|| Jai Sri Gurudev ||

Sri Adichunchanagiri Shikshana Trust (R)

SJC Institute of Technology

Chickballapur - 562 101, Karnataka

VTU Affiliated, AICTE Approved, Accredited by NAAC & NBA (CSE, ECE, ME), Gold Rated by QS-I Quage

Department of Civil Engineering

Estd : 1986

Laboratory Manual

Surveying Practice

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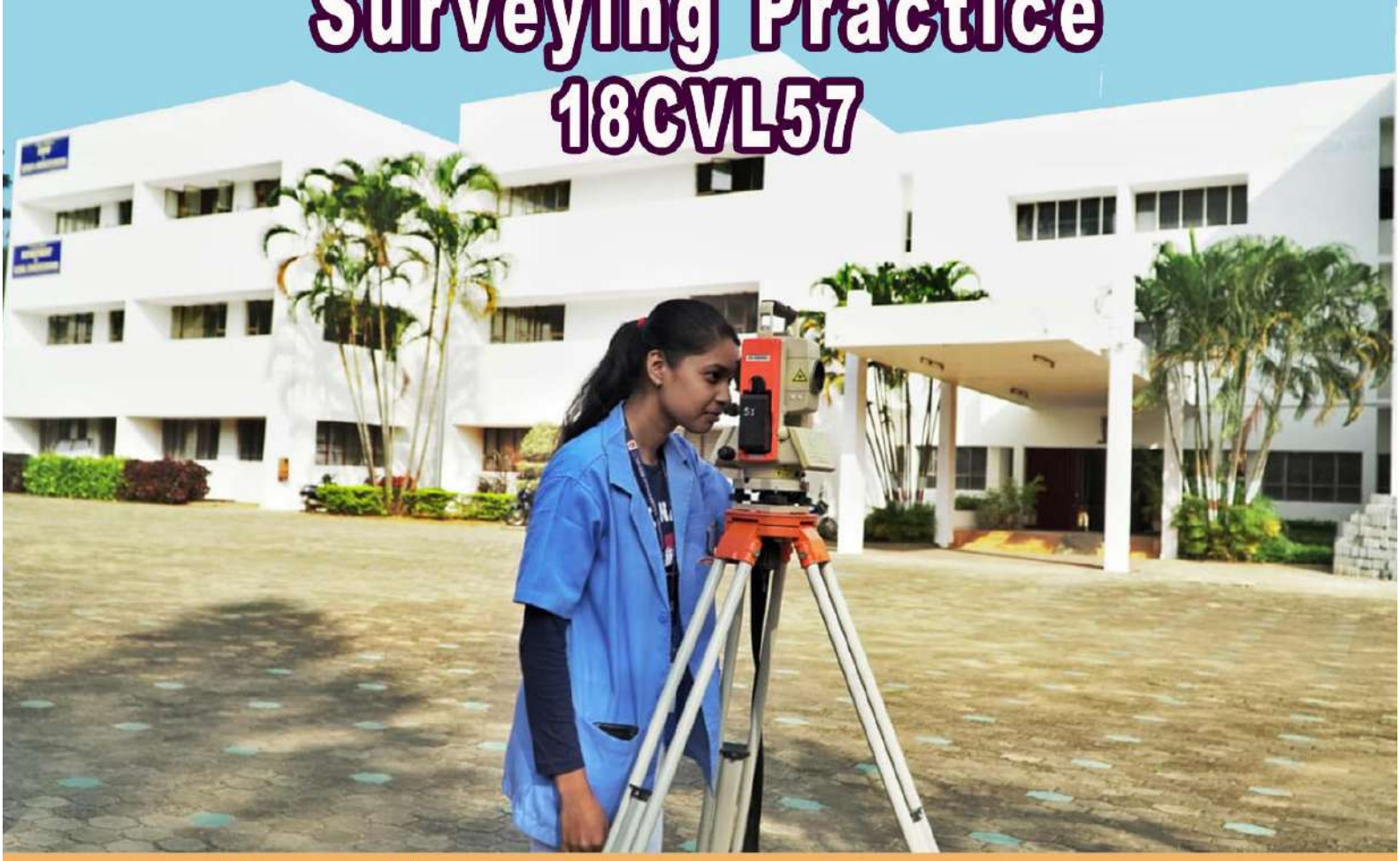

Prepared by

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Dr. G Narayana
Professor and Head

FOREWORD

I am extremely happy to place before all readers this manual prepared by the Department of Civil Engineering ***SJCIT*** *Chickballapur. The manual is prepared taking into view the new* ***VTU*** *syllabus for* ***V Semester B.E. (Civil)****. The manual gives a clear insight into the relevance of each experiments, calculations needed, necessary formulae, Graphs to be plotted and Inferences that could be drawn are clearly mentioned. It is hoped that this manual will clear doubts in minds of students about the experiments in* ***Surveying Practice****.*

I wish to express my heartfelt gratefulness to his ***Holiness Paramapoojya Jagadguru Padmabhushan Bhairavaikya Sri. Sri. Sri. Dr. Balagangadharanatha Maha Swamiji*** *and to his* ***Holiness Jagadguru Sri. Sri. Sri. Dr. Nirmalanandhanatha Maha Swamiji Pontiff, Adichunchanagiri Shikshna Trust®****.*

I would also like to thank our beloved principal ***Dr. G T Raju*** *for his continuous support and encouragement.*

I thank ***Mrs. Chandrakala S and Mr. Sathish Y A*** *Assistant professors in the department of civil engineering, having prepared this manual.*

Dr. G NARAYANA

Professor and Head

Department of Civil Engineering

|| Jai Sri Gurudev ||

Sri Adichunchanagiri Shikshana Trust ®

SJC INSTITUTE OF TECHNOLOGY

Chickballapur – 562 101

DEPARTMENT OF CIVIL ENGINEERING

LABORATORY CERTIFICATE

This is to certify that the Mr. / Ms. ……....

bearing USN ……..... Sem.……. Branch…….……

has satisfactorily completed the practical experiments of……

……. Laboratory prescribed by the Visvesvaraya Technological University, Belgavi for the year …….

Signature of the Teacher
(In charge of the Batch)

Head of the Department

|| Jai Sri Gurudev ||

SJC institute of Technology, Chickballapur
Department of Civil Engineering

Vision

Building Competent Civil Engineers with a Societal Perspective.

Mission

M1: Providing Conducive Learning Environment focusing on Planning, Analysis, Design and Detailing of Sustainable Infrastructure

M2: Imparting Training, Research and Consultancy in Collaboration with Research Institutes and Industries

M3: Equipping Students with Employability Skills through Internships, Industrial Interactions and Field Visits

M4: Exploring Comprehensive Environmental Aware Solutions for Various Fields of Civil Engineering with Multidisciplinary Approach

M5: Imbibing Lifelong Learning, Professionalism and Ethics among Civil Engineering Students

Program Educational Objectives (PEO's)

PEO1: Graduates will have successful career in civil engineering industries, public sector or as Entrepreneurs.

PEO2: Graduates will pursue higher education in leading institutes/engage in continuing education to be competitive in the organization.

PEO3: Graduates will design cost effective and sustainable civil engineering structures conforming to standards.

Program Specific Outcomes (PSO's)

After Successful completion of B.E program in Civil Engineering, the students will be able to:

PSO1: Apply Civil engineering knowledge in analysis, design, laboratory investigation & Construction aspects.

PSO2: Solve problems in various fields of civil engineering with appropriate construction materials and technology.

Course Learning Objectives: This course will enable students to

1. Apply the basic principles of engineering surveying and measurements
2. Followeffectivelyfieldproceduresrequiredforaprofessionalsurveyor
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:

1. Apply the basic principles of engineering surveying and for linear and angular measurements.
2. Comprehendeffectivelyfieldproceduresrequiredforaprofessionalsurveyor.
3. Use techniques, skills and conventional surveying instruments necessary for engineering practice.

Program Outcomes (POs)

- **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
- **Problem analysis:** Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
- **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
- **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions
- **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
- **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
- **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
- **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
- Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
- **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
- **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
- **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

List of Experiments

INDEX SHEET

Name of the Student :..... Class: ..... Sec:.....

Exp. No.	Date	Title of the Experiment	Page No.	Marks Obtained					Sign. of the Staff
				A (4M)	B (8M)	C (4M)	D (8M)	Total (24M)	

For 40 Marks:

Sl. No.	Description	Marks
1.	**Continuous Evaluation**	**24**
	A. Observation write up & punctuality	4.0
	B. Conduction of Experiment & output	8.0
	C. Viva Voce	4.0
	D. Record write up	8.0
2.	**Lab Internal Test**	**16**

Experiment No. 1 (a)

MEASUREMENTS OF DISTANCES USING TAPE ALONG WITH HORIZONTAL PLANES AND SLOPES

i) Measurements of distance along with horizontal plane

AIM

To measure distance between two points using tape and Direct ranging.

INSTRUMENTS REQUIRED

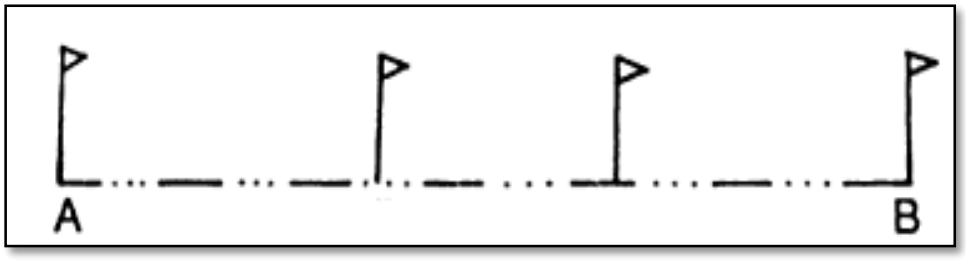
Tape, Ranging rods, Arrows.

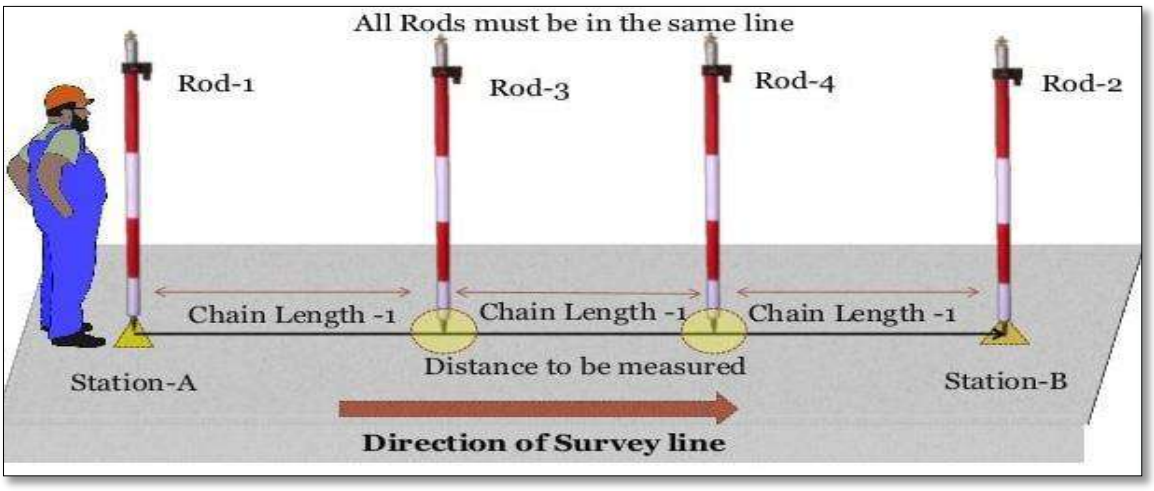
THEORY

The process of measuring the distance using chain or tape is called ***Chaining***. While measuring the length of a survey line chain or tape must be stretched straight along the line joining two terminal stations. When the length of the line exceeds the length of a tape, some intermediate points will have to be established in line with the two terminal points before chaining is started. This process of establishing such intermediate points is known as ***Ranging.*** ***Direct ranging*** is done when two end points of the survey lines are intervisible. In such cases ranging can either be done by eye or through some optical instrument such as line ranger or a theodolite.

Two persons engaged in the measurement of the distance are called ***Chainmen***. ***Counting of paces*** is one method to directly count the number of paces while walking along the length to be measured. The distance covered by one pace by an individual more or less remains constant and can be used for rough estimation of distance. ***Passometer*** is an instrument used to help in counting the number of paces made by an individual. It can be kept in the shirt or trouser pocket while pacing. The instrument records the number of paces made by the bearer. ***Pedometer*** has the facility of setting the pace distance of the individual. It records the number of paces directly indicates the distance. Indirect measurement of distance involves tacheometry, electromagnetic distance measurement [EDM] instruments.

