METHODIST
COLLEGE OF ENGINEERING & TECHNOLOGY
(An UGC-AUTONOMOUS INSTITUTION)
Estd : 2008
Accredited by NAAC with A+ and NBA
Affliated to Osmania University & Approved by AICTE

LABORATORY MANUAL

SURVEYING LABORATORY

BE III Semester

ACADEMIC YEAR : 2024-25

NAME: ______________________________

ROLL NO: ______________________________

DEPARTMENT OF CIVIL ENGINEERING

Empower youth- Architects of Future World

METHODIST
COLLEGE OF ENGINEERING & TECHNOLOGY
(An UGC-AUTONOMOUS INSTITUTION)
Accredited by NAAC with A+ and NBA
Affliated to Osmania University & Approved by AICTE
Estd : 2008

CERTIFICATE

This is to certify that this is a bonafide record of the work done by Mr./Ms. ………………………………………………………………………………….bearing Roll number……………………………………………………………………..………of B.E ………………………………………...semester…………………………………….branch in the ……………………………………..laboratory during the Academic year ………………………………………………….

Number of experiments conducted: ………………

Internal Examiner | Head of the Department | External Examiner

INDEX

Name of the laboratory course: Surveying Laboratory

Course code: 2PC351CE

S. No	Name of the Experiment	Date of Experiment	Date of Submission	Marks	Signature of faculty
1	Find out the area using chain and cross staff surveying.				
2	Introduction to levelling: Differential levelling using dumpy/Auto level				
3	Profile and cross-sectional levelling using Dumpy/Auto level				
4	Measurement of horizontal angles by repetition / reiteration methods using Vernier Theodolite				
5	Measurement of vertical angle: Application to simple problems of height and distance by measuring angle of elevation and depression				
6	Single plane method: Determination of R.L. of an elevated Object using two Instrument Stations which are placed in a same vertical plane- when the base of the Object is inaccessible.				
7	Two plane method: Determination of R.L. of an elevated Object using two Instrument Stations which are not placed in the same vertical plane- when base of the Object inaccessible.				
8	Introduction to Total station and applications: Application to simple problems of height and distance by measuring angle of elevation and depression and determination of R.L of the target object.				
9	Total station and applications: Determination of area enclosed in a closed traverse having minimum 5 stations				
10	Global Positioning System (GPS): Determination of Latitude and Longitude of any four stations and computation of the area				
11	Study of Digital Planimeter				

VISION

To produce ethical, socially conscious and innovative professionals who would contribute to sustainable technological development of the society.

MISSION

To impart quality engineering education with latest technological developments and interdisciplinary skills to make students succeed in professional practice.

To encourage research culture among faculty and students by establishing state of art laboratories and exposing them to modern industrial and organizational practices.

To inculcate humane qualities like environmental consciousness, leadership, social values, professional ethics and engage in independent and lifelong learning for sustainable contribution to the society.

DEPARTMENT OF CIVIL ENGINEERING

LABORATORY MANUAL

SURVEYING LABORATORY

Prepared
By
Mr. Shaik Mohammad Imran
Assistant Professor

DEPARTMENT OF CIVIL ENGINEERING

VISION

To evolve into a centre of excellence for imparting holistic civil engineering education contributing towards sustainable development of the society.

MISSION

- To impart quality civil engineering education blended with contemporary and interdisciplinary skills.
- To provide enhanced learning facilities and professional collaborations to impart a culture of continuous learning.
- To involve in trainings and activities on communication skills, teamwork, professional ethics, environmental protection and sustainable development.

DEPARTMENT OF CIVIL ENGINEERING

PROGRAM EDUCATIONAL OBJECTIVES

The Graduates of the programme shall be able to:

PEO 1: Engage in planning, analysis, design, construction, operation and maintenance of built environment.

PEO 2: Apply the knowledge of civil engineering to pursue research or to engage in professional practice.

PEO 3: Work effectively as individuals and as team members in multidisciplinary projects with organizational and communication skills.

PEO 4: Demonstrate the spirit of lifelong learning and career enhancement aligned to professional and societal needs.

DEPARTMENT OF CIVIL ENGINEERING

PROGRAM OUTCOMES

Engineering Graduates will be able to:

PO1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and civil engineering specialization to the solution of complex civil engineering problems.

PO2. Problem analysis: Identify, formulate, review research literature, and analyze complex civil engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/development of solutions: Design solutions for complex civil 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.

PO4. 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.

PO5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex civil engineering activities with an understanding of the limitations.

PO6. 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 civil engineering practice.

PO7. Environment and sustainability: Understand the impact of the professional civil engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the civil engineering practice.

PO9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. 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.

PO11. 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.

PO12. 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 OUTCOMES

Civil Engineering Graduates will be able to:

PSO 1. Investigate properties of traditional and latest construction materials using standard testing methods.

PSO 2. Use AutoCAD, STAAD Pro, ETABS, Revit Architecture and ANSYS software for computer aided structural analysis and design.

PSO 3. Describe the principles of sustainable development and green buildings for environmental preservation.

Laboratory Code of Conduct

1. Students should report to the concerned labs as per the time table schedule.
2. Students who turn up late to the labs will in no case be permitted to perform the experiment scheduled for the day.
3. Students should bring a note book of about 100 pages and should enter the readings/observations into the note book while performing the experiment.
4. After completion of the experiment, signature of the concerned staff in-charge in the observation book is necessary.
5. Staff member in-charge shall award 40 marks for each experiment based on continuous evaluation and will be entered in the continuous internal evaluation sheet.
6. The record of observations along with the detailed experimental procedure of the experiment performed in the immediate last session should be submitted and certified by the staff member in-charge.
7. Not more than three students in a group are permitted to perform the experiment on a set-up for equipment-based labs.
8. The components required pertaining to the experiment should be collected from the stores in-charge, only after duly filling in the requisition form/log register.
9. When the experiment is completed, students should disconnect the setup made by them, and should return all the components/instruments taken for the purpose.
10. Any damage of the equipment or burn-out of components will be viewed seriously by either charging penalty or dismissing the total group of students from the lab for the semester/year.
11. Students should be present in the labs for the total scheduled duration.
12. Students are required to prepare thoroughly to perform the experiment before coming to Laboratory.
13. Procedure sheets/data sheets provided to the students, if any, should be maintained neatly and returned after the completion of the experiment.

