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Vision of the Institute	Mission of the Institute
"To become a leading institute of providing professionally competent and socially responsive technocrats with high moral values."	⇨ To create an eco-system for the dissemination of technical knowledge, to achieve academic excellence. ⇨ To develop technocrats with creative skills and leadership qualities, to solve local and global challenges. ⇨ To impart human values and ethics in students, to make them socially and Eco-friendly responsible.

LAB MANUAL

OF

Surveying & Geomatics Lab

[BCE 352]

B.TECH, 2rd Year, 3rd Semester

Dr. A.P.J. Abdul Kalam Tech. University
Uttar Pradesh

2025-26

Department of Civil Engineering

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(Assistant Professor)

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(Associate Professor)
Head of the Department

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MANUAL CONTENTS

This manual is intended for the 2nd year students of Civil Engineering in the subject of **Surveying & Geomatics Lab**. This manual typically contains practical/lab sessions related to practical knowledge and hands-on training in land surveying, mapping, and modern geospatial techniques used in civil engineering projects. The lab helps students understand the principles of measurement, leveling, contouring, traversing, and setting out works required for planning and construction activities.

Students are advised to thoroughly go through this manual rather than only the topics mentioned in the syllabus, as practical exposure is essential for understanding and visualizing the theoretical concepts related to Surveying & Geomatics with site investigation.

Good luck, and we wish you an engaging and insightful laboratory experience.

PREFACE

This practical manual will be helpful for students of Civil Engineering for understanding the course from the point of view of applied aspects. Though all the efforts have been made to make this manual error free, yet some errors might have crept in inadvertently. Suggestions from the readers for the improvement of the manual are most welcomed.

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VISION OF THE DEPARTMENT

To impart academic excellence in civil engineering field with emphasis on holistic development of the professional, while inculcating ethics, socially and professionally responsive technocrats.

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MISSION OF THE DEPARTMENT

M1: To provide a comprehensive platform for academic expertise and proficiency

M2: To develop civil engineering professionals with creative skills and leadership qualities in order to face regional and global challenges.

M3: To develop ethics in students in order to promote socially responsible environmental awareness with innovative thinking.

Program Educational Objectives (PEOs) of Department

PEO 1: To enhance skill and expertise in field of civil engineering with aim of boosting employability and entrepreneurship.

PEO 2: To develop multidisciplinary approach of civil engineering system with lifelong learning solutions.

PEO 3: To develop the potential to pursue higher education and research in field of civil engineering

Program Outcomes :(PO)

Graduates will be able to achieve

PO 1.Engineering knowledge: Apply the knowledge of mathematics, science, engineering Fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO 2.Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, Natural sciences, and engineering sciences.

PO 3. 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.

PO 4. 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.

PO 5. 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.

PO 6. 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.

PO 7. 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.

PO 8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO 9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO 10. 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.

PO 11.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.

PO 12. 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.

Program Specific Outcome (PSO)

PSO 1: Graduates shall be able to apply critical thinking in research, design, analysis and implementation of civil engineering problems

PSO 2: Graduates shall be able to inculcate the idea of sustainability in engineering solution to meet real world challenges.

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Course Evaluation Scheme

Sr No	Subject Code	Subject Name	Periods			Evaluation Scheme				Total	Credit
						Sessional Assessment					
			L	T	P	CT	TA	PS	PE		
1.	**BCE352**	Surveying & Geomatics Lab	0	0	2	-	-	50	50	100	1

Lab Objectives:

In the Surveying & Geomatics Lab, the teacher explains the principles and practical applications of surveying instruments and geomatics techniques used in civil engineering. Students are guided to perform field measurements, leveling, traversing, contouring, and mapping activities using conventional and modern surveying equipment such as dumpy level, theodolite, total station, and GPS.

The lab helps students develop practical knowledge, accuracy in measurements, data recording skills, and understanding of real-world surveying procedures required for planning, design, and construction projects.