DIAGRAM





FORMULA

$$Pace\ value = \frac{Total\ distance}{Number\ of\ Paces}$$

PROCEDURE

1. Let the length of a line AB is to be measured, Point 'A' being the starting point.
2. Erect two ranging rods vertically at 'A' and 'B'.
3. The surveyor stands about half metre behind the ranging rod at 'A' in line with 'AB'.
4. The assistant then goes with another ranging rod and establishes the rod at a point approximately in line with 'AB' (by judgment) at a distance not greater than one chain length from 'A'.
5. The surveyor at 'A' directs the assistant to move the ranging rod till it is in line with 'AB'. The code of signals used for this purpose is given in the table below:

Sl. No.	Signal by the Surveyor	Action by the assistant
1	Rapid sweep with right hand	Move considerably to the right
2	Slow sweep with right hand	Move slowly to the right
3	Right arm extended	Continue to move to the right
4	Right arm up and moved to the right	Plumb the rod to the right
5	Rapid sweep with left hand	Move considerably to the left
6	Slow sweep with left hand	Move slowly to the left
7	Left arm extended	Continue to move to the left
8	Left arm up and moved to the right	Plumb the rod to the left
9	Both the hands above head and then brought down	Correct
10	Both the arms extended forward horizontally and the hands depressed briskly	Fix the rod

6. Similarly establish some intermediate stations by direct ranging.

7. The follower stands at the point ‘A’ holding one end of the tape while the leader moves ahead holding zero end of the tape in one hand and a bundle of arrows in the other. When he reaches approximately one tape length distance from ‘A’, the follower directs him for ranging in the line.
8. The tape is then pulled out and whipped gently to make sure that its entire length lies along the line.
9. The leader then pushes the arrow into the ground, opposite the zero.
10. When the second arrow has been established by the leader, the follower picks up the first arrow and both the persons move ahead as described in the step7, 8 and 9.
11. At the end of the line (at B) the last measurement will generally be a partial tape length. The leader holds the zero end of the tape at ’B’ while the follower pulls the tape back till it becomes taut and then reads against the arrow.

OBSERVATIONS & CALCULATIONS

Total distance measured = …….

Number of Paces = ……..

Pace value =

RESULTS

COMMENTS

ii) Measurement of Distance on Slopping Ground

AIM

To measure distance between two points on sloping ground using tape.

INSTRUMENTS REQUIRED

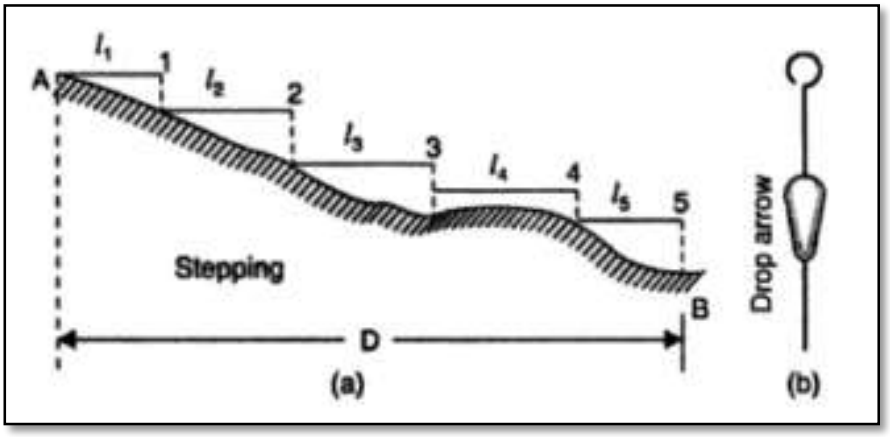
Tape, Ranging rods, Arrows, Drop arrow, Clinometer,

THEORY

In case of irregular slopes the direct method of chaining on slopping ground is suitable. ***Reciprocal ranging*** or ***Indirect ranging*** is employed when both the ends of the survey line are not intervisible either due to high intervening ground or due to long distance between them.

DIAGRAM

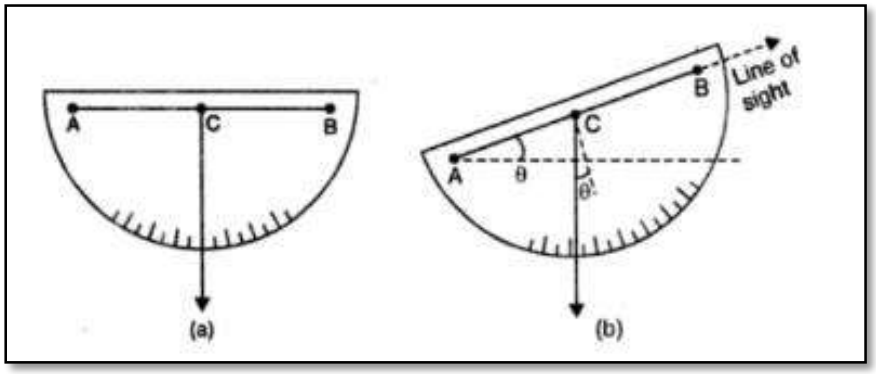
a) Direct method (Method of Stepping)



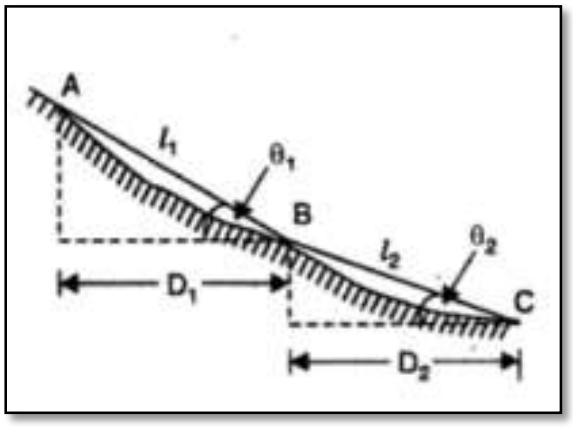
1. Let it is required to measure the horizontal distance between the two points A and B.
2. The follower holds the zero end of the tape at A while the leader selects any suitable length l_1 of the tape and moves forward. The follower directs the leader for ranging.
3. The leader pulls the tape tight, makes it horizontal and the point 1 is then transferred to the ground by a plumb bob. Sometimes, a special form of drop arrow is used to transfer the point to the surface, as shown in figure above.
4. The procedure is then repeated. The total horizontal distance D between the two points is then equal to $l_1+l_2+l_3+l_4+$…….
5. The lengths l_1, l_2 etc., to be selected depend on the steepness of slope. Steeper the slope, lesser the length and vice versa.

b) Indirect method

i. Angle measured

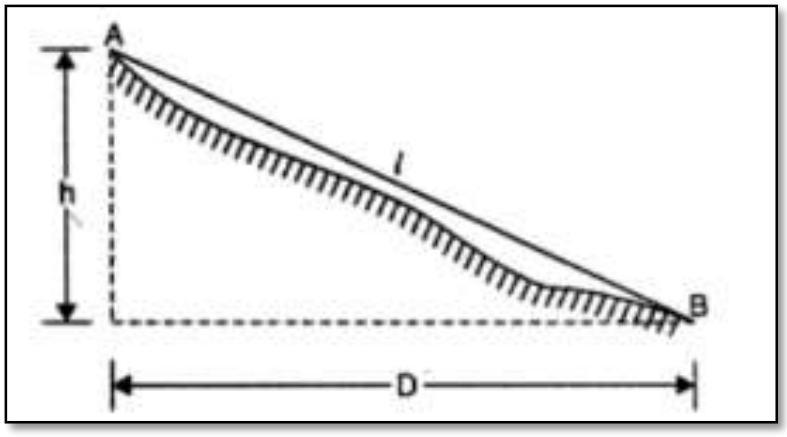


Clinometer



1. Measure the inclined distances l_1, l_2 etc.
2. The slopes of the lines (θ_1,$\theta_2$etc.) with the help of clinometer.
3. The total horizontal distance D between the two points is then equal to $\sum l_i \cos\theta_i$

ii. Difference in level measured



1. The difference in the level (h) between the points is measured with the help of levelling instrument.
2. The inclined length *l* is measured.
3. The total horizontal distance D between the two points is then equal to $\sqrt{h^2 + l^2}$

OBSERVATIONS & CALCULATIONS

RESULTS

COMMENTS

Experiment No. 1 (b)

SETTING OUT PERPENDICULARS

AIM

To set out perpendiculars to a given chain line using cross staff, optical square and tape.

INSTRUMENTS REQUIRED

Tape, Ranging rods, Arrows, Cross staff, Optical square.

THEORY

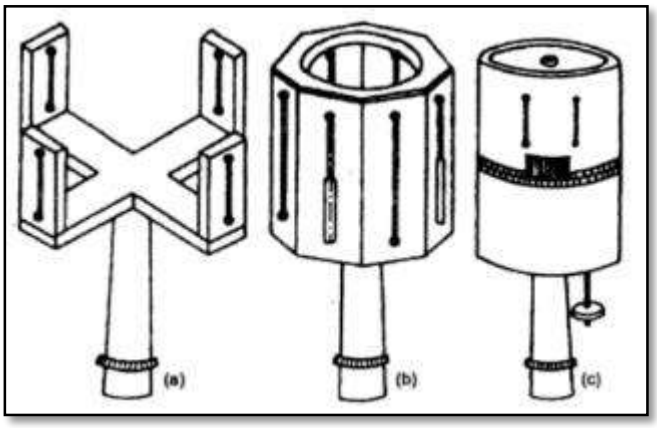
There are several types of instruments used to set out a right angle to a chain line. The most common being ***cross staff, optical square and prism square.*** The simplest instrument used for setting out right angle is a cross staff. It consists of either a frame or box with two pairs of vertical slits and is mounted on a pole for fixing in the ground. The common form of cross staff are ***open cross staff, French cross staff, adjustable cross staff. Optical square*** is somewhat more convenient and accurate instrument than the cross staff for setting out a line at right angles to another line. It consists of a circular box with three slits at E, F, and G. in line with the openings E and G, a glass silvered at the top and unsilvered at the bottom, is fixed facing the opening E. Opposite to the opening F, a silver glass is fixed at A making an angle of 45° to the previous glass. A ray from the ranging rod at Q passes through the lower unsilvered portion of the mirror at B and is seen directly by eye at the slit E. Another ray from the object at P is received by the mirror at A and is reflected towards the mirror at B which reflects it towards the eye. Thus the images of P and Q are visible at B, if both the images are in the same vertical line.

PROCEDURE

I. Perpendicular setting using optical square

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

II. Perpendicular setting using cross staff

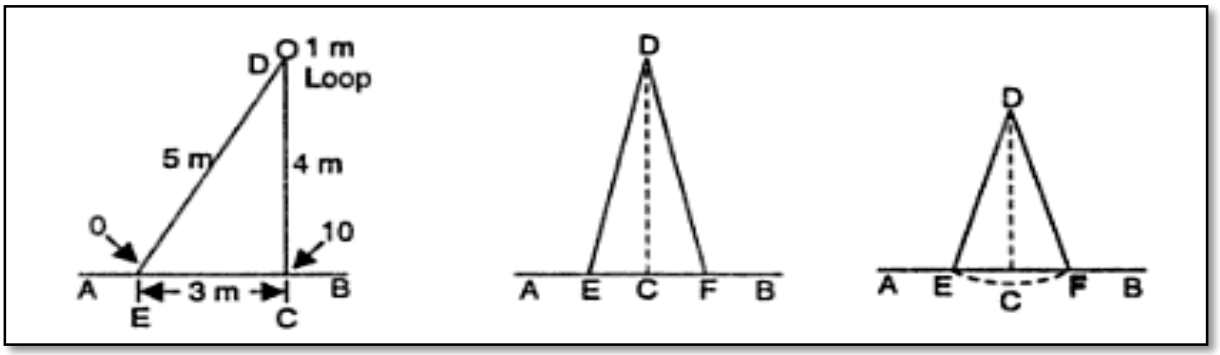


Cross staff

1. The cross staff is set up at a point on the line where perpendicular is to be set out.
2. The cross staff is turned until one line of sight bisects the ranging rod at the end of the survey line.
3. The line of sight through the other slit will be at right angle to the survey line and ranging rod may be established in that direction.

III. Perpendicular setting using tape

DIAGRAM



Let it be required to erect a perpendicular to the chain line AB at a point C.

- **3-4-5 method**
  1. Establish a point E at a distance 3m from C.
  2. Put the zero end of the tape at E and the 10m end at C. The 5m and 6m marks are brought together to form a loop of 1m.
  3. The tape is now stretched tight fastening the ends E and C. The point D is thus established. CD will be perpendicular to AB.

- **Second method**
    1. Select E and F equidistance from C.
    2. Hold the zero end of the tape at E and 10m end at F.
    3. Pick up 5m mark, stretch the tape tight and establish D. Join DC.CD will be perpendicular to AB.

- **To drop a perpendicular to a given chain line from a point outside it**
    1. Select any point E on the line AB.
    2. With D as centre and DE as radius, draw an arc to cut the chain line in F.
    3. Bisect EF at C. CD will be perpendicular to AB.

OBSERVATIONS & CALCULATIONS

RESULTS

COMMENTS

Experiment No. 2

SETTING OUT OF GEOMETRICAL FIGURES USING PRISMATIC COMPASS

AIM

To set out rectangle, pentagon, hexagon using tape/chain and compass.

INSTRUMENTS REQUIRED

Prismatic compass with stand, tape, ranging rods, arrows.

THEORY

Meridian is a fixed direction. Bearing of a line is its direction relative to a given meridian. A compass measures bearing of a line with reference to magnetic meridian.***In whole circle bearing (WCB)*** system the bearing of a line is measured from magnetic north in clockwise direction. The value of bearing may vary from 0° to 360°. In ***quadrantal bearing (QB)*** system the bearing of a line is measured in clockwise or anticlockwise direction either from magnetic north or from south whichever is nearer. The value of bearing may vary from 0° to 90°.The bearing of the line measured in the direction of the progress of survey is called ***forebearing (FB).*** The bearing of the line measured in the direction opposite to the survey is called ***back bearing (BB).***

DIAGRAM

FORMULAE

$$IA = \frac{(2n-4)90}{n}$$

Where IA = Internal included angle

n = Number of sides of polygon.