Name of the laboratory course: Surveying Lab

Course code: 2PC351CE

DOs and DON'Ts

DOs:

1. Students are expected to prepare thoroughly to perform the experiment before coming to laboratory.
2. Always perform the experiment precisely as directed by the faculty.
3. Don't forget to bring observation notes, calculator and other pencil accessories before coming to laboratory
4. Record should be updated from time to time and the previous experiment must be signed by the faculty in-charge before attending the lab.
5. After completion of the experiment, signature of the faculty in-charge in the observation book is necessary.
6. The components required pertaining to the experiment should be collected from lab technician after duly filling in the requisition form.
7. Handover all the accessories /material / instruments to the lab technician before leaving the laboratory
8. Wear shoes and apron while performing the experiment
9. Keep silence in the laboratory

DON'Ts

1. Don't use mobile phones during lab hours
2. Don't use instruments without permission
3. Don't be late for the lab session

Name of the laboratory course: Surveying Laboratory **CIE:** 40 marks

Course code: 2PC351CE **SEE:** 60 marks

Credits:1

List of Experiments

1. Find out the area using chain and cross staff surveying.
2. Introduction to levelling: Differential levelling using dumpy/Auto level
3. Profile and cross-sectional levelling using Dumpy/Auto level
4. Measurement of horizontal angles by repetition / reiteration methods using Vernier Theodolite.
5. Measurement of vertical angle: Application to simple problems of height and distance by measuring angle of elevation and depression
6. Single plane method: Determination of R.L. of an elevated Object using two Instrument Stations which are placed in a same vertical plane- when the base of the Object is inaccessible.
7. Two plane method: Determination of R.L. of an elevated Object using two Instrument Stations which are not placed in the same vertical plane- when base of the Object inaccessible.
8. Introduction to Total station and applications: Application to simple problems of height and distance by measuring angle of elevation and depression and determination of R.L of the target object.
9. Total station and applications: Determination of area enclosed in a closed traverse having minimum 5 stations
10. Global Positioning System (GPS): Determination of Latitude and Longitude of any four stations and computation of the area.

Experiment beyond Curriculum

1. Study of Digital Planimeter

METHODIST
COLLEGE OF ENGINEERING & TECHNOLOGY
(An UGC-AUTONOMOUS INSTITUTION)
Accredited by NAAC with A+ and NBA
Affiliated to Osmania University & Approved by AICTE
Estd : 2008

Name of the laboratory course: Surveying Laboratory

Course code: 2PC351CE

Course Outcomes

After completing this course, the student will be able to:

CO No.	Course Outcome	Taxonomy Level
351.1	**Demonstrate** the working principles and handling procedures of basic surveying instruments like chain, cross staff in finding out linear measurements	**Understanding**
351.2	**Demonstrate** the levelling instruments and **apply** the knowledge of levelling in finding out the reduced levels of ground	**Applying**
351.3	**Demonstrate** the working principles and handling procedures of theodolite, total station and Hand-held GPS	**Understanding**
351.4	**Make use of** surveying equipment in computing lengths, areas & bearings of given field work	**Applying**
351.5	**Apply** the knowledge of trigonometrical levelling in finding out reduced levels of elevated objects which are both accessible and inaccessible points	**Applying**

Faculty Sign

Name of the laboratory course: Surveying Laboratory

Course code: 2PC351CE

CO-PO mapping:

PO / CO	PO 1	PO 2	PO 3	PO 4	PO5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
351.1	3				3				3	3					
351.2	3				3				3	3					
351.3	3				3				3	3					
351.4	3				3				3	3					
351.5	3				3				3	3					
C351	**3**				**3**				**3**	**3**					

Faculty Sign

Name of the laboratory course: Surveying Laboratory

Course code: 2PC351CE

Experiments mapping to COs & POs

S. No	Name of the Experiment	COs	POs
1	Find out the area using chain and cross staff surveying.	CO1, CO4	PO1, PO5, PO9, PO10
2	Introduction to levelling: Differential levelling using dumpy/Auto level	CO2	PO1, PO5, PO9, PO10
3	Profile and cross-sectional levelling using Dumpy/Auto level	CO2	PO1, PO5, PO9, PO10
4	Measurement of horizontal angles by repetition / reiteration methods using Vernier Theodolite	CO3, CO4	PO1, PO5, PO9, PO10
5	Measurement of vertical angle: Application to simple problems of height and distance by measuring angle of elevation and depression	CO3, CO5	PO1, PO5, PO9, PO10
6	Single plane method: Determination of R.L. of an elevated Object using two Instrument Stations which are placed in a same vertical plane- when the base of the Object is inaccessible.	CO3, CO5	PO1, PO5, PO9, PO10
7	Two plane method: Determination of R.L. of an elevated Object using two Instrument Stations which are not placed in the same vertical plane- when base of the Object inaccessible.	CO3, CO5	PO1, PO5, PO9, PO10
8	Introduction to Total station and applications: Application to simple problems of height and distance by measuring angle of elevation and depression and determination of R.L of the target object.	CO3, CO5	PO1, PO5, PO9, PO10
9	Total station and applications: Determination of area enclosed in a closed traverse having minimum 5 stations	CO3, CO4	PO1, PO5, PO9, PO10
10	Global Positioning System (GPS): Determination of Latitude and Longitude of any four stations and computation of the area	CO3, CO4	PO1, PO5, PO9, PO10
11	Study of Digital Planimeter	CO4	PO1, PO5, PO9, PO10

Faculty Sign

EXPERIMENT NO.1

FIND OUT THE AREA USING CHAIN AND CROSS STAFF SURVEYING

Aim:

To calculate the area of the given field by using cross staff.

Equipment and Accessories:

1. Chain
2. Cross staff
3. Ranging Rods
4. Arrows
5. Tape

Theory:

Cross staff survey is done to locate the boundaries of a field and to determine its area. A chain line is run through the Centre of the area which is divided into a number of triangles and trapezoids. The offsets to the boundary are taken in order of their chainages/Tape. After the field work is over, the survey is plotted to a suitable scale.

