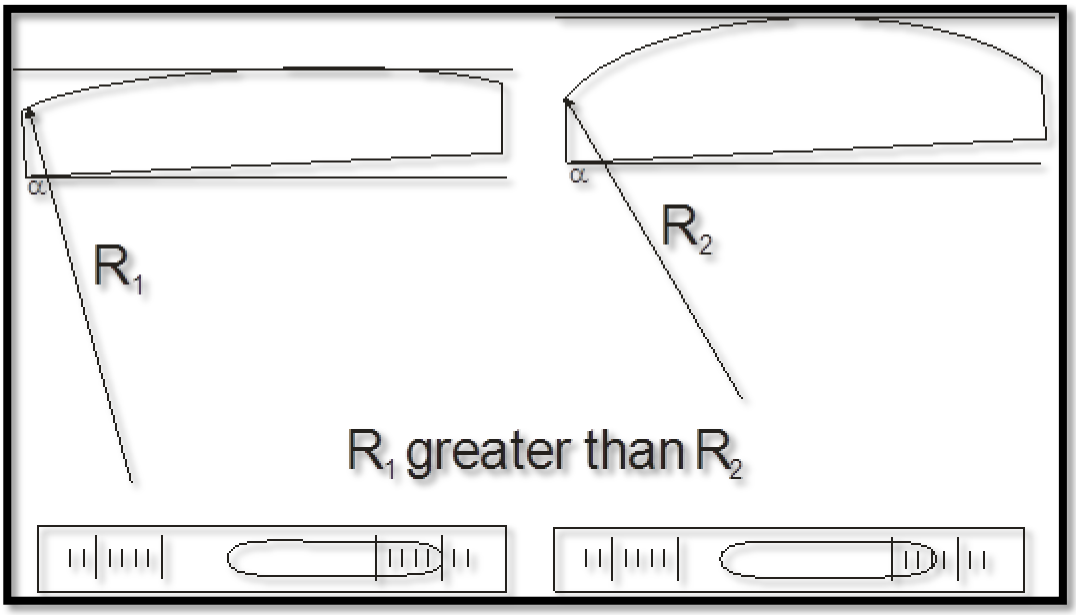
- **Sensitivity of Bubble Tube**:

It is define as the angular value of one division of the bubble tube. Generally, the linear value of one division is kept as 2mm.

How much the bubble moves due to a given amount of inclination is sensitivity of bubble tube. The more the bubble moves, the more sensitive the bubble tube is.

The sensitivity of bubble tube can be increased by-

1. Increasing the internal radius of the tube
2. Increasing diameter of the tube
3. Increasing length of the bubble
4. Decreasing roughness of the wall
5. Decreasing viscocity of the liquid



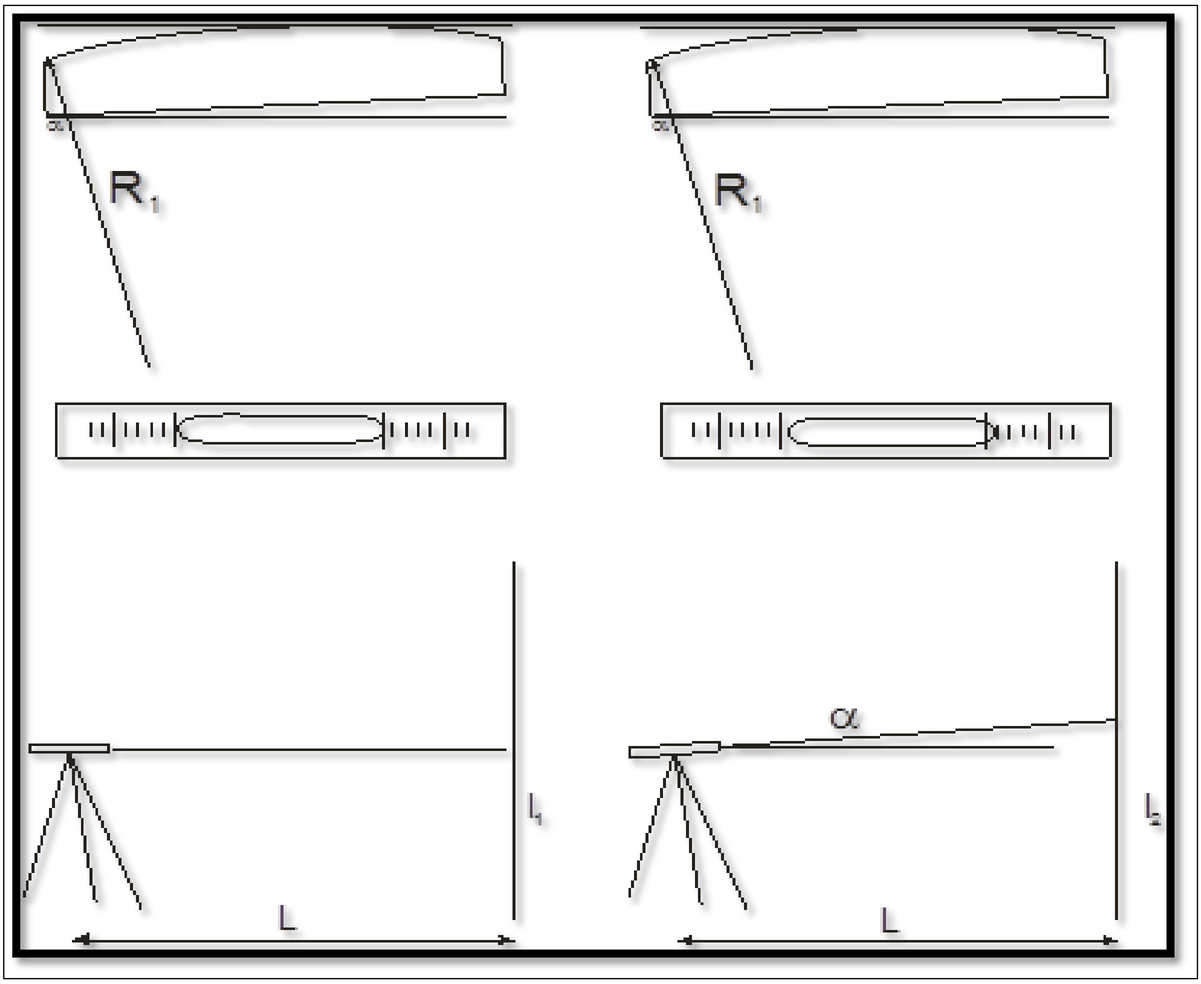


Figure: **Expression for the Sensitivity of BubbleTube:**

Procedure:-

1. Set the instrument at O and keep a staff at C
2. Sight a staff kept at C, distant D from O. Let the staff reading be CF.
3. Using a foot screw, deviate a bubble over n number of divisions and again sight the staff. Let the reading be CE.
4. Find the difference between the two staff readings. Thus,

$$S = CE – CF$$

From triangle BEF,

$$\tan \alpha = \alpha = (S/D) \text{ --------------------------(1)}$$

Similarly, from triangle AOB,

$$\alpha = (AB/R) = (nL/R) \text{ ------------------------- (2)}$$

where,

R = radius of curvature of bubble tube

l = length of one division on the bubble tube

Equating (1) & (2), we get,

$$(S/D) = (nL/R)$$

$$\mathbf{R = nLD /S} \text{------------------------- (a)}$$

Above equation (a) gives the an expression for the radius of curvature of bubble tube.

Again from (2) we have, $\alpha = (nL/R)$

α' = Sensitivity of Bubble Tube

α'' = L/R (by putting n = 1)

But, R = nLD /S

Hence putting value of R in α'' we get,

$$\alpha'' = (S / nD) \text{ radians}$$

$$\boldsymbol{\alpha' = (S / nD) \times 206265 \text{ seconds}} \text{--------------------- (b)}$$

Above equation (b) gives the expression for the Sensitivity of Bubble Tube

Observations:

1. **Observation Table: For Bubble Forward:** n = 0 then, ho =________m

Sr. No.	No. of Deviation	Staff reading (X)	Staff Difference S = (ho – X)	Radius of Curvature (R)	Sensitivity of Bubble Tube (α')
1	1	X1 =	S1 =	R1 =	α1"=
2	2	X2 =	S2 =	R2 =	α2"=
3	3	X3 =	S3 =	R3 =	α3"=

2. **For Bubble Backward:** n = 0 then, ho =________m

Sr. No.	No. of Deviation	Staff reading (X)	Staff Difference S = (ho – X)	Radius of Curvature (R)	Sensitivity of Bubble Tube (α')
1	1	X1 =	S1 =	R1 =	α1"=
2	2	X2 =	S2 =	R2 =	α2"=
3	3	X3 =	S3 =	R3 =	α3"=

- **Specimen Calculation: Formula:**

a. Radius of Curvature = R = nLD /S

b. Sensitivity of Bubble Tube, α" = (S / nD) x 206265 seconds

For bubble forward,

Radius of Curvature, R = (R1 + R2 + R3) / 3 = _______M ----------------------------(a1)

Sensitivity of Bubble Tube, α" = (α1" + α2" + α3") / 3 = ______ Sec ---------------(b1)

Bubble backward,

Radius of Curvature, R = (R1 + R2 + R3) / 3 = _______M ----------------------------(a2)

Sensitivity of Bubble Tube, α" = (α1" + α2" + α3") / 3 = _______ Sec -------------- (b2)

Average values,

Radius of Curvature, R = (a1 + a2) / 2 = _______M

Sensitivity of Bubble Tube, α" = (b2 + b2) / 2 = ________ Sec

Result:

1. Radius of Curvature, R =________M
2. Sensitivity of Bubble Tube, α‟ =_________Sec

Question Bank for Viva:

1. What is mean by sensitivity of bubble tube?
2. What is the use of bubble tube?
3. Sensitivity of bubble tube increased by?
4. Which liquid is used in the bubble tube?
5. Derive expression for sensitivity of bubble tube?

EXPERIMENT NO. 3

"PERMANENT ADJUSTMENT OF DUMPY AND TILTING LEVEL"

Name of Equipment: Dumpy and Tilting level.

Title of Experiment: Permanent adjustment of Dumpy and Tilting level.

Aim of Experiment: To study the permanent adjustment of Dumpy and Tilting level..

Experimental Setup: - Dumpy level, Tilting level.

Theory: I) Dumpy Level:

Dumpy level is a precise instrument which helps in finding out the elevation for heights of different points these levels are useful in calculation the volume of earthwork, or in understanding the profile of the ground. Hence the permanent adjustments need to be properly. This can be maintained by keeping the desired relations between various axes in place

- **Fundamental axis / line:**
    - Collimation axis / axis of line of sight
    - Vertical axis
    - Axis of bubble tube
- **Desired relation**
    - Collimation axis perpendicular to axis of bubble tube
    - Axis of bubble tube perpendicular to vertical axis
    - Vertical axis perpendicular to horizontal cross hair

A) Collimation axis parallel to Axis of bubble tube:

Aim: Collimation axis should be parallel to axis of bubble tube

Necessity: Only if axis of collimation is parallel to axis of bubble once the instrument is leveled we get horizontal line of sight through telescope this is an important aspect as the entire principle of leveling depends on horizontal line of sight.

Testing: Two peg tests adopted to rectify the collimation axis: (Refer fig No.3.1)

1. Two level staffs are kept at 100m apart on a level ground say at A & B
2. Dumpy level to be tested in placed closed to staff A and reading on staff B is taken as ha & hb. The difference in elevation between A and B is having which is partially correct.
3. Instrument is shifted and placed very close to staff B, such that telescope is in contact with

level staff

4. The staff readings on B and A are taken as ha‟ and hb‟, the true difference between A and B is obtained as ha‟ - hb‟ which is partially correct.
5. The actual difference in elevation between A and B is calculated as,

$$[(ha - hb) + (ha'' - hb'')] / 2$$

6. If the difference in elevation obtained when instrument is at P is equal to difference in elevation when the instrument in at Q instrument is said to be in adjustment. If not correction has to be applied.

Correction/Adjustments:

1) With the calculated the difference in elevation the correct staff reading at B is calculated as Reading at A correct difference in elevation = Reading at B

2) Releasing the capstans screw on the today of the telescope and looking through the eye piece diaphragm is moved till the calculated ready on staff B is bisected keeping instrument at B.

B) Vertical axis perpendicular to bubble tube axis:

Aim: To make the bubble tube axis truly perpendicular to the vertical axis

Necessity: If the bubble tube axis is perpendicular to vertical axis the true verticality of the instrument in maintained. Or else the telescope will not given the horizontal line of sight

Testing: (Refer fig No.3.2)

1) Instrument is placed on a level ground and is leveled in 2 positions of telescope.

2) When the telescope is in the second position above the third foot screw telescope is rotated through 180°.

3) If the bubble in still in the center the instrument is said to be in adjustment, If not rectification has to be done.