- For clockwise traverse,
  IA = Bearing of previous line – Bearing of next line.
- For anticlockwise traverse,
  IA = Bearing of next line – Bearing of previous line.

PROCEDURE

1. The bearings for various sides of regular geometrical figure are tabulated.
2. The prismatic compass is setup at first station and carry out temporary adjustment s.
3. The fore bearing of first line is set out and the next station is located by measuring the distance in that direction.
4. Now the instrument is shifted to the next station and the fore bearing for the next line is set out. The next station is located by measuring the distance along that direction.
5. The procedure is repeated for all the lines.

OBSERVATIONS & CALCULATIONS

Sl. No.	Line	FB	BB
1			
2			
3			
4			
5			
6			

RESULT

COMMENT

Experiment No. 3

DISTANCE BETWEEN TWO INACCESSIBLE POINTS USING COMPASS

AIM

To determine the distance between two inaccessible stations using chain or tape and compass.

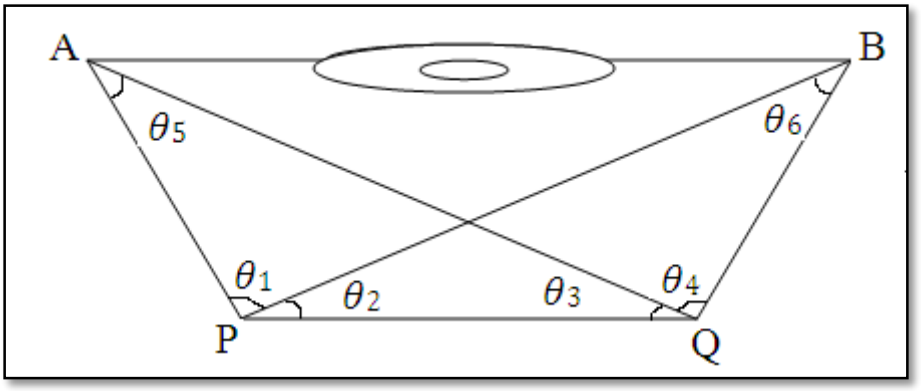
INSTRUMENTS REQUIRED

Prismatic compass with stand, Chain/tape, Ranging rods, Arrows.

THEORY

The stations are said to be inaccessible, if the distance between two stations cannot be measured due to obstacles like pond, lake, or marshy land. A triangle is said to be well-conditioned when no angle in it is less than 30° and greater than 120°. An equilateral triangle is considered to be best-condition or ideal triangle. A triangle in which angle is less than 30° or greater than 120° is said to be ill condition triangle.

DIAGRAM



FORMULAE

- Sine rule for Δ^{le} PQA is

$$\frac{PQ}{\sin\theta 5} = \frac{PA}{\sin\theta 3} = \frac{QA}{\sin(\theta 1 + \theta 2)}$$

- Sine rule for Δ^{le} PQB is

$$\frac{PQ}{\sin\theta 6} = \frac{QB}{\sin\theta 2} = \frac{PB}{\sin(\theta 3 + \theta 4)}$$

- Cosine(COS) rule for Δ^{le}ABP is
  $AB^2 = PA^2 + PB^2 - 2PA.PB\cos\theta_1$
- Cosine(COS) rule for Δ^{le}ABQ is
  $AB^2 = QA^2 + QB^2 - 2QA.QB\cos\theta_4$

PROCEDURE

1. Let it be required to determine the distance between two inaccessible stations A and B.
2. Select a line PQ approximately parallel to AB.
3. Set the compass at P and take the bearings of the lines PA, PB and PQ.
4. Now shift the instrument to station Q. Level it. Now take the fore bearings of the lines QP, QA and QB.
5. Measure the distance PQ.

OBSERVATIONS & CALCULATIONS

Instrumentat	Line	Bearing
P	PA	
	PB	
	PQ	
Q	QP	
	QA	
	QB	

Distance PQ =…….m

RESULTS

COMMENTS

Experiment No. 4

SIMPLE LEVELLING

AIM

To determine the reduced level of point using dumpy level or auto level (Simple leveling)

INSTRUMENTS REQUIRED

Dumpy level/Auto level with tripod, Levelling staff.

THEORY

Levelling is a branch of surveying the object of which is

- To find the elevations of given points with respect to a given or assumed datum.
- To establish points at a given elevation or at different elevations with respect to a given or assumed datum.

The instruments commonly used in direct levelling are; a level and levelling staff.

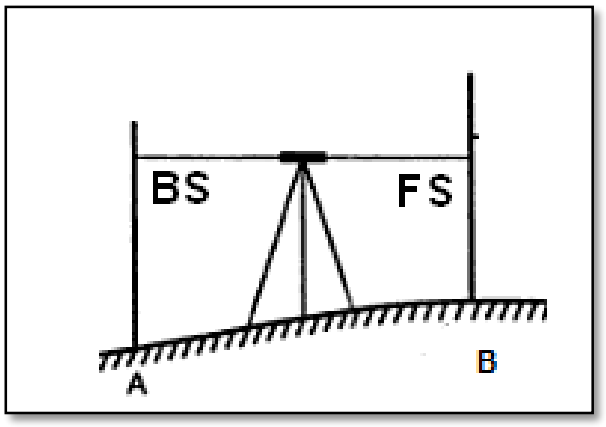
Level: The purpose of a level is to provide a horizontal line of sight. Essentially, a level consists of the following four parts:

1. A telescope to provide line of sight
2. A level tube to make the line of sight horizontal
3. A levelling head to bring the bubble in its centre of run
4. A tripod to support the instrument.

There are various types of levels, viz. ***Dumpy level, Wye level or Y level, Cooke's reversible level, Cushing's level, Modern tilting level.*** The temporary adjustments of dumpy level are setting up, levelling up, focussing the eye piece and focussing object glass.

Levelling staff: A levelling staff is a straight rectangular rod having graduations, the foot of the staff representing zero reading. The levelling staff may be ***target staff*** or ***self reading staff***.

DIAGRAM



FORMULAE

Height of instrument method or Plane of collimation method:

- HI or PC= RL+BS
- RL= HI- IS or FS
- Check: $\sum BS$-$\sum FS$= Last RL – First RL

Rise and fall method:

- Rise: Previous reading – Present reading is positive
- Fall: Previous reading – Present reading is negative
- Check: $\sum BS$-$\sum FS$=$\sum Rise$-$\sum Fall$= Last RL – First RL

PROCEDURE

1. Set up dumpy level at suitable place and carry out temporary adjustments.
2. Hold the staff on bench mark, take BS.
3. Determine plane of collimation by adding back sight to the reduced level of the bench mark.
4. Hold the staff on point B, take FS.
5. The elevation or RL of change point is calculated by subtracting the fore sight from plane of collimation.

OBSERVATIONS & CALCULATIONS

Problem

Height of instrument method:

BS	IS	FS	HI	RL	STATION	REMARKS

Rise and fall method:

BS	IS	FS	HI	RL	STATION	REMARKS

Check

RESULTS

COMMENTS

Experiment No. 5(a)

DIFFERENTIAL LEVELLING

AIM

To determine the reduced level of points using differential levelling technique.

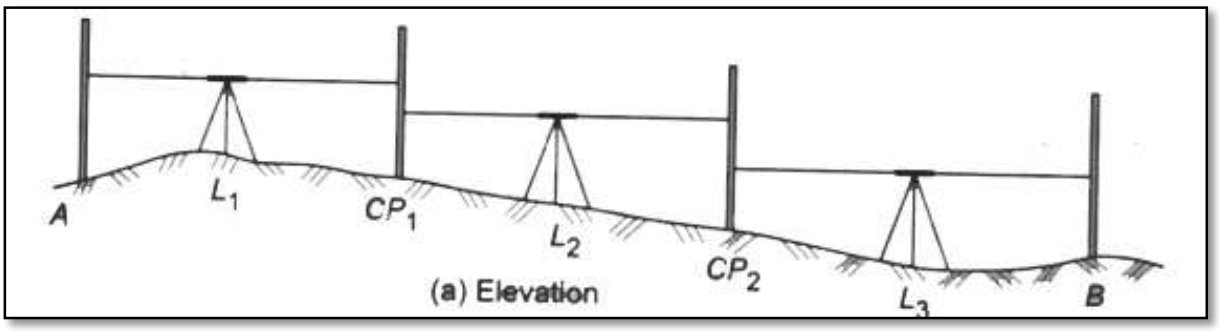
INSTRUMENTS REQUIRED

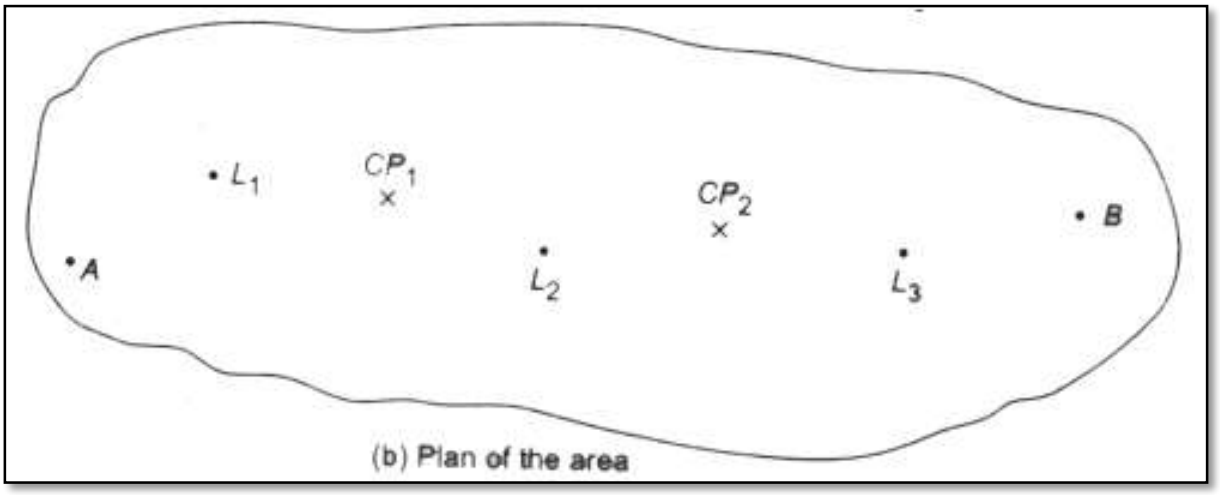
Dumpy level/Auto level with tripod, Levelling staff.

THEORY

Station is the point, the elevation of which is to be determined or the point to be established at a given elevation. In other words station is the point where leveling staff is held and not the point where level is kept. For any setup of the level, the ***Height of instrument*** is the elevation of the line of sight with respect to the assumed datum. This is also known as ***Plane of collimation. Reduced level*** of a point is the level of a point with respect to assumed datum. ***Back sight (BS)*** is the sight taken on a level staff held at a point of known elevation with an intention of determining the plane of collimation. It is always first reading after setting the instrument. It is also known as a plus sight as this reading is always added to the reduced level of the point to get plane of collimation. ***Intermediate sight (IS)*** is the sight taken on stations after taking back sight and before taking the last sight from an instrument station. The intension is to get reduced levels of the points where staff is held. These are also known as minus sights, since these reading are to be subtracted from plane of collimation to get reduced levels of the points. ***Fore sight (FS)*** is the last staff reading taken from an instrument station. This is also a minus sight. ***Change point (CP) or Turning point (TP)*** is a point on which both foresight and back sight are taken. The staff held at this point first fore sight is taken, then instrument is shifted to new point and back sight is taken on the same point.

DIAGRAM





(b) Plan of the area

FORMULAE

Height of instrument method or Plane of collimation method:

- HI or PC = RL+BS
- RL = HI - IS or FS
- Check: $\sum BS$-$\sum FS$= Last RL – First RL

Rise and fall method:

- Rise: Previous reading – Present reading is positive
- Fall: Previous reading – Present reading is negative
- Check: $\sum BS$-$\sum FS$=$\sum Rise$-$\sum Fall$= Last RL – First RL

PROCEDURE

1. Set up dumpy level at suitable place and carry out temporary adjustments.
2. Hold the staff on bench mark, take BS.
3. Determine plane of collimation by adding back sight to the reduced level of the bench mark.
4. Hold the staff on change point, take FS.
5. The elevation or RL of change point is calculated by subtracting the fore sight from plane of collimation.
6. The instrument is shifted to new point and back sight is taken on the same point.
7. Repeat the step 4, 5, 6 to get elevation of required point.

OBSERVATIONS & CALCULATIONS

Problem

Height of instrument method:

BS	IS	FS	HI	RL	STATION	REMARKS

Rise and fall method:

BS	IS	FS	HI	RL	STATION	REMARKS

Check

RESULTS

COMMENTS

Experiment No. 5(b)

INVERTED LEVELLING

AIM

To determine the reduced level of an object above the plane of collimation using inverted levelling.

