



Partnering in Academic Excellence

# Channabasaveshwara Institute of Technology

(Affiliated to VTU, Belgaum & Approved by AICTE, New Delhi)

(NAAC Accredited & ISO 9001:2015 Certified Institution)

NH 206 (B.H. Road), Gubbi, Tumkur – 572 216. Karnataka.



## Department of Civil Engineering

# Surveying Practice Laboratory

## 18CVL57

### B.E - V Semester

### Laboratory Manual 2022-23

Name: \_\_\_\_\_

USN: \_\_\_\_\_

Batch: \_\_\_\_\_ Section: \_\_\_\_\_



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# Surveying Practice Laboratory

## 18CVL57

October 2022

**Prepared by:**

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**DEPARTMENT OF CIVIL ENGINEERING**

**SURVEYING PRACTICE**

[As per Choice Based Credit System (CBCS) & Outcome Based Education (OBE)]

Subject Code 18CVL57

Teaching Hours/Week (L:T:P): (0:2:2)

Credits: 02

CIE Marks: 40

SEE Marks: 60

Exam Hours: 03

**COURSE OBJECTIVES:**

**This course will enable students to:**

1. Apply the basic principles of engineering surveying and measurements
2. Follow effectively field procedures required for a professional surveyor
3. Use techniques, skills and conventional surveying instruments necessary for engineering practice.

Exp. No.	TITLE OF THE EXPERIMENT
1	A. Measurements of distances using tape along with horizontal planes and slopes, direct ranging. B. Setting out perpendiculars. Use of cross staff, optical square
2	Measurements of bearings / directions using prismatic compass, setting of geometrical figures using prismatic compass.
3	Determination of distance between two inaccessible points using compass and accessories.
4	Determination of reduced levels of points using dumpy level/auto level (simple leveling)
5	Determination of reduced levels of points using dumpy level/auto level (differential leveling and inverted leveling)
6	To determine the difference in elevation between two points using Reciprocal leveling and to determine the Collimation error.
7	To conduct profile leveling, cross sectioning and block leveling. Plotting profile and cross sectioning in excel. Block contour on graph paper to scale.

8	Measurement of horizontal angle by repetition and reiteration methods and Measurement of vertical angles using theodolite.
9	Determination of horizontal distance and vertical height to a base inaccessible object using theodolite by single plane and double plane method.
10	To determine distance and elevation using tachometric surveying with horizontal and inclined line of sight.
11	Closed traverse surveying using Theodolite and applying corrections for error of closure by transit rule and Bowditch rule.
12	To locate the points using Radiation and Intersection method of Plane table surveying.
13	To solve three point problem in plane table using Bessel's graphical solution.
14	Demonstration of Minor instruments like Clinometer, Ceylon Ghat tracer, Box sextant, Hand level, Planimeter, nautical extant and Penta graph.

#### **QUESTION PAPER PATTERN:**

- All are individual experiments.
- Instructions as printed on the cover page of answer script for split up of marks to be strictly followed.
- All exercises are to be included for practical examination.

#### **TEXT BOOKS:**

1. B.C. Punmia, "Surveying Vol.1", Laxmi Publications pvt. Ltd., New Delhi– 2009.
2. Kanetkar T P and S V Kulkarni , Surveying and Levelling Part I, Pune Vidyaarthi Griha Prakashan, 1988

#### **REFERENCE BOOKS:**

1. S.K. Duggal, "Surveying Vol.1", Tata McGraw Hill Publishing Co. Ltd. New Delhi. – 2009.
2. K.R. Arora, "Surveying Vol. 1" Standard Book House, New Delhi. – 2010

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Sl. No	Name of the Experiment	Date			Manual Marks (Max - 20)	Record Marks (Max. 10)	Signature (Student)	Signature (Faculty)
		Conduction	Repetition	Submission of Record				
<b>Average</b>								

**Note: If the student fails to attend the regular lab, the experiment has to be completed in the same week. Then the manual/observation and record will be evaluated for 50% of maximum marks.**



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## DEPARTMENT OF CIVIL ENGINEERING

### Course objectives:

**The objectives of this course are to make students to learn**

This course will enable students to:

1. Apply the basic principles of engineering surveying and measurements
2. Follow effectively field procedures required for a professional surveyor
3. Use techniques, skills and conventional surveying instruments necessary for engineering practice.

### Course outcomes:

After a successful completion of the course, the student will be able to:

- **Apply** the basic principles of engineering surveying and for linear and angular measurements
- **Evaluate** the elevation of points, establishing bench marks, conduct profile leveling for a stretch of land using level and plotting LS & CS for engineering applications
- **Execute** the field procedures effectively required for a professional surveyor
- **Apply** the techniques and skills to solve the problems by using surveying instruments necessary for engineering practice
- **Execute** the Work effectively as a member in a team & contribute to the team's goal

## **'Instructions to the Candidates'**

- 1. Students should come with thorough preparation for the experiment to be conducted.**
- 2. Students without uniform will not be permitted to attend the laboratory classes**
- 3. Students will not be permitted to attend the laboratory unless they bring the practical record fully completed in all respects pertaining to the experiment conducted in the previous class.**
- 4. All the calculations should be made in the observation book. Specimen calculations for one set of readings have to be shown in the practical record.**
- 5. Wherever graphs are to be drawn, A-4 size graphs only should be used and the same should be firmly attached to the practical record.**
- 6. Practical record should be neatly maintained.**
- 7. They should obtain the signature of the staff-in-charge in the observation book after completing each experiment.**

**DEPARTMENT OF CIVIL ENGINEERING**

**CONTENTS**

<b>EXP. NO</b>	<b>TITLE OF THE EXPERIMENT</b>	<b>PAGE NO</b>
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<b>3.</b>	Determination of distance between two inaccessible points using compass and accessories.	25-28
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<b>9.</b>	Determination of horizontal distance and vertical height to a base inaccessible object using theodolite by single plane and double plane method.	61-68
<b>10.</b>	To determine distance and elevation using tachometric surveying with horizontal and inclined line of sight.	69-72
<b>11.</b>	Closed traverse surveying using Theodolite and applying corrections for error of closure by transit rule and Bowditch rule.	73-78
<b>12.</b>	To locate the points using Radiation and Intersection method of Plane table surveying.	79-86
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**Fig. 1.1 Direct ranging**

**MEASUREMENT OF DISTANCE****Exercise : 1.A****Case 1:** Horizontal plane**Aim:**To measure distance between two points using direct ranging (Fig. 1.1)**Instruments used:**

<b>Sl. No.</b>	<b>Particulars</b>	<b>Quantity</b>
1.	Chain	01
2.	Tape	01
3.	Ranging Rods	03
3.	Arrows	Few

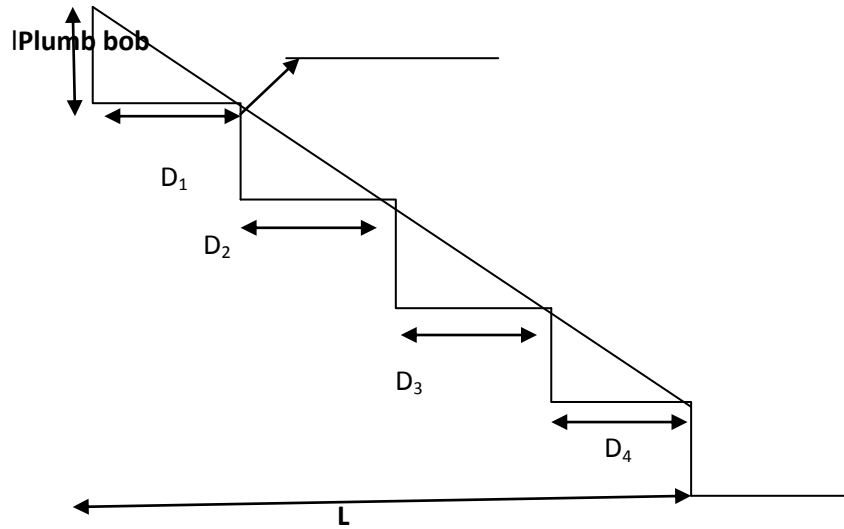
**Theory:** Measurement of distance between two points, which are at a large distance , involves two steps namely ranging and chaining. Ranging is a process of locating points on a given straight line. There are two methods of ranging, namely direct ranging and indirect ranging. Direct ranging may be done with eye judgment or by using instrument like line ranger.

**Chaining** is a process of measuring a distance either by a chain or a tape.

**Procedure:**

Let A and B be the two points at the ends of a survey line. One ranging rod is erected at the B while surveyor stands with another ranging rod at point A. The assistant then goes with another ranging rod and establishes the rod at a point approximately in the line with AB at a distance not greater than one chain length from A. Surveyor at A signals the assistant to move transverse to the chain line, till he is in line with A and B. Similarly, other intermediate points can be established. Now measure the distance between the points A and B.

**RESULTS:-**



**Fig. 1.2 Indirect ranging (Stepping method)**

$$L = D_1 + D_2 + D_3 + D_4$$

Where,  $L$  = Total horizontal distance

$D$  = horizontal distances between the intervals

**Case 2:** Sloping ground

**Aim:**To measure distance between two points using direct ranging (Fig. 1.2)

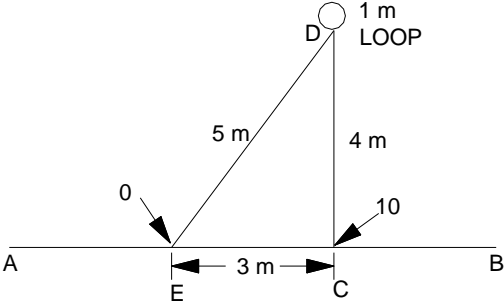
**Instruments used:**

<b>Sl. No.</b>	<b>Particulars</b>	<b>Quantity</b>
1.	Chain	01
2.	Tape	01
3.	Ranging Rods	03
3.	Arrows	Few

**Theory:**

**Procedure:**

**RESULTS:-**



**Fig. 1.3 First method (3-4-5 method)**

**ERECTION OF PERPENDICULAR****Exercise : 1.B**

**Aim:** To erect perpendicular from a given chain line to a given point using chain and tape only.

**Instruments used:**

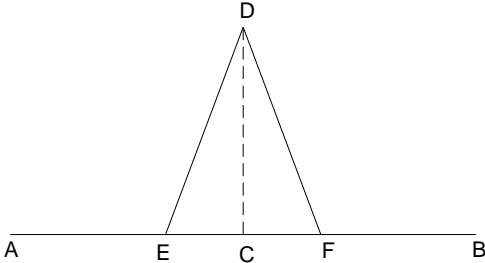
<b>Sl. No.</b>	<b>Particulars</b>	<b>Quantity</b>
1.	Chain	01
2.	Tape	01
3.	Ranging Rods	03
3.	Arrows	few

**Procedure:**

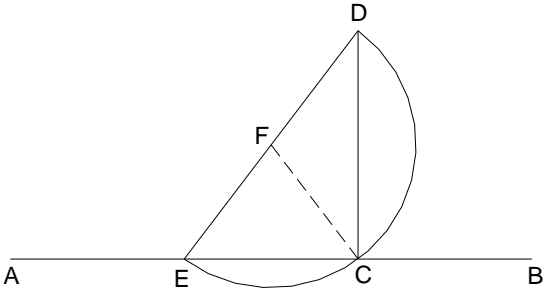
Let AB be the given chain line and C be the given point on AB at which it is desired to erect a perpendicular.

**First method (3-4-5 method) :( Fig 1.3)**

1. Establish a point E at distance of 3m from C.
2. Put the zero end of the tape at E and the 10m end at C.
3. The 5m and 6m marks are brought together to form a loop of 1m.
4. Fastening the ends E and C stretch the tape tightly.
5. The point D is thus established.
6. Join DC, and point D gives the position of the perpendicular CD at C on the chain line AB.



**Fig.1.3Second method**



**Fig. 1.4 Third method**

**Second method: (Fig 1.4)**

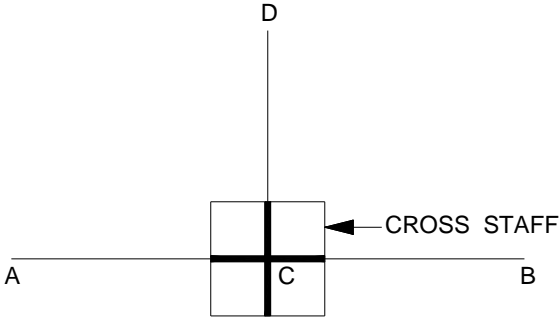
1. Select E and F equidistant from C.
2. Hold zero end of the tape at E and hold the 10 m end at F.
3. Pick up 5 m mark, stretch the tape tight and establish D.
4. Join DC, and point D gives the position of the perpendicular CD at C on the chain line AB.