Correction/Adjustments

1) The no. of divisions by which bubble has moved is observed

2) Bubble is brought back by half the distance with the help of foot screw.

3) Remaining half the distance is rectified by releasing of adjusting the clip screw of the bubble tube.

C) Horizontal cross hair should be in a plane perpendicular to vertical axis:

Aim: To make horizontal cross hair perpendicular to vertical axis of the instrument.

Necessity: If the relation do not exists while finding out same RL points we will not be getting the same RL but points having higher or lower RL points Also while calculating volume of earth work in longitudinal retinoic we end up in calculating wrong values.

Testing:

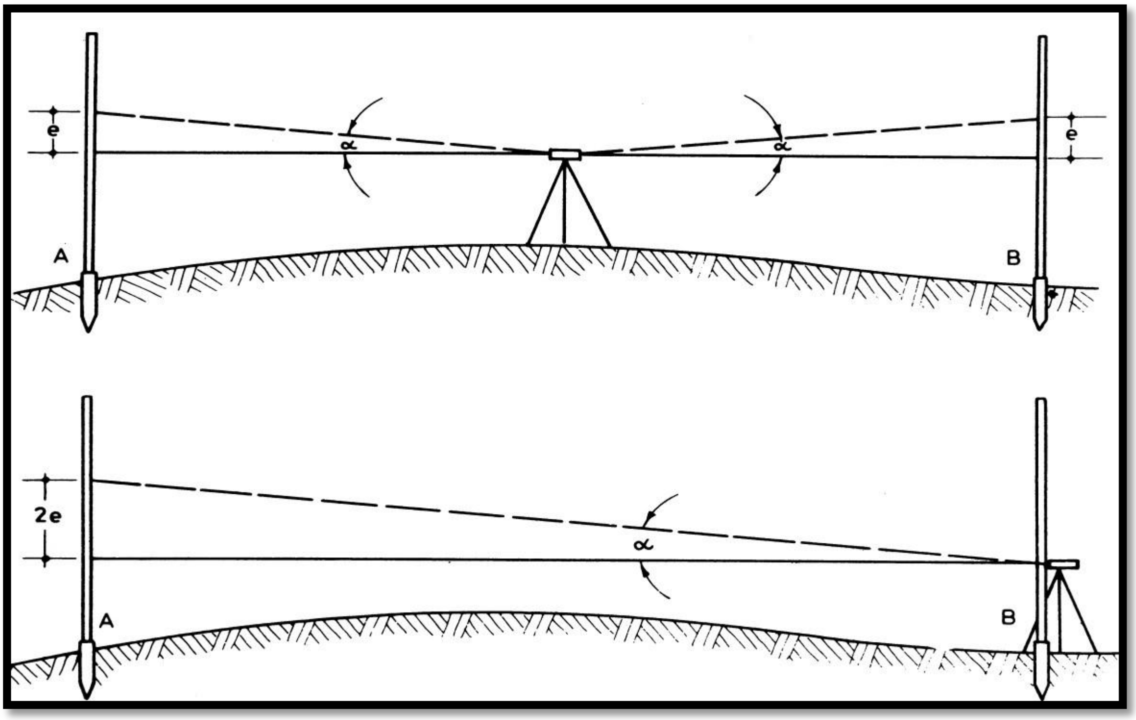
1. Instrument is set on a level ground with all temporary adjustments.
2. A sharp object is bisected at one end of the telescope (Right of the view or left of the view)
3. Observing through the eyepiece telescope is turned slowly so that object comes to the other side of the view.
4. If image of the object moves along the H.A., the instrument is said to be in adjustment; if not corrections has to be made.

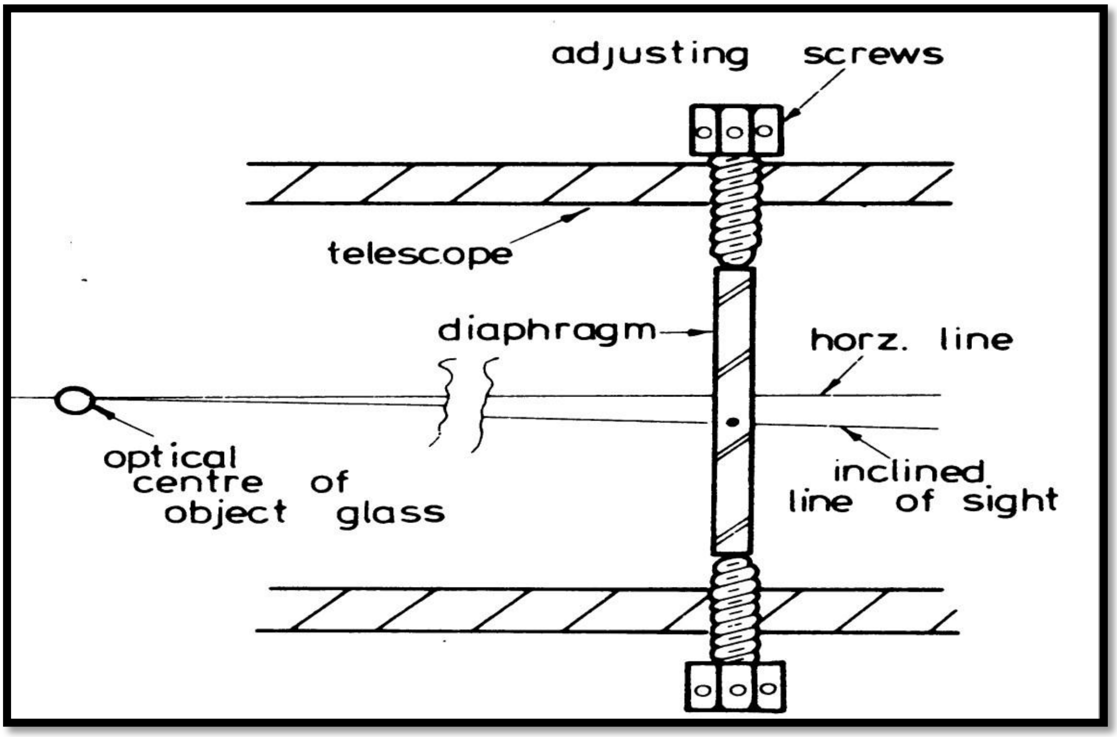
Correction/Adjustments:

1. Releasing the capstan screw of the telescope the objective is turned so that the horizontal cross hair in approximately horizontal.
2. Testing is again repeated to check the adjustment.

II) Tilting Level:

The tilting level differs from the dumpy in that the vertical axis need only be approximately vertical for the instrument to be in good adjustment. This condition is fulfilled satisfactorily by centering the small circular sprit level at each set-up.The line of collimation must be horizontal when the bubble of the main spirit level is central.





Testing:

The test is identical to that for the Dumpy level, namely the „two peg" test. Suppose that the test has been carried out and it is discovered that the line of collimation is not horizontal i.e. staff reading A does not equal to staff height B when instrument is set up over B.

Correction/Adjustments:

The line of sight can be tilted using the tilting screw until the reading at A agrees with staff height B. The line of sight is now horizontal, since pegs A & B are at the same height. However, since the tilting screw has been moved, the mains sprit level will no longer be central.

It is adjusted by means of spirit level capstan screw until the bubble is exactly central. The main spirit level is therefore parallel to the horizantal line of sight and the condition is fulfilled.

Conclusion:____

Question Bank for Viva:

1. Explain do you understand by Permanent adjustment of instrument?
2. Explain Permanent adjustment of Dumpy Level?
3. Explain Permanent adjustment of Tilting Level?
4. What are the fundamental axes of the Dumpy Level?
5. What is the fundamental axis of the Tilting Level?
6. Explain the conditions to be satisfied during Permanent adjustment of instrument?

EXPERIMENT NO. 4

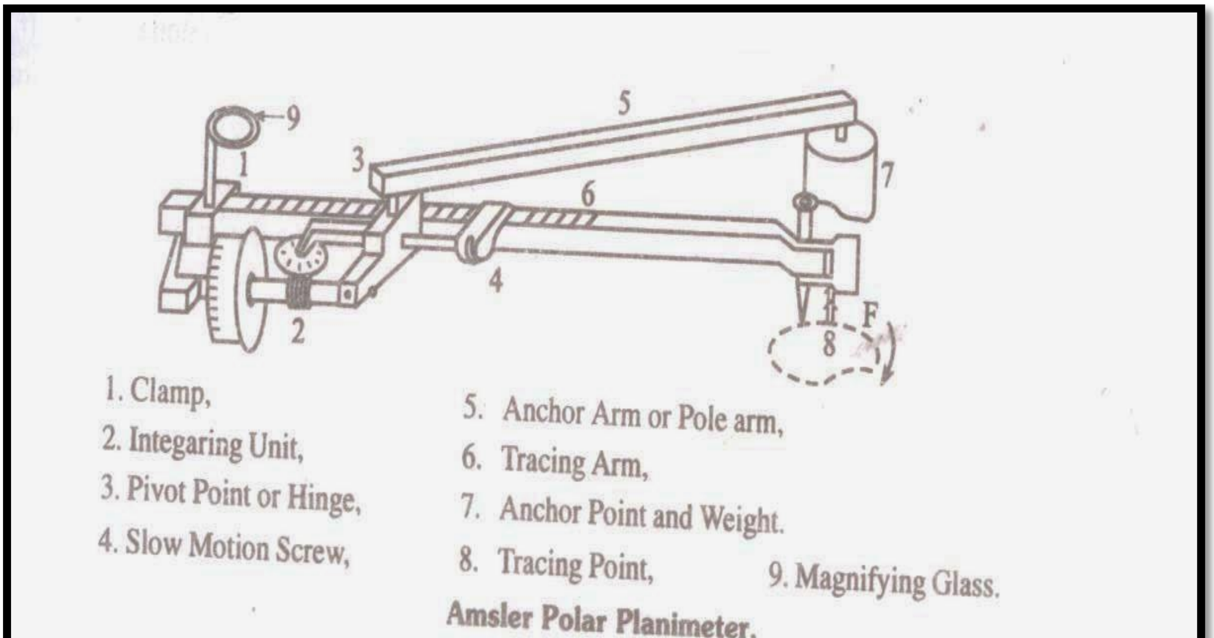
"AREA MEASUREMENTS BY MECHANICAL AND DIGITAL PLANNIMETER"

Name of Equipment: Mechanical and Digital Planimeter.

Title of Experiment: A) Area Measurements by Mechanical Plannimeter

Aim of Experiment: To determine the area of a given shape by mechanical Plannimeter.

Theory: Ampler Polar Planimeter is the most useful in finding the areas of the figures plotted to the scale, especially when the boundaries are irregular or curved such as boundaries of the rivet etc. It consists of two arms hinged together at the pivot point (3) or hinge. Arm (5) is of fixed length and is called the pole arm. It carries a needle point or pole point or anchor point (7) which can be pressed into the paper and held in a position by a small weight, which is detachable. The anchor point becomes a fulcrum. The instrument can move around this point. The other arm, called the tracing arm (6) is of adjustable length and can slide in a sleeve and clamped to any scale with the help of the clamp (1). It‟s one end carries the tracing point (8) which is moved round the boundary (f) of the area to be measured.

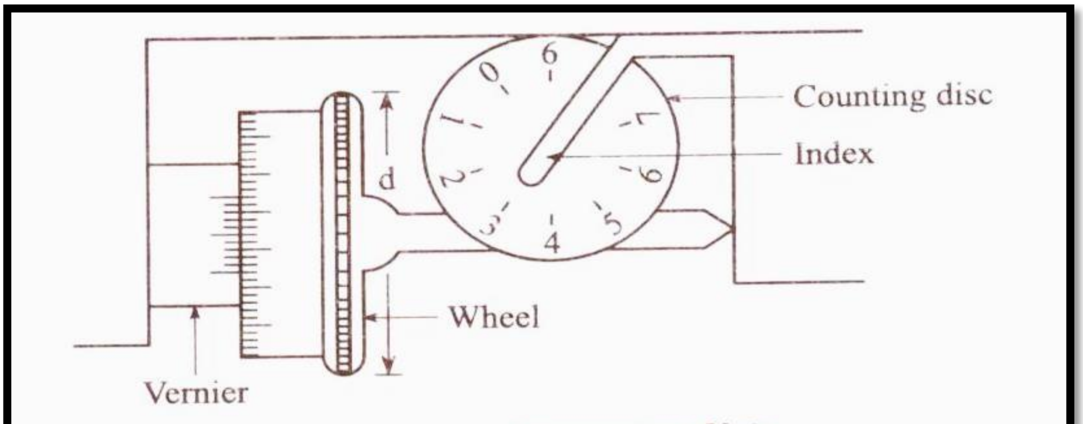


Amsler Polar Planimeter.