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Lab Outcomes (LOs)

Lab Outcomes: The students should be able to:		**Knowledge Level**
LO1	**Chain & Compass Surveying** 1. Ranging and chaining of line. 2. Measurement of distances using chain and tape. 3. Compass traversing and determination of bearings. 4. Plotting of chain survey and compass survey.	**L3**
LO2	**Leveling** 1. Study of dumpy level and leveling staff. 2. Fly leveling and differential leveling. 3. Profile leveling and cross-sectioning. 4. Determination of reduced levels by HI and Rise & Fall methods.	**L4**
LO3	**Theodolite Surveying** 1. Measurement of horizontal and vertical angles using theodolite. 2. Traversing using theodolite. 3. Determination of heights and distances by trigonometric leveling.	**L5**
LO4	**Tacheometry & Curves** 1. Determination of horizontal distance and elevation by tacheometry. 2. Setting out of simple circular curves. 3. Contouring and preparation of contour maps.	**L4**
LO5	**Modern Surveying & Geomatics** 1. Study and use of Total Station. 2. Measurement of coordinates using Total Station. 3. Introduction to GPS and GIS applications in surveying. 4. Preparation of field survey report and mapping.	**L5**

K1- Remember, K2- Understand, K3- Apply, K4- Analyze, K5- Evaluate, K6- Create

CO-PO-PSO Mapping

COs /POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	2	3	1	1	–	–	–	–	1	3	2
CO2	3	2	2	2	3	1	1	–	–	–	–	1	3	2
CO3	3	3	2	2	3	1	1	–	–	1	–	1	3	3
CO4	3	3	2	3	3	1	1	–	–	1	–	1	3	3
CO5	3	2	2	3	3	1	2	–	1	1	–	1	3	3
AVG	**3.0**	**2.4**	**1.8**	**2.4**	**3.0**	**1.0**	**1.2**	–	**1.0**	**1.0**	–	**1.0**	**3.0**	**2.6**

The extent of mapping is as follows: 1 for low, 2 for moderate, 3 for high &"-" for No correlation between CO & PO.

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List of Experiments

S. No.	Experiment
1.	To measure bearings of a closed traverse by prismatic compass and to adjust the traverse by graphical method.
2.	To find out reduced levels of given points using Auto/dumpy level
3.	To study parts of a Vernier and electronic theodolite and measurement of horizontal angle.
4.	To study parts of a Vernier and electronic theodolite and measurement of vertical angle.
5.	To measure horizontal angle between two objects by repetition/reiteration method.
6.	To determine the height of a vertical structure (e.g. chimney/ water tank etc.) using trigonometrical leveling by taking observations in single vertical plane.
7.	To set out a simple circular curve by Rankine's method.
8.	Demonstration and working on Electronic Total Station. Measurement of distances, horizontal & vertical angles, coordinates and area of a land parcel.
9.	Visual Interpretation of standard FCC (False colour composite).
10.	Coordinates measurement using GPS.

Beyond Syllabus:

S.No.	Experiment
1	To Perform Plane table Surveying Using Radiation/Intersection/Traversing Methods
2	To Determine the Position of Various by Linear Measurements (Chain Survey)

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S.No.	Name of the Experiment	CO	BTL	Lab Conduction Date	Remark/ Grade/ Marks	Faculty Signature with Date

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Software & Hardware Required:

Hardware Required:

Peripherals/Lab Equipment:

1. Chain and Steel Tape
2. Prismatic Compass
3. Dumpy Level and Leveling Staff
4. Theodolite
5. Plane Table and Alidade
6. Total Station
7. GPS Receiver
8. Ranging Rods and Arrows
9. Tripod Stand
10. Measuring Wheel
11. Levelling Pegs and Plumb Bob
12. Clinometer
13. EDM (Electronic Distance Measurement) Instrument
14. Auto Level
15. Surveying Software/System for Mapping and Data Processing

Laboratory Safety Instructions (DO's)

1. Handle surveying instruments carefully and keep them properly calibrated.
2. Record all field observations neatly and accurately in the field book.
3. Carry and set up instruments properly on stable ground.
4. Follow the instructions of the teacher/lab instructor during field work.
5. Clean and return all instruments to their proper place after use.

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Laboratory Precautions (Don'ts)

1. Do not mishandle or drop surveying instruments.
2. Do not take readings without proper leveling and centering.
3. Do not leave instruments unattended in the field.
4. Do not erase or overwrite field observations carelessly.
5. Do not use any equipment without permission or guidance from the instructor.

EXPERIMENT – 1

TO MEASURE BEARINGS OF A CLOSED TRAVERSE BY PRISMATIC COMPASS AND TO ADJUST THE TRAVERSE BY GRAPHICAL METHOD

Aim

To measure the bearings of a closed traverse using prismatic compass and adjust the traverse graphically.

Apparatus Required

1. Prismatic Compass
2. Tripod Stand
3. Ranging Rods
4. Chain/Tape
5. Pegs and Arrows
6. Field Book

Theory

A traverse consists of series of connected lines. In compass traversing, lengths of traverse lines and their magnetic bearings are measured using chain/tape and compass respectively.