Procedure:

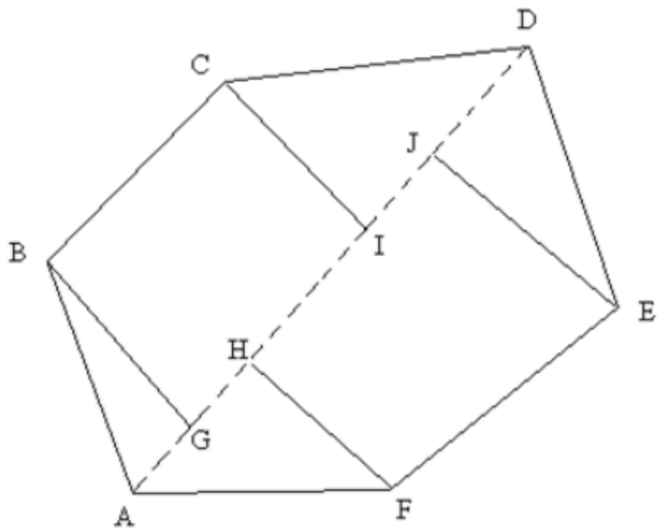


Fig. Open Field

- ❖ The area of the given field ABCDEFA is to be determined by cross staff survey. A chain line is run through the centre of the area (line AD) which is divided into a number of triangles and trapezoids.
- ❖ The offsets (BG, HF, CI, EJ) to the boundary are taken in order of their chainages/Tape length.
- ❖ The offsets are taken alternatively on either side of the chain line with the help of cross staff in the following way.
- ❖ The cross staff is held vertically on the chain line at a point where the foot of the offsets (Point G or H or I or J) is likely to occur. It is then turned so that one of sight passes through the ranging rod fixed at the end of the survey line (Point A or D).
- ❖ Looking through the other slit, it is seen if the point to which the offset is to be taken is bisected. If not, the cross staff is moved backward or forward till the line of sight also passes through the point.
- ❖ The area of the field is the sum of area of all the triangles and trapezoids.

Result:

- ❖ The area of the given field is ……………………

Space for Calculation:

Space for Calculation:

Precautions:

- ❖ Cross staff should be held vertically
- ❖ Establish intermediate points accurately by means of direct ranging.

Expected Viva Questions:

1) What is the least count of a metric chain?
2) How many types of chains and types are there?
3) Define offset and type of offsets
4) What are the principles of Surveying?
5) What is the principle of Chain Surveying?
6) What is Well-conditioned Triangle?
7) What are the different types of Cross staffs?

EXPERIMENT NO.2

INTRODUCTION TO LEVELLING: DIFFERENTIAL LEVELLING USING DUMPY LEVEL/AUTO LEVEL

Aim:

To find the reduced levels of the given stations by differential levelling.

Equipment and Accessories:

Dumpy Level, Tripod, levelling staff, Levelling book.

Theory:

In order to find difference of level between two points on the ground, it is necessary to establish a level surface above the two points and measure the vertical distance from it to the points. The difference between these measurements will give the difference in level between the points. It is possible to get a horizontal surface from the line of sight of a telescope adjusted into the horizontal position. This is done by any Levelling instrument.

Therefore, by setting up a Levelling instrument at a suitable location on the ground it is possible to obtain difference between levels of two points. When the difference in level between two points cannot be obtained by one set-up of Levelling instrument, it is necessary to repeat the process. This process of using a series of several set-ups of Levelling instrument to find the level difference between two distantly placed points is called Differential Levelling.

Procedure:

- ❖ Set-up the dumpy/auto level at point ‘P’ near to the Bench Mark (BM) (Let the R.L of BM is 100.000 m) as shown in figure and level the instrument.
- ❖ Focus the telescope towards BM and bisect the staff correctly and take the back sight (BS) on it and record the reading in the Levelling book.
- ❖ Keep the levelling staff at a convenient intermediate point(s) and take the intermediate sight (IS) and enter the reading.
- ❖ Continue this process till the line of sight is clear. When there is a need to shift the station, take the last reading as Fore Sight (FS) on that point (Change Point – CP) and don’t remove the level staff.
- ❖ Shift the instrument to the next station ‘Q’ and now take BS on the change point. Again, continue taking Intermediate Sights and Fore Sights till the survey completes
- ❖ Calculate the Reduced levels by Height of Instrument Method and also by Rise and Fall Method as shown in Table 1 & 2 respectively.

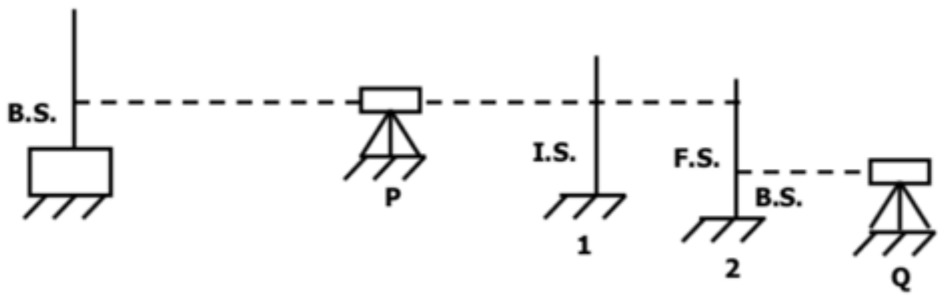


Fig. Differential levelling

Observations and Calculations:

Table 1: **Height of Instrument Method**

S.No	Station	Sight to	B.S. (m)	I.S. (m)	F.S. (m)	H.I. (m)	R.L. (m)	Remarks

Table 2: **Rise and Fall Method**

S.No.	Station	Sight to	B.S (m)	I.S (m)	F.S (m)	Rise (m)	Fall (m)	R.L (m)	Remarks

a) Height of Instrument Method:

Height of Instrument (H.I.)	=	R.L. of B.M. + B.S.
R.L. of a station	=	H.I. – (I.S. or F.S.)
Height of Instrument at CP. (H.I.)	=	R.L. of C.P. + B.S.
R.L. of a station	=	H.I. at C.P. – I.S. or F.S.
CHECK: Sum of B.S. – Sum of F.S.	=	First R.L. – Last R.L.

b) Rise and Fall Method:

If the difference of successive observations is +ve, it indicates fall, otherwise it indicates rise.

R.L. of a station	=	R.L. of B.M. + Rise or (-Fall)
CHECK: Sum of B.S. – Sum of F.S.	=	Sum of Rise – Sum of Fall
	=	First R.L. – Last R.L.

Space for Calculation:

Space for Calculation:

Space for Calculation:

Precautions:

- ❖ The levelling staff should not unfold or fold in vertical position and should fold or unfold only in horizontal position, by keeping the levelling staff on the ground.
- ❖ The third fold of levelling staff should not be unfolding except for any special survey work by prior permission.
- ❖ While doing fly levelling along the road, the instrument as well as levelling staff should not be kept at the centre of the road.