**Third method: (Fig 1.5)**

1. Select any point F out side the chain, preferably at 5 m distance from C.
2. Hold the 5 m mark at F and zero end of the tape at C, with F as center draw an arc to cut the chain line at E.
3. Join EF and produce it to D such that  $EF = FD = 5$  m.
4. Thus, point D will lie at the 10 m mark of the tape laid along EF with its zero end at E.
5. Join DC, and point D gives the position of the perpendicular CD at C on the chain line AB.

**Results:**





**Fig. 1.5 Cross - Staff**

**Exercise 1.3****Date:** \_\_ / \_\_ / \_\_**Aim:** To erect perpendicular from a given chain line to a given point using Cross - Staff.**Instruments used:**

<b>Sl. No.</b>	<b>Particulars</b>	<b>Quantity</b>
1.	Chain	01
2.	Tape	01
3.	Ranging Rods	03
3.	Arrows	few

**Theory:** Cross staff consists of a wooden block of about 150mm square and about 35mm thick. The block has on its top surface, two grooves or slits at perpendicular to each other. The grooves are about 10mm deep. The wooden block is fixed at the top of a vertical pole or rod

**Procedure:(Fig 1.4)**

Let AB be the given chain line and C be the given point on AB at which it is desired to erect a perpendicular. Erect ranging rods at both the ends of the chain line AB.

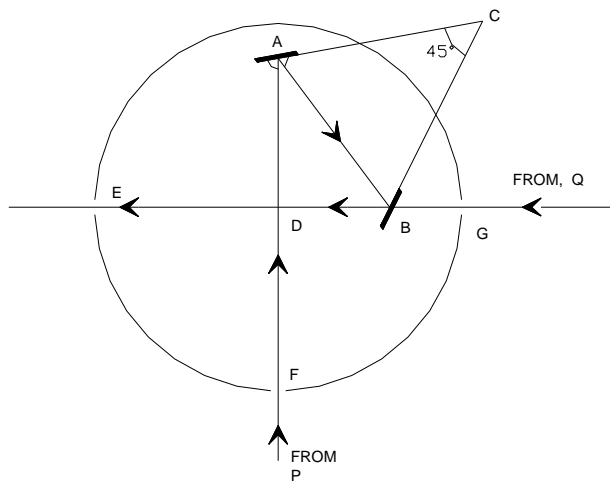
The cross - staff is set up at a point C on the chain line from which the perpendicular is to erect.

Now cross - staff is then turned until one line of sight passes through the ranging rod at the end of the chain line.

The line of sight through the other two vanes will be a line at right angles to the chain line AB and a ranging rod may be established in that direction at D.

Join C and D. CD will be the perpendicular to the chain line AB.

**Results:**



**Fig. 1.6 Optical square**

**Aim:** To erect perpendicular from a given chain line to a given point using Optical square.

**Instruments used:**

<b>Sl. No.</b>	<b>Particulars</b>	<b>Quantity</b>
1.	Chain	01
2.	Tape	01
3.	Ranging Rods	02
3.	Arrows	few
4.	Optical square	01

**Theory:** Optical Square is a compact instrument used for setting out perpendicular to the chain line. It consists of a horizon glass H, which is half silvered and half unsilvered and an index glass which is fully silvered. These two glasses are placed at an angle  $45^\circ$  inside the circular box. The box has three openings. One is circular for eye and the other diametrically opposite to this is rectangular is located perpendicular to the line of sight. Fig shows sectional plan of optical square. The optical square works on the following principal.

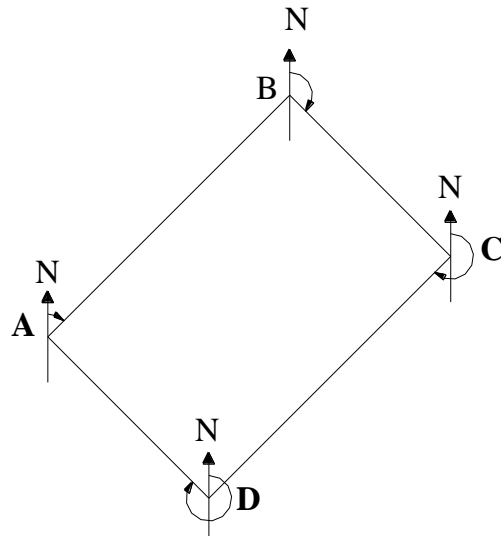
***"If a ray of light undergoes two successive reflections, the angle between the incident ray and the last reflected ray is twice the angle between the mirrors"***

In the optical square, as the angle between the mirrors is  $45^\circ$ , the last reflected ray is perpendicular to the incident ray

**Procedure: (Fig 1.7)** Let AB be the given chain line and C be the given point on AB at which it is desired to erect a perpendicular.

1. To set a right angle on a chain line AB the instrument is held on the line with its center on the point C at which perpendicular is erected.
2. The slits F and G are directed towards the ranging rod fixed at the end of the chain line.
3. The surveyor (holding the instrument) then directs the person, holding a ranging rod and stationing in a direction roughly perpendicular to the chain line to move till the two images coincide.

**Results:**



**Fig. 2.1 Construct of rectangle using compass**

### SETTING OUT OF GEOMETRICAL FIGURES USING PRISMATIC COMPASS

**Aim:** Construct the Rectangle in the field using chain and compass

**Instruments used:**

Sl. No.	Particulars	Specification	Quantity
1.	Chain		01
2.	Tape		01
3.	Ranging Rods		02
3.	Arrows		few
4.	Prismatic Compass		01

**Procedure: (Fig 2.1)**

1. Calculate the necessary data to construct the Rectangle in field using the following relations

$$\text{Sum of all Included Angle} = (2n - 4) 90^\circ/n$$

Where  $n$  = Number of sides

Each Included Angle = Sum of all Included Angle/ Number of sides

Deflection Angle =  $180^\circ$ - Included Angle

Bearing of any line = Fore bearing of previous line + Deflection Angle

Bearing of AB = Given

Bearing of BC = Bearing of AB + Deflection Angle

Bearing of CD = Bearing of BC + Deflection Angle

Bearing of DA = Bearing of CD + Deflection Angle

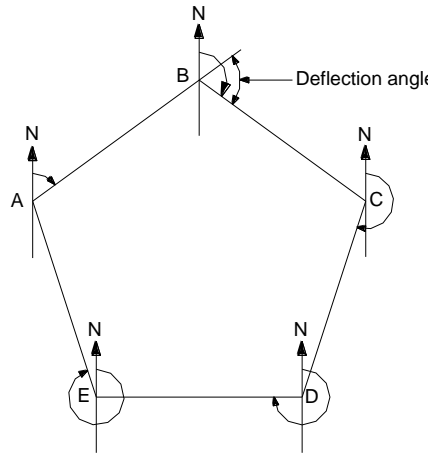
CHECK: Bearing of AB -  $360^\circ$  = Given Bearing of AB



2. Set the compass at A and set given bearing of AB by turning the compass, with the zero end of the tape pointed at A and an arrow held at a distance equal to length of AB, swing the tape around A till the arrow is bisected by the cross-hairs. Thus the point B is fixed.
3. Now shift the compass to other stations ( such as B , C and D ) and repeat the step-2 till the points C and D are fixed.
4. Join the points A, B, C and D. Thus the Rectangle is formed.

**Results:**





**Fig. 2.2 Construct of pentagon using compass**

**Aim:** To Construct Pentagon in the field using prismatic compass.

**Instruments used:**

<b>Sl. No.</b>	<b>Particulars</b>	<b>Specification</b>	<b>Quantity</b>
1.	Chain		01
2.	Tape		01
3.	Ranging Rods		02
3.	Arrows		few
4.	Prismatic Compass		01

**Procedure :( Fig 2.2)**

1. Calculate included interior angle using the following relation.

$$\text{Included interior angle} = \frac{(2n - 4)90^\circ}{n}$$

Where n = Number of sides

$$\text{Included Interior Angle} = 108^\circ$$

$$\begin{aligned}\text{Deflection Angle} &= 180^\circ - \text{Included Interior Angle} \\ &= 180 - 108 = 72^\circ\end{aligned}$$

$$\text{Bearing of AB} = 50^\circ$$

$$\text{Bearing of BC} = \text{Bearing of AB} + \text{Deflection Angle}$$

$$\text{Bearing of CD} = \text{Bearing of BC} + \text{Deflection Angle}$$

$$\text{Bearing of DE} = \text{Bearing of CD} + \text{Deflection Angle}$$

$$\text{Bearing of EA} = \text{Bearing of DE} + \text{Deflection Angle}$$

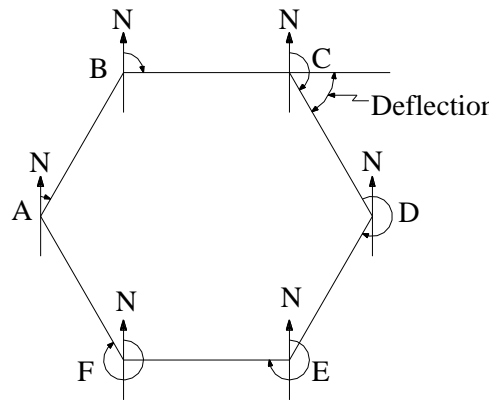


### **18CVL– 57 Surveying practice**

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2. Set the compass at A and set given bearing of AB. Fix the ranging rod along the bearing of AB at B at a distance 10m from A.
3. Now shift the compass to other stations such as B , C, D and E and repeat the step-2 to get points C, D and E respectively.
4. Join the points A, B, C, D and E. Thus the Pentagon is formed.

### **Results:**



**Fig. 2.3 Construct of hexagon using compass**

**Aim:** To Construct Hexagon in the field using prismatic compass.

**Instruments used:**

Sl. No.	Particulars	Specification	Quantity
1.	Chain		01
2.	Tape		01
3.	Ranging Rods		02
3.	Arrows		few
4.	Prismatic Compass		01

**Procedure: (Fig 2.3)**

1. Calculate included interior angle using the following relation.

$$\text{Included interior angle} = \frac{(2n - 4)90^\circ}{n}$$

Where n = Number of sides

$$\text{Included Interior Angle} = 120^\circ$$

$$\begin{aligned}\text{Deflection Angle} &= 180^\circ - \text{Included Interior Angle} \\ &= 180^\circ - 120^\circ = 60^\circ\end{aligned}$$

$$\text{Bearing of AB} = 50^\circ$$

$$\text{Bearing of BC} = \text{Bearing of AB} + \text{Deflection Angle}$$

$$\text{Bearing of CD} = \text{Bearing of BC} + \text{Deflection Angle}$$

$$\text{Bearing of DE} = \text{Bearing of CD} + \text{Deflection Angle}$$

$$\text{Bearing of EF} = \text{Bearing of DE} + \text{Deflection Angle}$$

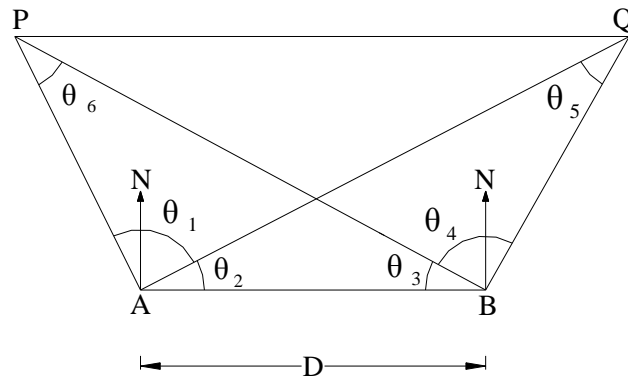
$$\text{Bearing of FA} = \text{Bearing of EF} + \text{Deflection Angle}$$



2. Set the compass at A and set given bearing of AB. Fix the ranging rod along the bearing of AB at B at a distance 10m from A.
3. Now shift the compass to other stations such as B , C, D, E and F and repeat the step-2 to get points C, D , E and F respectively.
4. Join the points A, B, C, D, E and F. Thus the Hexagon is formed.

**Result:**





**Fig. 3.1 Plan view of station points A & B and inaccessible points P & Q**

**DETERMINATION OF DISTANCE BETWEEN INACCESSIBLE POINTS**

**Aim:** To determine the distance between two inaccessible points by using chain and compass.

**Instruments used:**

Sl. No.	Particulars	Quantity
1.	Chain	01
2.	Tape	01
3.	Ranging Rods	03
3.	Arrows	Few
4.	Prismatic Compass	01

**Procedure: (Fig 3.1 )**

Set the compass over the station A and make temporary adjustments.