Procedure

1. Select traverse stations A, B, C, and D.
2. Set up compass at station A.
3. Measure fore bearing of line AB.
4. Measure length of line AB.
5. Repeat for all traverse lines.
6. Plot the traverse graphically.
7. Adjust closing error by graphical method.

Observation Table

Line	Length (m)	Fore Bearing	Back Bearing	Included Angle
AB				
BC				
CD				
DA				

Calculations

1. Included angles are computed from bearings.
2. Traverse is plotted to scale.
3. Closing error is adjusted graphically.

Result

The bearings of the closed traverse were measured and traverse was adjusted graphically.

Precautions

1. Keep compass away from magnetic substances.
2. Ensure accurate centering.
3. Avoid parallax while reading bearings.
4. Measure distances carefully.

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EXPERIMENT – 2
TO FIND OUT REDUCED LEVELS OF GIVEN POINTS USING AUTO/DUMPY LEVEL

Aim

To determine reduced levels of given points using dumpy level/auto level.

Apparatus Required

1. Dumpy Level/Auto Level
2. Leveling Staff
3. Tripod Stand
4. Pegs
5. Field Book

Theory

Leveling is the process of determining elevation of points relative to a datum.

Procedure

1. Set up the level instrument on tripod.
2. Perform temporary adjustments.
3. Take back sight reading on benchmark.
4. Take intermediate sight readings.
5. Take foresight reading.
6. Shift instrument and continue observations.
7. Compute reduced levels.

Observation Table (HI Method)

Station	BS	IS	FS	HI	RL	Remarks
BM						Benchmark
1						
2						
CP						Change Point

Formula

HI = RL + BS
RL = HI – FS

Result

Reduced levels of given points were determined successfully.

Precautions

1. Ensure bubble is centered.
2. Keep staff vertical.
3. Avoid parallax.
4. Read staff carefully.

EXPERIMENT – 3

TO STUDY PARTS OF A VERNIER AND ELECTRONIC THEODOLITE AND MEASUREMENT OF HORIZONTAL ANGLE

Aim

To study the parts of Vernier and Electronic Theodolite and measure horizontal angles.

Apparatus Required

1. Vernier Theodolite
2. Electronic Theodolite
3. Tripod Stand
4. Plumb Bob
5. Ranging Rods

Main Parts of Theodolite

1. Telescope
2. Vertical Circle
3. Horizontal Circle
4. Vernier Scale
5. Clamp Screws
6. Tangent Screws
7. Level Tubes
8. Tribrach
9. Levelling Screws

Procedure

1. Set up the theodolite over station.
2. Perform centering and leveling.
3. Focus eyepiece and object.
4. Measure horizontal angle between two points.
5. Measure vertical angle.
6. Record observations.

Observation Table

Station	Face	Initial Reading	Final Reading	Angle
AOB	Left			
AOB	Right			

Result

Horizontal and vertical angles were measured using Vernier and Electronic Theodolite.

Precautions

1. Ensure proper centering.
2. Avoid touching instrument during observations.
3. Take readings carefully.
4. Remove parallax before observations.

EXPERIMENT – 4
TO STUDY PARTS OF A VERNIER AND ELECTRONIC THEODOLITE AND MEASUREMENT OF VERTICAL ANGLE

To study the parts of Vernier and Electronic Theodolite and measure vertical angles.

Apparatus Required

1. Vernier Theodolite
2. Electronic Theodolite
3. Tripod Stand
4. Plumb Bob
5. Ranging Rods

Main Parts of Theodolite

1. Telescope
2. Vertical Circle
3. Horizontal Circle
4. Vernier Scale
5. Clamp Screws
6. Tangent Screws
7. Level Tubes
8. Tribrach
9. Levelling Screws

Procedure

1. Set up the theodolite over station.
2. Perform centering and leveling.
3. Focus eyepiece and object.
4. Measure horizontal angle between two points.
5. Measure vertical angle.
6. Record observations.

Observation Table

Station	Face	Initial Reading	Final Reading	Angle
AOB	Left			
AOB	Right			

Result

Horizontal and vertical angles were measured using Vernier and Electronic Theodolite.

Precautions

1. Ensure proper centering.
2. Avoid touching instrument during observations.
3. Take readings carefully.
4. Remove parallax before observations.