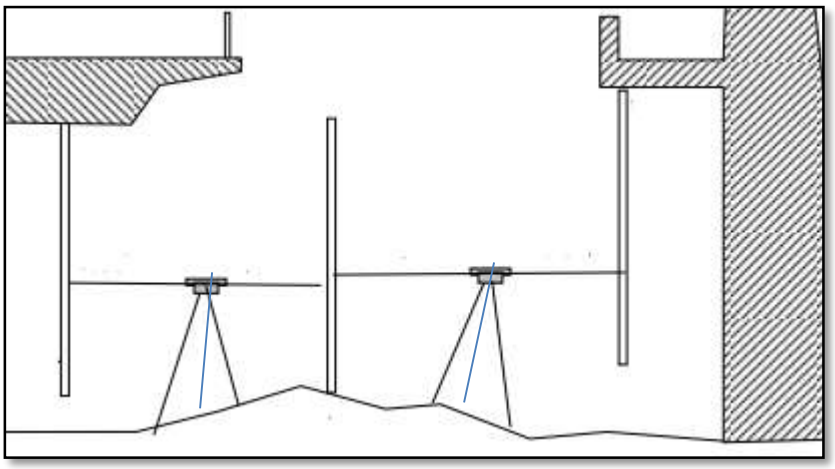
INSTRUMENTS REQUIRED

Dumpy level/ Auto level with tripod, Levelling staff.

THEORY

If level of an overhead point like chejja of a window is required , the staff can be inverted(the foot of the staff touching the overhead point) and read. This reading is entered as a negative reading and in remarks column noted as inverted reading.

DIAGRAM



FORMULAE

Height of instrument method or Plane of collimation method:

- HI or PC= RL+BS
- RL= HI- IS or FS
- Check: $\sum BS$-$\sum FS$= Last RL – First RL

PROCEDURE

1. Set up dumpy level at suitable place and carry out temporary adjustments.
2. Hold the staff (inverted) on bench mark, take BS (enter with negative).
3. Determine plane of collimation by adding back sight to the reduced level of the bench mark.
4. Hold the staff on change point, take FS.
5. The elevation or RL of change point is calculated by subtracting the fore sight from plane of collimation.
6. The instrument is shifted to new point and back sight is taken on the same point.
7. Repeat the procedure to get elevation of required point.

OBSERVATIONS & CALCULATIONS

Problem

Height of instrument method:

BS	IS	FS	HI	RL	STATION	REMARKS

Rise and fall method:

BS	IS	FS	HI	RL	STATION	REMARKS

Check

RESULTS

COMMENTS

Experiment No. 6

RECIPROCAL LEVELLING

AIM

To determine difference in elevation between two points using reciprocal levelling and to determine the collimation error.

INSTRUMENTS REQUIRED

Dumpy level/ Auto level with tripod stand, Levelling staff.

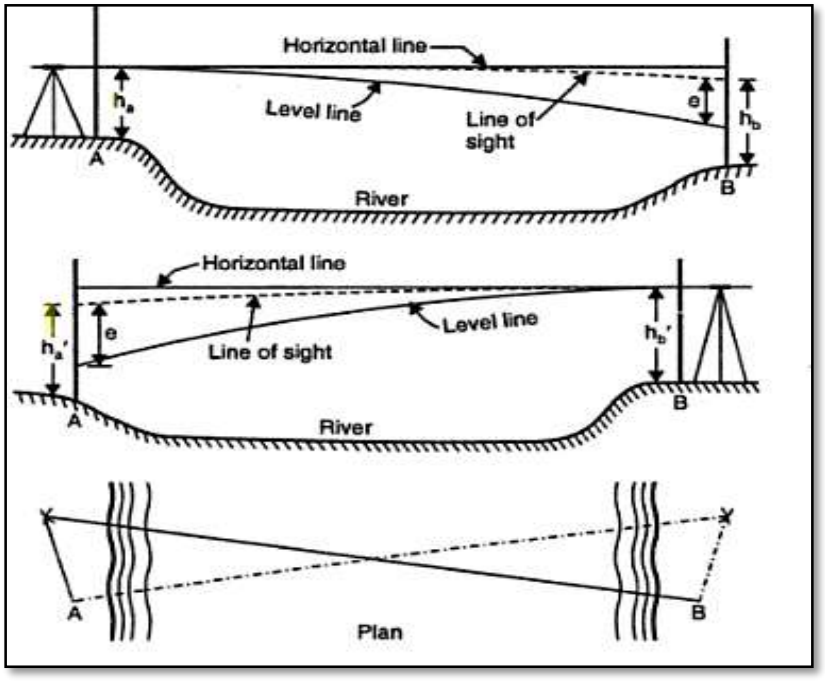
THEORY

Reciprocal levelling is the method of levelling in which the difference in elevation between two points is accurately determined by two sets of observations when it is not possible to set up the level midway between the two points. In case of a river or valley, it is not possible to set up the level midway between two points on opposite banks. In such cases, the method of reciprocal levelling is adapted.

The errors eliminated by using reciprocal levelling are:

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

DIAGRAM



FORMULAE

- $H = \frac{(ha-hb)+(ha'-hb')}{2}$
- $e = \frac{(ha-hb)-(ha'-hb')}{2}$

Where H = Difference in elevation.

e = Collimation error

h_a = Staff reading on A when instrument is near A.

h_b = Staff reading on B when instrument is near A.

h_a^l = Staff reading on A when instrument is near B.

h_b^l = Staff reading on B when instrument is near B.

PROCEDURE

1. Let 'A' and 'B' are two points on the banks of a river.
2. Dumpy level is set up near 'A' and after proper temporary adjustment, staff readings are taken at 'A' and 'B'. Let the readings be h_a and h_b.
3. The level is shifted and set up near 'B' after proper temporary adjustment, staff readings are taken at 'A' and 'B'. Let the readings be h_a^l and h_b^l.

OBSERVATIONS & CALCULATIONS

Problem

Instrument at	Staff reading on A	Staff reading on B

RESULTS

COMMENTS

Experiment No. 7(a)

PROFILE LEVELLING

AIM

To conduct profile levelling for water supply/sewage line and to draw the longitudinal section to determine depth of cut and depth of filling for a given formation level.

INSTRUMENTS REQUIRED

Dumpy level/Auto level with Tripod stand, Levelling staff, Tape, Arrows.

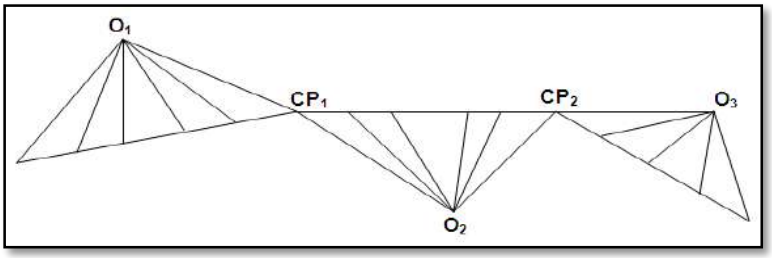
THEORY

Profile levelling is also called as ***longitudinal sectioning or longitudinal levelling.*** The object of profile levelling is to determine elevations of points at regular interval along a predetermined line, which is usually the centre line of a road, railway, canal, pipe line. The predetermined line may be a single straight line or may consist of a series of straight lines changing directions, or connected by curves.

Profile levelling requires the establishment of turning points on which both back sight and fore sights are taken. In addition any number of intermediate sights may be obtained on points along the line from each setup of the instrument. In fact, points on the profile line are merely intermediate stations. It is generally best to set up the level to one side of the profile line.

After getting reduced level of various points along the line, profile of the ground is plotted. Normally, vertical scale is much larger than the horizontal scale to clearly view the profile. Then engineers decide the formation level of the proposed project. The decision is mainly based on balancing cutting and embanking so that the transportation of earth is minimum.

DIAGRAM



FORMULAE

- Depth of fill (DOF), if Formation level – Reduced level is positive.
- Depth of cut (DOC), if Formation level – Reduced level is negative.
- HI or PC= RL+BS
- RL= HI- IS or FS
- Check: $\sum BS$-$\sum FS$= Last RL – First RL

PROCEDURE

1. The dumpy level is placed at suitable positions and after temporary adjustment the staff readings are taken.
2. The first staff reading of any set up is entered in the BS column and the last in the FS column. The other readings are entered in the IS column.
3. Calculate the RL's of the stations and plot a graph in excel.
4. The plotted points are joined to obtain the profile of the ground.
5. The formation level of the water supply or sewage line is to be mentioned and the depth of cut or depth of fill may be ascertained.

OBSERVATIONS & CALCULATIONS

Problem

BS	IS	FS	HI	RL	Distance	FL	DOF	DOC	Station	Remarks

RESULTS

COMMENTS

Experiment No. 7(b)

CROSS SECTIONING

AIM

To conduct cross sectioning for water supply/sewage line.

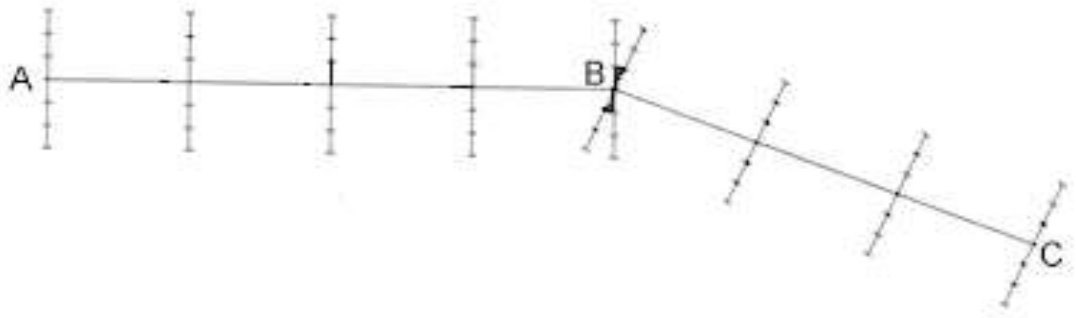
INSTRUMENTS REQUIRED

Dumpy level/Auto level with Tripod stand, Levelling staff, Tape, Arrows.

THEORY

In many engineering projects, to calculate earth work involved, not only longitudinal but also profile of cross sectioning is required at regular intervals. The distances on cross sectioning are treated as left or right of the line as they are found while facing forward point of surveying. The length of cross section depends on nature of work.

DIAGRAM



FORMULAE

- Depth of fill (DOF), if Formation level – Reduced level is positive.
- Depth of cut (DOC), if Formation level – Reduced level is negative.
- HI or PC= RL+BS
- RL= HI- IS or FS
- Check: $\sum BS$-$\sum FS$= Last RL – First RL

PROCEDURE

1. The dumpy level is placed at suitable positions and after temporary adjustment the staff readings are taken.
2. The first staff reading of any set up is entered in the BS column and the last in the FS column. The other readings are entered in the IS column.
3. Calculate the RL's of the stations and plot a graph in excel.
4. The plotted points are joined to obtain the cross sectioning profile of the ground.
5. The formation level of the water supply or sewage line is to be mentioned and the depth of cut or depth of fill may be ascertained.

OBSERVATIONS & CALCULATIONS

Problem

BS	IS	FS	HI	RL	Distance	FL	DOF	DOC	Station	Remarks

RESULTS

COMMENTS

Experiment No. 7(c)

BLOCK LEVELLING

AIM

To conduct block levelling and preparation of contours on graph paper to scale.

INSTRUMENTS REQUIRED

Dumpy level/Auto level with Tripod stand, Levelling staff, Tape, Arrows.

THEORY

This method is suitable, if the area to be surveyed is not very large and undulation of the ground is not much. A ***contour*** is an imaginary line on the ground joining the points of equal elevation. The vertical distance between any two consecutive contours is called ***contour interval***.

DIAGRAM

FORMULAE

Height of instrument method or Plane of collimation method:

- HI or PC= RL+BS
- RL= HI- IS or FS
- Check: $\sum BS$-$\sum FS$= Last RL – First RL

Require contour RL from small RL point= $\frac{Required\ R\ L-small\ RL}{large\ RL-small\ RL}\ X\ scale$

PROCEDURE

1. Area is divided into a number of squares and all grid points are marked.
2. By levelling reduced levels of all the grid points are obtained.
3. The grid of squares is plotted, reduced levels of all grid points marked and contour lines interpolated.

OBSERVATIONS & CALCULATIONS

Problem

Height of instrument method:

BS	IS	FS	HI	RL	STATION	REMARKS

Check

RESULTS

COMMENTS

Experiment No. 8(a)

HORIZONTAL ANGLE – REPETITION METHOD

AIM

To determine the horizontal angle PQR with respect to the station Q by repetition method.

INSTRUMENTS REQUIRED

Theodolite, Arrow, Ranging rods.

THEORY

The method of repetition is used to measure a horizontal angle to a finer degree of accuracy than that obtainable with the least count of vernier.