The number of complete revolution made by the wheel or roller is read on the counting disk or dial to which the wheel is geared. One complete rotation of the wheel moves the counting disk by one division. There are 10 such divisions on the counting disc on its circumference. A vernier is fixed along with the wheel to record the minor readings. Each complete reading thus consist of four digits, the units being on the counting disc, the tenth and hundredths on the drum and thousands on the vernier e.g. 1243 means that the index is between the divisions 1 and 2 on the counting disc, 24 is the reading on the rotating wheel against the zero of the vernier and vernier reading is 3.

When the planimeter is placed on the plane surface, it rests on three points – viz. the pole or anchor point, the tracing point and the rim of the measuring wheel. The axis of wheel is parallel to the tracing arm. When tracing point moves at right angles to the tracing arm, it slips without recording any movement. In between, it partly slips depending upon the direction of the movement. Thus the rotation of the wheel measures total normal displacement and thereby the area of the figure. If the area is required in sq.cm. The figure being drawn to the natural scale i.e. full size, set the index mark accurately to the division 100‟ cm. on the tracing arm. When so adjusted one unit of reading is equal to 100 sq.cm. and the value of the multiplier M is equal to 100. When the area is required in sq.in.

The figure being drawn to the natural scale set the index mark to 10‟in. on the tracing arm. When so adjusted the multiplier is equal to 10 if the figure is plotted to any other to scale say 1cm = 12cm the area of the figure should be first found in sq.cm. and then converted into the sq.m.by the relation 1sq.cm. =12×12 sq.m. Alternately the tracing arm should be set to the given scale if marked on it. The area of the figure may then be calculated directly in sq.m. or hectares etc. by making use of multiplying constant calibrated against that scale mark‟s.



Integrating Unit.

- **Method of using planimeter:**

The planimeter is used in determining the area of the figure in two ways.

1) By placing the anchor point outside the figure and

2) By placing the anchor point inside the figure.

If the figure is large the anchor point may be kept inside while if it small the same maybe placed outside. The larger figure may be divided into parts and the area of each part is measured separately and the results so obtained are added together to get required area.

Experimental Procedure:

Observations: The procedure is common for both the above cases.

1) Set out the index arm on the tracing arm (position of measuring unit), to given scale as per manufactures instruction, exactly by using the clamp and fine motion screw.

2) Stretch the map sheet until it is flat and free from wrinkles.

3) Fix the anchor point firmly in the paper outside or inside the figure according as the figure is small or large.

4) Mark a point on the boundary of the figure and set the tracing point exactly over it.

5) Now take initial reading (I.R) as described previously, reading the dial, wheel and vernier. It is not necessary to set the dial and wheel to zero.

6) Move the tracing point exactly around the boundary, always in clockwise direction using one hand to keep the point exactly on the boundary and the other hand to keep the anchor point from moving, stop exactly at the starting point.

7) While tracing point is moved along the boundary of the figure, note the number of times the zero mark in clockwise or anticlockwise direction. Again take the reading of dial, wheel and vernier recording it as the final reading (F.R) .The area of the figure is then calculated by using the following formula.

$$\textbf{Area } (\Delta) = M\ (F.R.-I.R. \pm 10N + C)$$

Where,

M=multiplying constant which is different for different scales and supplied in the instruction sheet by the manufacture. It is equal to the area of one revaluation of the wheel i.e. unit area.

F.R.= the final reading

I.R= the initial reading

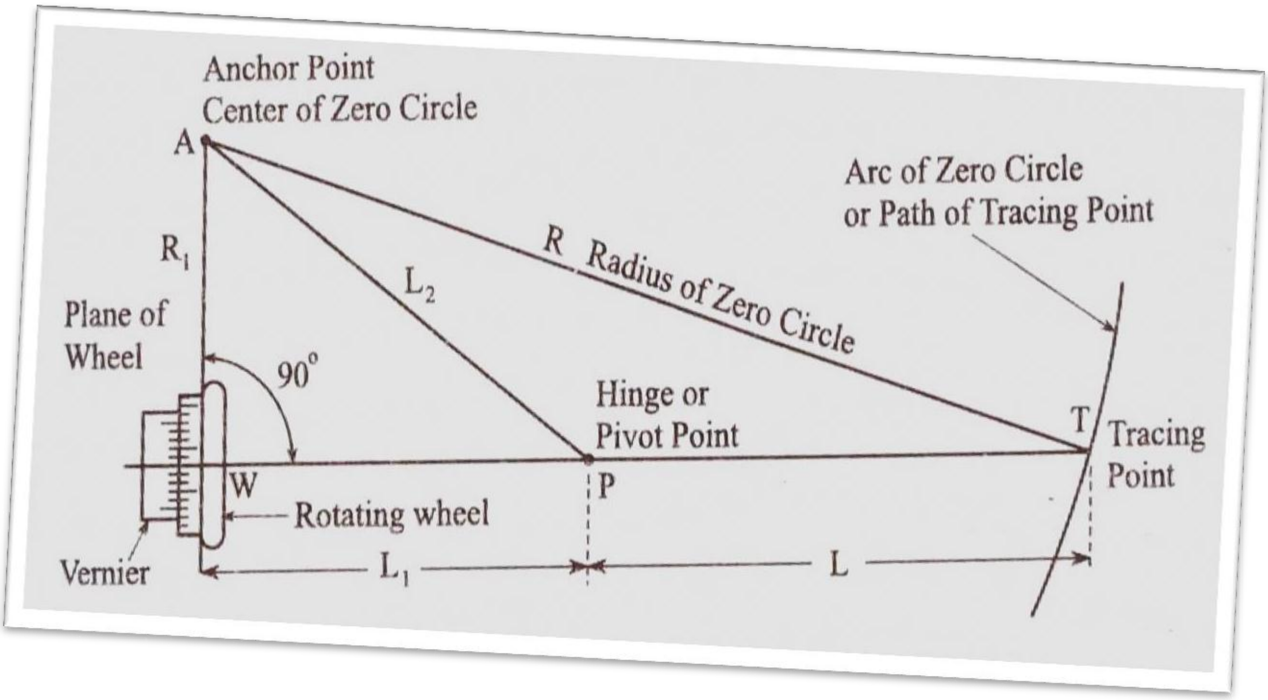
N=number of times the zero of dial passes the fixed index mark use the +ve sign when moves clockwise & -ve sign moves anticlockwise.

C= constant of instrument supplied by manufacture & different for different scales & it isoffset when anchor point is kept inside otherwise it is taken zero if it is kept outside.

``

- **Area of the zero circles (MC)**:-

It is also called as „ circle of correction „ is the circle round the circumference of which if tracing point is moved , no rotation of the wheel takes place but actually the wheel only slides on the paper without changing the reading. This happens when the line joining the pole point to the wheel is at right angles to the line joining the tracing point to the wheel. The pole or anchor point is the centre of the zero circles and the line joining the pole point to the tracing point is its radius.



The area of the zero circle may be obtained in the by using the formula:-

i) Radius of zero circle,

$$R = \sqrt{\qquad} \qquad = \sqrt{\qquad}$$

Where,

L= the length of the tracing arm hinge to the tracing point.

L_1 = the distancefrom the hinge to the wheel,

L_2 = the length of the pole arm (anchor arm) from the hinge to the pole point (anchor point)

ii) Also from radius of zero circle,

$$R = \sqrt{\qquad\qquad}$$

$$= \sqrt{\qquad\qquad}$$

(a) Area of zero circle = = $(L^2 \pm 2LL_1 + L_2^2)$

Use + sign if the wheel is beyond the pivot away from the tracing point and – sign if the wheel is in between the pivot and tracing point.

(b) Area of the zero circle= M×C = L d ×C

Where, M and C are as described above,

L=length of the tracing arm and d = diameter of the wheel

Observation Table:

Sr.No.	**Specimen No.**	**Initial Reaing**	**Final Reaing**
1	A		
2	B		

Result: The area of a given shape by Mechanical Plannimeter = _________

Title of Experiment: -B) Area Measurements by Digital Plannimeter

Aim of Experiment:-. To determine the area of a given shape by Digital Plannimeter.

Theory:

Digital planimeters:- These are the area curvimeters, which measure the area of curved contours and irregular figures with high degree of precision.There are different types of digital planimeters such as X-PLAN 360, PLANIX 5000 etc. Figureshows a digital planimeter PLANIX7 manufactured by Tamaya Technique Inc. Tokyo, Japan. It consist of the following parts.

It has display capacity as follows: -

LCD 8 digits input/ output; symbols showing SCALE, SCALEX, SCALEY, HOLD, MEMO, Batt, E, cm^2, m^2, km^2, in^2, ft^2, acre. The functions of these symbols are as below.

SYMBOL	FUNCTIONS
SCALE	Indicates that the scale factor is stored.
HOLD	Indicates that key is pressed and displayed figure is frozen.
MEMO	Lights up when key is pressed .The display figure is memorized.
Batt	Indicates low batter level.
E	Indicates (i) overflow (more than 8 digits on the display), (ii) Key has been pressed more than ten times.
cm^2 .in^2	Indicates metric system (cm^2, $m^{2,}$ $km^{2)}$ or British system (in^2, ft^2, acre)
m2, ft2	selected by key.
●	Indicates the unit selected.
X	When you press key , the value of the stored horizontal scale displayed with X mark .
Y	When you press key twice, the value of the stored vertical scale displayed with Y mark.

Procedure:-

- **Working-**

1. Level and fix the object on a drawing board placed in horizontal position . Set the PLANIX7 with its roller axle and trace arm placed at right angles to each other. Keep the tracer arm on the exact centre line of the object.
2. Push the Key. The display will indicate “O”.

3. Push the key. The units of metric system and British system are displayed alternately

on the right side of display. Select and set either unit symbol. Push the key made and selected unit symbol is displayed. This symbol will be protected even after the power is turned off unless key and the key are pushed.

4. Each time the key is pushed the ● mark shifts to the higher unit namely cm^2 (in^2) to m^2 (ft^2) to km^2 (acre). Set selected unit when the mark reaches it. If the area cannot be traced by the unit display because of overflow, then the display unit shifts automatically to higher unit symbol e.g. cm^2 m^2 km^2 pulse count. Even if the overflow occurs at the highest unit (km^2) the pulse count mode results and measured figure will not be lost. The display will return to O and continue the counting after it counts up to 99999.

5. Mark the starting point at any position on the outline of the area to be measured. Set the pinpoint of the circle in the tracer lens on it . Push the key and see that “O” appears on the display with a sound “beep”. Then move the tracer clockwise along the outline of the area until it comes to the starting point. The figure displayed indicates the area of the object that has been measured. Push the key and measure the same area again. Repeat this procedure contiously several times. Eventually push the key to obtain the final average result. Push the key to cut off the power.

To measure and accumulate several areas, trace the first area and push the key, then trace the second area and push the key. Repeat the same till all the areas are traced. Push the key and accumulated area is displayed.

PLANIX 7 also shows the areas in minus quantity if you trace the figure anticlockwise. Therefore, by using this feature you can subtract the area of the inner contained figure from the area of the outer figure.

First trace the figure A clockwise, then freeze the value by the key. Then move the unit close to the figure B. Release the key and trace the figure anticlockwise. Automatically, PLANIX7 subtracts the area of the figure B from the stored area of the figure A. The same procedure can be adopted for the figure C. In this way PLANIX 7 can measure the area of the most complicated figure.

In tracing you should trace exactly on the outline of the area. However, if you felt you came out slightly inside of the line this error may be quickly compensated by going out the line by the same amount. This kind of personal technique will be gained by the practice and experience and may help you to save a lot of measuring time.

- **Special features:-**

It offers few distinguishing facilities. Some of them are :

1) It is compact cordless operation unit.
2) It measures both in metric system and British system of units.
3) If the measured number exceeds 8 figures, during operation, the highest unit is shifted immediately.
4) It has a measuring range of 300cm ×30cm.
5) One digit corresponds to $0.1cm^2$ or $0.0155in^2$.
6) It has accuracy better than 0.2.
7) Its operational period is nearly 30 hours with rechargeable Ni-Cd battery as power source.
8) It has a battery power provision. The power is automatically turned off when the unit is left unoperated for more than three minutes.
9) The same area measured several times may be averaged by a single push button.
10) Cumulative measurements can be made.
11) It shows the area in minus quantity, if the figure is traced in anticlockwise direction.
12) It weigh approximately 500gr. (1.1 lbs)
13) It occupies very less space because of its size of 240(L) ×150(W)×39(H)

Observation Table:

Sr. No.	Area
1	
2	

Result:

The area of a given shape by digital planimeters is,

1. Area of First sample = _______
2. Area of Second Sample = ______

Question Bank for Viva:

1. What is formula for calculating area by planimeter?
2. Which are the constants used in the planimeter?
3. Show sample calculation of calculating area by planimeter?
4. How the readings are taken by using planimeter, explain procedure?
5. What is area of Zero Circle? Give its different formula?

EXPERIMENT NO. 5

"METHOD OF PLANE TABLE SURVEY"

Name of Equipment: 1) The Plane table with tripod 2) Alidade 3) Trough compass 4) Sprit level 5) Plumbing fork or U-frame 6) Plumb bob 7) Tape ,chain, pegs, ranging rods, wooden mallet etc.