- (i) Establish a point B almost parallel to the line PQ at certain distance "D" from A such that the triangles formed are well conditioned.
- (ii) Measure the bearings of lines AP, AQ and AB bisecting the points P,Q and B.
- (iii) Shift the instrument to station B and measure the bearings of lines BA, BP and BQ by bisecting points A, P and Q.

Calculations: From measured bearings calculate the angles  $\theta_1$ ,  $\theta_2$ ,  $\theta_3$ ,  $\theta_4$ ,  $\theta_5$  and  $\theta_6$  using following equations

$$\theta_1 = \text{Bearing of line AQ} + (360 - \text{Bearing of line AP})$$

$$\theta_2 = \text{Bearing of line AB} - \text{Bearing of line AQ}$$

$$\theta_3 = \text{Bearing of line BP} - \text{Bearing of line BA}$$

$$\theta_4 = \text{Bearing of line BQ} + (360 - \text{Bearing of line BP})$$

$$\text{Now, in the triangle AQB, } \theta_5 = 180 - (\theta_2 + \theta_3 + \theta_4)$$



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In the triangle ABQ, applying sine rule,

$$\text{Distance AQ} = \text{AB} * \sin (\theta_3 + \theta_4) / \sin \theta_5$$

In the triangle ABP,  $\theta_6 = 180 - (\theta_1 + \theta_2 + \theta_3)$

$$\text{Distance AP} = \text{AB} * \sin \theta_3 / \sin \theta_6$$

Lastly, from the triangle APQ, applying cosine rule,

$$PQ = \sqrt{AP^2 + AQ^2 - 2 \times AP \times AQ \times \cos \theta_1}$$

**Results:**

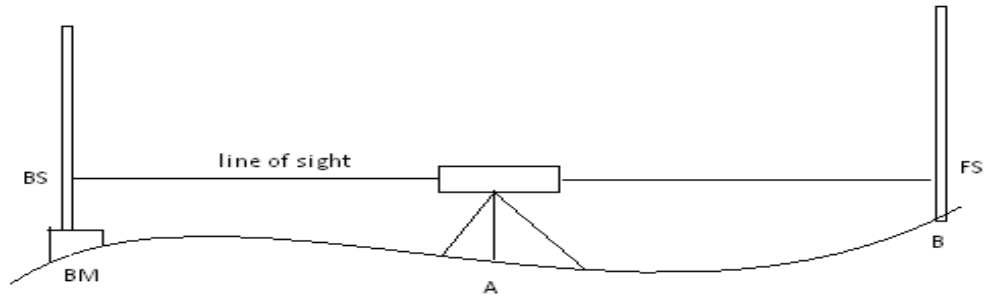


Fig. 4.1 Simple Leveling

**Observations and tabulations:**

**Simple leveling**

Station	B. S.	F. S.	H.I	R. L.	Remarks
					B.M.
	$\Sigma$ B.S.	$\Sigma$ F.S			

**Experiment No : 4****Date:** \_\_\_ / \_\_\_ / \_\_\_**SIMPLE LEVELING****Aim:** To determine the reduced level of points using dumpy level**Instruments used:**

<b>Sl. No.</b>	<b>Particulars</b>	<b>Quantity</b>
1.	Dumpy level	01
2.	Tripod	01
3.	Levelling Staff	01

**Procedure:**

1. The instrument is set up at a convenient point A (Fig 4.1), and back sight is taken on the staff held on the temporary bench mark of assumed RL. The height of the instrument is determined by adding BS reading to the RL of TBM.
2. The staff is now kept at the destination point and reading is taken. This reading is entered in FS column.
3. Arithmetic check is made using the following equation.

$$\Sigma \text{B.S.} - \Sigma \text{F.S.} = \text{Last R.L.} - \text{First R.L.}$$

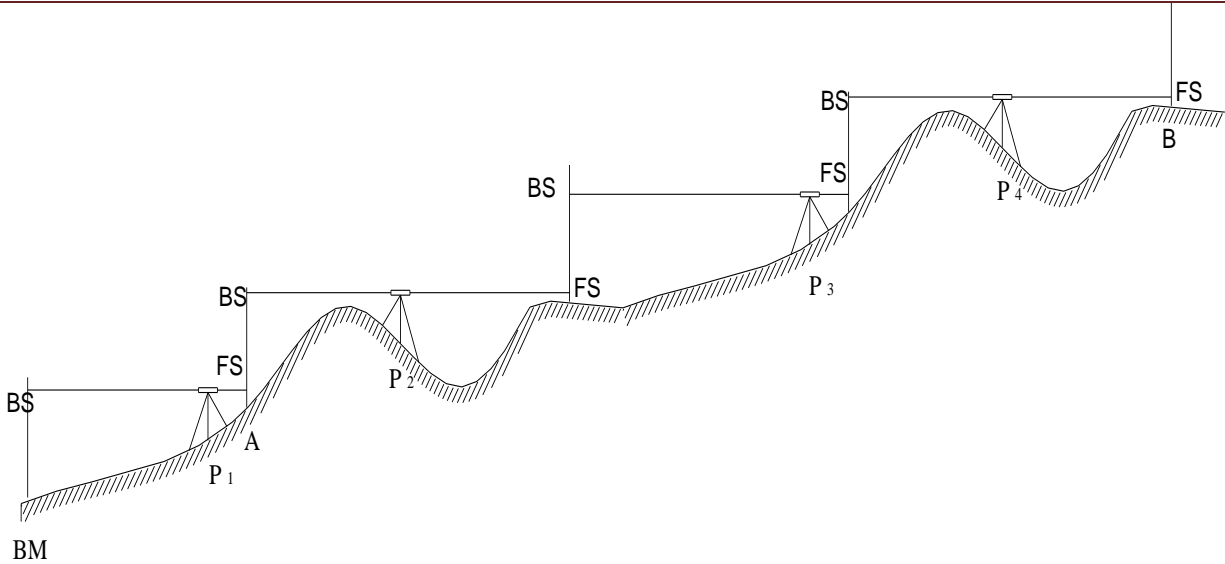


Fig. 5.1 Differential leveling.

Station	B. S.	I. S.	F. S.	H.I	R. L.	Remarks
						B.M.
	$\Sigma$ B.S.		$\Sigma$ F.S			

**DIFFERENTIAL LEVELING**

**Aim:**To determine difference in elevation between two points using differential leveling

**Instruments used:**

<b>Sl. No.</b>	<b>Particulars</b>	<b>Quantity</b>
1.	Dumpy level	01
2.	Tripod	01
3.	Levelling Staff	01

**Procedure:**

1. The instrument is set up at a convenient point  $P_1$ (Fig 5.1) and back sight is taken on the staff held on the temporary bench mark of assumed RL. The height of the instrument is determined by adding BS reading to the RL of TBM.
2. The staff reading is taken at the starting point and is entered in fore sight column. The R.L. of the starting point is determined by subtracting staff reading from height of the instrument.

$$\text{R.L. of starting point} = \text{Height of the instrument} - \text{Fore sight}$$

3. The instrument is shifted to the position  $P_2$  and staff reading is taken at starting point and is entered in back sight column in level with fore sight reading from previous station in the level book. The new height of the instrument is determined.
4. Above procedure is repeated for rest of the points.
5. Arithmetic check is made using the following equation.

$$\sum \text{B.S.} - \sum \text{F.S.} = \text{Last R.L.} - \text{First R.L.}$$



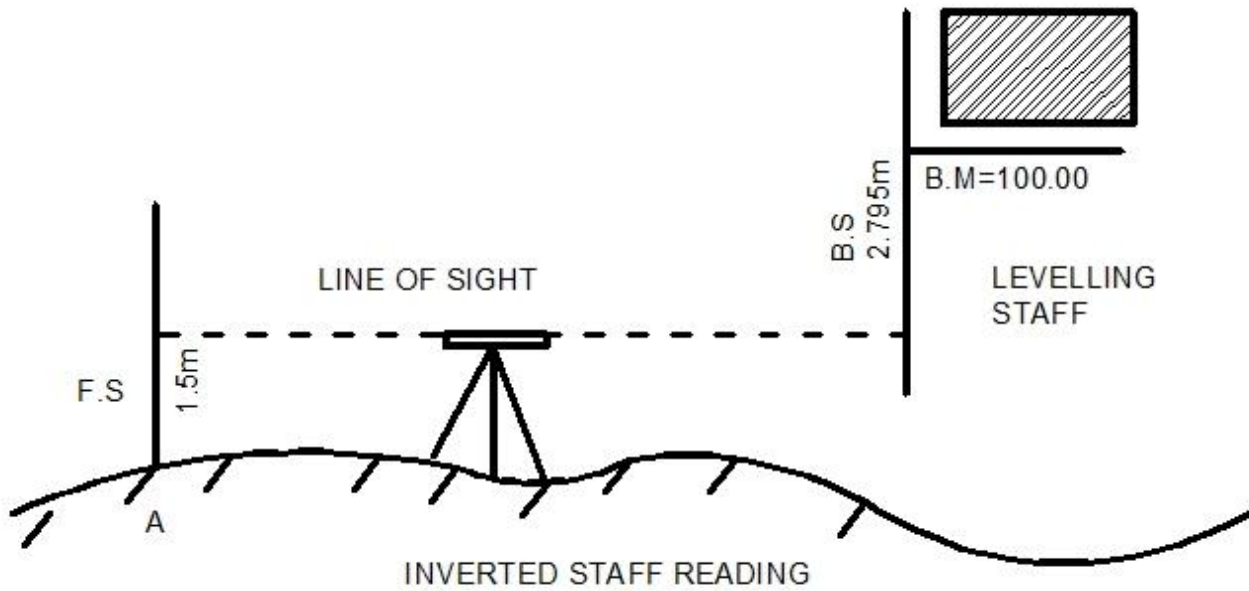


Fig. 5.2 Inverted leveling.

SI No	Back Sight (BS)	Intermediate Sight (IS)	Fore Sight (FS)	Height of the Instrument (HI)	Reduced Level (RL)	Remarks

**INVERTED LEVELING**

**Aim:** To Determination the RL of an object above the plane of collimation using inverted leveling.

**Instruments used:**

Sl. No.	Particulars	Quantity
1.	Dumpy level	01
2.	Tripod	01
3.	Levelling Staff	01

**Theory:** When the B.M of staff station is above the line of collimation (or line of sight) the staff is held inverted on the point and reading is taken .This reading being negative is entered in the level field book with minus sign, or to avoid confusion, 'Staff inverted' should be written in the remarks column against the entry of the reading. (fig. 5.2)

**Procedure:**

1. Setup the tripod at the convenient plane surface & fix the dumpy level on it.
2. Temporary adjustments are done and the instrument is leveled by using the bubble tube.
3. After leveling the instrument, the leveling staff is held on the given bench mark which is above the line of sight. Here the staff is held inverted as the object lies above the line of sight of the instrument.
4. The reading is entered in BS column with a negative sign.
5. Required numbers of intermediate staff readings are taken in the direction of last point.
6. The RL of the given point is calculated by plane of collimation method.

**Result:**

The RL of the given point with respect to the bench mark which is above the line of sight is \_\_\_\_\_

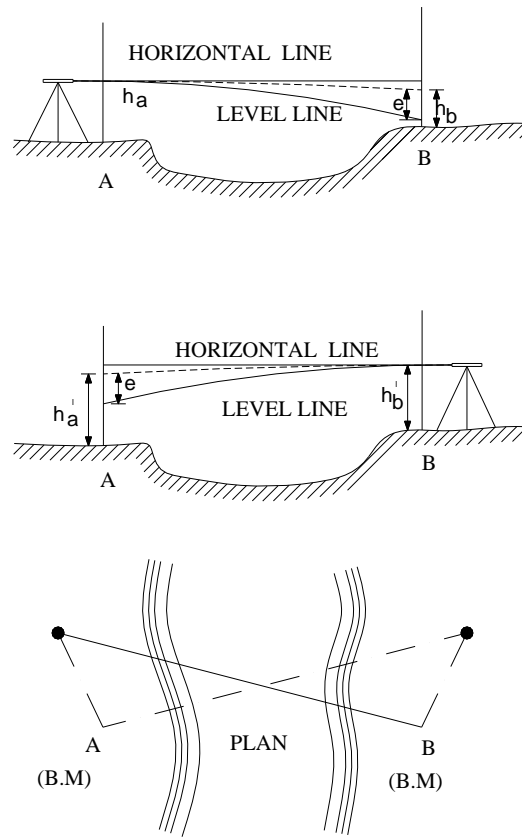


Fig. 6.2 Reciprocal leveling.