The following errors are eliminated by method of repetition:

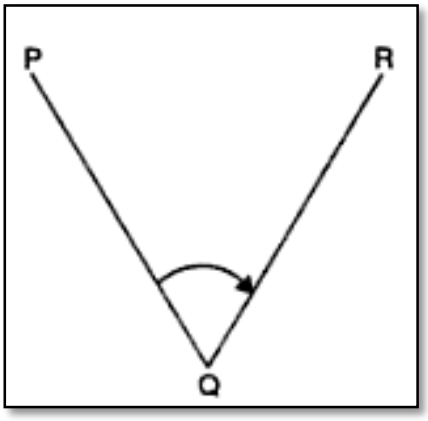
a. Error due to inaccurate graduations are eliminated by taking readings at different parts of the circle.
b. Errors due to eccentricity of verniers and centres are eliminated by taking both vernier readings.
c. Error due to inadjustments of line of collimation and the trunnion axis are eliminated by taking both face readings.
d. Errors due to inaccurate bisection of the object, eccentric centring ect., may be to some extent counter balanced by taking many observations.

Limitations of method of Repetition:

The following errors are not eliminated:

a. Error due to slip.
b. Error due to displacement of signal.
c. Error due to non verticality of vertical axis when the bubble is out of centre.
   If the sighting distances are less than 100m, the errors in sighting and centring are more significant. They upset the increased precision achieved by the method of repetition. Hence, there is not much advantage for going to this method when sight distances are small, say less than 100m.

DIAGRAM



PROCEDURE

1. Set the instrument at Q and level it. With the help of upper clamp and upper tangent set vernier A to 0º00´00´´. Note the reading of vernier B.
2. Loose the lower clamp and direct the telescope towards the point P. Clamp the lower clamp and bisect point P accurately by lower tangent screw.
3. Unclamp the upper clamp and turn the instrument in clockwise direction towards R. Clamp the upper clamp and bisect R accurately with the upper tangent screw. Note the reading of verniers A and B.
4. Unclamp the lower clamp and turn the telescope clockwise to sight P again. Bisect P accurately by using the lower tangent screw. It should be noted that the vernier readings will not be changed in this operation.
5. Unclamp the upper clamp, turn the telescope clockwise and sight R. Bisect R accurately by upper tangent screw.
6. Repeat the process until the angle is repeated the required number of times (usually 3). The average angle with face left will be equal to final reading divide by three (number of repetitions).
7. Change face and make three more repetitions as described above. Find the average angle with face right, by dividing the final reading by three (number of repetitions).
8. The average horizontal angle is then obtained by taking the average of the two angles obtained with face left and face right.

   Any number of repetitions may be made. However, three repetitions with the telescope normal and the three with the telescope inverted are quite sufficient for anything, except very precise work.

OBSERVATIONS & CALCULATIONS:

$$Least\ Count = \frac{1\ Main\ Scale\ Reading}{Number\ of\ Vernier\ Scale\ Divisions}$$

$$L.C. = \frac{1\ MSR}{Number\ of\ VSD}$$

L.C. =

Instrument at	Q			
Sighted to	P	R	R	R
Face: Left				
A				
B				
Mean				
Swing: Right				
No. of Repetitions				
Face: Right				
A				
B				
Mean				
Swing: Right				
No. of Repetitions				
Average Horizontal Angle				

RESULTS

The average horizontal angle PQR =

COMMENTS

Experiment No. 8(b)

HORIZONTAL ANGLE – REITERATION METHOD

AIM

To determine the horizontal included angles with respect to station O by the reiteration method.

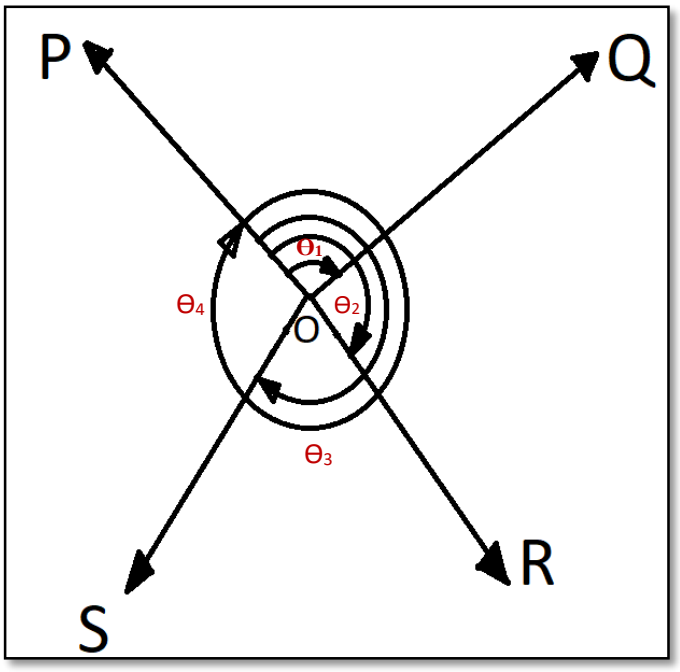
INSTRUMENTS REQUIRED

Theodolite, Arrow, Ranging rods.

THEORY

The method of reiteration or direction method or method of series is generally used when several angles are to be measured at the same station. All the angles are measured successively starting from the initial station. The angle between the last station and initial station is also measured and thus horizon is closed (Closing the horizon is the process of measuring the angle at an instrument station round the point to obtain a check on their sum, which should be equal to 360^0). The final reading of the vernier should be the same as its initial reading. If the discrepancy is small, the error is equally distributed among all the angles measured. If it is large, the readings should be cancelled and new sets taken.

DIAGRAM



Where,

O = Instrument station

P, Q, R and S = Objects

PROCEDURE

1. Set the instrument at O and level it. With the help of upper clamp and upper tangent screw set the vernier A to $0^0 00' 00''$.
2. Unclamp the lower clamp and direct the telescope to the ranging rod at P. Tighten the lower clamp screw. Bisect P accurately using the lower tangent screw. (Generally the object at P is called 'Reference object').
3. Loosen the upper clamp screw and turn the telescope clockwise until the ranging rod at Q is bisected. Tighten the upper clamp. Use the upper tangent screw for exact bisection. Read both the verniers. The mean of the vernier readings gives the horizontal angle POQ.
4. Unclamp the upper clamp screw and turn the telescope clockwise until R is bisected. Tighten the upper clamp. Use the upper tangent screw for exact bisection. Read both the verniers. The angle QOR is obtained by taking the difference between the reading on R and Q.
5. Similarly determine the angle ROS.
6. Finally close the horizon by sighting the reference object P again. The vernier A should now read 360^0 (or 0^0). If not, note the vernier reading and find the error.
7. If the error is small, distribute it equally to all the angles. If the error is large, discard the readings and take a fresh set of readings.
8. Now change the face of the instrument to right by transiting the telescope. Measure the angles in the same manner by swinging in anticlockwise direction (Left).

OBSERVATIONS & CALCULATIONS

$POQ = \Theta_1$
$QOR = \Theta_2 - \Theta_1$
$ROS = \Theta_3 - \Theta_2$
$SOP = \Theta_4 - \Theta_3$

Check: $POQ + QOR + ROS + SOP = 360^0$

Instrument at	Sighted to	Face: Left Swing: Right												Face: Right Swing: Left												Average horizontal Included angle		
		A			B		Mean			Horizontal Included angle				A			B		Mean			Horizontal Included angle						
		o	′	″	′	″	o	′	″	o	′	″		o	′	″	′	″	o	′	″	o	′	″		o	′	″
O	P																											
	Q																											
	R																											
	S																											
	P																											

RESULTS

The average horizontal included angles:

POQ =

QOR =

ROS =

SOP =

COMMENTS

Experiment No. 8(c)

VERTICAL ANGLE

AIM

a) To measure the vertical angles of the objects A and B shown in figure with respect to the station P.
b) To determine the vertical height of an object or electric pole when base is accessible.

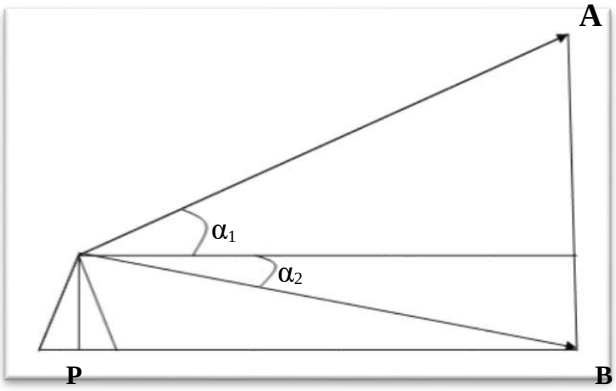
INSTRUMENTS REQUIRED

Theodolite, Arrow.

THEORY

A vertical angle is defined as the angle of inclined line of sight to an object makes with the horizontal. The vertical angle is the angle of elevation when the line of sight is inclined upwards from the horizontal line. It is the angle of depression when the line of sight is inclined downwards from the horizontal line. The angle of elevation is noted as positive angle and the angle of depression as negative angle.

DIAGRAM



PROCEDURE

1. Set up the theodolite over the station P and level it accurately with reference to the altitude bubble.
2. Unclamp the vertical circle clamp and direct the telescope towards the object A. clamp the vertical circle. Bisect A exactly by turning the vertical tangent screw.
3. Read both the verniers C and D. The mean of the two readings gives the value of required angle.
4. Change the face of the instrument and repeat the same procedure. The mean of the two readings gives the second value of the required angle.
5. The average of the two values thus obtained gives the value of the required vertical angle.
6. Similarly measure the angle of depression by bisecting object B.

OBSERVATIONS & CALCULATIONS

Instrument at	Face: Left				Face: Right				Average Vertical angle
Sighted to	C	D	Mean	Vertical angle	C	D	Mean	Vertical angle	
P A	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
B									

$h_1 = D\tan\alpha_1$

$h_2 = D\tan\alpha_2$

$H = h_1 + h_2$

RESULTS

The angle of Elevation = ……

The angle of depression=……

The height of electric pole = ……m

COMMENTS

Experiment No. 9(a)

SINGLE PLANE METHOD

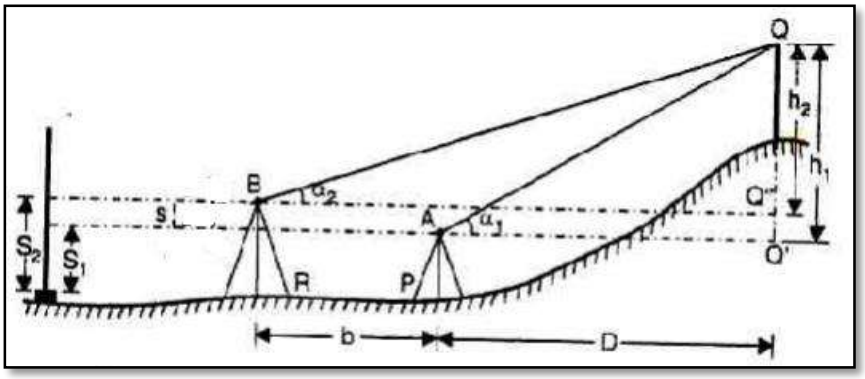
AIM

To find the reduced level of the top of an object when the base is inaccessible by Single plane method. Given the R.L. of the B.M.

INSTRUMENTS REQUIRED

Theodolite with tripod, Leveling staff, Tape, Ranging rod, Arrow.

DIAGRAM



Where

α_1= Angle of elevation from A to Q.

α_2= Angle of elevation from B to Q.

b= Horizontal distance between the instrument stations.

D= Horizontal distance between P and Q.

S_1= Staff reading on B.M. from instrument station P.

S_2= Staff reading on B.M. from instrument station R.

PROCEDURE

1. Set up theodolite at P and level it accurately with respect to the altitude bubble.
2. Direct the telescope towards Q and bisect it accurately. Clamp both the plates. Read the vertical angle.
3. Transit the telescope so that line of sight is reversed. Mark the second instrument station R on the ground. Measure the distance PR accurately.
4. Repeat step 2 and step 3 for both face observations. The mean value should be adopted (α_1).
5. With the vertical vernier set to zero reading (line of sight horizontal), and the altitude bubble in the centre of its run, take the reading on staff (S_1) kept at B.M.
6. Set up theodolite at R. Measure the vertical angle α_2 to Q with both face observations. Take staff reading on B.M. when line of sight is horizontal (S_2).