Title of Experiment: Method of Plane Table Survey.

Aim of Experiment: Locating given plot by methods plane table surveying.

Experimental set up: 1) The Plane table with tripod 2) Alidade 3) Trough compass 4) Sprit level 5)Plumbing fork or U-frame 6) Plumb bob 7) Tape ,chain, pegs, ranging rods, wooden mallet etc.

Theory: Plane table surveying: The system of surveying in which field observation and plotting work i.e. both are done simultaneously is called plane table surveying.

Following figure shows all the accessories of plane table survey.

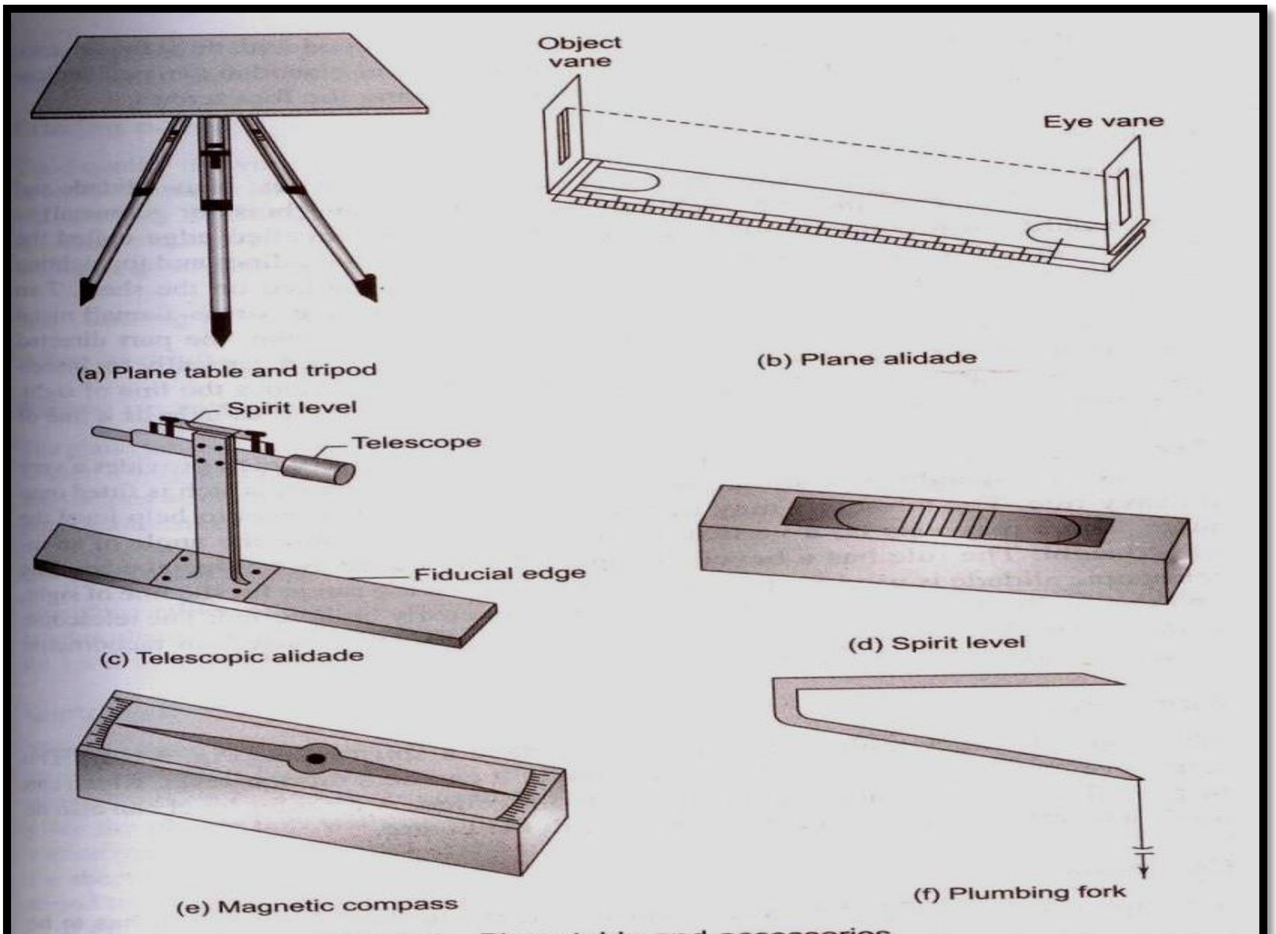


Fig. 5.1 Plane table and accessories

1. The plane Table: - The drawing board made of well seasoned wood such as teak or pine which is used for the purpose of plotting is called plane table. It is available in sizes 500x400x15mm, 600x5000x15mm and 750x600x20mm.The top surface of board is perfectly plane and to the underneath it is fitted with a leveling head or ball and socket arrangement. The table is mounted on a tripod by means of a central screw with a wing nut or in such a manner so that the board can be revolved, leveled and clamped in any position.

2. Alidade: The tool or instrument which consists of metal (usually of brass) or wooden (well seasoned) rule 40cm to 60cm long, 3cmto5cm wide and fitted with two vanes at the ends is called an alidade. The beveled graduated edge is known as the fiducial edge. Such an alidade is known as plain alidade.

3. Sprit Level: - A small sprit level circular or rectangular is required for seeing if the table is properly level. The level must have flat base so that it can be placed on the table.

4. Trough Compass: - The compass which is used to mark the direction of the magnetic meridian on the plane table is called trough compass. It consists of a long narrow rectangular non magnetic metallic box 8cm to 15cm long, 3cm to 5cm wide and 2cm to 3cm high on the covered with a glass cover. It the centre of the box is provided a magnetic needle with a agate stone mounted on the sharp steel pivot. At the end the through compass graduated scales are with zero degree at the centre and up to 5° on either side of the zero line. A counter weight is also used for North end of the needle to represent north and is also used for balancing the dip of the needle.

5. Plumbing fork or U-frame: - The plumbing fork to which is attached a plumb bob, used for centering the plane table over the station occupied by the plane table. It is also meant for transforming the ground point on to sheet so that both the points should be in the same vertical line It consists of two light metal arms as shown in fig. approximately of equal lengths. A hook for suspending a plumb bob is provided at the lower arm immediately below the end point of the upper arm. The upper arm is placed on the plane table while the lower arm with a plumb bob is moved below the table for centering over the ground station mark, thus in the exact position the pointed end of the upper arm will give the corresponding position on the paper.

- **Methods of plotting:**

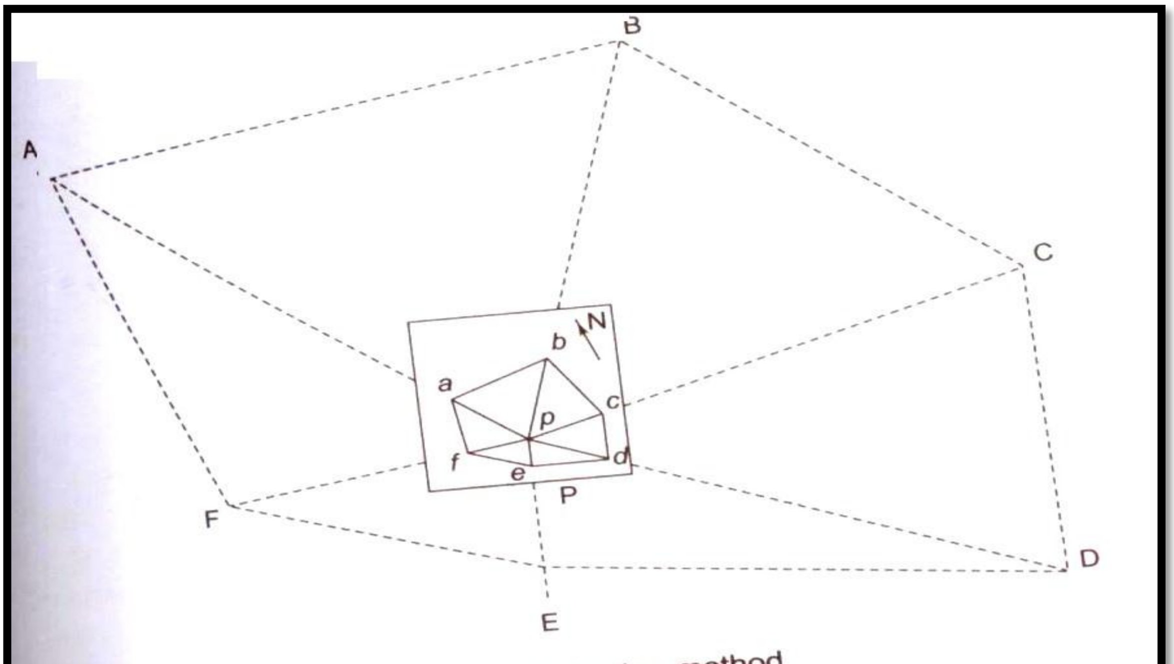
  Following are the methods of surveying with plane table.

  1. Radiation 2. Intersection

3. Traversing 4. Resection

1. Radiation Method:-

When from a single set of plane table on instrument station different details are located on the sheet, the method is known as radiation method In this method the rays are drawn from the instrument station to the point to be located, then the distances are measured from the instruments station to the point and the position of the each point is plotted on the sheet using a suitable scale. The method is most suited for surveying small areas which can be controlled by single setting. It can also be used in combination with other method. This method can be applied for locating distant points if the distances are obtained tacheometrically with the help of the telescope alidade.



Radiation method

Experimental Procedure:

1) Select the position of the table where it is be set so that all the points to be located are visible from it. Let "O" be the position of such a point on the ground.

2) Set the plane table over this point and level it. Draw the North line in the top corner of sheet by means of trough compass at the table.

3) Now transfer the position of the point „O" on the ground to the sheet by means of the plumbing fork. The point „O" will represent point „o" will represent point „O" on the ground.

4) With the alidade touching the point „o" (may be represented by fixing a pin), sight the point A in the field. Draw the ray along the fiducial edge. Measure the distance of this point

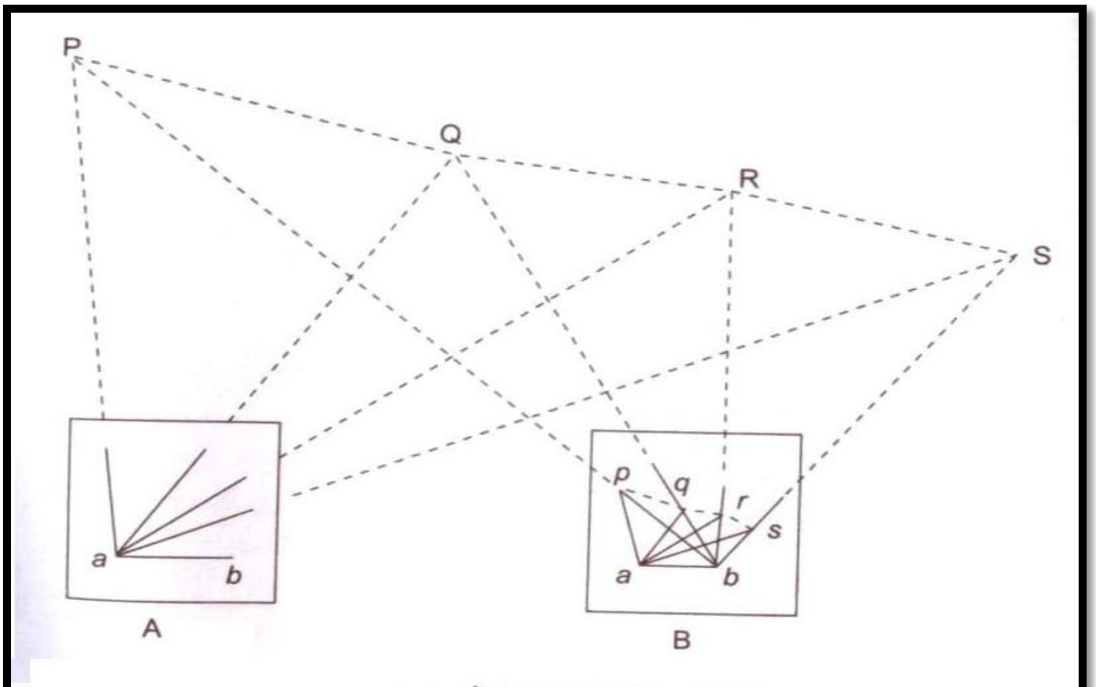
from the instrument station by means of tape and plot the point „a‟ corresponding to point „A‟ in the field to scale in the sheet.

5) Similarly sight other points such as B, C, D, E etc. and measure their distances from the instrument station. Plot them to scale to get their position on the sheet such as b, c, d etc. on the sheet.

2. Intersection method:-

When the location of an object is obtained on the sheet of paper by the intersection of the rays drawn after sighting at the object from two plane table stations (previously plotted), it is called intersection method.