Tabulations and Calculations:

Instrument at	Staff reading on		Remarks
<b>A</b>			
<b>B</b>			

**RECIPROCAL LEVELING**

**Aim:** To determine the difference in elevation between two points using reciprocal leveling and determination of collimation error.

**Theory:** When it is necessary to carry leveling across a river or any other obstacle requiring a long sight between two points so situated that no points for the level is found in between them, in that cases reciprocal leveling may be used (if the width of is small) to obtain accuracy and to eliminate the following:

1. Error in the instrument adjustment;
2. Combined effect of earth's curvature and the refraction of the atmosphere; and
3. Variation in the average refraction.

Let A and B be the points on the opposite banks of a river. The following procedure is used.

**Instruments used:**

<b>Sl. No.</b>	<b>Particulars</b>	<b>Quantity</b>
1.	Dumpy level	01
2.	Tripod	01
3.	Levelling Staff	01

**Procedure:**

1. Drive pegs at A and B. Set up the instrument near the peg A. Take readings  $h_a$  and  $h_b$  on the staffs held at A and B respectively. The reading  $h_a$  will have to taken through the objective if instrument is very near to A.
2. Shift the instrument to near the peg B. Take readings  $h_a^1$  and  $h_b^1$  on the staffs held at A and B respectively. The reading  $h_b^1$  will have to taken through the objective if instrument is very near to B.



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3. Determine the true difference in elevation using following relation

$$\text{True Difference in elevation} = \frac{1}{2} [(h_a^1 - h_b^1) + (h_a - h_b)]$$

4. Determine the total error **e** using following relation

$$\mathbf{e} = \frac{1}{2} [(h_a^1 - h_b^1) - (h_a - h_b)]$$

The total error can be expressed as

$$e = e_l + e_c - e_r$$

where  $e_l$  = collimation error, assumed positive when the line of collimation is inclined upwards

$$e_c = \text{error due to curvature} = - 0.0785 d^2$$

$$e_r = \text{error due to refraction} = 0.0112 d^2$$

$d$  = distance between two points A and B

5. Determine the collimation error **e<sub>l</sub>** using following relation

$$e_l = e - 0.0673 d^2$$

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SL No	BS	IS	FS	HI	Distance			RL	Remarks
					Left	Center	Right		

**PROFILE AND CROSS SECTION LEVELING**

**Aim:**To conduct profile leveling and cross sectioning, plotting using excel

**Theory:** It is the operation to determine the elevations of points, which are equally spaced along a given alignment to know the profile of the ground. The purpose of profile levelling is to determine the depth of cut or height of embankment for a given gradient selected. It is very useful for projects like constructions and design of sewers, pipelines, Highways, Railways, Canals, etc.

**Instruments used:**

<b>Sl. No.</b>	<b>Particulars</b>	<b>Quantity</b>
1.	Dumpy level	01
2.	Tripod	01
3.	Levelling Staff	01
4	Chain	01
5	Tape	01
6	Compass	01
7	Arrows	few
8	Ranging rods	few

**Procedure:** Following procedure is adopted in Profile leveling along a given alignment.

1. Lay the chain on the ground and stretch it.
2. Locate the points on the chain line at equal distance in the longitudinal direction and transverse direction using cross staff.
3. Setup the tripod at the convenient plane surface & fix the dumpy level on it.
4. Temporary adjustments are done and the instrument is leveled by using the bubble tube.



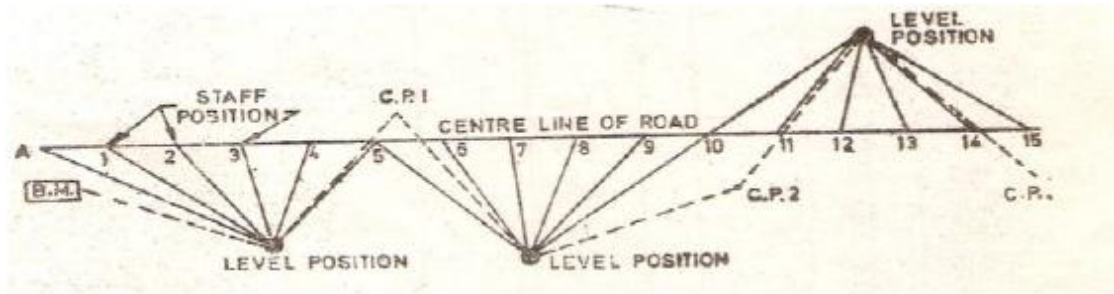


Fig. 7.1 Profile leveling.

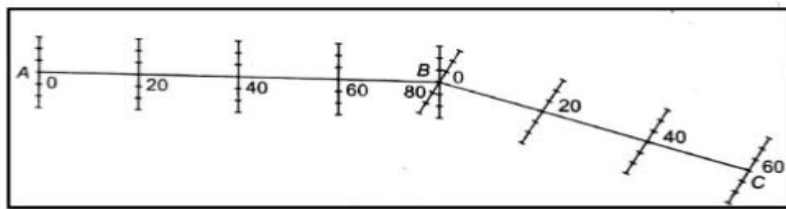


Fig. 7.2 Cross-sectional leveling.

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5. After leveling the instrument, the leveling staff is held on the given bench mark.
6. Take the levels at the marked points on the chain line along the longitudinal and  
and transverse direction and enter the readings in respective columns.
7. Shift the level if required. The procedure is repeated until we reach the last point.
8. The longitudinal and cross sections of the ground are plotted using excel.

		<b>20</b>	
		<b>15</b>	
		<b>10</b>	
		<b>5</b>	
<b>10</b>	<b>5</b>	<b>0</b>	<b>5</b>
			<b>10</b>

Position of anchor point	Initial Reading	Final Reading	Value of N	Remark

**BLOCKLEVELING**

**Aim:** To conduct block leveling, preparation of contour plan using excels. Use of planimeter/graph and computations of Areas and volumes.

**Instruments used:**

<b>Sl. No.</b>	<b>Particulars</b>	<b>Quantity</b>
1.	Dumpy level	01
2.	Tripod	01
3.	Levelling Staff	01
4	Chain	01
5	Tape	01
6	Compass	01
7	Arrows	few
8	Ranging rods	few

**Theory: CONTOURING:** The elevation and depression 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.

**Procedure:**

1. Lay the chain on the ground and stretch it.
2. Locate the points on the chain line at equal distance in the longitudinal direction and transfers direction.
3. Setup the tripod at the convenient plane surface & fix the dumpy level on it.
4. Temporary adjustments are done and the instrument is leveled by using the bobble tube.
5. After leveling the instrument, the leveling staff held on the given bench mark.
6. Divide the total area into number of blocks having equal area.
7. The corners of the blocks are marked with arrows.
8. The elevations of the ground at the corners of squares are taken and enter in to tabular columns

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SL No	BS	IS	FS	HI	Distance			RL	Remarks
					Left	Center	Right		

9. The systems of squares are potted on the drawing sheet. The respective RL shall be entered near each respective corners.
10. The contour of required RL's are plotted.

**LOCATING CONTOURS:**

This method is commonly used in rough survey, cross sections are run traverse to the contour line of road, and railway as canal and the point of change of slope (representations) are located. The cross-section line may be inclined at any angle To the centerline if necessary. The spacing of the cross sections depends upon the characteristics of the ground.

By interpolation of contour is meant the process of spacing the contour proportioning between the plotted ground points. Contour may be interpolated by

- 1) Estimation
- 2) Arithmetical calculations
- 3) Graphical method .in all these methods

It is assumed that the slope of the ground between any two random points is uniform.

**RESULT:**The contour of given land is drawn in excel sheet.

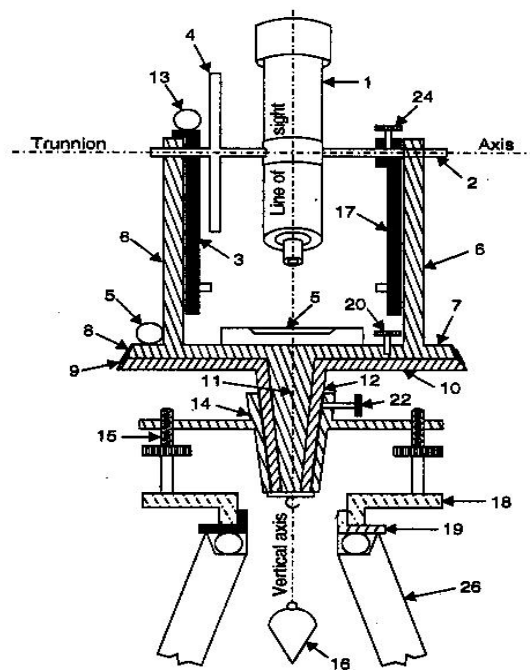
## INTRODUCTION ON THEODOLITE

**Theodolite** is a survey instrument widely used in survey for its capability of being employed in the very accurate determination of horizontal and vertical angles.

There are two types of theodolite, namely:

- 1) Transit theodolite.
- 2) Non-transit theodolite.

**Transit theodolite:** A transit theodolite is one in which the line of sight is reversed by revolving the telescope through  $180^\circ$  in the vertical plane. This complete revolution is known as transit theodolite.



**Transit theodolite**

### **Non-Transit theodolite:**

A non-transit theodolite is either plain theodolite or Y- theodolite in which the telescope can not be rotated in a vertical plane through complete revolution. The transit is mainly used & non-transit theodolite is now become absolute.

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The transit theodolite contains the following parts,

- |                    |                       |
|--------------------|-----------------------|
| 1. Telescope       | 12. foot screw        |
| 2. Clamp screw     | 13. trivet            |
| 3. Focussing screw | 14. tripod stand      |
| 4. Horizontal axis | 15. wing nut          |
| 5. tangent screw   | 16. plumb bob         |
| 6. standard        | 17. plate bubble      |
| 7. upper plate     | 18. index bar         |
| 8. Lower plate     | 19. tabular compass   |
| 9. inner axis      | 20. altitude bubble   |
| 10. outer axis     | 21. adjustable mirror |
| 11. Tribbranch     | 22. vertical circle   |

**Trivet:** It is a circular plate having a central threaded hole for fixing the theodolite on the tripod stand by a wingnut. It is also called the base plate. Three foot screws are secured to this plate by means of a ball and socket arrangement.

**Foot screws:** These are meant for levelling the instrument. The lower part of the foot screws are secured in the trivet by means of a ball and socket arrangements and the upper threaded part passes through the threaded hole in the tribbranch plate.

**Levelling head:** The trivet, foot screws and the tribbranch constitute a body which is known as the levelling head.

**Spindles:** The theodolite consists of two spindles or axes, one inner and the other outer. The inner axis is solid and conical and the outer is hollow. Two spindles are co-axial.

**Lower plate:** The lower plate is attached to the outer axis and is also known as the scale plate. It is bevelled and the scale is graduated from  $0^\circ$  to  $360^\circ$  in a clockwise direction. Each degree is again subdivided into two, three or four divisions. Thus the value of one small division may be 30, 20 & 15 respectively.

The lower plate is provided with a clamp screw and a tangent screw which control its movements when the clamp screw is tightened. This plate is fixed with the outer axis for fine adjustment of the



lower plate. The tangent screw is rotated to the extent required the size of the theodolite is designated according to the diameter of the lower plate.

**Upper plate:**The upper plate contains the vernier scales A & B. it is attached to the inner axis. Its motion is controlled by the upper clamp screw and upper tangent screw. When the clamp screw is tightened the vernier scales are fixed with the inner axis and for fine adjustment of the scale the tangent screw is rotated.

**Plate bubble :**Two plate bubbles are mounted at right angle to each other on the upper surface of the vernier plate. one bubble is kept parallel to the horizontal axis of the theodolite sometimes one plate bubble is provided on the vernier plate. The bubble is provided on the vernier plate the bubbles are meant for levelling the instrument at the times of measuring the horizontal angles.

**Standard or A-frame:**Two frames (shaped like the letter A) are provided on the upper plate to support the telescope, the vertical circle and the vernier scales. These frames are known as standards or A frames.

**Telescope:**The telescope is provided between the standards at right angles to the horizontal axis it can be rotated about its horizontal axis in a vertical plane. The telescope is provided with a focussing screw clamping screw and tangent screw.

**Vertical circle:**The vertical circle is rigidly fixed with the telescope and moves with it. It is divided in to four quadrant, each quadrant is graduated from 0 90 in opposite direction with the zero mark at the ends of the horizontal diameter through vertical circle.