Expected Viva Questions:

1) What is levelling?
2) What is level surface?
3) Define Bench mark, Datum and Reduced level.
4) What are the types of Bench marks?
5) What are the types of levelling?
6) What is Height of Instrument?
7) What is line of collimation?
8) What is differential levelling?
9) What is change Point?
10) Define Backsight, Foresight and Intermediate Sight.
11) What is Fly levelling?
12) What is Profile and cross sectional levelling? Where it is used?
13) What are the temporary adjustments of Dumpy level?
14) What are the arithmetical checks for HI method and Rise & fall method?
15) What is the least count of a levelling staff?

EXPERIMENT NO.3

PROFILE AND CROSS-SECTIONAL LEVELLING USING DUMPY/AUTO LEVEL

Aim:

To plot the profile section and cross section along a proposed alignment of a highway.

Equipment and Accessories:

Dumpy Level, tripod, Levelling staff, chain, tape, cross staff, arrows, ranging rods, pegs, hammer, Levelling book.

Theory:

Profile Levelling is an operation to determine elevations of points spaced apart at known distances along a given line. The purpose of profile Levelling is to provide data from which a vertical section of the ground surface along a surveyed line can be plotted. Longitudinal sectioning and cross sectioning are examples of profile Levelling.

a. Longitudinal sectioning: To find out the elevations of the points on the ground at fixed intervals along the centre line of proposed sewer lines, pipelines, highways, railways, canals, etc.
b. Cross sectioning: To find out the elevations of the points on the ground at fixed intervals on either side or perpendicular to centre line of proposed highways, canals, etc.

Procedure:

- ❖ Establish points on the ground at fixed interval say 5 m along the proposed centre line of the highway by direct ranging and fix arrows as shown in figure given below.
- ❖ Establish perpendicular lines on either side of the proposed centre line of the highway using cross staff as shown in figure given below.
- ❖ Along the perpendicular lines that are established in the previous step fix arrows on the ground at a fixed interval say 2 m as shown in figure given below.
- ❖ Carry out differential Levelling to find the R.Ls of every arrow point and enter the readings in table.
- ❖ Calculate the R.Ls of all the points.
- ❖ Draw the longitudinal section along the centre line of the proposed highway to a suitable scale.
- ❖ Draw cross section in the transverse direction at each chainage point along the centre line of the proposed highway to a suitable scale

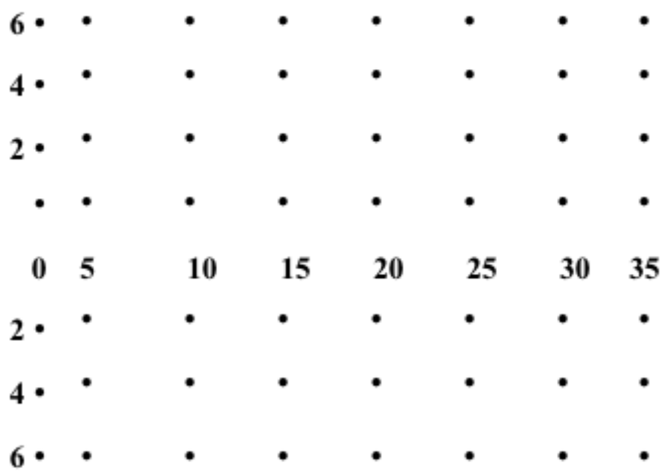


Fig. Longitudinal and cross sectioning

Observations and Calculations:

Table:

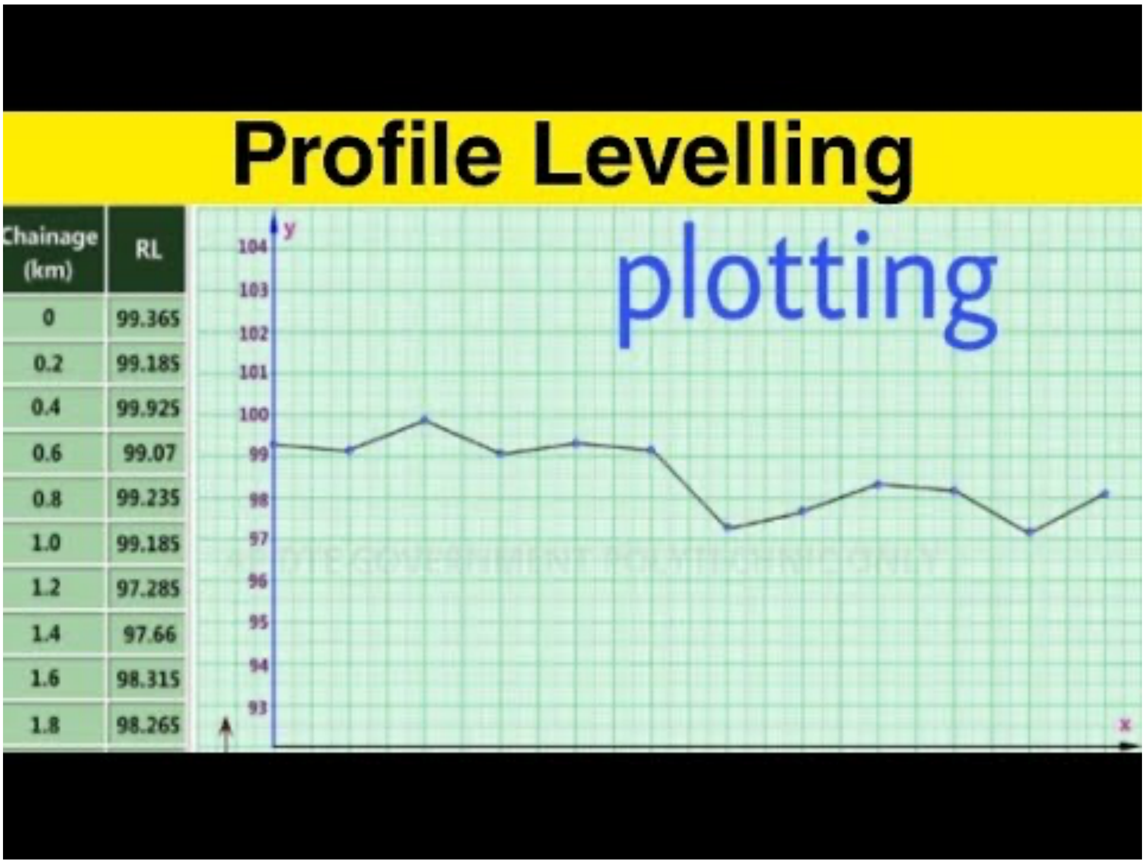
S.No	Chainage of center line	Chainage Left C.S.	Chainage Right C.S	B.S (m)	I.S. (m)	F.S (m)	H.I. (m)	R.L. (m)	Remarks

Height of Instrument = R.L. of B.M. + B.S.