OBSERVATIONS & CALCULATIONS:

Instrument at	Sighted to	Face: Left											Face: Right											Average Vertical angle		
		C			D		Mean			Vertical angle			C			D		Mean			Vertical angle					
		°	′	″	′	″	°	′	″	°	′	″	°	′	″	′	″	°	′	″	°	′	″	°	′	″
P	Q																									
R	Q																									

Instrument station	**Staff Reading on B.M. in m**	**Vertical angle**	**Remarks**
P	S_1=	α_1=	The horizontal distance between instrument stations=b=…………….m
R	S_2=	α_2=	The R.L. of B.M.=……………….m

RESULTS

The R.L. of the top of the object is……..m

COMMENTS

Experiment No. 9(b)

DOUBLE PLANE METHOD

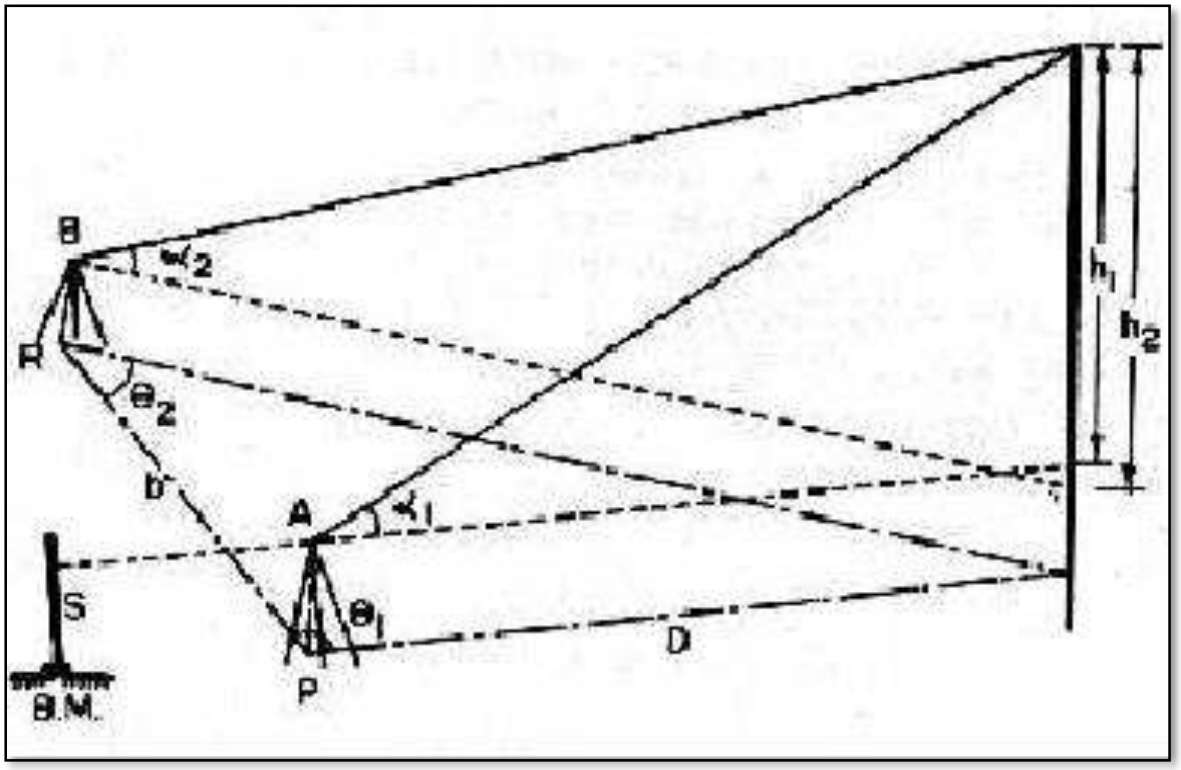
AIM

To find the reduced level of the top of an object when the base is inaccessible by Double plane method. Given the R.L. of the B.M.

INSTRUMENTS REQUIRED

Theodolite with tripod, Levelling staff, Tape, Ranging rod, Arrow.

DIAGRAM



Where

α_1= Angle of elevation from A to Q.

α_2= Angle of elevation from B to Q.

b= Horizontal distance between the instrument stations.

D= Horizontal distance between P and Q.

S_1= Staff reading on B.M. from instrument station P.

S_2= Staff reading on B.M. from instrument station R.

PROCEDURE

1. Set up theodolite at P and level it accurately with respect to the altitude bubble.
2. Direct the telescope towards Q and bisect it accurately. Clamp both the plates. Read the vertical angle.
3. Transit the telescope so that line of sight is reversed. Mark the second instrument station R on the ground. Measure the distance PR accurately.
4. Repeat step 2 and step 3 for both face observations. The mean value should be adopted (α_1).
5. With the vertical vernier set to zero reading (line of sight horizontal), and the altitude bubble in the centre of its run, take the reading on staff (S_1) kept at B.M.
6. Sight the point R with reading on horizontal circle as zero, and measure the angle RPQ_1 i.e., the horizontal angle Θ_1 at P.
7. Set up theodolite at R. Measure the vertical angle α_2 to Q with both face observations. Take staff reading on B.M. when line of sight is horizontal (S_2). Measure horizontal angleΘ_2.

OBSERVATIONS & CALCULATIONS

Measurement of Horizontal angle:

Instrument at	Sighted to	Face : Left					Swing : Right		
		A			B		Mean		
		°	′	″	′	″	°	′	″
P									
R									

Instrument at	Face: Left						Face: Right						Average Vertical angle		
Sighted to	C		D	Mean		Vertical angle	C		D	Mean		Vertical angle			
	°	′	″	′	″	°	′	″	′	″	°	′	″	°	′	″
P																
Q																
Q																
P																
R																

Instrument station	Staff Reading on B.M. in m	Vertical angle	Horizontal angle	Remarks
P	S_1 =	α_1 =	Θ_1 =	The horizontal distance between instrument stations=b=……m
R	S_2 =	α_2 =	Θ_2 =	The R.L. of B.M.=……m

From the $\Delta^{le}\ PRQ_1$
$\Theta_1 + \Theta_2 + \Theta_3 = 180^0$
$\Theta_3 = 180^0 - (\Theta_1 + \Theta_2) =$……

Applying Sine rule to the $\Delta^{le}\ PRQ_1$

$$\frac{\boldsymbol{PR}}{\sin \boldsymbol{\theta_3}} = \frac{\boldsymbol{RQ_1}}{\sin \boldsymbol{\theta_1}} = \frac{\boldsymbol{PQ_1}}{\sin \boldsymbol{\theta_2}}$$

$$\frac{\boldsymbol{b}}{\sin \boldsymbol{\theta_3}} = \frac{\boldsymbol{RQ_1}}{\sin \boldsymbol{\theta_1}} = \frac{\boldsymbol{PQ_1}}{\sin \boldsymbol{\theta_2}}$$

$$RQ_1 = \frac{b \sin \theta_1}{\sin \theta_3} =$$

$$PQ_1 = \frac{b \sin \theta_2}{\sin \theta_3} =$$

$h_1 = PQ_1 \text{ X } \tan\alpha_1 =$

$h_2 = RQ_1 \text{ X } \tan\alpha_2 =$

R.L. of top of object = R.L. of B.M. + S_1+ h_1 =

OR

R.L. of top of object = R.L. of B.M. + S_2+ h_2 =

Note: Adopt the mean value as the R.L. of Q

RESULTS

The R.L. of the top of the object is……..m

COMMENTS

Experiment No. 10

TACHEOMETRIC SURVEYING

AIM

To determine the distance and elevation of an object by finding tacheometric constants when the line of sight is horizontal and inclined.

INSTRUMENTS REQUIRED

Tacheometer with tripod, Levelling staff, Arrows.

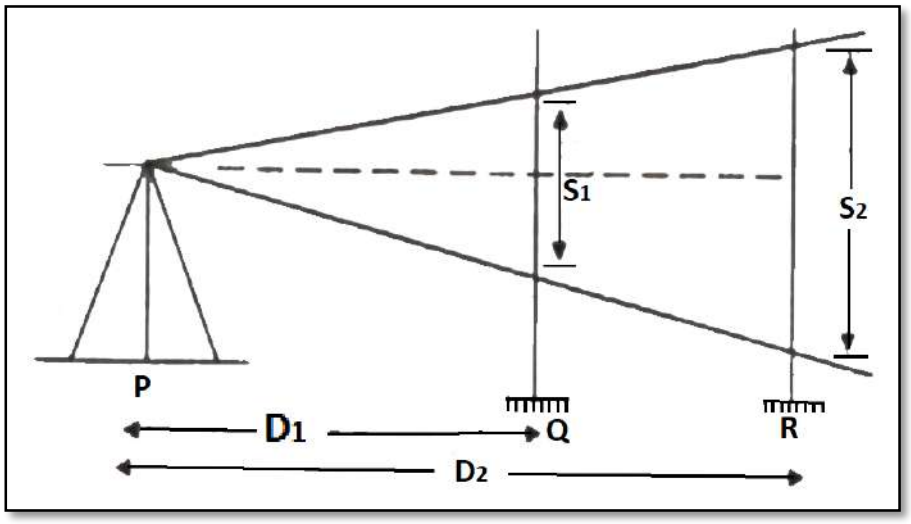
THEORY

Tacheometry is a branch of angular surveying in which the horizontal and vertical distance of points are obtained by optical means. An ordinary theodolite fitted with a stadia diaphragm is generally used for tacheometric survey. The stadia diaphragm essentially consists of one stadia hair above and the other an equal distance below the horizontal cross hair.

Determination of Tacheometric Constants

a) Line of sight is horizontal

DIAGRAM



Where,
P = Instrument station.
Q and R = Staff station.

FORMULA

- **D = KS + C**

  Where

  D= Distance measured from tacheomter to the point sighted in m.

  S= Staff intercept in m.

  K= Multiplying Constant.

  C= Additive Constant.

PROCEDURE:

1. Set up the tacheometer, at P and level it.
2. The line of sight of a telescope is made horizontal by setting verniers C and D to zero.
3. Keep the levelling staff at 20m from P. Read out the staff readings corresponding to the top and bottom Stadia hairs. The staff intercept S_1 is obtained by the algebraic difference of both the readings.
4. Keep the levelling staff at 30m from P. Read out the staff readings corresponding to the top and bottom Stadia hairs. The staff intercept S_2 is obtained by the algebraic difference of both the readings.

OBSERVATIONS & CALCULATIONS:

Instrument Station	Staff Station	Staff reading	Staff intercept in m	Distance in m
P	A			
	B			

$D_1 = KS_1 + C$

20 = K ( ) + C……1

$D_2 = KS_2 + C$

30 = K ( ) + C……2

By solving equation 1 and 2

K = ... and C = …….

b) Line of sight inclined

DIAGRAM:

Where
P=Instrument station.
Q and R= Staff station.

FORMULA:

- **$D = KS\cos^2\theta + C\cos\theta$**

  Where

  D = Distance measured from tacheomter to the point sighted in m.
  S = Staff intercept in m.
  θ = Vertical angle.
  K = Multiplying Constant.
  C = Additive Constant.

PROCEDURE:

1. Set up the tacheometer, at P and level it.
2. Make the line of sight incline. Clamp the vertical circle clamp. Read both the verniers C and D. The mean of the two readings gives the value of θ.
3. Keep the levelling staff at 20m from P. Read out the staff readings corresponding to the top and bottom Stadia hairs. The staff intercept S_1 is obtained by the algebraic difference of both the readings.
4. Keep the levelling staff at 30m from P. Read out the staff readings corresponding to the top and bottom Stadia hairs. The staff intercept S_2 is obtained by the algebraic difference of both the readings.

OBSERVATIONS & CALCULATIONS:

Instrument Station	Staff Station	Staff reading	Staff intercept in m	Vertical angle	Distance in m
P	A				
	B				

$D_1 = KS_1Cos^2\theta + Ccos\theta$

20 = K ( )Cos^2 ( )+C……1

$D_2 = KS_2Cos^2\theta + Ccos\theta$

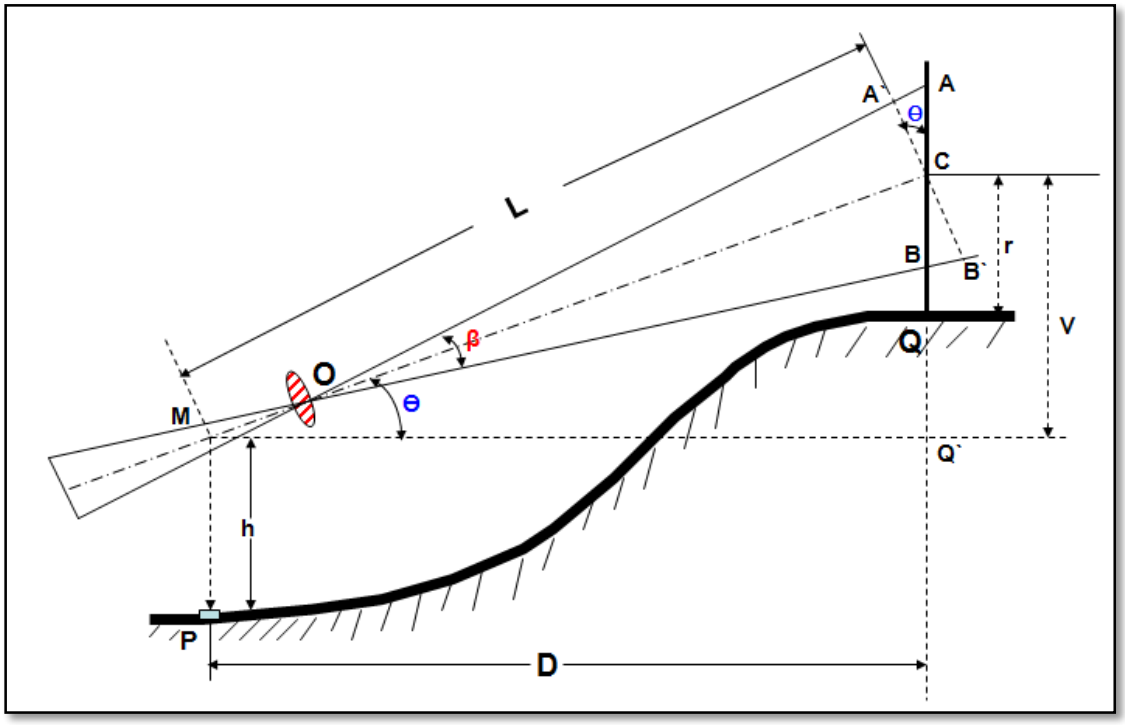
30 = K ( )Cos^2 ( ) + C……2

By solving equation 1 and 2

K = ... and C = …….