EXPERIMENT – 5
TO MEASURE HORIZONTAL ANGLE BETWEEN TWO OBJECTS BY REPETITION/REITERATION METHOD

Aim

To measure horizontal angle between two objects by repetition and reiteration methods.

Apparatus Required

1. Vernier Theodolite
2. Tripod Stand
3. Ranging Rods

Theory

Repetition method improves accuracy by measuring the same angle repeatedly. Reiteration method is used for measuring several angles around a point.

Procedure (Repetition Method)

1. Set up and level the instrument.
2. Bisect first object and set vernier to zero.
3. Rotate telescope towards second object.
4. Record angle.
5. Repeat process multiple times.
6. Divide final accumulated angle by number of repetitions.

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Observation Table

No. of Repetition	Initial Reading	Final Reading	Total Angle	Mean Angle
1				
2				
3				

Result

Horizontal angle between two objects was measured successfully.

Precautions

1. Maintain proper leveling.
2. Bisect targets accurately.
3. Tighten clamps properly.
4. Avoid jerks during rotation.

EXPERIMENT – 6
TO DETERMINE THE HEIGHT OF A VERTICAL STRUCTURE USING TRIGONOMETRICAL LEVELING

Aim

To determine the height of a vertical structure using trigonometric leveling.

Apparatus Required

1. Theodolite
2. Levelling Staff
3. Measuring Tape
4. Tripod Stand

Theory

Trigonometric leveling determines elevation differences by measuring vertical angles and distances.

Formula

Height of Object = $D \tan \theta + h$

Where,
D = Horizontal distance
θ = Vertical angle
h = Height of instrument

Procedure

1. Set up the theodolite.
2. Measure horizontal distance to object.
3. Measure vertical angle to top of object.
4. Calculate height using formula.

Observation Table

Station	Distance (m)	Vertical Angle	Height of Instrument	Height of Object
A				
B				
C				

Result

Height of the vertical structure was determined successfully.

Precautions

1. Ensure accurate distance measurement.
2. Use stable instrument setup.
3. Avoid parallax.
4. Take repeated observations.

\

EXPERIMENT – 7

TO SET OUT A SIMPLE CIRCULAR CURVE BY RANKINE'S METHOD

Aim

To set out a simple circular curve by Rankine's method.

Apparatus Required

1. Theodolite
2. Chain/Tape
3. Pegs
4. Arrows
5. Tripod Stand

Theory

Rankine's method is also called deflection angle method used for setting circular curves.

Formula

Deflection Angle = 1718.9 × C / R

Where,
C = Chord length
R = Radius of curve

Procedure

1. Calculate tangent length.
2. Set up theodolite at tangent point.
3. Calculate deflection angles.
4. Mark points on curve using chord lengths.
5. Fix pegs at curve points.

Observation Table

Chainage	Chord Length	Deflection Angle	Remarks

Result

Simple circular curve was set out successfully by Rankine's method.

Precautions

1. Measure chord lengths accurately.
2. Set instrument properly.
3. Avoid observational errors.
4. Use proper ranging.

EXPERIMENT – 8
DEMONSTRATION AND WORKING ON ELECTRONIC TOTAL STATION

Aim

To study the working of Electronic Total Station and measure distances, angles, coordinates, and area.

Apparatus Required

1. Electronic Total Station
2. Reflector Prism
3. Tripod Stand
4. Data Cable
5. Field Book

Theory

Total Station is an electronic surveying instrument combining EDM and electronic theodolite with data
Storage capability.

Procedure

1. Set up total station over known point.
2. Perform centering and leveling.
3. Input station coordinates.
4. Sight reflector prism.
5. Measure horizontal angle, vertical angle, and slope distance.
6. Record coordinates.
7. Compute area of land parcel.

Observation Table

Point	Horizontal Angle	Vertical Angle	Distance	Easting	Northing	RL
A						
B						
C						

Result

Distances, angles, coordinates, and area were measured using Total Station.

Precautions

1. Ensure proper battery charge.
2. Keep prism vertical.
3. Protect instrument from moisture.
4. Avoid direct sunlight on display.

EXPERIMENT – 9

VISUAL INTERPRETATION OF STANDARD FCC (FALSE COLOUR COMPOSITE)

Aim

To perform visual interpretation of standard False Color Composite image.

Apparatus Required

1. FCC Satellite Image
2. Magnifying Lens
3. Interpretation Key
4. GIS Software

Theory

False Col.