R.L. of each arrow point = H.I. – I.S. or F.S.

Space for Calculations:

Sample profile plot:



Result:

Profile of the centre line of the proposed highway and various cross sections along the centre line of the proposed highway are shown on the drawing sheet.

Expected Viva Questions:

1) What is levelling?
2) What is level surface?
3) Define Bench mark, Datum and Reduced level.
4) What are the types of Bench marks?
5) What are the types of levelling?
6) What is Height of Instrument?
7) What is line of collimation?
8) What is differential levelling?
9) What is change Point?
10) Define Back Sight, Fore Sight and Intermediate Sight.
11) What is Fly levelling?
12) What is Profile and cross sectional levelling? Where it is used?
13) What are the temporary adjustments of Dumpy level?
14) What are the arithmetical checks for HI method and Rise & fall method?
15) What is the least count of a levelling staff?

EXPERIMENT NO.4

MEASUREMENT OF HORIZONTAL ANGLES BY REPETITION METHOD USING VERNIER THEODOLITE

***Aim*:**

To Measure the horizontal angle between the two given stations P and Q with respect to instrument station ‘O’.

***Equipment and Accessories*:**

Transit Vernier Theodolite and its accessories & Ranging Rods.

***Theory*:**

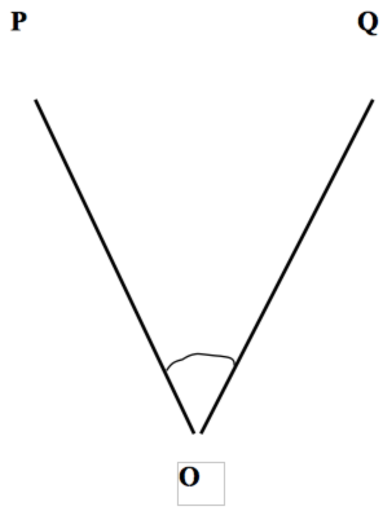
The Theodolite is most accurate instrument used for measurement of horizontal and vertical angles. To measure the horizontal angle, the angles obtained are added and is divided with number of angles. Firstly for taking every angle vernier ‘A’ is made to zero, if it is provided with ‘B’ also make it to zero, otherwise its vernier reading is noted down. The angles are measured by keeping the telescope in normal and inverted positions. Then the readings are taken by swinging the telescope to the right and left, which is called as right swing and left swing.

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 the vernier. By this method an angle is measured two (or) more times by allowing the vernier to remain clamped each time at the end of each measurement instead of setting it back at zero when sighting at the previous station. Thus an angle reading is mechanically added several times depending upon the number of repetitions. The average horizontal angle is then obtained by dividing the final reading by number of repetitions. Generally six repetitions are done three with the telescope normal and three with the telescope inverted.

***Procedure*:**

REPETITION METHOD

Let P and Q be the two given stations. It is required to measure the angle POQ by the method of repetition where ‘O’ is the station occupied by the theodolite as shown in figure below.



- Set up the instrument over ‘O’ and level it accurately.
- Set the reading on vernier A to 0^0 0' 0" exactly using upper clamp and upper tangent screw. Loosen the lower clamp, direct the telescope to the station ‘P’ and bisect ‘P’ exactly using lower clamp and lower tangent screw.
- Unclamp the upper clamp screw, turn the telescope clockwise (Right swing) and bisect station ‘Q’ exactly by using the upper clamp and upper tangent screw.
- Read both the verniers A and B and enter the readings in Table 1.
- Leaving the verniers unchanged (with upper clamp screw clamped), unclamp the lower plate and turn the telescope until the station P is attain again bisected accurately using lower clamp and lower tangent screw.
- Release the upper clamp screw, turn the telescope clock-wise and again bisect the station ‘Q’ exactly using upper clamp and its slow motion screw. The verniers will read now twice the value of angle POQ.
- Repeat the process until the angle is measured for the required number of times (usually three repetitions). Read both the verniers. The final reading is divided by the number of repetitions to get the correct value of the angle POQ.

***Observations & Calculations*:**

Table 1: Face left observations

Station	**Repetition No.**	**Initial reading (Sighting to P)**		**Final reading (Sighting to Q)**		**Angles on Vernier**		**Average reading of Vernier A & Vernier B**
		Vernier A	**Vernier B**	**Vernier A**	**Vernier B**	**Vernier A**	**Vernier B**	
O	1							
	2							
	3							

Horizontal angle between P & Q = Sum of Average Readings / No. of repetitions

***Result*:** Horizontal angle between P and Q =

Space for Calculation:

Expected Viva Questions:

1) What is a transit theodolite?
2) What are the functions of a theodolite?
3) What are the functions of clamp screw, tangent screw and clip screw?
4) What do you mean by face left and face right conditions?
5) What is transiting?
6) What is the least count of a theodolite?
7) What is the least count of main scale in theodolite?

REITERATION METHOD

***Theory*:**

In the method of reiteration, several angles at a station are measured one after the other and finally the origin is closed by sighting the first station. If there is any error in the first and final readings taken on the initial station, the error is distributed equally among all the measured angles

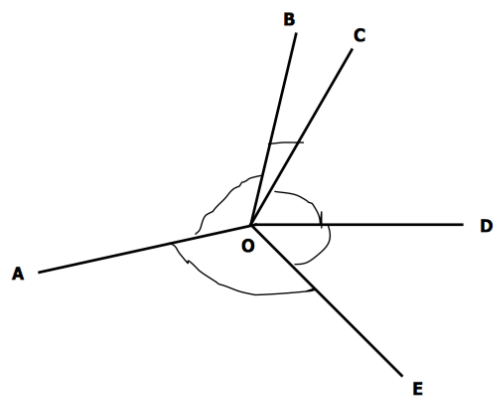
***Procedure*:**

Let A, B, C, D & E be the given stations and 'O' be the station occupied by the theodolite as shown below. It is required to measure the angles AOB, BOC, COD, DOE and EOA by the method of reiteration.

- Set up and level the instrument over 'O'.
- Round 1. Inst. – Face Right.
    a. Set the leading vernier at 0^0 0' 0" exactly and clamp the upper clamp screw.
    b. Turn the whole instrument round and strike A. A is now called the REFERENCE OBJECT (R.O.)
    c. Fix the lower clamp and loose the upper clamp and range to B, C, D, E and A in succession, swinging the inst. to the right, and note the corresponding angles and enter in Table 2.