The line joining the zero marks corresponding to the collimation. The sub divisions of the vertical circle are similar to these of the horizontal circle. The vertical circle can be clamped or finely adjusted with the help of the clamping screw and the tangent screw provided along with the telescope

**Index bar or T-frame:**The index bar is provided on the standard in front of the vertical circle. It carries two verniers(C&D) at the two ends of the horizontal arm the vertical leg of the index bar is provided with a clip screw at the lower end by means of which the altitude bubble can be brought to the centre.

**Altitude bubble:**A long sensitive bubble tube is provided on the top of index bar, the bubble it contains is known as the altitude bubble. This bubble is brought to the centre by the clip screw at the

time of measuring the vertical angle. A mirror is provided on the top of the bubble to help observe it when the instrument is set up above normal height.

**Compass:** Some times a circular box compass is mounted on the vernier scale between the standard in modern theodolites, an adjustable through compass or tabular compass can be fitted with a screw to the standard. The compass is provided for taking the magnetic bearing of a line.

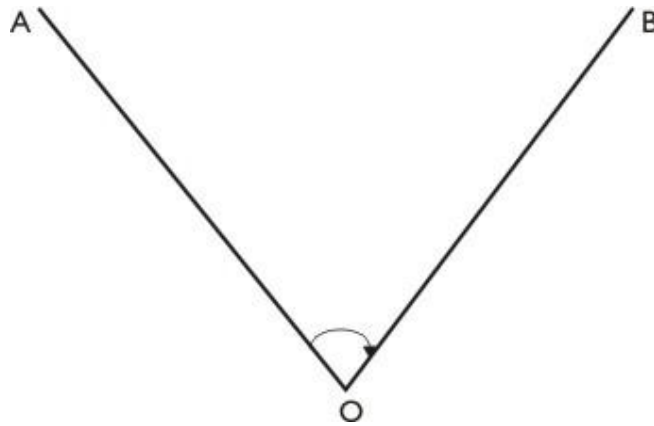


Fig: 8.1 Method of repetition

Instrument station	Sighted To	Face Left			Swing Right				No Of Repetitions	Face Right			Swing Right				No Of Repetitions	Horizontal Angle			Average Horizontal Angle
		A	B	Mean	Horizontal Angle	A	B	Mean		Horizontal Angle											
		o	'	"	o	'	"	o		'	"	o	'	"	o	'		"	o	'	
	A																				
	B																				
	A																				
	B																				

**Experiment No. 8****Date:** \_\_ / \_\_ / \_\_**MEASUREMENT OF HORIZONTAL ANGLES****Exercise 8.1 Method of Repetition****Aim:** To measure the horizontal angles AOB w.r.t O by the method of repetition**Instruments used:**

<b>Sl. No.</b>	<b>Particulars</b>	<b>Quantity</b>
1.	Theodolite	01
2.	Tripod	01
3.	Ranging Rods	02

**Theory:** Method of repetition is used to measure a horizontal angle to a finer degree of accuracy that is obtainable with the least count of the vernier. In this method, the angle is measured 2 or more times by allowing the vernier to remain clamped each time at the end of each measurement instead of setting it back to zero. Thus, an angle reading is added several times depending upon the number of repetitions. The average horizontal is then obtained by dividing the final reading by the number of repetitions.

**Procedure:**

1. Set up the instrument at O and level accurately
2. Adjust the plates such that the vernier A reads zero (vernier B shall read  $180^\circ$  if there is no instrumental error). Bring the vertical circle to the left of the telescope.
3. Loose the lower clamp and turn the instrument towards A. Bisect A accurately using the lower tangent screw. (There shall be no change in readings as the upper plate is clamped).
4. Unclamp the upper clamp and rotate the instrument in the clockwise direction to bisect B. Clamp the upper clamp and use the upper tangent screw to bisect B accurately. Note the reading of vernier A & B to get the approximate value of angle AOB
5. Unclamp the lower clamp and turn the telescope clockwise to sight A again. Bisect A accurately using the lower tangent screw. The vernier readings will not change as the upper plate is clamped.



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6. Unclamp the upper clamp and rotate the instrument in the clockwise direction to bisect B. Clamp the upper clamp and use the upper tangent screw to bisect B accurately.
7. Repeat the process till the angle is repeated the required number of times.
8. Change the face by transiting the telescope and repeat the whole process for the other face readings
9. The average horizontal angle is then obtained by taking the mean of the two readings with different faces

**RESULTS:- The average horizontal angle = \_\_\_\_\_**

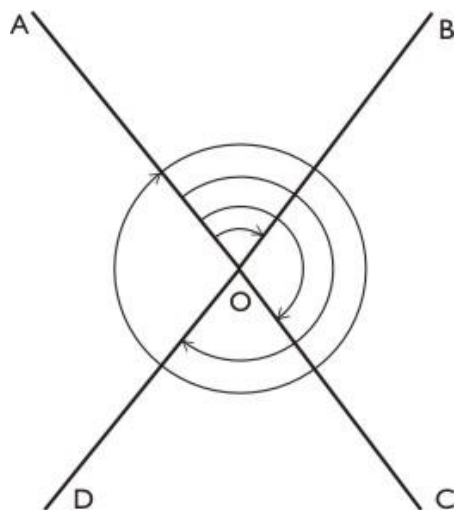


Fig 8.2 Method of Reiteration

Instrument station	Sighted To	Face Left			Swing Right				Face Right			Swing Right				Average Horizontal Angle																			
		A			B		Mean		No Of Reiterations	Horizontal Angle		A			B				Mean		No Of Reiterations	Horizontal Angle													
		o	'	"	'	"	o	'		"	o	'	"	o	'	"	'	"	o	'		"	o	'	"	o	'	"	o	'	"				

**Exercise No. 8.2**

Date: \_\_ / \_\_ / \_\_

**Aim:** To measure the horizontal angles AOB, BOC, COD etc by the method of reiteration**Instruments used:**

Sl. No.	Particulars	Specification	Quantity
1.	Theodolite		01
2.	Tripod		01
3.	Ranging Rods		04

**Theory:** This method is suitable for measurements of the angles of a group having a common vertex point. Several angles are measured successively and finally the horizon is closed (closing the horizon is the process of measuring the angles around a point to obtain a check on their sum, which should be  $360^\circ$ )

**Procedure:**

1. Set up the instrument at O and level accurately
2. Adjust the plates such that the vernier A reads zero (vernier B shall read  $180^\circ$  if there is no instrumental error). Bring the vertical circle to the left of the telescope.
3. Loose the lower clamp and turn the instrument towards A (or any other reference point). Bisect A accurately using the lower tangent screw.
4. Unclamp the upper clamp and rotate the instrument in the clockwise direction to bisect B. Clamp the upper clamp and use the upper tangent screw to bisect B accurately. Note the reading of vernier A & B the mean of the vernier readings will give angle AOB
5. Similarly bisect C and D successively, thus closing the circle. Each included angle is obtained by taking the difference between two consecutive readings
6. On the final sight to A, the reading of the vernier should be either  $0^\circ$  or  $360^\circ$ . If not note the vernier readings and find the error due to slip, and if the error is small distribute it equally to all the angles. If large repeat the procedure and take fresh readings.
7. Repeat the step with the other faces

**Results: The average horizontal angle**

AOB = \_\_\_\_\_ BOC = \_\_\_\_\_ COD = \_\_\_\_\_ DOA = \_\_\_\_\_



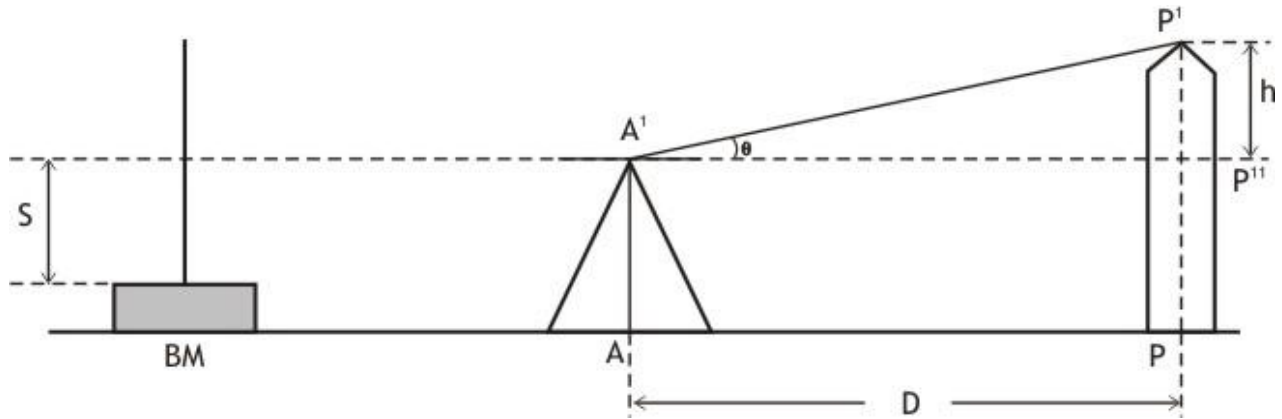


Fig 9.1 Single plane method (Base accessible)

Instrument At	Sighted To	Face : Left				Face : Right				Average vertical Angle			
		C	D	Mean	Vertical Angle	C	D	Mean	Vertical Angle				
		o ' "	' "	o ' "	o ' "	o ' "	' "	o ' "	o ' "				
A	P'												

Date: \_\_ / \_\_ / \_\_

**VERTICAL ANGLE****Exercise No. 8.3 SINGLE PLANE METHOD****Aim:** To determine the elevation of an object using single plane method when base is accessible**Instruments used:**

<b>Sl. No.</b>	<b>Particulars</b>	<b>Quantity</b>
1.	Theodolite	01
2.	Tripod	01
3.	Ranging Rods	few
4.	Tape	01
5	Leveling staff	01

**Theory:** The method is said to be a single plane method when the instrument station are in the same vertical plane as that of the elevated object**Procedure:**

1. Identify the object whose elevation is to be determined
2. Identify the BM and record the RL of BM
3. Set up the instrument at station A and perform the temporary adjustments
4. Take the staff reading on BM keeping the telescope horizontal (vernier C and D reading zero)
5. Focus the telescope to the top of the object (P') and measure the angle of elevation  $\theta$  (take face left and face right observations)
6. Measure the distance D accurately



**Calculations:**

Let A = Instrument station

A' = Centre of the instrument

P' = Point to be observed

P'' = Projection of P'

h = P''P'

s = Reading of staff kept on BM with line of sight horizontal

$\theta$  = Angle of elevation from A' to P'

h' = PP''

consider triangle A'P'P''

$$\tan\theta = h/D$$

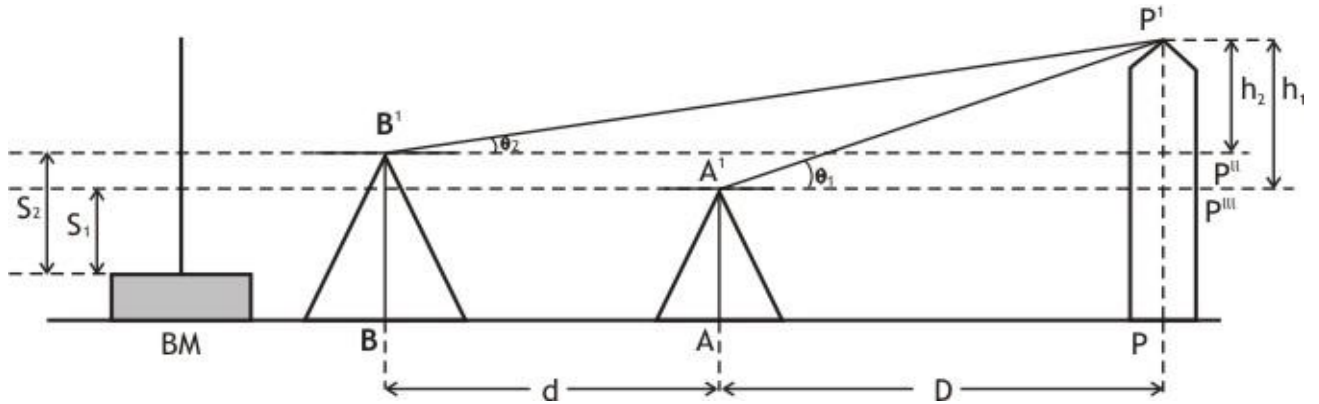
Therefore h = D tan $\theta$

$$\text{RL of P}' = \text{RL of BM} + s + D \tan\theta$$

The height of the object = h' + h

1. Staff reading s = \_\_\_\_\_m
2. Angle of elevation  $\theta$  = \_\_\_\_\_ (average of both the face values)

**Results: Level of top of the object when the base is accessible = \_\_\_\_\_m**



**Fig 9.4 single plane method (base Inaccessible)**

Instrument At	Sighted To	Face : Left								Face : Right								Average vertical Angle				
		C		D		Mean		Vertical Angle		C		D		Mean		Vertical Angle						
		o	'	"	'	"	o	'	"	o	'	"	o	'	"	o	'	"	o	'	"	
A	P'																					
B	P'																					