TO DETERMINE DISTANCE AND ELEVATION

DIAGRAM



Where

P = Instrument station.

Q = Staff station.

FORMULAE

- **$D = KS\cos^2\theta + C\cos\theta$**
- **$V = KS \frac{\sin 2\theta}{2} + C\sin\theta$**
- **For angle of elevation:**
  Elevation of Q = Elevation of instrument station + h + V- r
- **For angle of depression:**
  Elevation of Q = Elevation of instrument station + h – V - r

Where,

D = Horizontal distance measured from tacheomter to the point sighted in m.
S = Staff intercept in m.
θ = Vertical angle.
K = Multiplying Constant.
C = Additive Constant.
H = Height of the instrument
V = Vertical intercept at Q
r = Central hair reading

PROCEDURE

1. Set up the tacheometer, at P and level it.
2. Make the line of sight incline. Clamp the vertical circle clamp. Read both the verniers C and D. The mean of the two readings gives the value of θ.
3. Read the staff reading corresponding to lower, central and upper hairs.
4. Measure the height of instrument using tape.

OBSERVATIONS & CALCULATIONS

Vertical angle = θ =
Staff intercept = S =
Central hair reading= r =

RESULTS

COMMENTS

Experiment No. 11

THEODOLITE TRAVERSING

AIM

To measure the bearings of the sides of the closed traverse using theodolite and adjustment of the closing error by Transit method.

INSTRUMENTS REQUIRED

Theodolite fitted with compass, tape, Ranging rods, Arrows.

THEORY

In traversing by ***Fast needle method*** the magnetic bearings of traverse lines are measured by a theodolite fitted with compass. However, the direction of the magnetic meridian is not established at each station but instead, the magnetic bearings of the lines are measured with reference so the direction of magnetic meridian established at the *first station*. The method is, therefore, more accurate than the loose needle method.

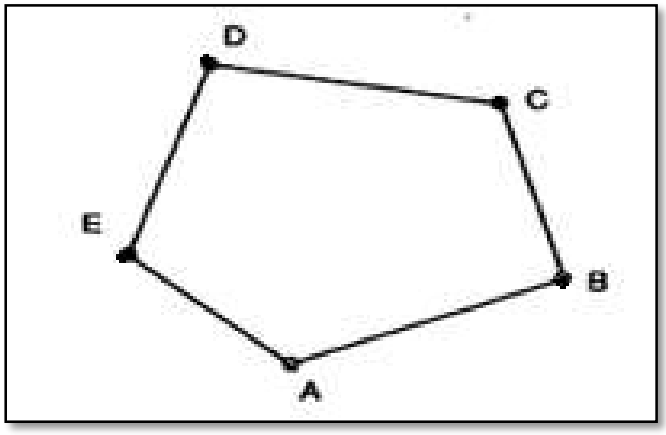
There are three methods of observing the bearings of lines by fast needle method:

a) Direct method with transiting
b) Direct method without transiting
c) Back bearing method

Of the three methods of fast needle, the second method is the most satisfactory.

Transit method may be employed to balance the traverse when the angular measurements are more precise than the linear measurements. In this method the total error in latitude and departure is distributed in proportion to the latitude and departure of the traverse lines.

DIAGRAM



FORMULAE

- Transit method:

$$\mathbf{C_L = \sum L \times \frac{L}{LT}}$$

$$\mathbf{C_D = \sum D \times \frac{D}{DT}}$$

Where

C_L = Correction to latitude of any side
C_D = Correction to departure of any side
$\sum L$ = Total error in latitude
$\sum D$ = Total error in departure
L = Latitude of that side
L_T = Arithmetic sum of latitudes (Ignoring the signs)
D = Departure of that side
D_T = Arithmetic sum of departures (Ignoring the signs)

PROCEDURE

1. Let A, B, C, D, E are the traverse stations.
2. Using upper clamp and tangent screw take a foresight on B. the reading on vernier A gives the magnetic bearing of AB.
3. With both plates clamped, move the instrument and set it at B.take a backsight on A. Check the reading on vernier A which should be the same as before. The line of sight is out of orientation by 180°.
4. Loose the upper clamp and rotate the instrument clockwise to take a foresight on C. Read the vernier. Since the orientation at B is 180° out, a correction of 180° is to be applied to the vernier reading to get the correct bearing of BC. Add 180°if the reading on the vernier is less than 180° and subtract 180° if it is more than 180°.
5. Shift the instrument to C and take backsight on B. The orientation at C will be out by 180° with respect to that at B and 360° with respect to that at A. thus, after taking foresight on the next station, the vernier reading will directly give magnetic bearing of the next line, without applying correction of 180°.

The application of 180° correction is, therefore, necessary only at 2^{nd},4^{th}, 6^{th} station occupied. Instead of applying correction at even station, opposite vernier may be read alternatively, i.e., vernier A at A, vernier B at B, vernier A at C etc.

OBSERVATIONS & CALCULATIONS

Transit method

Sl. No.	Line	Length (l)in m	Bearing	Latitude L= $lCos\theta$	Departure D= $lSin\theta$	Corrections		Corrected	
						Latitude	Departure	Latitude	Departure
1									
2									
3									
4									
5									
6									

D_T =……..

L_T =……...

RESULTS

COMMENTS

Experiment No. 12

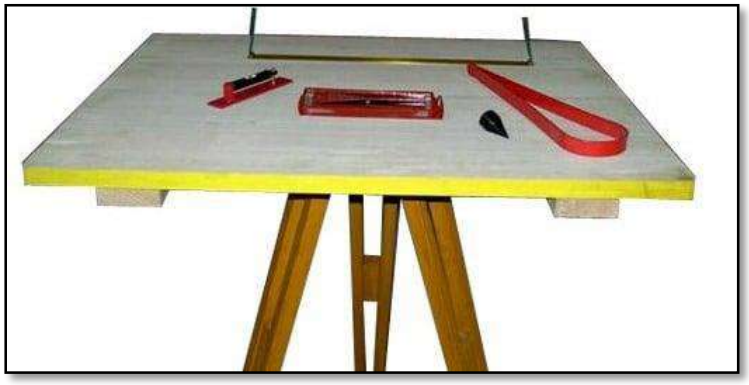
PLANE TABLE SURVEYING

Principle: The principle of plane tabling is parallelism means "All the rays drawn through various details should pass through the survey station".

Plane table surveying is a graphical method of survey in which the field observations and plotting are done simultaneously. It is simple and cheaper than Theodolite survey but it is mostly suitable for small scale survey. The plan on drawing sheet drawn by surveyor in the field itself so there is chance of occurrence of any mistake is very less.

Equipment's Used in Plane Table Survey

a. ***The drawing board:*** The board is made of well-seasoned wood and varies in size from 40cm x 30 cm to 75cm x 60cm or 50 – 60 cm square.
b. ***The Alidade:*** The alidade consists of metal or box wood straight edge or ruler about 50cm long. The welled edge of the alidade is called the fiducially edge.
c. ***Tripod:*** It is rigid and light equipment having three legs. The plane table is mounted on tripod. It have three foot screw to level the plane table.
d. **Accessories to the plane table**
    i. *Trough compass*: The compass is used to mark the direction of the meridian (North Direction) on the paper.
    ii. *U – frame or plumbing fork:* U frame with a plumb bob used for centering the table.
    iii. *Water proof cover:* Water Proof cover protects the sheet from rain
    iv. *Spirit level or level tube:* A level tube is used to level the plane table.
    v. *Drawing sheet:* The drawing sheet is fixed on the top of the drawing board.
    vi. *Pencil or eraser*: A pencil is used for constructing lines and eraser is used for erasing lines after completion of the plan.



Methods of Plane Table Survey

a. Radiation
b. Intersection
c. Traversing
d. Resection

Experiment No. 12(a)

RADIATION METHOD

AIM

To locate the object points from a single station.

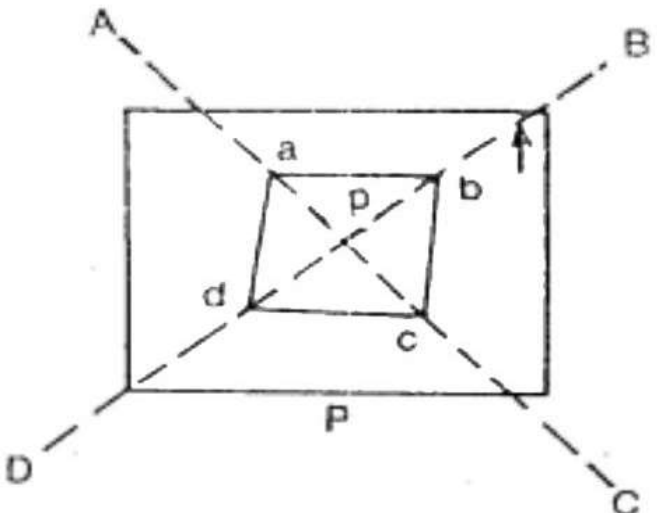
INSTRUMENTS REQUIRED

Plane table with accessories and tape.

THEORY

In Radiation method, rays are drawn from the station to the objects, and the distances from the station to the objects are measured and plotted to any suitable scale along the respective rays.

DIAGRAM



PROCEDURE

1. Suppose P is a station on the ground from where the objects A, B, C and D are visible.
2. The plane table is set up over the station P. A drawing sheet is fixed on the table, which is then levelled and centered. A point p is selected on the sheet to represent the station P.
3. The north line is marked on the right-hand top corner of the sheet with trough compass or circular box compass.
4. With the alidade touching p, the ranging rods at A, B, C and D are bisected
5. The distances PA, PB, PC, and PD are measured and plotted to any suitable scale to obtain the points a, b, c, and d, representing the objects A, B, C and D on paper.

RESULTS

COMMENTS

Experiment No. 12(b)

INTERSECTION METHOD

AIM

To locate the inaccessible points from two instrument stations.

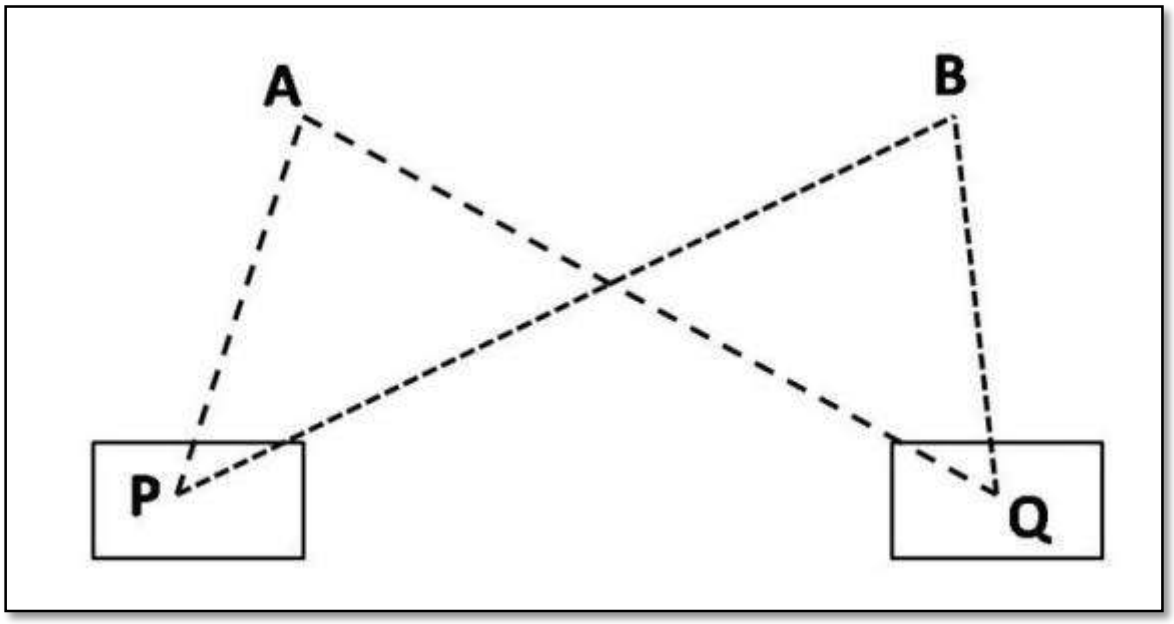
INSTRUMENTS REQUIRED

Plane table with accessories and tape.

THEORY

This method is suitable for locating inaccessible points by the intersection of the rays drawn from two instruments stations.

DIAGRAM



PROCEDURE

1. Select two points P and Q such that the points (building corners) to be plotted are visible from their stations.
2. Set the table on ‘P’ and locate on the sheet.
3. Pivot on ‘P’ bisect ‘Q’ draw a ray.
4. Measure the distance ‘PQ’ and locate ‘Q’ on the sheet to a convenient scale.
5. Now ‘pq’ is known as the base line.
6. Pivot ‘p’ bisects the inaccessible objects A and B (building corners) and draw rays.
7. Shift the table to ‘a’ such that ‘q’ is over ‘Q’ and do temporary adjustments.
8. Place the alidade along ‘qp’ and the rotate the table till ‘p’ is bisected clamp table.

9. Pivot on q bisect the objects A and B and draw rays.
10. The instruction of rays drawn from P and Q will give the points ‘a’ and ‘b’.
11. To check the accuracy measured AB and compare with plotted distance ‘ab’.
12. The same procedure is applied for other features of the campus. each point is bisected from two stations.