The first and the last readings for 'A' may not agree. If the difference is not too great record both readings. The final reading of the R.O. must never be assumed. If the difference is too great reject the entire round.

- Round 2. Inst. – Face Left.
    a. Re-level and re-centre the inst. if necessary
    b. Set the leading vernier at 180^0 0' 0" exactly and clamp the plate.
    c. Turn the whole inst. round and strike the R.O.
    d. Fix the lower clamp and loose the upper clamp and range to E, D, C, B and A in succession, swinging the inst. to the left and note the angles correspondingly.



***Observations & calculations*:**

Table 2:

Inst. at	**Sight to**	**Face Right - Right Swing**				**Face Left - Left Swing**				**Remarks**
		Vernier A	**Vernier B**	**Mean**	**Hor. Angle**	**Vernier A**	**Vernier B**	**Mean**	**Hor. Angle**	
		0 ' "	**' "**	**0 ' "**	**0 ' "**	**0 ' "**	**' "**	**0 ' "**	**0 ' "**	
O	A									
	B									
	C									
	D									
	E									
	A									

Correction =

Corrected horizontal angles are ∠ AOB =

∠ BOC =

∠ COD =

∠ DOE =

∠ EOA =

***Results*:**

Horizontal Angles between the lines are ……………..

Space for Calculation:

Note:

1. Follow the form. It is essential that from whatever side the stations A, B, C, D and E are approached, they must never be over-ridden, i.e., passed.

2. It is desirable to see A, B, C, D and E are arranged in such a way that at least one angle is too small and one angle is too large and the rest in between so as to gain practice in measuring angles of different magnitudes.

Expected Viva Questions:

1) What is a transit theodolite?
2) What are the functions of a theodolite?
3) What are the functions of clamp screw, tangent screw and clip screw?
4) What do you mean by face left and face right conditions?
5) What is transiting?
6) What is the least count of a theodolite?
7) What is the least count of main scale in theodolite?

EXPERIMENT NO.5

MEASUREMENT OF VERTICAL ANGLE: APPLICATION TO SIMPLE PROBLEMS OF HEIGHT AND DISTANCE BY MEASURING ANGLE OF ELEVATION AND DEPRESSION

***Aim*:**

To find the elevation of the top of a spire/tower/building using the principle of trigonometrical levelling.

***Equipment and Accessories*:**

Transit Vernier Theodolite and it's accessories, Tape & Levelling Staff.

***Procedure*:**

It is required to find the elevation (R.L.) of the top of a tower 'Q' from the instrument station 'P' as shown in figure.

- ❖ Set up theodolite at P and level it accurately with respect to the altitude bubble. See that the vertical circle reads 0^0 0' 0" when the line of sight is horizontal.
- ❖ Direct the telescope towards Q and bisect it accurately, clamp both the plates. Read the vertical angle α_1 and enter the readings in Table .
- ❖ Plunge the telescope and sight to the same point 'Q' and take the vertical angle (α_1). Calculate the average of the vertical angles measured in both faces.
- ❖ With the vertical vernier set to zero reading and the altitude bubble in the centre of its run take the reading on the levelling staff kept at A.B.M. Let it be "S".

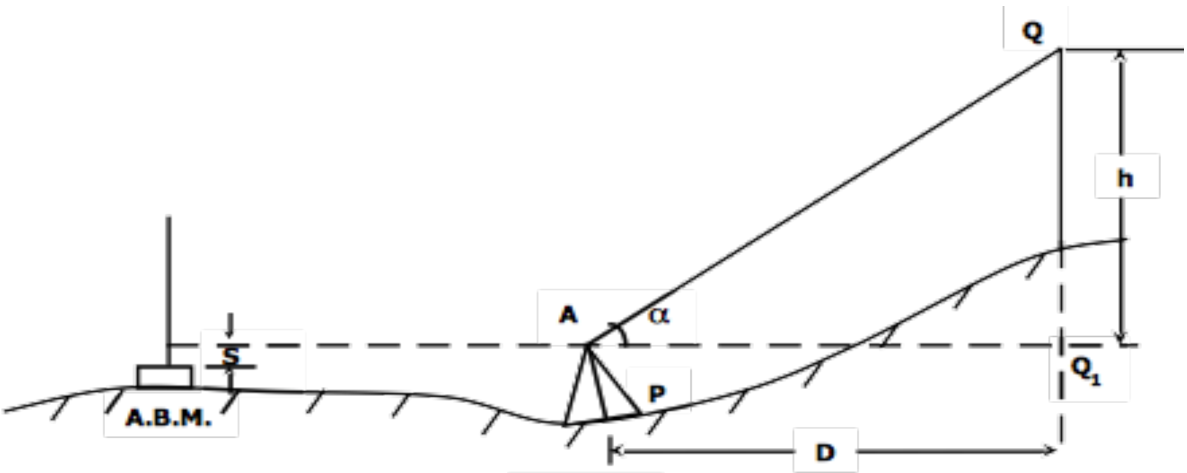


Fig. 1

***Observations & Calculations*:**

Table: Face left observations

Instrument at	Sight to	Initial reading		Final reading		Angles on Vernier		Average Reading
		Vernier C	Vernier D	Vernier C	Vernier D	Vernier C	Vernier D	
P	Q							

Distance between the instrument station (P) and the given point (Q) = D = m

From triangle QAQ_1, $h = D \tan \alpha$

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

Result:

R.L. of the given point Q =

Space for Calculation:

***Precautions*:**

- The leveling staff should not unfold or fold in vertical position and should fold or unfold only in a horizontal position, by keeping the leveling staff on the ground.
- The third fold of leveling staff should not be unfold except for any special survey work by prior permission.
- While measuring the elevations of various station points on the ground surface, the leveling staff should be changed from one station to the other station only in the horizontal direction and vertical movement is prohibited.
- In case of contour surveying the students are instructed to be cautious about the presence of unexpected things in the field such as bushes, rocks, electric poles, electric wires, transformers etc so as to prevent certain type of accidents.
- While doing fly leveling along the road, the instrument as well as leveling staff should not be kept at the centre of the road.

Expected Viva Questions:

1) What is a transit theodolite?
2) What are the functions of a theodolite?
3) What are the functions of clamp screw, tangent screw and clip screw?
4) What do you mean by face left and face right conditions?
5) What is transiting?
6) What is the least count of a theodolite?
7) What is the least count of main scale in theodolite?
8) What is trigonometrical levelling?