**Exercise No. 9.1**

**Aim:** To determine the elevation of an object using **single plane method** when base is **inaccessible**

**Instruments used:**

<b>Sl. No.</b>	<b>Particulars</b>	<b>Quantity</b>
1.	Theodolite	01
2.	Tripod	01
3.	Ranging Rods	few
4.	Tape	01
5	Leveling staff	01

**Case 1 : when the instrument station near the object is at lower elevation than the other**

Let  $h_1 = P''P'$

$h_2 = P'''P'$

$s_1$  = Reading of staff kept on BM from instrument station A

$s_2$  = Reading of staff kept on BM from instrument station B

$\theta_1$  = Angle of elevation from A' to P'

$\theta_2$  = Angle of elevation from B' to P'

$d$  = Horizontal distance between two instrument stations

$D$  = Horizontal distance between A and P

Considering triangle A'P'P''

$$\tan \theta_1 = h_1/D$$

$$h_1 = D \tan \theta_1 \rightarrow \mathbf{(1)}$$

Considering triangle B'P'P'''

$$\tan \theta_2 = h_2/(d+D)$$



$$h_2 = (d+D) \tan \theta_2 \rightarrow (2)$$

From (1) & (2)

$$D = (d \tan \theta_2 \pm s) / (\tan \theta_1 - \tan \theta_2) \rightarrow (3)$$

RL of P' from A = RL of BM + s<sub>1</sub> + h<sub>1</sub>

**Check:** RL of P' from B = RL of BM + s<sub>2</sub> + h<sub>2</sub>

s is +ve when station A is lower than B

s is -ve when station A is higher than B

**Procedure:**

1. Identify the object whose elevation is to be determined
2. Set up the instrument at station A and perform the temporary adjustments. Take the staff reading on BM keeping the telescope horizontal as s<sub>1</sub> (vernier C and D reading zero)
3. Focus the telescope to the top of the object (P') and measure the angle of elevation  $\theta_1$  (take face left and face right observations)
4. Transit the theodolite to reverse the line of sight and fix a point B at a measured distance d.
5. Shift the instrument to B and perform the temporary adjustments. Take the staff reading on BM keeping the telescope horizontal as s<sub>2</sub> (vernier C and D reading zero)
6. Focus the telescope to the top of the object (P') and measure the angle of elevation  $\theta_2$  (take face left and face right observations)

**Results:**

**RL of P' = \_\_\_\_\_m**



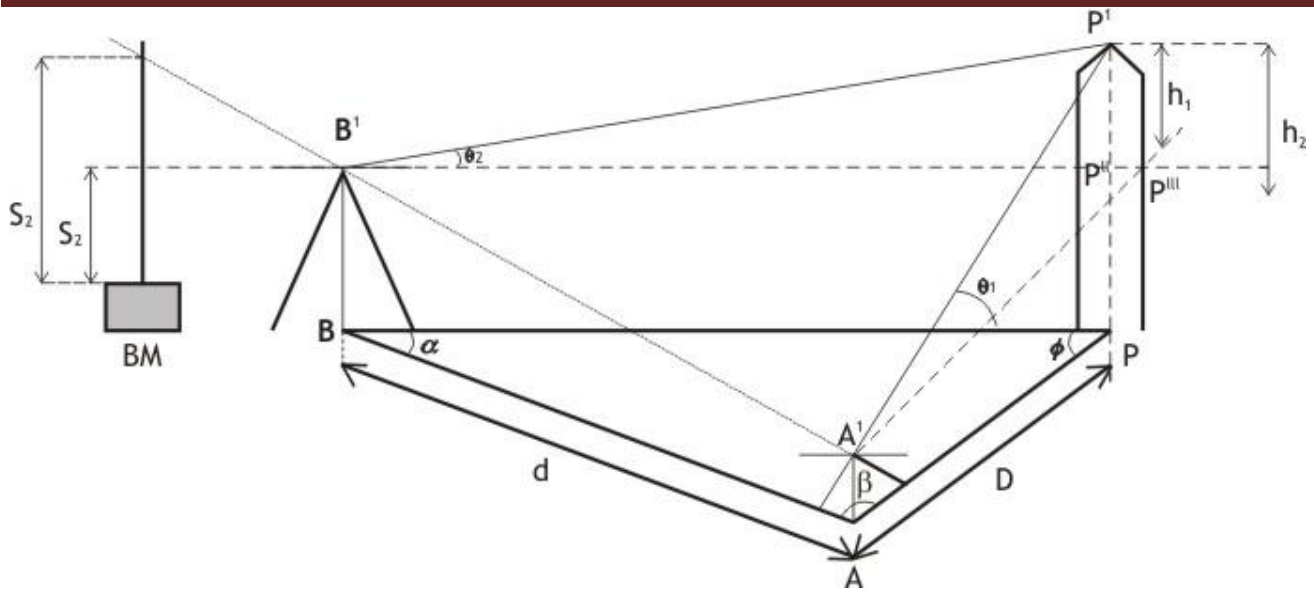


Fig:9.5 Double Plane Method

Instrument At	Sighted To	Face : Left				Swing : Right				Face : Right				Swing : Right				Average			
		A		B		Mean		Horizontal Angle	A		B		Mean		Horizontal Angle	Horizontal Angle					
		o	'	"	'	"	o		'	"	o	'	"	o		'	"	o	'	"	

**DOUBLE PLANE METHOD****Exercise No. 9.2**

**Aim:** To determine the distance and difference in elevation between two inaccessible points using double plane method.

**Instruments used:**

Sl. No.	Particulars	Specification	Quantity
1.	Theodolite		01
2.	Tripod		01
3.	Ranging Rods		few
4.	Tape		01
5	Levelling staff		01

**Theory:** Method is said to be double plane when the instrument stations are not in same vertical plane as that of elevated objects

Let A & B = Instrument stations

P = Base of the object

$\alpha_1$  = Angle of elevation from A' to P'

$\alpha_2$  = Angle of elevation from B' to P'

s1 = Reading of staff kept on BM from instrument station A

s2 = Reading of staff kept on BM from instrument station B

Considering triangle ABP

We have

$\alpha$  &  $\beta$  = Known(measured)

Instrument At	Sighted To	Face : Left												Face : Right												Average vertical Angle								
		C			D			Mean			Vertical Angle			C			D			Mean			Vertical Angle											
		o	'	"	'	"		o	'	"	o	'	"	o	'	"	'	"		o	'	"	o	'	"		o	'	"	o	'	"		
A	P'																																	
B	P'																																	

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Therefore  $\phi = (180 - \alpha - \beta)$

Applying sine rule

$$AP/\sin \alpha = BP/\sin \beta = AB/\sin \phi$$

But  $AB = d$

Therefore

$$AP = d \sin \alpha / \sin \phi, \quad BP = d \sin \beta / \sin \phi$$

To determine the elevation of  $P'$

$$RL \text{ of } P' = RL \text{ of BM} + s_1 + AP \tan \theta_1$$

$$RL \text{ of } P' = RL \text{ of BM} + s_2 + BP \tan \theta_2$$

### Procedure:

1. Set up the theodolite at A and measure distance  $d$  accurately to mark B
2. Measure angle BAP ( $\beta$ )
3. Sight  $p'$  and measure the vertical angle  $\theta_1$
4. With the telescope horizontal take the staff reading  $s_1$  on the BM
5. Shift the instrument to station B and measure the horizontal angle PBA ( $\alpha$ )
6. Sight  $P'$  and measure the vertical angle  $\theta_2$
7. With the telescope horizontal take staff reading  $s_2$  on the BM

**Results: RL of to of the object = \_\_\_\_\_m**

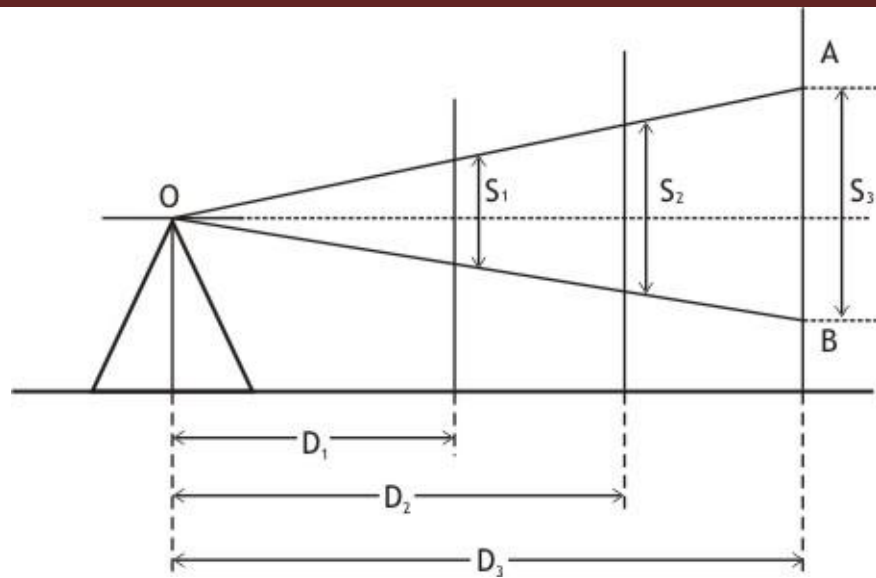


Fig: 9.1

Distance	Staff Reading		Staff Intercept	Multiplying Constant K	Additive Constant C
	Upper Hair (m)	Lower Hair (m)			

**TACHEOMETRY****Exercise No. 10.1**

**Aim:** To determine the tacheometric constants using horizontal line of sight.

**Instruments used:**

Sl. No.	Particulars	Specification	Quantity
1.	Theodolite		01
2.	Tape		01
3.	Ranging Rods		03
4.	Arrows		few
5.	Leveling staff		01
6.	Chain		01

**Procedure:**

1. Measure a total distance of 80m on the ground and put pegs at 20m interval (on a fairly level ground)
2. Set the tacheometer at the zero chain age and do the temporary adjustments
3. Take the stadia readings keeping the levelling staff at 20m, 40m, 60m and 80m keeping the telescope horizontal thought

**Calculations:**

$$D_1 = Ks_1 + C$$

$$D_2 = Ks_2 + C \dots \text{so on}$$

Solving any 2 equations we get set of K & C values.

**Results:** Average value of the tacheometric constants

$$K = \underline{\hspace{2cm}}$$

$$C = \underline{\hspace{2cm}}$$

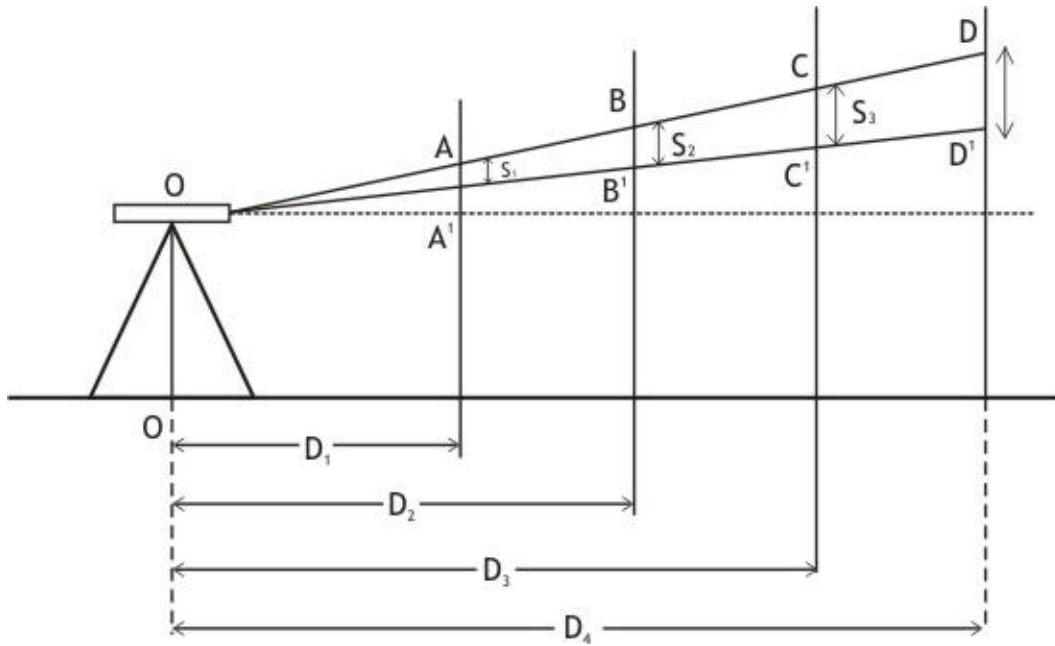


Fig4.2

Distance	Staff Reading		Staff Intercept	Multiplying Constant K	Additive Constant C
	Upper Hair (m)	Lower Hair (m)			

**Aim:** To determine the tacheometric constants using inclined line of sight.

**Instruments used:**

<b>Sl. No.</b>	<b>Particulars</b>	<b>Specification</b>	<b>Quantity</b>
1.	Theodolite		01
2.	Tape		01
3.	Ranging Rods		03
4.	Arrows		few
5.	Leveling staff		01
6.	Chain		01

**Procedure:**

1. Measure a total distance of 80m on the ground and put pegs at 20m interval (on a fairly level ground)
2. Set the tacheometer at the zero chainage and do the temporary adjustments
3. Fix the telescope to some angle and take the stadia readings keeping the levelling staff at 20m, 40m, 60m and 80m.