RESULTS

COMMENTS

Experiment No. 13

THREE POINT PROBLEM BY BESSEL'S GRAPHICAL METHOD

AIM

To establish a new station at the required position using Bessel's graphical method.

INSTRUMENTS REQUIRED

Plane table with accessories.

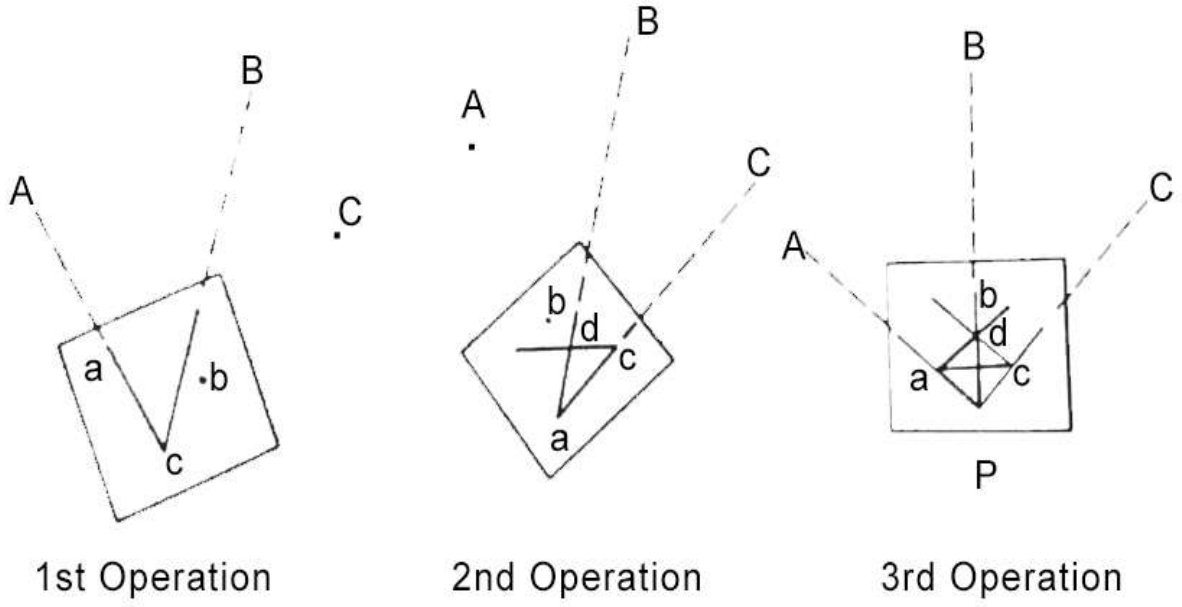
THEORY

In this problem, three well- defined points are selected whose positions have already been plotted on the map. Then by perfectly bisecting these three well-defined points, a new station is established at the required position.

No auxiliary station is required in order to solve this problem. The table is directly placed at the required position. The problem may be solved by three methods:

(a) The graphical or Bessel's method
(b) The mechanical method
(c) The trial and error method

DIAGRAM



PROCEDURE

1. Suppose A, B and C are three well-defined points which have been plotted as a, b, and c. Now it is required to locate a station at P.
2. The table is placed at the required station 'P' and levelled. The alidade is placed along the line 'ca' and the point 'A' is bisected. The table is clamped.
3. With the alidade centered on 'C', the point 'B' is bisected and ray is drawn.
4. Again the alidade is placed along the line 'ac' and the point 'C' is bisected and the table is clamped.
5. With the alidade touching 'a', the point B is bisected and a ray is drawn.
6. Suppose this ray intersects the previous ray at 'a' point 'd'.
7. The alidade is placed along 'db' and the point 'B' is bisected. At this position the table is said to be perfectly oriented.
8. Now the rays Aa, Bb and Cc are drawn. These three rays must meet at a point 'p' which is the required point on the map.
9. This point is transferred to the ground by U-fork and plumb bob.

RESULTS

COMMENTS

Experiment No. 14

DEMONSTRATION OF MINOR INSTRUMENTS

➢ Clinometer

The clinometers are light compact hand instruments commonly used for the measurement of slopes, tracing contours, setting grades, to determine the difference in elevation. They are adapted for rough and rapid work. The simplest form of clinometers consists of i) a semicircle graduated in degrees in both directions with zero placed at the middle of the arc, ii) a light plumb bob suspended from the centre. The various types of clinometersare: Abney clinometers or Abney level, Indian pattern clinometers or tangent clinometers, De lisle's clinometer, Watkin's mirror clinometers, foot rule clinometers.

➢ Ceylon Ghat Tracer

This instrument is used for setting out a grade contour, i.e. locating points of a given gradient in the preliminary survey of a hill road, and alsofor measuring the angles of slope. It essentially consists of a long circular tube having a peephole at one end and cross wires at the other ends. The tube is supported by aA- frame having a hole at its top to fix the instrument to a straight rod or stand. The tube is also engraved to give readings of gradient. A heavy weight slides along the tube by a suitable rack and pinion arrangement. The weight at its top contains one bevelled edge which slides along the graduations of the bar, and serves as an index. The line of sight is defined by the line joining the hole to the intersection of the cross wires and its prolongation. When the beveled edge of the weight is against the zero reading, the line of sight is horizontal. For the elevated gradients, the weight slided towards the observer. For falling gradients, the weight is slided away from the observer.

- **Boxbsextant**

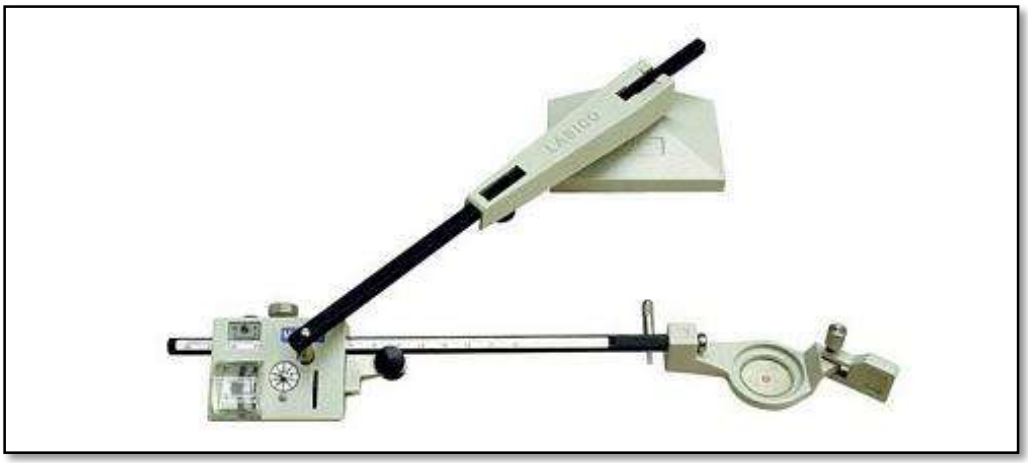
It is a small pocket instrument used for measuring horizontal and vertical angles, measuring chain angles and locating inaccessible points. By setting the vernier to 90°, it may be used as an optical square.

➢ Hand Level

It is a simple compact instrument used for reconnaissance and preliminary survey, for locating contours on the ground and for taking short cross-sections. It consists of a rectangular or circular tube, 10 to 15cm long, provided with a small bubble tube at the top.

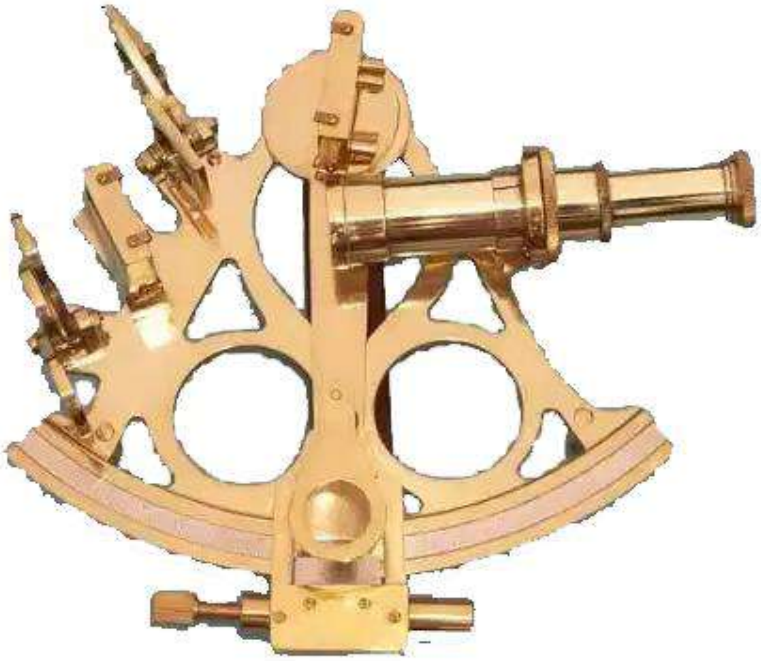
➢ Planimeter

It is an instrument which measures the area of plan of any shape very accurately. There are two typesofplanimeters: 1) Amsler polar planimeter, and 2) Roller planimeter.



➢ Nautical Sextant

Nautical sextant, also called as vernier sextant or marine sextant, is an instrument mainly used to determine latitude and longitude by measuring angles between two objects. Celestial objects such as sun, moon, and stars are sighted using a nautical sextant, and angular measurements between them and the horizon can be determined.



➢ Pantagraph

It is an instrument used for reproducing, enlarging or reducing the maps. It is based on the principle of similar triangles.

VIVA QUESTIONS

1. What is surveying?
2. What is reconnaissance survey?
3. What is an index sketch?
4. What is base line of survey?
5. How the north line of the chain survey map is fixed?
6. Suppose you are asked to conduct a chain survey in a crowded town. What would you say?
7. What should be the maximum length of offset?
8. How is a station marked on the ground?
9. What is the need of reference sketch?
10. How will you set up a perpendicular with the help of only a chain or a tape?
11. Who are 'leader' and 'follower', when a line is being chained?
12. Why does the field book open lengthwise?
13. Why is the scale always drawn in the map?
14. What is the necessity to provide tallies in the chain?
15. What do you mean by the ideal triangle?
16. What is the principle of compass surveying?
17. What is the difference between triangulation and traversing?
18. What does the term 'chain angle' means?
19. What is a 12cm compass?
20. What is the fundamental difference between the prismatic compass and Surveyor's compass?
21. How would you detect the presence of local attraction?
22. The FB of the line is 96°30′ and BB is 276°00′. How will you adjust the bearing?
23. What is local attraction?
24. What is declination?
25. What are isogonic and agonic lines?
26. What do you mean by azimuth?
27. The FB of line is 145°30′. What is its BB?
28. What are the precautions to be taken while shifting an prismatic compass from one station to another?
29. A compass was properly balanced at the equator. What will be the effect on the needle if it is taken to the northern hemisphere?
30. What is the angular check of a closed traverse?
31. How would you check the accuracy of open traverse?
32. What does traverse surveying mean?
33. Distinguish between closed and open traverse?
34. What is the datum surface?
35. What does the term GTS mean?

36. What is bench mark?
37. What is the datum adopted for GTS bench mark?
38. What are the types of bench marks that you know of?
39. For any engineering work, how will you get the RL of the starting point?
40. What is the difference between a level surface and a horizontal surface?
41. What is the difference between the line of collimation and axis of the telescope?
42. In a particular set up of the level, suppose four readings are taken. How should they be entered in the level book?
43. What is a change point?
44. The staff readings on A and B are 1.735 and 0.965 respectively. Which point is higher?
45. What is the procedure of levelling foot screws?
46. Suppose a level is given to you whose line of collimation is not in adjustment. What is the procedure that you would follow in order to work with this instrument?
47. How will you continue levelling across a river?
48. How will you continue levelling across a lake or pond?
49. What are the arithmetical checks for the HI method?
50. What are the arithmetical checks for the rise and fall method?
51. What is fly levelling?
52. What is temporary bench mark?
53. Why is datum assumed for plotting a levelling operation?
54. What is the difference between temporary and permanent adjustment?
55. What would you mean by positive RL and negative RL?
56. How will you measure the distance between two points with only a level and staff?
57. What is contour line?
58. Define the terms contour interval and horizontal equivalent?
59. Why is the horizontal equivalent not constant?
60. In some places consecutive contours run close together and in some places they are wide apart. What does this mean?
61. How will you distinguish between a valley line and a ridgeline?
62. How will you distinguish between a depression and summit by studying the nature of the contour?
63. In a map, it is found that two consecutive contours cross each other. What would you comment?
64. What is a contour gradient?
65. What is the object of preparing a contour map?
66. Define the terms ‘contour line’.
67. What are the characteristics of contour lines?
68. Show with neat sketches the characteristic features of contour lines of the following: a) a pond b) a hill c) a ridge d) a valley e) a vertical cliff.
69. State the uses of contour map.

70. What are the different methods of contouring? Describe any method along with sketch?
71. What is a grade contour? Describe along with sketch how you would locate one in the field.
72. Explain repetition and reiteration method of measuring horizontal angle using theodolite.
73. Explain the procedure for measurement of vertical angle using theodolite.
74. What are face left and face right observations? Why it is necessary to take both face observations?
75. Define the terms:

i) Swinging the telescope.
ii) Transiting the telescope.
iii) Telescope normal.