EXPERIMENT NO.6

SINGLE PLANE METHOD: DETERMINATION OF R.L. OF AN ELEVATED OBJECT USING TWO INSTRUMENT STATIONS WHICH ARE PLACED IN A SAME VERTICAL PLANE- WHEN BASE OF THE OBJECT INACCESSIBLE.

***Aim*:**

To find the elevation of the top of a building 'Q' using the principle of trigonometrical levelling with two instrument stations in the same vertical plane as that of the object when the base of the object is inaccessible.

***Equipment and Accessories*:**

Transit Vernier Theodolite and it's accessories, Tape & Levelling Staff.

***Procedure*:**

It is required to find the elevation (R.L.) of the top of a building 'Q' from the instrument stations 'P & R' as shown in figure.

- ❖ Set up theodolite at P and level it accurately with respect to the altitude bubble. See that the vertical circle reads 0^0 0' 0" when the line of sight is horizontal.
- ❖ Direct the telescope towards Q and bisect it accurately, clamp both the plates. Read the vertical angle α_1 and enter the readings in Table.
- ❖ Transit the telescope so that the line of sight is reversed. Mark the instrument station R on the ground along the line of sight. Measure the distance between P & R accurately. Let it be 'b' repeat the steps (2) and (3) for both face observations. The mean values should be adopted in the calculations.
- ❖ With the vertical vernier set to zero reading and the altitude bubble in the centre of its run take the reading on the levelling staff kept at A.B.M. Let it be "S_1".
- ❖ Shift the instrument to R and set up the theodolite there. Measure the vertical angle α_2 to Q with both face observations.
- ❖ Repeat step (4) and R and to the same A.B.M. Let the reading at R be "S_2".

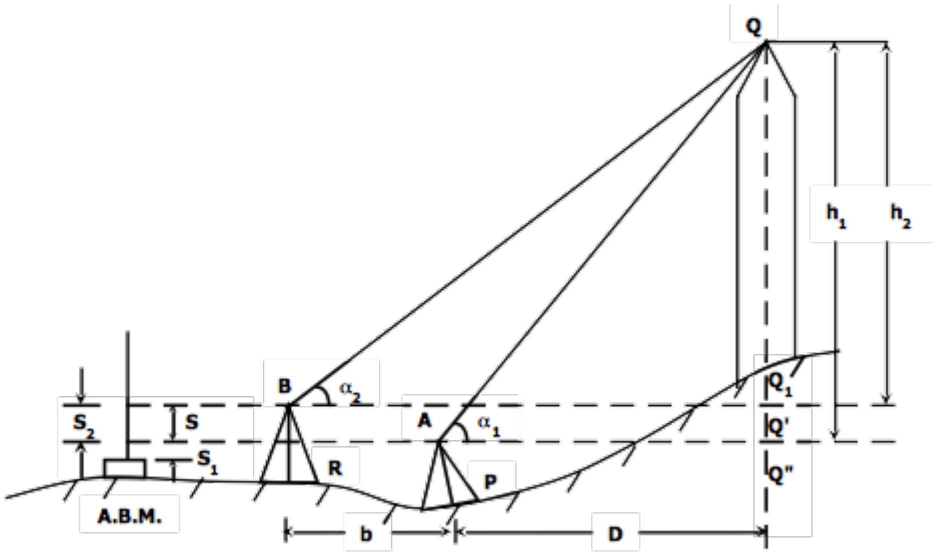


Fig.1

***Observations & Calculations*:**

Table: Face left Observations

Instrument at	Sight to	Initial reading		Final reading		Angles on Vernier		Average Reading
		Vernier C	Vernier D	Vernier C	Vernier D	Vernier C	Vernier D	
P	Q							
R	Q							

Horizontal distance between P & R = b = m

$h_1 - h_2 = S_2 - S_1 = S$

$D = S \pm b \tan \alpha_2 / (\tan \alpha_1 - \tan \alpha_2)$

$h = D \tan \alpha_1$

R.L. of Q = R.L. of A.B.M. + $S_1 + h_1$

or

R.L. of Q = R.L. of A.B.M. + $S_2 + h_2$

Note: use + sign if $S_2 > S_1$ and use –ve sign if $S_2 < S_1$ in the expression of D.

***Result*:**

R.L. of The Given Point ‘Q’ =

Space for Calculation:

***Precautions*:**

- ❖ The leveling staff should not unfold or fold in vertical position and should fold or unfold only in a horizontal position, by keeping the leveling staff on the ground.
- ❖ The third fold of leveling staff should not be unfold except for any special survey work by prior permission.
- ❖ While measuring the elevations of various station points on the ground surface, the leveling staff should be changed from one station to the other station only in the horizontal direction and vertical movement is prohibited.
- ❖ In case of contour surveying the students are instructed to be cautious about the presence of unexpected things in the field such as bushes, rocks, electric poles, electric wires, transformers etc so as to prevent certain type of accidents.
- ❖ While doing fly leveling along the road, the instrument as well as leveling staff should not be kept at the centre of the road.
- ❖ The leveling staff should not unfold or fold in vertical position and should fold or unfold only in a horizontal position, by keeping the leveling staff on the ground.
- ❖ The third fold of leveling staff should not be unfolded except for any special survey work by prior permission.
- ❖ While measuring the elevations of various station points on the ground surface, the leveling staff should be changed from one station to the other station only in the horizontal direction and vertical movement is prohibited.
- ❖ In case of contour surveying the students are instructed to be cautious about the presence of unexpected things in the field such as bushes, rocks, electric poles, electric wires, transformers etc so as to prevent certain type of accidents.
- ❖ While doing fly leveling along the road, the instrument as well as leveling staff should not be kept at the centre of the road.

Expected Viva Questions:

1) What is a transit theodolite?
2) What are the functions of a theodolite?
3) What are the functions of clamp screw, tangent screw and clip screw?
4) What do you mean by face left and face right conditions?
5) What is transiting?
6) What is the least count of a theodolite?
7) What is the least count of main scale in theodolite?
8) What is trigonometrical levelling?

EXPERIMENT NO.7

TWO PLANE METHOD: DETERMINATION OF R.L. OF AN ELEVATED OBJECT USING TWO INSTRUMENT STATIONS WHICH ARE NOT PLACED IN THE SAME VERTICAL PLANE- WHEN BASE OF THE OBJECT INACCESSIBLE.

***Aim*:**

To find the R.L. of the top of an object, when the base of the object is inaccessible and the instrument stations are not in the same vertical plane as the elevated object (double plane method) by Trigonometrical levelling**.**

***Equipment and Accessories*:**

Theodolite and its accessories, Levelling Staff, Tape, Ranging Rod & Pegs.