The method is suitable when the distance between the point and the instrument station is either too large or cannot be measured accurately due to some field conditions as in case of mountainous country. It is also employed for filling up details, locating distant and inaccessible object, locating the broken boundaries as in the case of rivers etc. The method can also be used for checking of plotted points. The line joining the two instrument stations is known as the base line. No linear measurement other than the base line is made.



Intersection method

Procedure:-

1) Select two points L and M in such a way so that all the points to be plotted are visible from them. Now set the table at station, point L in such a position so that the sheet should cover all the points. Level the table and clamp it.

2) Draw the north line in the top corner of sheet by means of trough compass

3) Now transfer the position of station point L on the sheet as „l‟ with the help of plumbing fork so that it is vertically above the instrument station.

4) With the alidade pivoted about „l‟ sight the ranging rod fixed at station point M and draw the line in the direction of M. Now measure the distance LM by means of the tape and cut off lm to some suitable scale along the ray drawn toward M; thus fixing the position of „m‟ on the sheet corresponding to station point M on the ground. The line lm is called the base line.

5) With the alidade touching the point ‟l‟ sight the objects in the field such as A,B,C,D,E etc. as shown in figure and draw the rays towards them. The direction of each line is marked with an arrow and a letter A, B, C, D, E etc. corresponding to above details.

6) Now shift the table to the station point M and approximately set it in the line with ML. Set it up so that the point „m‟ is vertically above the station point „M‟ and level it.

7) Orient the table roughly by compass, then finally by placing the alidade along ml and bisecting the ranging rod fixed at station point „L‟ i.e. by back sighting „L‟. Clamp the table in this position.

8) With the alidade centered at m sight the same object in the field such as A, B, C, D, E etc; and draw rays. The intersection of these rays with the respective rays from l locate the object A,B,C,D,E etc; as a, b, c, d, e etc; on the sheet.

Conclusion:____

Question Bank for Viva:

1. On which principle does the Plane Table works?
2. Explain the Principal of Parallisum?
3. Describe the accessories used in the Plane Table Survey?
4. Difference between mechanical and telescopic alidade?
5. What are the methods of PTS?

EXPERIMENT NO. 6

"MEASUREMENT OF HORIZONTAL ANGLE BY DIFFERENT METHODS BY USING THEODOLITE"

Name of Equipment: Theodolite, Tripod Stand, Ranging rod, pegs.

Title of Experiment: Measurement of Horizontal Angles by Different Methods by using theodolite.

Aim of Experiment: To measure the horizontal angle by Repetition and Reiteration method of theodolite.

Experimental set up: Theodolite, Ranging rod, pegs.

- **Theory: Theodolite :**

The theodolite is the most intricate and accurate instrument used for measurement of horizontal and vertical angles. It consists of telescope by means of which distant objects can be sighted. The telescope has two distinct motions on in the horizontal plane and the other in the vertical plane. The former being measured on a graduated Horizontal vertical circle of two verniear.

Theodolite are primarily classified as

1) Transit theodolite

2) Non-transit theodolite

A theodolite is called transit theodolite when its telescope can be resolved through a complete revolution about its horizontal axis. The transit type is largely used.

Various parts of transit theodolite are,

1) Telescope: It is an integral part and is mounted on the spindle known as horizontal axis or turn on axis. Telescope is either internal or external focusing type.

2) The leveling head: It may consists of circular plates called as 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 tribranch is supported by means of four or three leveling screws by which the instrument may be leveled.

3) To lower plate or screw plate: - It carries horizontal circle at its leveled screw. It carries a lower clamp screw and tangent screw with the help of which it can be fixed accurately in any desired position.

4) The upper plate or vernier plate: - It is attached to inner axis and carries two vernier and at two extremities diametrically opposite.

5) Compass: The compass box may be either of circular form or of a rough type. The former is mounted on the vernier plate between the standards while the latter is attached to the underside of the scale or lower plate or screwed to one of the standards. Modern theodolite is fitted with a compass of the tubular type and it is screwed to one of the standards.

6) Vertical circle: The vertical circle is rigidly attached to the telescope and moves with it. It is silvered and it is usually divided into four quadrants.

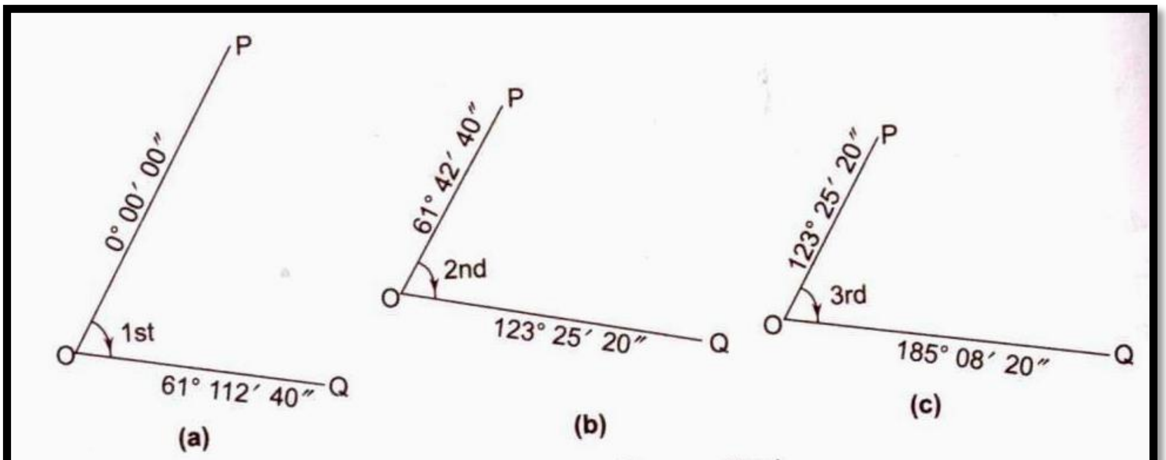
7) Index bar or T-frame: The index bar is T shaped and centered on horizontal axis of the telescope in front of the vertical axis. It carries two vernier of the extremities of its horizontal arms or limbs called the index arm. The vertical leg called the clip or clipping screws at its lower extremity. The index arm and the clipping arm are together known as T-frame.

8) Plumb bob: To centre the instrument exactly over a station mark, a plumb bob is suspended from the hook fitted to the bottom of the central vertical axis.

- **Methods of Measuring Horizontal Angles:**

1. Repetition method:-

When it is required to measure horizontal angles with great accuracy as in the case of traverse, the method of repetition may be adopted. In this method the same angle is added several times by keeping the vernier to remain clamped each time at the end of each measurement instead of setting it back to zero when sighting at the previous station. The corrected horizontal angle is then obtained by dividing the final reading by the number of repetitions. Usually six reading, three with face left and three with face right, are taken The average horizontal angle is then calculated.



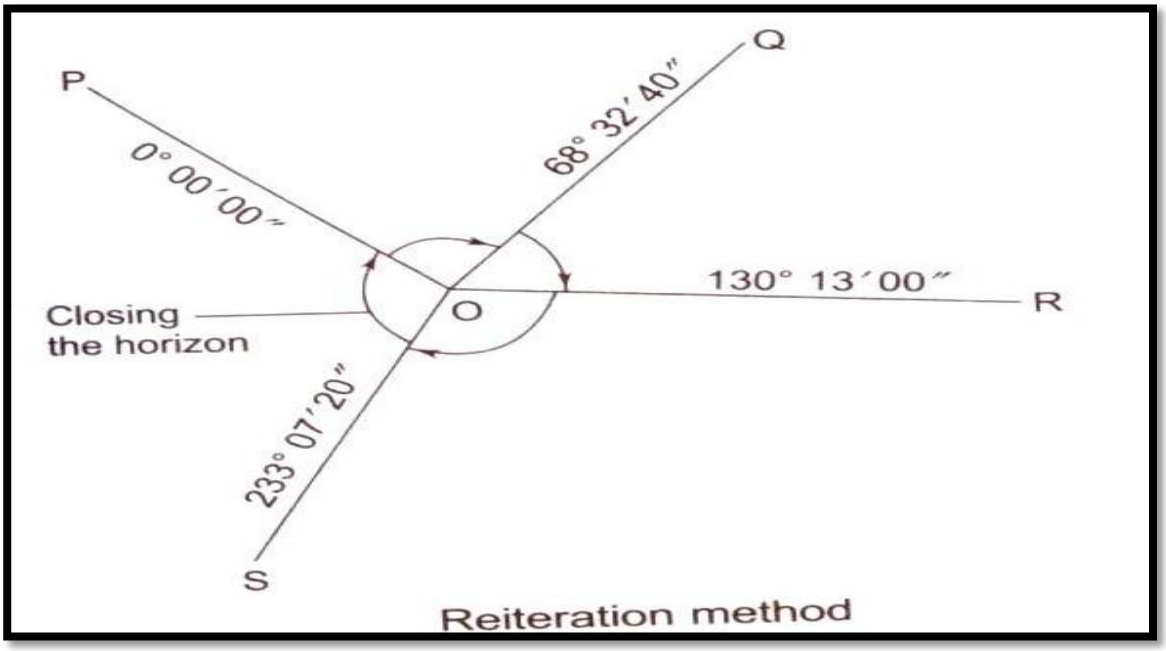
Repetition method

- **Experimental Procedure: Procedure:-**

1) Let LOM is the horizontal angle to be measured as shown in fig. O is the station point fixed on the ground by a peg. Set up the theodolite over the peg „o‟ and level it accurately.
2) Set the horizontal graduated circle vernier A to read zero or 360° by upper clamp screw and slow motion screw. Clamp the telescope to bisect the bottom shoe of the flag fixed at point „L‟ and tighten the lower clamp. Exactly intersect the centre of the bottom shoe by means of lower slow motion screw. Check that the face of the theodolite should be left and the telescope in normal position.
3) Check the reading of the vernier A to see that no slip has occurred .Also see that the plate levels are in the centre of their run. Read the vernier B also.
4) Release the upper clamp screw and turn the theodolite clockwise. Bisect the flag bottom shoe fixed at point M by a telescope. Tighten the upper clamp screw and bisect the shoe exactly by means of upper slow motion screw.
5) Note the reading on both the vernier to get the approximate value of the angle LOM.
6) Release the lower clamp screw and rotate the theodolite anticlockwise. Bisect again the bottom shoe of the flag at „L‟ and tighten the lower clamp screw. By means of slow motion screw bisect exactly the centre of the shoe.
7) Release now the upper clamp screw and rotate the theodolite clockwise. Bisect the bottom shoe of the flag fixed at M and tighten the upper clamp screw. By means of slow motion screw bisect exactly the centre of the shoe. The vernier readings will be now twice the of the angles.
8) Repeat the process until the angle is repeated the required number of times (usually 3). Add 360° for every complete revaluation to the final reading and divided the total angle by number of repetitions to get the value of angle LOM.
9) Change the face of the theodolite the telescope will now be inverted. Repeat the whole process exactly in the above manner and obtain value of angle LOM.
10) The average horizontal angle is then obtained by taking the average of the two angles obtained with face left and face right.
11) Usually three repetitions face left and three with face right should be taken and the mean angle should be calculated.

2. Reiteration method:-

It is the another method of measuring Horizontal angles with high precision It is less tedious and is generally preferred when several angles are measured successively, and finally the horizon is closed. i.e. the angle between the last station is measured. The final reading of the leading vernier should be same as its initial reading.



- **PROCEDURE:-**

1. Set up the instrument over O and level it correctly.
2. Set the vernier A to zero.
3. Direct the telescope to the some well –defined object P or say, the station point A, which is known as the "Referring Object" and bisect it accurately by using the lower clamp and lower tangent screw. Note the vernier reading.
4. Loosen the upper plate and turn the telescope clockwise until the point B is exactly bisected by turning the upper tangent screw. Read both verniers. The mean of two vernier readings will give the value of the angle AOB.
5. Similarly, bisect C and D successively, reading both verniers at each bisection.
6. Finally close the horizon by sighting the referring object (P) or the station point A.
7. The vernier A should now read 360^0. If not, note the reading and find the error. It may be noted that the lower clamp and lower tangent screw remain untouched during the revolution of the telescope.
8. If the error be small, it is equally distributed among the several observed angles. If large, the reading should be discarded and a new set taken.

- **Notes: -**

i) The theodolite should be turned clockwise from the back station to the forward station.

ii) Bring the crosswire into exact coincidence with signal from left to right with upper tangent screw

iii) The mean of the vernier readings is taken in each case, and the differences between these means will give required value of the angles.