EXPERIMENT – 10

COORDINATES MEASUREMENT USING GPS

Purpose

This manual explains the basic procedure for measuring coordinates using GPS/GNSS equipment for
Surveying and mapping works.

Equipment Required

- GPS/GNSS Receiver
- Antenna
- Tripod or Range Pole
- Data Collector/Controller
- Batteries and Charger

Coordinate System

Use the required:

- Datum (e.g., WGS84)
- Coordinate System (UTM/Local Grid)

Record coordinates as:

- Easting
- Northing
- Elevation

Pre-Survey Checks

Before starting:

- Ensure open sky visibility
- Check battery level
- Verify satellite availability
- Confirm correct project settings

Recommended:

- Minimum 5 satellites
- PDOP less than 3

GPS Survey Procedure

A. Base Station Setup (RTK)

1. Set tripod over known point
2. Level the instrument
3. Enter known coordinates
4. Start broadcasting corrections

B. Rover Setup

1. Connect rover to base station
2. Wait for FIXED solution
3. Keep pole vertical

C. Coordinate Measurement

At each point:

1. Stand steadily on the point
2. Wait for stable accuracy

Quality Control

- Recheck important points
- Verify antenna height
- Avoid trees and buildings
- Repeat doubtful measurements

Common Errors

Error	Cause
Poor accuracy	Obstructions
Signal loss	Weak satellite coverage
Wrong elevation	Incorrect antenna height

Safety

- Wear safety gear
- Protect equipment from rain
- Work carefully near roads and construction sites

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Sample Coordinate Table

Point	Easting	Northing	Elevation
P1			
P2			
P3			
P4			

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BEYOND SYLLABUS EXPERIMENTS:

EXPERIMENT 1
PLANE TABLE SURVEYING USING RADIATION, INTERSECTION AND TRAVERSING METHODS

Purpose

This manual explains the basic procedure for conducting plane table surveying using:

- Radiation Method
- Intersection Method
- Traversing Method

Equipment Required

- Plane Table Board
- Tripod
- Alidade
- Plumbing Fork and Plumb Bob
- Spirit Level
- Drawing Sheet
- Trough Compass
- Measuring Tape

General Setup Procedure

1. Fix drawing sheet on plane table
2. Set up tripod firmly
3. Level the table using spirit level
4. Center the table over station point
5. Orient the table using compass or backsight

Radiation Method

Procedure

1. Set up plane table at a single station
2. Mark station point on sheet
3. Sight objects using alidade
4. Draw rays toward objects
5. Measure ground distances
6. Plot distances to scale along rays

Use

Suitable for small areas where all points are visible from one station.

Intersection Method

Procedure

1. Select two survey stations
2. Measure and plot baseline
3. Set up table at first station
4. Draw rays to objects
5. Shift to second station
6. Orient table by backsighting
7. Draw rays again
8. Intersection of rays gives object position

Use

Suitable for locating distant or inaccessible objects.

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Traversing Method

Procedure

1. Set up at first station
2. Plot first station on sheet
3. Sight next station and draw line
4. Measure distance between stations
5. Move to next station
6. Orient by backsighting
7. Continue process for all traverse stations

EXPERIMENT 2

CHAIN SURVEY: DETERMINATION OF POSITIONS BY LINEAR MEASUREMENTS

Purpose

This manual explains the procedure for determining the position of various points using linear measurements in chain surveying.

Equipment Required

- Chain or Tape
- Ranging Rods
- Arrows/Chain Pins
- Pegs
- Cross Staff or Optical Square
- Field Book
- Hammer

Principle of Chain Survey

Chain surveying is based on:

- Linear measurements only
- Division of area into triangles
- Measurement of sides and offsets

Reconnaissance

1. Inspect the survey area
2. Select survey stations
3. Prepare index sketch
4. Mark main survey lines

Procedure

A. Setting out Survey Lines

1. Fix ranging rods at survey stations
2. Range straight lines between stations
3. Measure chain lines accurately

B. Taking Measurements

1. Measure main chain line using chain/tape
2. Record distances in field book
3. Take perpendicular offsets to locate details
4. Measure tie lines and check lines if required

C. Plotting

1. Select suitable scale
2. Plot chain lines
3. Plot offsets and details
4. Join plotted points to complete survey map

Types of Offsets

- Perpendicular Offsets
- Oblique Offsets

Precautions

- Keep chain straight and horizontal
- Avoid sagging of tape
- Ensure accurate ranging
- Record measurements clearly
- Check measurements regularly