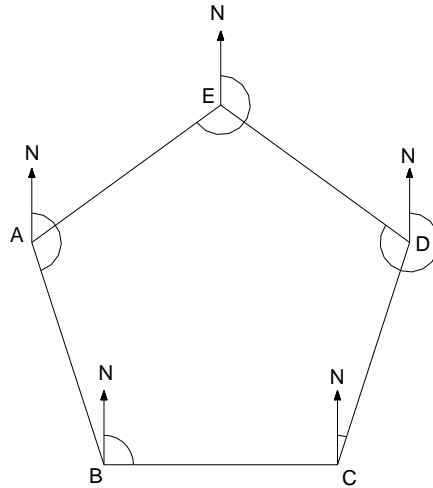
**Calculations:**

$$D_1 = Ks_1 \cos^2 \theta + C \cos \theta$$

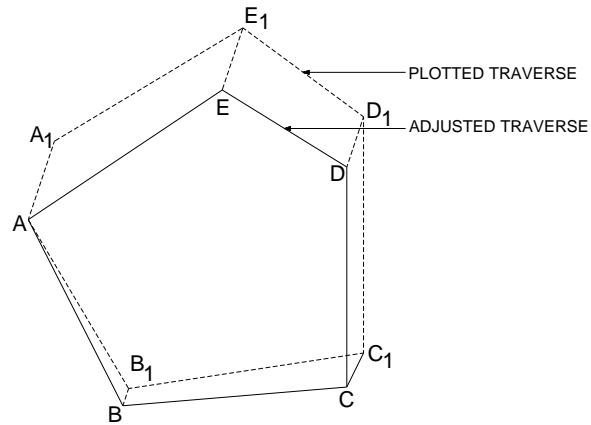
$$D_2 = Ks_2 \cos^2 \theta + C \cos \theta \dots \text{so on}$$

Solving any 2 equations we get set of K & C values.





**Fig. 11.1 Compass traverse**



**Fig. 11.2 Plotted and adjusted traverse**

**COMPASS SURVEYING**

**Aim:** Measurement of bearings of a Closed traverse surveying using Theodolite and applying corrections for error of closure by transit rule and Bowditch rule.

**Instruments used:**

<b>Sl. No.</b>	<b>Particulars</b>	<b>Quantity</b>
1.	Chain	01
2.	Tape	01
3.	Ranging Rods	01
3.	Arrows	02
4.	Prismatic Compass	01

**Theory:** Prismatic compass is an instrument used to measure the bearings of the lines. The bearing of a line is the angle made by that line with magnetic north. There are two systems of designating the bearings. They are whole circle bearing system (WCB) Quadratic bearing system (QB). Prismatic compass gives the bearing in WCB system. It consists of a circular box of about 85 to 100mm dia. In the center of the box, there is a board magnetic needle balanced on a hard steel pointed pivot. The needle carries a aluminum ring graduated to degrees and half degree. The graduation starts from 360° at north or 270° at east. The readings are engraved inverted. The box is fitted with a glass disc at its top. The sighting vane consists of 45° reflecting prism with its horizontal and vertical faces slightly convex so as to magnify the image of graduations. The graduations after reflection appear to be erect. The prism on the mounting frame can be raised or lowered for focusing of prism. The image of the graduations is viewed through a small circular aperture in the prism mounting. Just above the aperture, there is a narrow slit used as eye vane. Dark colored glasses are provided near the eye vane for sighting vane or eye vane. It consists of a metal frame hinged to the box having a vertical cross hair. It is usually provided with a hinged mirror, so that the objects which are either too low or too high can be sighted by inclined mirror. The line sight is the line joining the slit in eye vane and vertical cross hair of object vane. When the instrument is not in use the object vane is folded on glass over. In this process the lifting pin is pressed which lifts the needle off the pivot. TO dampen the oscillations of the needle and to bring it to rest a spring brake is provided. It operates when the brake pin is pressed.



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When the compass is not in use, the box is covered with a brass lid. While taking readings, the compass is mounted on the light tripod

A traverse is a series of connected lines whose length and directions are measured in the field. The traverse may be open or closed. In closed traverse if plotting is made from the observed values of lengths and directions, sometimes the last point does not coincide with the starting point. Such a closed traverse is said to have closing error. Such traverses are to be adjusted before plotting by Bowditch's rule and transit rule. Bowditch's rule and transit rule use the concept of latitude and departure. Latitude is the distance of that line measured parallel to NS direction and obtained by the relation  $L = l \cos \theta$  where  $l$  is the length of the line and  $\theta$  the reduced bearing of that line. Departure is the distance of that line measured perpendicular to NS direction by the relation  $D = l \sin \theta$

### Procedure: (Fig 11.1)

1. Let ABCDE be the closed traverse shown the fig.
2. The distances AB, BC, CD, DE and EA are measured accurately with the tape
3. The prismatic compass is placed centrally over the station. At the same time it is also leveled. The line of sight is turned to sight the ranging rod at B, the FB of AB is recorded. The line of sight is turned to sight the ranging rod at E & the BB of EA is noted.
4. Similarly keep the compass at
  - B, BB of AB & FB of BC are noted
  - C, BB of CB & FB of CD are noted
  - D, BB of CD & FB of DE are noted
  - E, BB of ED & FB of EA are noted
5. The traverse is then checked for local attraction and corrected. Then it is checked for closing error. If any, it is adjusted by Bowditch rule and Transit rule as given below

### Bowditch Rule

Correction to latitude of any side =  $C_L = \pm \sum L \times \frac{\text{Length of that side}}{\text{Perimeter of Traverse}}$

Correction to Departure of any side =  $C_D = \pm \sum D \times \frac{\text{Length of that side}}{\text{Perimeter of Traverse}}$

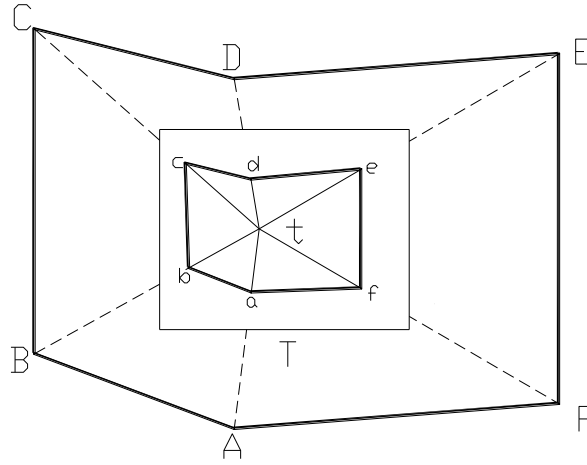


**Transit Rule**

Correction to latitude of any side =  $C_L = \pm \sum L \times \frac{\text{Latitude of that line}}{\text{Arithmetic sum of latitudes}}$

Correction to Departure of any side =  $C_D = \pm \sum D \times \frac{\text{Length of that side}}{\text{Arithmetic sum of departure}}$

**Note:** If error is negative, Correction is positive and vice versa



**Fig. 12.1 Radiation**

**Experiment No. 12****Date:** \_\_ / \_\_ / \_\_**PLANE TABLE SURVEYING****Exercise – 12.1****Aim:** To obtain the plan of given area by plane table surveying using method of Radiation**Instruments used:**

<b>Sl. No.</b>	<b>Particulars</b>	<b>Specification</b>	<b>Quantity</b>
1.	Plane table		01
2.	Alidade		01
3.	Plumbing fork		01
3.	Plumb bob		01
4.	Spirit level		01
5.	Trough compass		01
6.	Drawing paper		01

**Theory:**

In Radiation method, a ray is drawn from the instrument station towards the point, the distance is measured between the instrument station and that point, and the point is located by plotting to some scale the distance so measured. This method is more suitable when the distances are small (within a tape length) and one single instrument can control the points to be detailed.

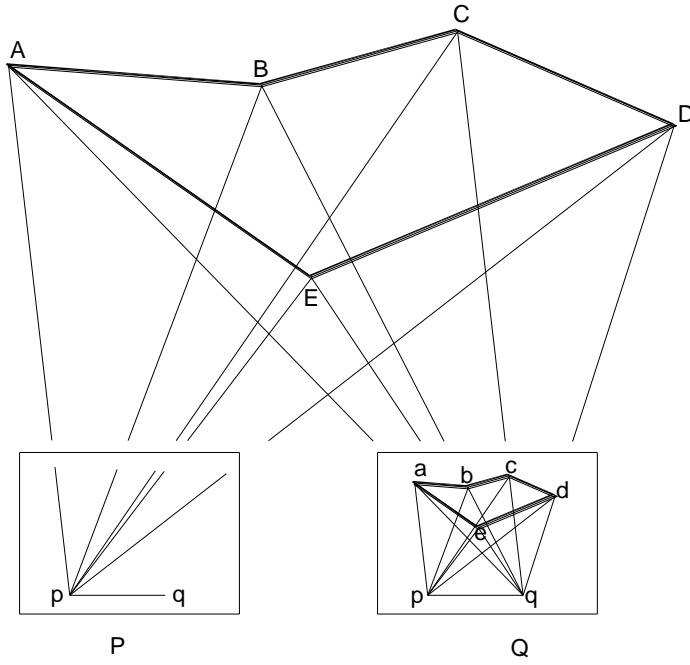
**Procedure: (Fig 12.1)**





1. Set the table at T, level it and transfer the point on to the sheet by means of plumbing fork, thus getting representing T. Clamp the table.
2. Keeps the alidade touching t and sight to A. Draw the ray along the fiducial edge of the alidade. Similarly, sight different points B, C, D, E etc., and draw the corresponding rays. ( A pin may be inserted at t, and the alidade may be kept touching the pin while sighting the points ).
3. Measure TA, TB, TC, TD, TE etc., in the field and plot their distances to some scale along the corresponding rays, thus getting a, b, c, d, e etc. Join these points to getting the map of the given area.

**Results:**



**Fig. 12.2 Intersection**

**Exercise – 12.2**

Date: \_\_ / \_\_ / \_\_

**Aim:** To obtain the plan of given area by plane table surveying using method of intersection

**Instruments used:**

Sl. No.	Particulars	Specification	Quantity
1.	Plane table		01
2.	Alidade		01
3.	Plumbing fork		01
3.	Plumb bob		01
4.	Spirit level		01
5.	Trough compass		01
6.	Drawing paper		01

**Theory:**

Intersection is resorted to when the distance between the point and the instrument station is either too large or cannot be measured accurately due to some field conditions. The location of an object from two plane table stations (previously plotted) and drawing the rays. The intersection of these rays will give the position of the object. It is, therefore, very essential to have at least two instrument stations to locate any point. The distance between the two instrument stations is measured and plotted on the sheet to some scale. The line joining the two instrument stations is known as the *base line*. No linear measurement other than that of the base line is made. The point of intersection of the



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two rays forms the vertex of a triangle having two rays as two sides and the base line as third line of the triangle. Due to this reason, intersection is also sometimes known as graphic triangulation.

### **Procedure: (Fig 12.2)**

1. Set the table at P, level it and transfer the point P on to the sheet by way of plumbing fork. Clamp the table.
2. With the help of the trough compass, mark the north direction on the sheet.
3. Pivoting the alidade about p, sight it to Q. Measure PQ and plot it along ray to get q. The base line pq is thus drawn.
4. Pivoting the alidade about p, sight the details A, B, C, etc., and draw corresponding rays.
5. Shift the table at Q and set it there. Orient the table roughly by trough compass and finally by back sighting P.
6. Pivoting the alidade about q, sight the details A, B, C, etc., and draw corresponding rays along the edge of the alidade to intersect with the previously drawn rays in a, b, c etc. The positions of the points are thus mapped by way of intersection. Join these points to getting the map of the given area.