Observations:

Observation Table: 1) For Repetition Method:

SN	Station Point	Face	Observed Station Point	Reading on Vernier A	Reading on Vernier B	Mean Reading (1)	Mean Reading (2)	Mean Reading (3)
1	O	Left	P					
2			Q					
3			P					
4			Q					
5			P					
6			Q					
1	O	Right	P					
2			Q					
3			P					
4			Q					
5			P					
6			Q					

1) For Reiteration Method:

SN	Station Point	Face	Observed Station Point	Reading on Vernier A	Reading on Vernier B	Mean Reading (1)	Mean Reading (2)

1			P				
2			Q				
3	O	Left	R				
4			S				
5			P				
1			P				
2			Q				
3	O	Right	R				
4			S				
5			P				

Specimen Calculation:

Result:

1. The horizontal angle between P & Q measured by Repetition method is = ___________

2. The horizontal angle measured by Reiteration method is,

   a) Angle PQ =

   b) Angle QR =

   c) Angle RS =

   d) Angle SP =

Conclusion:____

Question Bank for Viva:

1. What is least count of theodolite?
2. Explain the component parts of the theodolite?
3. How to take readings on upper and lower plate of the theodolite?
4. Difference between repetition and Reiteration Method?

EXPERIMENT NO. 7

"MEASUREMENT OF VERTICAL ANGLES BY USING THEODOLITE"

Name of Equipment: Theodolite, Ranging rod, pegs.

Title of Experiment: Measurement of Vertical Angles by using Theodolite.

Aim of Experiment: To measure the vertical angle with theodolite.

Experimental set up: Theodolite, Ranging rod, pegs.

- **Theory: Theodolite :**

Theodolite is an instrument designed for the measurement of horizontal and vertical angle. It is most precise method it is also used for laying of horizontal angles locating points on line prolonging the survey line establishing the gradient, determination of difference in the elevation setting out curve. Theodolite is of two types i.e. transit and non-transit. Transit theodolite is commonly used now days. Transit theodolite telescope can be revolved a complete revolution about its horizontal axis in a vertical plane.

MESURMENT OF VERTICAL ANGLE:-

A vertical angle is the angle between the inclined line of sight to an object and the horizontal. It may be an angle of elevation or on angle of depression according as the point is above or below the horizontal plane passing through the trunnion axis of the instrument. To measure angle of elevation or depression LOM shown in fig. proceed as follows:

1) Set up the theodolite at station point O and level it accurately with reference to the altitude level.

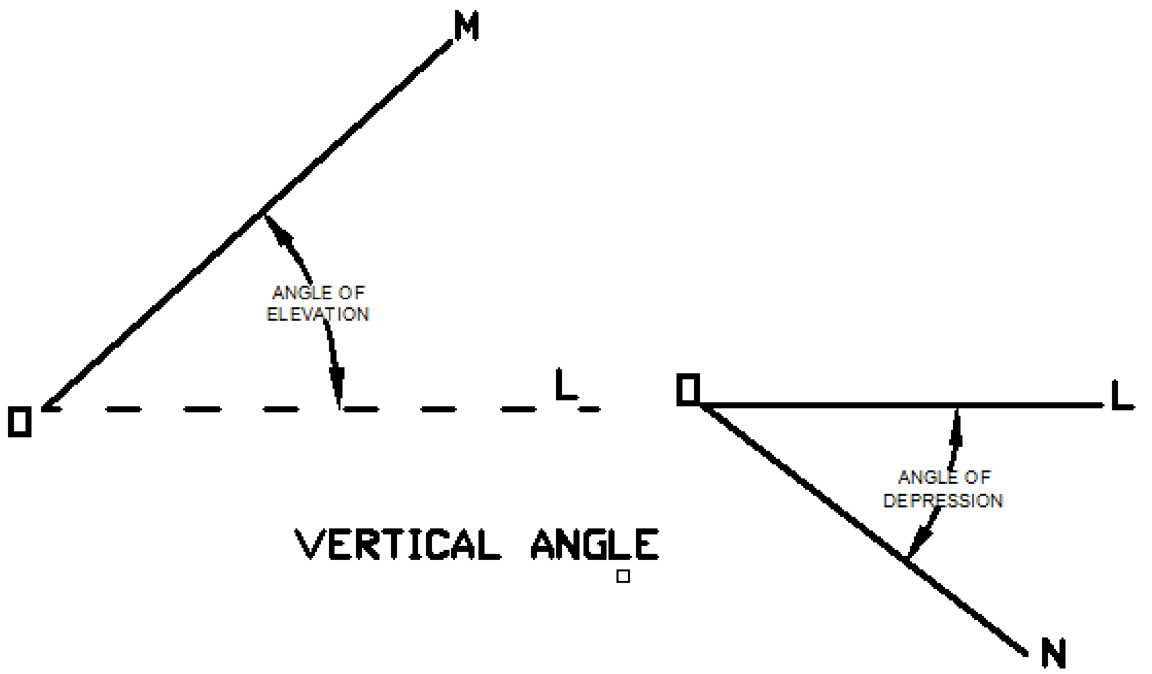
2) Set vertical verniers C and D exactly to zero by using the vertical circle clamp and tangent screw, while the altitude level should remain in the centre of its run. Also the face of the theodolite should be left.

3) Release the vertical circle clamp screw and rotate the telescope in vertical plane so as to bisect the object M. tighten the vertical circle clamp and exactly bisect the object by slow motion screw.

4) Read both verniers C and D. the mean of the tow readings gives the value of the required angle.

5) Similar observation may be made with other face. The average of the tow values thus obtained gives the value of the required angle which is free from instrumental errors.

6) Similarly the angle of depression can be measured following the above steps.



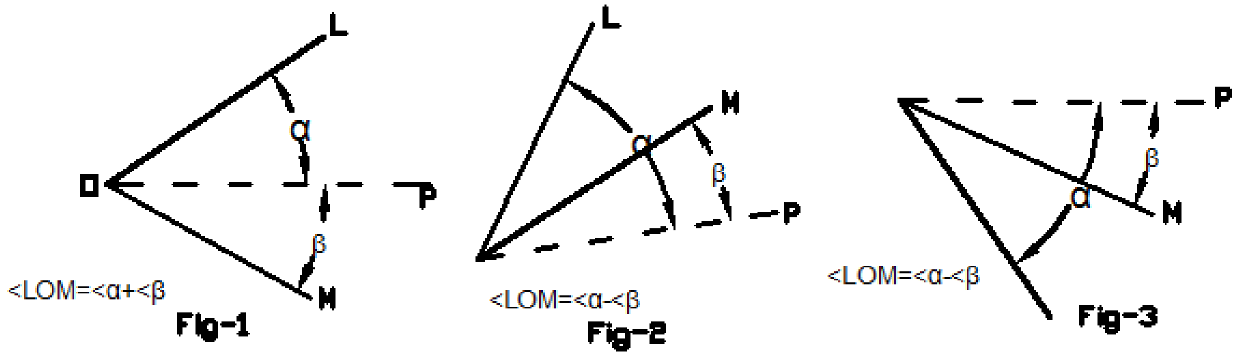
➢ **To measure the vertical angle between two points L and M:**

Sometimes it is required to measure vertical angle between two points L and M . There can be three possibilities.

(a) One point is above the line of sight and the other is below the line of sight then angle LOM as shown in fig will be equal to (α +ß)

(b) Both the points are above the line of sight. Then the angle LOM= α -ß (Refer Fig 2)

(c) Both the points are below the line of sight, then the angle LOM= α -ß (Refer Fig 3)



➢ **To measure the angle between two points L and M proceed as follows:**

1) Set the theodolite at station point O and accurately level it.

2) Bisect the flag at L as explained already and take the reading on the verniers C and D. Calculate the mean angle.

3) Bisect the flag at M as before and take the reading on the verniers C and D. Calculate the mean angle.

4) The sum or difference of these angles will give the value of the vertical angle between points L and M as shown in the figure (4).

Observation Table:

S N	**Station Point**	**Face**	**Observed Station Point**	**Reading on Vernier A**	**Reading on Vernier B**	**Measured Angle**	**Mean Angle (α & ß)**	**Mean Angle (α + ß)**	**Average Angle of left & right face**
1	O	Left	L						
2			M						
3			L						
4			M						
5			L						
6			M						
1	O	Right	L						
2			M						
3			L						
4			M						
5			L						
6			M						

Specimen Calculation:

Result: The average value of vertical angle is found to be ____________

Conclusion:____

Question Bank for Viva:

1. What is least count of theodolite?
2. Explain the component parts of the theodolite?
3. How to take readings on vertical plate of the theodolite?
4. Sketch the vertical plate showing vernier and reading ?

<u>**EXPERIMENT NO. 8**</u>

"MEASUREMENT OF BEARING, DEFLECTION ANGLE AND PROLONGING OF LINE BY THEODOLITE"

Name of Equipment: Theodolite, Tripod Stand, Ranging rod, Measuring Staff.

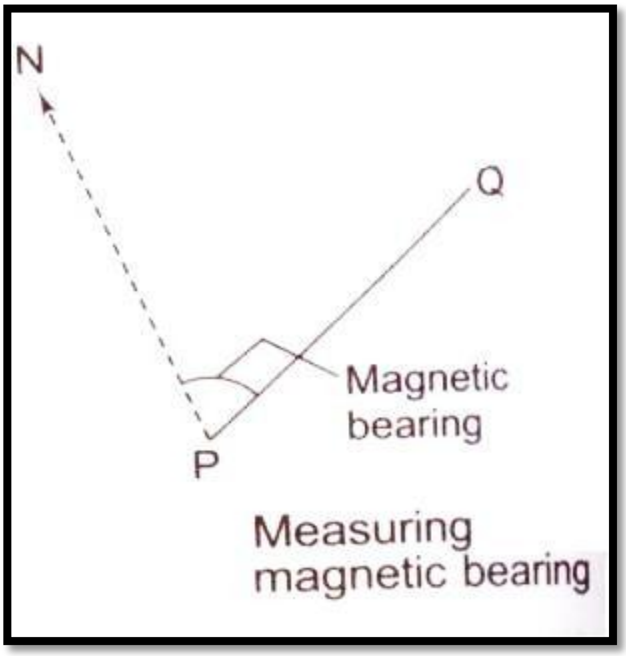
Title of Experiment: Measurement of bearing, deflection angle and prolonging of line by theodolite

Aim of Experiment: Measurement of bearing, deflection angle and prolonging of line by theodolite.

Experimental set up: Theodolite, Tripod Stand, Ranging rod, Measuring Staff.

1. **Theory: MEASUREMENT OF BEARING:**

- **The procedure for measuring magnetic bearings as follows:**



1) To determine the magnetic bearing of line PQ , set and level the theodolite at P.

2) Use the upper tangent screw , to release the upper plate and swing the instrument to set the reading on vernier A to read zero approximately. Clamp the upper plate and with upper tangent screw, make the zero of the vernier and circle coincide exactly.

3) Release the lower plate and the magnetic needle of the compass. Swing the instrument so that the magnetic needle is nearly at the centre of its run , with the north end of the needle

pointing to zero of the graduations on the compass. Tighten the lower clamp and using the lower tangent screw, bring the magnetic needle to read exactly zero at the north end. Check the verniers at AandB. They should read zeroand 180^0 as set earlier.

4) The line of sight of the instrument is in the direction of the magnetic meridian at P. Release the upper clamp and swing the instrument to bisect the signal at Q. Using upper tangent screw , bisect the signal exactly at Q.
5) Read both the verniers. The average of the two reading gives the magnetic bearing of the line PQ.

2. **MEASUREMENT OF DEFLECTION ANGLE:**

Figure:

A deflection angle is the angle which the survey line makes with the prolongation of the preceding line. It is designated as Right or Left according as it is measured to the clockwise or anticlockwise from the prolongation of the previous line. Its value may vary from 0° to 180°. The deflection angle at Q is α° and that at R is ß°.

Experimental Procedure:

1. Set With both plates clamped at 0°, take back sight on P.
2. the instrument at Q and level it.

3. Plunge the telescope. Thus the line of sight is in the direction PQ produced when the reading on verniers A is 0°.
4. Unclamp the upper clamp and turn the telescope clockwise to take the foresight on R. Read both verniers.
5. Unclamp the lower clamp and turn the telescope to sight P again. The verniers still read the same reading as in (4). Plunge the telescope.
6. Unclamp the upper clamp and turn the telescope to sight R. Read both verniers. Since the deflection angle is doubled by taking both face readings, one-half of the final reading gives the deflection angle at Q.

3. PROLONGING A LINE:

Prolonging a line is an important supplementary work carried out by theodolite. This procedure helps in continuing a line during base line measurement in laying out pipe line or roadway, setting out curves etc. the work is accurate and is faster.

Figure:

- **Procedure:**

1. Let AB be the line to be prolonged
2. Instrument is placed at pt. B with all temporary adjustments
3. Releasing the UCS and LCS telescope is turned about the vertical axis till the peg or arrow at pt A is bisected then the plate ensues i.e. (UCS & LCS) are clamped.
4. Telescope is plunged there by line of sight shifts after B in line with AB.
5. Telescope is now rotated to bisect the tip of the ranging rod at a convenient distance. This gives point C.
6. Now again the instrument is shifted to point C and the procedure in step 3 & 4 us repeated to get further pints D, E, F etc. and hence the line is prolonged.

Conclusion:____

Question Bank for Viva:

1. Describe the procedure of Measurement of Bearing?
2. Describe the procedure of Measurement of deflection Angle?
3. Describe the procedure of Prolonging of a given line?

<u>EXPERIMENT NO. 9</u>

"TRIGONOMETRIC LEVELLING"

Name of Equipment: Theodolite, Tripod Stand, Ranging rod, Measuring Staff.

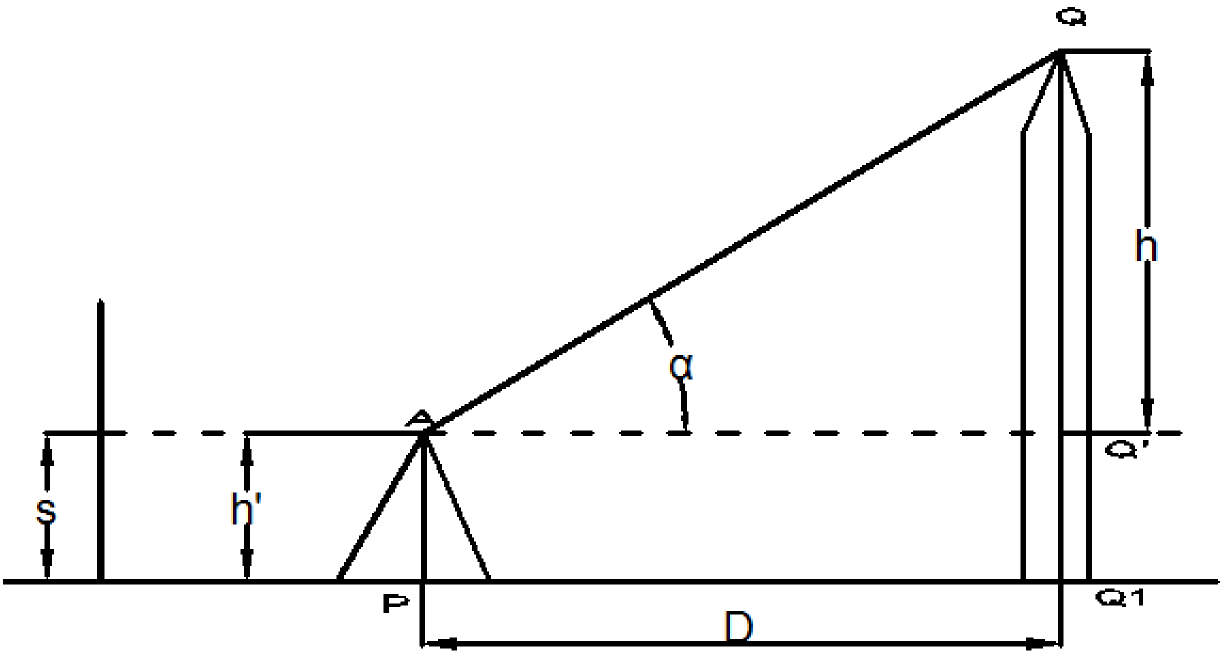
Title of Experiment: Trigonometric levelling

Aim of Experiment: Determination of elevation of point by trigonometric levelling.

Experimental set up: Theodolite, Tripod Stand, Ranging rod, Measuring Staff.

Theory: Trigonometrical leveling is the process of determining the difference of elevation of station from observed vertical angles and known distances, which are assumed to be either horizontal or geodetic length at mean sea level. The vertical angles may be measured by means of an accurate theodolite and the horizontal distances may either be measured (in case of plane surveying) or computed (in case of geodetic observation)

1. Base of the object accessible:-



- **Height and Distances:**

1) Base of the object accessible.-

The horizontal distance between the instrument and the object can be measured accurately.

Let, P= instrument station.

Q=Point to be observed

A=centre of the instrument

Q‟ =projection of Q on horizontal plane through A

D= AQ‟=horizontal distance between P&Q

h‟=height of the instrument at P

h=QQ‟

S=Reading on staff kept at B.M, with line of sight horizontal.

P=angle of elevation from A to Q

From triangle AQQ‟, h = Dtanα

R.L of Q= R.L of instrument axis + Dtanα

If the R.L. of P is known, then

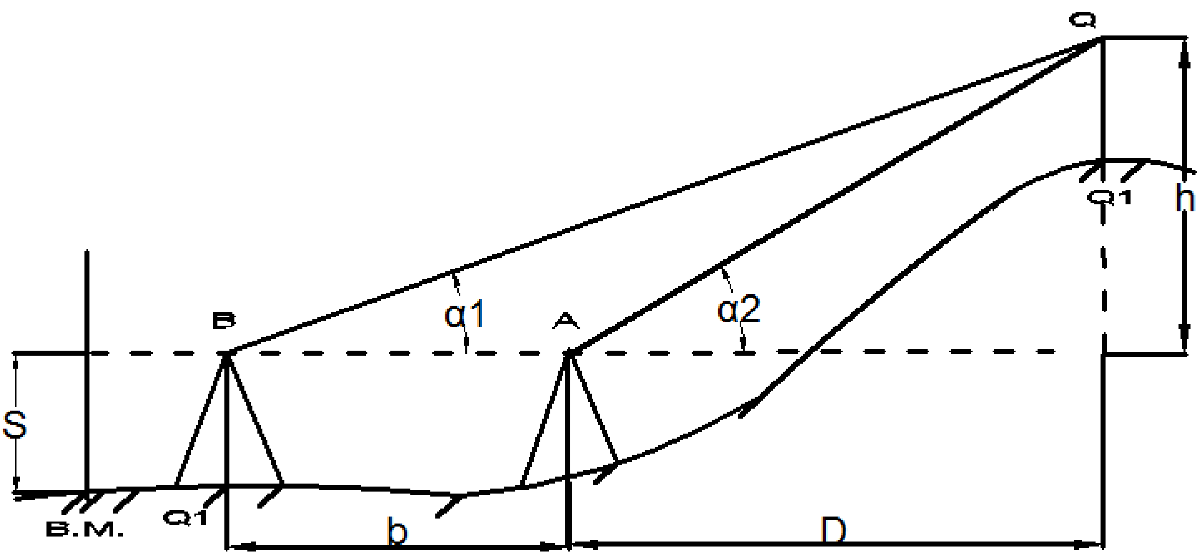
R.L. of Q = R.L of P + h‟+ Dtanα

If the reading on the staff kept at the B.M. is S with the line of sight horizontal, then

R.L of Q = R.L. of B.M + S + Dtanα

2) Base of the object inaccessible: -

If the horizontal distance between the instrument and the object can be measured due to obstacles etc., two stations are used so that they are in the same vertical plane as the elevated object.



a) Instrument axes at the same level:-

Let, h=QQ‟,

P1 = angle of elevation from A to Q,

P2=angle of elevation from B to Q

S= staff reading on B.M taken from both A and B, the reading being the same in the both the cases.

b=horizontal distance between the instrument stations,

D= horizontal distance between P&Q

From triangle AQQ'', h = Dtanα1 ----------------------------------- (1)

From triangle BQQ'', h = (b + D) tanα2 ----------------------------- (2)

Equating (1) and (2), we get,

Dtanα1 = (b+D) tanα2

D(tanα1-tanα2) = btanα2

$$D = \frac{b \tan \alpha_2}{\tan \alpha_1 - \tan \alpha_2}$$

h=Dtanα2

$$= \frac{b \tan \alpha_1 \tan \alpha_2}{\tan \alpha_1 - \tan \alpha_2}$$

$$= \frac{b \sin \alpha_1 \sin \alpha_2}{\sin(\alpha_1 - \alpha_2)}$$

R.L. of Q = R.L of B.M. + S + h

Experimental Procedure:

1) Set up the theodolite at P and level it accurately with respect to the altitude bubble.

2) Direct the telescope toward Q and bisect it accurately. Clamp both the planes. Read the vertical angle P1.

3) Transit the telescope so that the line of sight is reversed. Mark the second instrument station R on the ground. Measured the distance RP accurately. Repeat steps (2) and (3) for both face observation. The mean values should be adopted.

4) With the vertical vernier set to zero reading, and the altitude bubble in the centre of the run, take the reading on the staff kept at nearby B.M.

5) Shift the instrument to R and set up the theodolite there. Measured the vertical angle P2 to Q with both face observations.

6) With the vertical vernier set to zero reading, and the altitude bubble in the centre of the run, take the reading on the staff kept at the nearby B.M

Observations:

Observation Table:

Instrument Station	R.L. at B.M.	Reading on staff kept at B.M.	Vertical angle (α)	Horizontal distance between instrument station and object	R.L. o f the object

Specimen Calculation:

Result: The elevation of the object from the B.M is found to be,

1. When base of the object accessible =__________m
2. When base of the object inaccessible =___________m

Conclusion:____

Question Bank for Viva:

1. What do you understand by Trignometrical Levelling?
2. Enlist the different cases of Trignometrical Levelling?
3. Describe the formula of D and h1 of all cases?
4. What do you understand by accessible and inaccessible point?
5. Derive an expression of any one case of Trignometrical Levelling?

EXPERIMENT NO. 10

"USAGE OF MINOR INSTRUMENTS"

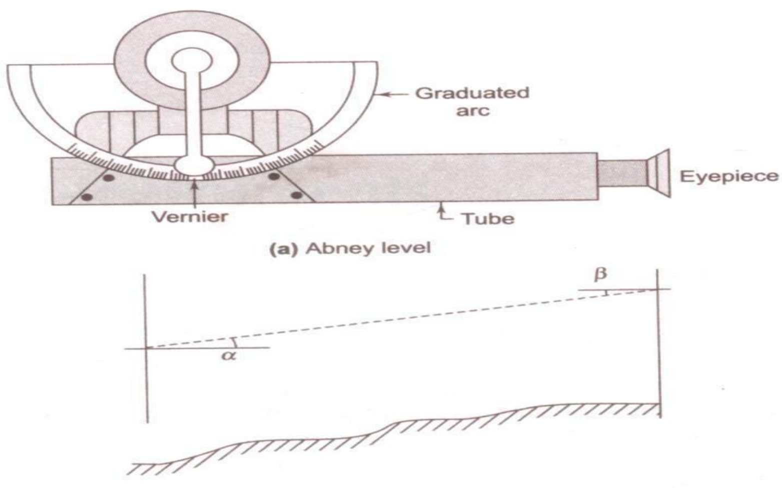
Name of Equipment: Abney Level, Box Sextant, Hand Level, De Lisle"s Clinometers, & Ceylon Ghats tracer.

Title of Experiment: Usage of minor instruments.

Aim of Experiment: To Study of Abney level, Box sextant, Hand Level, Clinometers, Ceylon Ghatstracer.

Experimental set up: Abney Level, Box Sextant, Hand Level, De Lisle"s Clinometers, & Ceylon Ghats tracer.

1. **Theory: ABNEY LEVEL:-**



(a) Abney level
(b) Testing the Abney level
Abney level (clinometer)

Abney level is a light compact bond instrument of low elevation. It is widely used for-measuring the angle of elevation or depression.

1) Taking alone of the ground when chaining along the uneven ground.

2) Tracing a great contour or a alignment of a road.

Abney level consist of-

1) A square lighting tube fitted with an eye piece or small telescope at one end at the other end the mirror is placed at an angle of 450 inside the tube the wire is lanced across the tube behind the mirror by which object can be bisected.

2) A small bubble tube is attached to the mirror arm which can be rotated by means of worm wheel.

3) A semicircular quadrate arch is marked zero at the middle point. The graduation are made from 00 – 60

- **Measurement of vertical angle-**

Direct the instrument towards the object & bisect it with cross wire & at the same times the middle wheel until the crass wire bisect the reflection of the required angle in the arc by means of the vernier it may be noted that the bubble tube is always horizontal & the vertical arm vertical , whatever may be the inclination of telescope.

- **Measurement of slope on the ground:-**

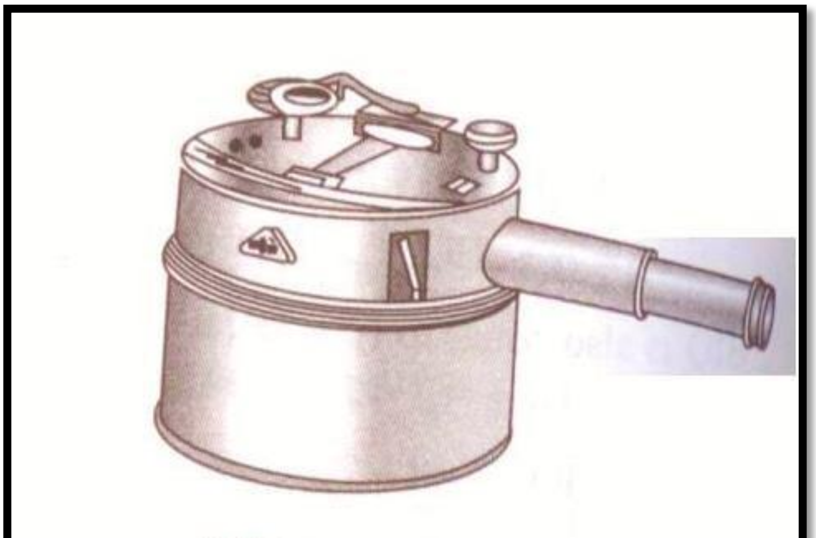
The observer stands at one end of the slope & direct the instrument on to the mark all vane fixed on the ranging rod at the same height as the observer wheel until the reflected image of the bubble is brought to the centre of its run & intersected by the cross wire the bubble tube is now horizontal while the telescope is parallel to the slope of the ground. The angle read on the arc gives the slope of the ground.