### **Results:**

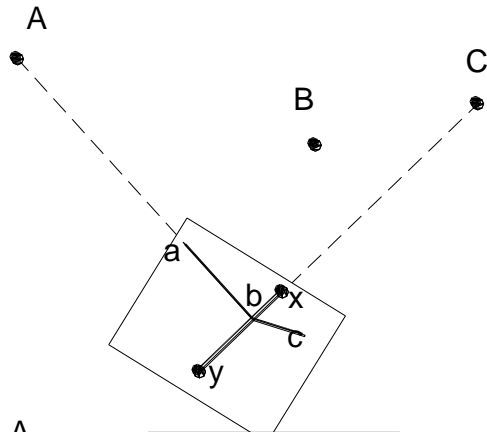


Fig. 13.3.1

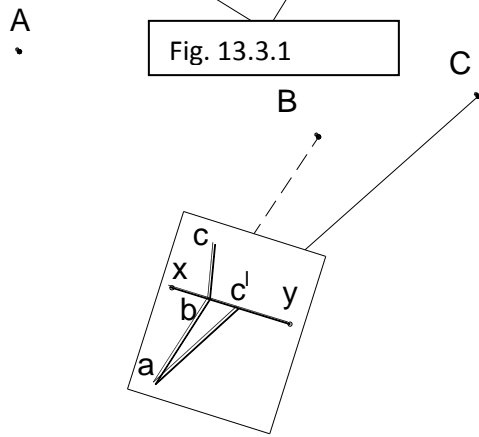


Fig. 13.3.2

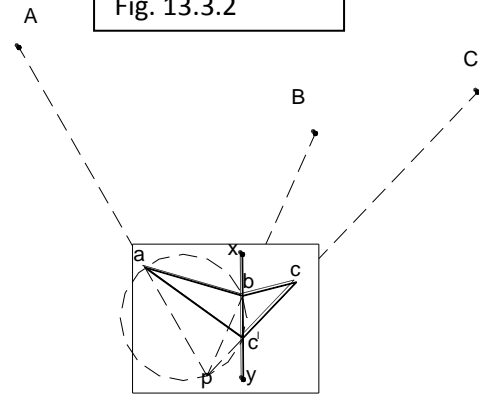


Fig. 13.3.3

**BESSEL'S GRAPHICAL SOLUTION**

**Aim:** Solving three point problem by Bessel's graphical solution.

**Instruments used:**

Sl. No.	Particulars	Specification	Quantity
1.	Plane table		01
2.	Alidade		01
3.	Plumbing fork		01
3.	Plumb bob		01
4.	Spirit level		01
5.	Trough compass		01
6.	Drawing paper		01

**Statement:**

Location of the position, on the plan, of the station occupied by the plane table by means of observations to three well – defined points whose positions have been previously plotted on the plan.

**Procedure:** Let A, B, C be the known points and a, b, c be their plotted positions.

Let P be the position of the instrument station to be located on the map.

1. After having set the table at station P, keep the alidade on  $ba$  and rotate the table so that A is bisected. Clamp the table.
2. Pivoting the alidade about  $b$ , sight to C and draw the ray  $xy$  along the edge of the alidade **(Fig.13.3.1)**.
3. Keep the alidade along  $ab$  and rotate the table till B is bisected. Clamp the table.





4. Pivoting the alidade about  $a$ , sight to C. Draw the ray along the edge of the alidade to intersect the ray  $xy$  in  $c'$  (**Fig.13.3 2**). Join  $cc'$ .
5. Keep the alidade along  $cc'$  and rotate the table till C is bisected. Clamp the table. The table is correctly oriented (**Fig. 13.3.3**).

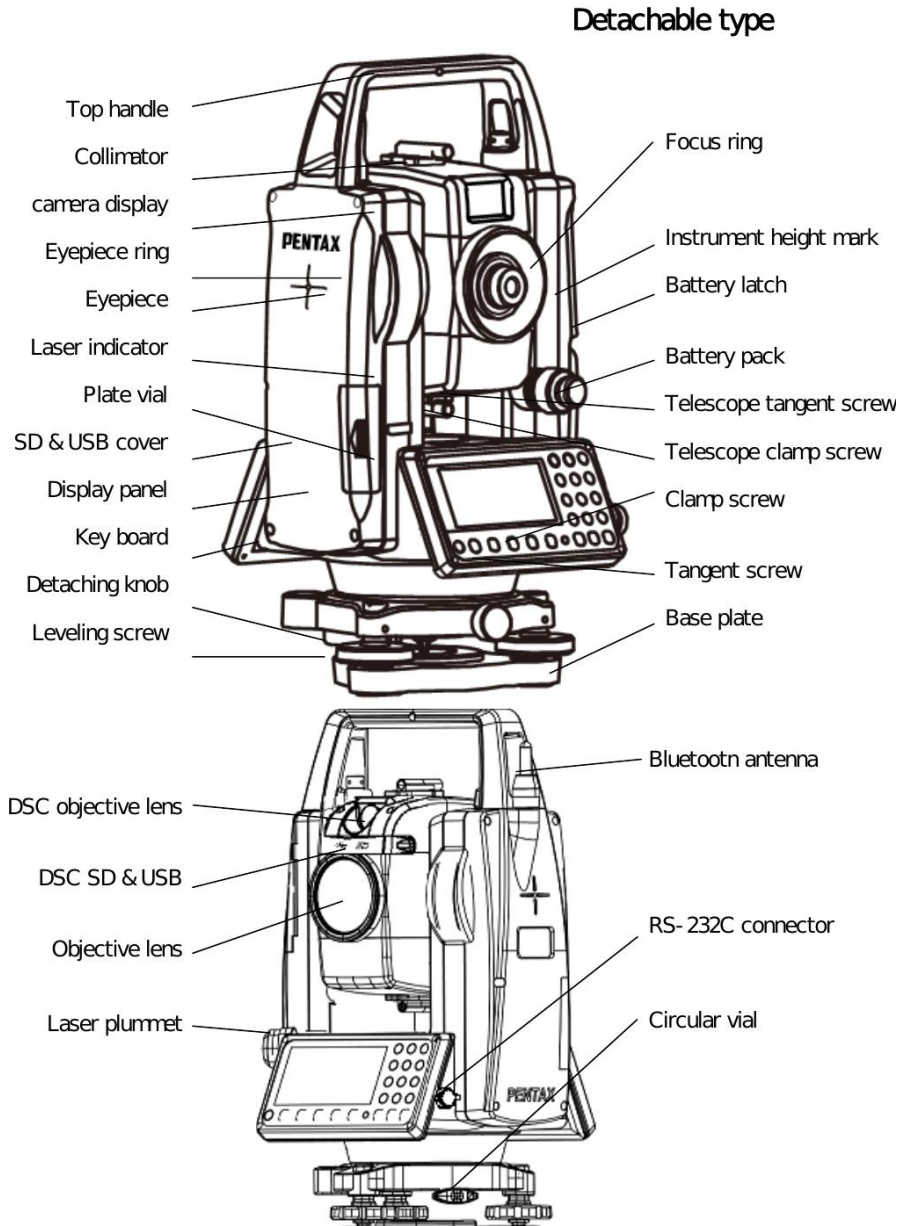
Pivoting the alidade about  $b$ , sight to B. Draw the ray to intersect  $cc'$  in  $p$ . Similarly, if alidade is pivoted about  $a$  and A is sighted, the ray will pass through  $p$  if the work is accurate. The points  $a$ ,  $b$ ,  $c$  and  $p$  form a quadrilateral and all the four points lie along the circumference of a circle. Hence, this method is known as "Bissell's Method of Inscribed Quadrilateral".

**Results:**

**OUT OF SYLLABUS EXPERIMENTS**

**TOTAL STATION:**

A total station is a combination of an "electronic theodolite" and Electronic Distance Meter [EDM]. The electronic theodolite measures the horizontal and vertical angles. It works with electronic speed and efficiency. The EDM measures the distance.



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The following are the learnings of total station,

- Study of total station, its parts & adjustments, steps to set up the instrument over a station.
- Orientation with reference to north, measurement of horizontal distances, sloping distances, horizontal angles in angular measuring mode

Thus the features of total station are as follows.

1. Angle measurement with an electronic theodolite.
2. Distance measurement with EDM. Total station uses co-axial optics in which EDM transmitter and receiver are combined with theodolite telescope. Total station measures the slope distance.
3. Control panel: Total station is activated through its control panel. It consists of keyboard and multiple lines Liquid Crystal Display. There are two control panels, one on each face of electronic theodolite to make them easier to use. Key board incorporates multifunction keys to carry out specific tasks.
4. Power Supply: Rechargeable Nickel-Cadmium batteries are used as power supply.
5. Retro-reflector: A special form of reflector known as "corner cube prism", which is mounted on a pole is used as a target.
6. Onboard software: A micro-processor is programmed to perform many calculations like
  - a) Horizontal distance
  - b) Vertical distance (reduced levels)
  - c) Co-ordinates (northing, casting etc.)

All data recorded can be downloaded to a computer and required plotting details can be performed using software.

A total station when aimed at an appropriate target measures the following three parameters

- a) Horizontal angle with respect to North or any reference.
- b) Vertical angle with respect to vertical (plumb) called "Zenith angle" and
- c) Sloped distance between instrument and target.

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All other data, like horizontal distance, vertical distance (reduced levels), co-ordinates (Easting and Northing) are derived from the above three fundamental parameters.

Advantages of total station over conventional instruments:

- a) Measurement of distances with chain and tape are eliminated.
- b) Measurement of bearings, distances, calculation of coordinates like northing, easting etc. are eliminated
- c) Recording staff readings using level and reduction of levels are eliminated.
- d) Reading vernier of theodolite, recording and averaging of horizontal and vertical angles are all eliminated.
- e) Variation in results due to variation in atmospheric conditions like temperature, pressure etc. are eliminated. This is because, the values obtained with total station are automatically corrected through sensors.
- f) Manual plotting works are eliminated.

Dis-Advantages of total station over conventional instruments:

- a) Total stations are dependent on batteries and electronics. The LCD screen does not work well when it is cold.
- b) Battery life is short. The batteries and electronics both do not work well when wet.
- c) Total stations are typically heavier than a transit.
- d) Loss of data is an important consideration.

### **Applications of total station:**

- a) Traverse survey
- b) Topography reduction (RLs & Contour mapping)
- c) Remote object elevation.
- d) Distance between remote points.
- e) Setting out works.
- f) Transfer of data to computer.
- g) Transfer of computer file to the data recorder of total station etc.

**Procedure for operation of total station**

1. Fix the instrument to the tripod stand.
2. Carry out necessary levelling for the tripod by operating foot screws.
3. Insert the battery and lock it.
4. Switch on the instrument by operating power button. The screen will display the electronic bubble.
5. Level the instrument by operating the foot screw and bring the bubble tube centre.
6. If you want to check press F1 button (tilt) and set  $0^{\circ} 0'' 0''$  by operating foot screw. Press Enter button.
7. Mode A will appear on the screen and it will display horizontal angle, vertical angle, horizontal distance, vertical distance and slope distance.
8. Set the telescope towards the other part of the bund (pt. B) and lock the horizontal movement of the instrument.
9. To measure the horizontal distance press F1 button.
10. Change the instrument to mode B by pressing F5 button.
11. Create a file by pressing F1 button (special function button).
12. Again press F1 button and create a file by operating downward arrow button.
13. After selecting the create option press Enter button and give the required file name (Say, NTPB-2). Press Enter button.
14. Then press F2 button.
15. Select rectangular coordinate and press Enter button.
16. Select station and press Enter button.
17. Again press Enter button to give the point numbers says 1, and press Enter button.

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18. Select X coordinate by using downward key and press Enter button and then give the value of X coordinate (say 2000) and press Enter button.
19. Repeat the same for Y coordinate and enter the value. (say 3000) Press Enter button.
20. Give the Z value (i.e. RL of the instrument station).
21. Enter the instrument height value and press Enter button.
22. Point code will be displayed on the screen and press Enter button and enter the point code name (Say station A) and again press Enter button.
23. Press F1 button and check the details entered.
24. Again press Enter button (horizontal angle will appear on the screen and it may be set to Zero) by pressing F5 button twice and again press Enter button. Next point will be displayed on the screen.
25. Press F4 button and select prism height, enter the value of prism height and again press Enter button. Instrument is ready to take subsequent reading.
26. Press F1 to measure the RL of the next point. Repeat the above steps for subsequent points. To bring back the instrument to its initial position, press Esc button until mode A appears on the screen.
27. Press switch of button and remove the battery.