- **To trace the grade contour:-**

With the help of the vernier the rolling gradient can be obtained mark the height of the observer on the ranging rod. Direct the instrument towards the mark on the ranging rod held at the convenient distance ray 30-50meter the ranging rod is then moved upward downward until the observer bisect the vane with cross hair & simultaneously over the bubbled centered is the instrument station to the point on which ranging rod is held parallel to this point & repeat the process to establish the next point the process is continued until the last point is established. If the abney level is not giving correct values of angle of inclination of there is difference of two observations then adjust the instrument to the mean value. i.e. (T1+T2/2) light the object & centre the bubble by means of adjusting screw of the bubble tube.

2. BOX SEXTANT:-

It is reflected type of instrument capable of measuring angle up to 1200 & reads to one minute.



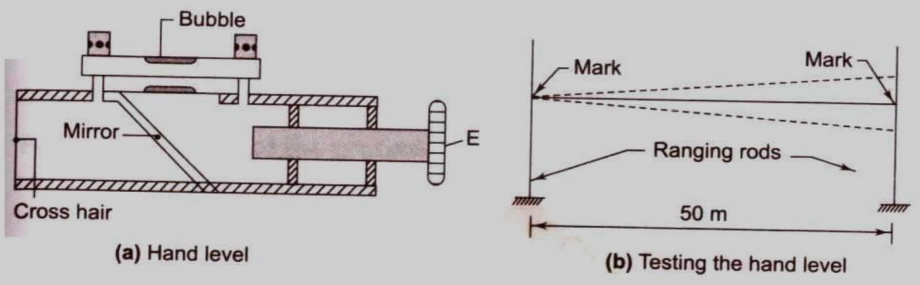
(d) Box sextant

Construction: - It consist of,

1. A box about 7.5 cm in dia & 4cm in depth
2. A cover which server as a handle when occurred to the bottom.
3. A horizontal glass having the lower half & the nipper half.
4. An index glass wholly.
5. A Oliver all graduated from 00 to 1400 degrees & half degrees.
6. An index arm carries a vernier which reads to single minute.
7. An adjustable magnifying glass.
8. A milled handle screw to rotate the index glass & index arm.
9. An eye hole in a sliding arm.
10. A pair of colored glasses for use when observations are taken on the brought object or the sun.
11. A telescope for a long distance sighting.
12. A slot in the side of the box through which entrees the rays from the object sighted.
13. A bay for adjusting the instrument.

Uses:- The box sextant is a compact hand instrument by setting the vernier to 90 it may be used as a optical square & therefore after included in the instrument (equipment) For a chain survey it is very useful for measuring chain angles. Locating inaccessible point at measuring angles for checking purpose.

3 HAND LEVEL:



Hand level

It is the simple instrument to use .It is used in reconnaissance operations and preliminary surveys to obtain the levels of salient points before taking up a detailed survey for determining levels. It consists of 150 mm long metallic tube of circular or rectangular cross section. It has a spirit level attached to top of tube with screws. the tube has rectangular opening just below the level through which the image of bubble of level can be seen on mirror fixed inside tube. Mirror occupies only half the width of tube, other half being open. E is the eyehole through which observer can see bubble"s image as well as staff held at distance. There is horizontal cross hair at other end of tube, which acts as reference mark for reading the staff. the observer can hold hand level in such a way that bubble is cantered while viewing staff.

To use the hand level, proceed is as follows.

1) Hold instrument in hand or against ranging rod at eye level.

2) have a helper hold a leveling staff at the point whose elevations is required.

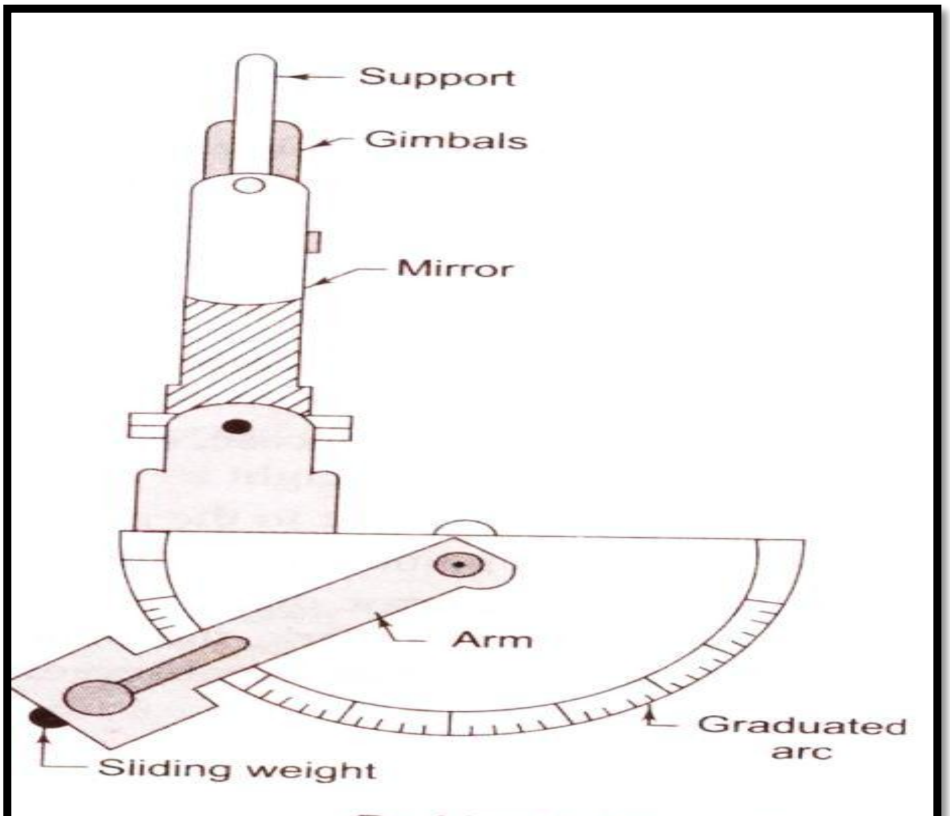
3) Looking through a eyehole observe image of bubble reflected in mirror and staff through empty part along with cross hair at other end of the tube.

4) Adjust the hand level so that cross hair bisects image of bubble. Note reading of the staff.

5) A hand level is useful for rough work in contours.

4. DE LISLE'S CLINOMETERS:

It is used for the same purpose- measuring vertical angles and slopes. The instrument consist of mirror consist of mirror held in the frame suspended from gimbals. The frame is connected to a ring from which it can be suspended, either held in the hand or hung from a nail on a rod or pole. The mirror occupies half the width of the frame, the other half being open. The edge of mirror acts as a vertical reference line. A heavy semicircular arc is connected to the frame. The arc has graduations marked in gradients. When at the extreme outer end of its slide, the weight balances the weight of the metal arc in the horizontal position and the mirror lies in a vertical plane. The line of sight is made horizontal by sliding the weight to the outer end and turning the radial arm back to its full extends.



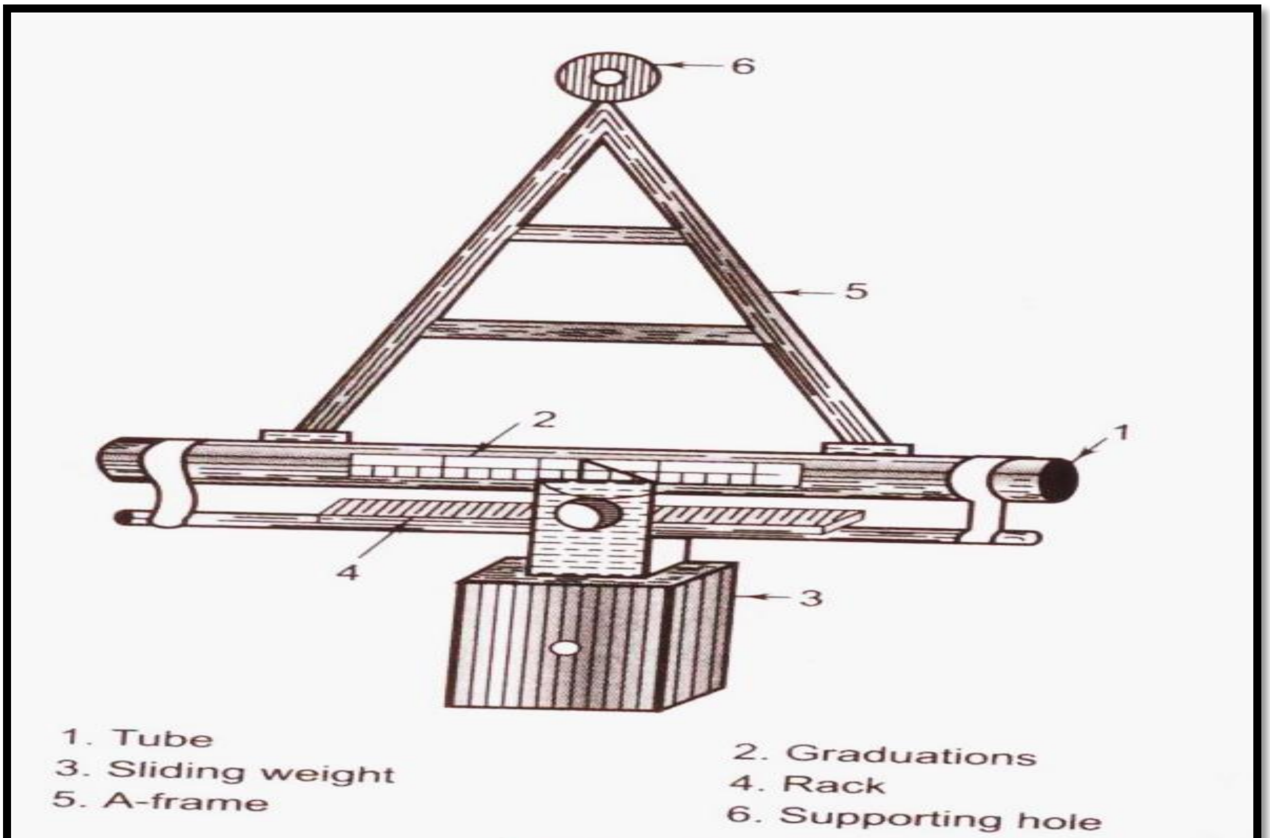
De Lisle's clinometer

The Clinometers can be used to: -

1. Measuring vertical angles
2. Measuring slope.
3. Locating points on a given grade

5) CEYLON GHATSTRACER: -

It is popular in earlier years; it can be used to find slopes or lo0cate points on a gradient. The instrument consists of a hollow brass tube suspended from a triangular bracket with a hook that can be used to hang the instrument from a vertical rod. The brass tube has an eyehole at one end and across wire at the other. The line of sight is defined by the line joining the eyehole to intersection of the cross hair.



Ceylon ghat tracer

It is used by hanging it freely from a vertical staff, following the procedure to measure a slope**.**

1) Hold the instrument at a station, suspending it from the vertical staff at one end of the slope.
2) Measure the height of the axis of sighting tube from the base of vertical staff.
3) On the ranging rod or another such rod, mark this height.
4) Have a assistant with marked rod move along the slope to the end of the slope.
5) Now move the weight along the tube while looking through the eyehole until the cross hair bisects the mark on the rod.
6) Note the reading against the index mark on the weight. This gives the slope of the ground.

Experimental Procedure:

When measuring angles between the two objects at a station hold the instrument is the right hand over the station & look through the eye lenses at the left hand object through the lower position of the horizontal angle. The middle headed screw slowly until the image of the right hand object seen is the upper silvered half of the horizon glass is with left hand

Conclusion: Abney level, Box sextant, Hand Level, Clinometers, Ceylon Ghatstracer is studied.

Question Bank for Viva:

1. Describe the component part of Abney level, Box sextant, Hand Level, Clinometers, Ceylon Ghatstracer?
2. Describe the Uses of Abney level, Box sextant, Hand Level, Clinometers, Ceylon Ghatstracer?
3. Describe the procedure of Abney level, Box sextant, Hand Level, Clinometers, Ceylon Ghatstracer?