***Procedure*:**

Let P and R be the two instrument stations which are not in the same vertical plane as that of the elevated object 'Q' as shown in fig. 1. P and R are should be selected such that the triangle PQR is a well-conditioned triangle. It is required to find out the elevation of the top of an object 'Q'.

- ❖ Set up the instrument at P and level it accurately with respect to the altitude bubble. Bisect the point Q and measure the angle of elevation α_1. Enter the readings in Table.
- ❖ Sight to point R with reading on horizontal circle as zero and measure the horizontal angle RPQ_1 (θ_1) from P.
- ❖ Take a back-sight S on the staff kept at A.B.M.
- ❖ Shift the instrument to R and measure α_2 and θ_2 from R.
- ❖ Measure the distance between two instrument stations R and P (equals to 'b')

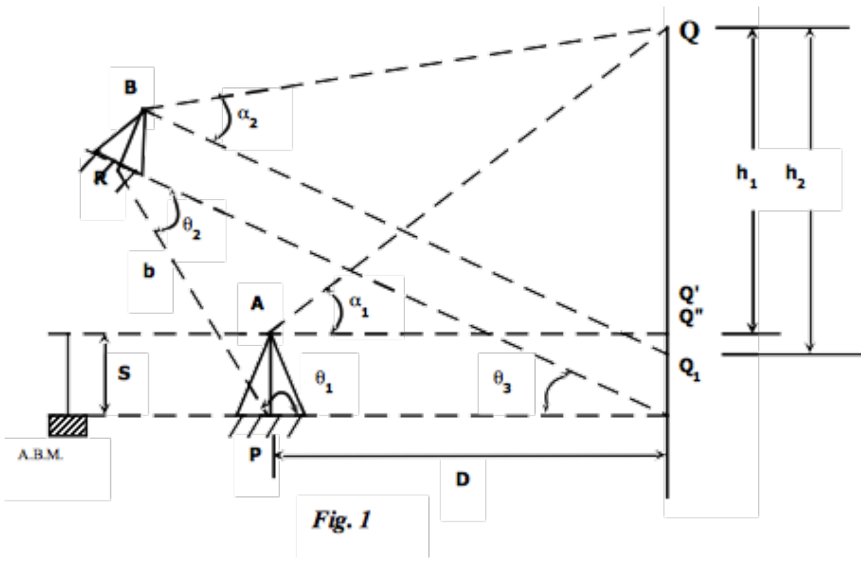


Fig. 1

***Observations & Calculations*:**

Table : **Vertical Angle Measurements**

Instrument at	Sight to	Initial reading		Final reading		Angles on Vernier		Average Reading
		Vernier C	Vernier D	Vernier C	Vernier D	Vernier C	Vernier D	
P	Q							
R	Q							

Table : **Horizontal Angle Measurements**

Station	Angle	Initial reading (Sighting to Q)		Final reading (Sighting to R)		Angles on Vernier		Average reading of Vernier A & Vernier B
		Vernier A	Vernier B	Vernier A	Vernier B	Vernier A	Vernier B	
P	$\theta 1$							

Station	Angle	Initial reading (Sighting to Q)		Final reading (Sighting to P)		Angles on Vernier		Average reading of Vernier A & Vernier B
		Vernier A	Vernier B	Vernier A	Vernier B	Vernier A	Vernier B	
R	$\theta 2$							

From triangle AQQ' h1 = D tan α_1

From triangle PRQ_1, angle $PQ_1R = \theta_3 = 180^0 - (\theta_1 + \theta_2)$

By applying sine rule,

$(PQ_1 / \sin \theta_2) =(RQ_1 / \sin \theta_1)=(RP / \sin \theta_3)$

$PQ_1 = D = b \sin \theta_1 / \sin (\theta_1 + \theta_2)$ And $RQ_1 = b \sin \theta_1 / \sin (\theta_1 + \theta_2)$

$h_1 = D \tan \alpha_1$ or $h_2 = RQ_1 \tan \alpha_2$

R.L. of Q = R.L. of A.B.M. + S (from A) + h_1

(or)

R.L. of Q = R.L. of A.B.M. + S (from B) + h_2

***Result*:**

R.L. of the given station Q = m

Expected Viva Questions:

1) What is a transit theodolite?
2) What are the functions of a theodolite?
3) What are the functions of clamp screw, tangent screw and clip screw?
4) What do you mean by face left and face right conditions?
5) What is transiting?
6) What is the least count of a theodolite?
7) What is the least count of main scale in theodolite?
8) What is trigonometrical levelling?

EXPERIMENT NO.8

INTRODUCTION TO TOTAL STATION AND APPLICATIONS: APPLICATION TO SIMPLE PROBLEMS OF HEIGHT AND DISTANCE BY MEASURING ANGLE OF ELEVATION AND DEPRESSION AND DETERMINATION OF R.L OF THE TARGET OBJECT

Total Station is three-dimensional surveying technology unit. Total station combines the follow three basic components into one integral unit

• an electronic distance measurement instrument

• an electronic digital Theodolite

• a computer or microprocessor

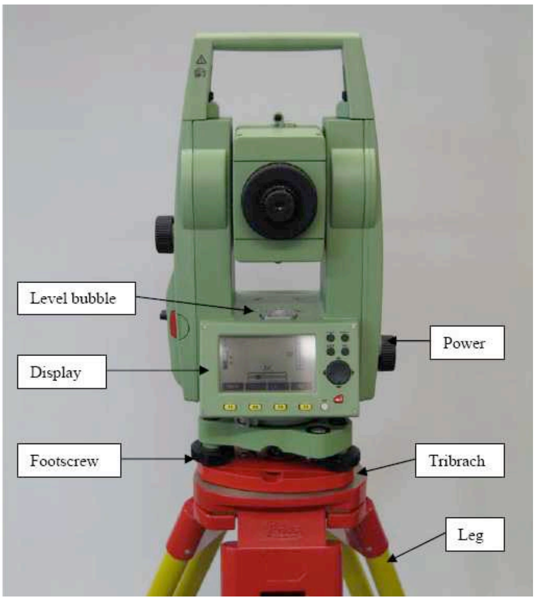
Total station can automatically measure horizontal and vertical angles as well as slope distances from a single setup. From these data it can instantaneously compute:

• horizontal and vertical distance components

• elevations

• coordinates and display the results on an LCD.

Total station can also store data either on board in internal memory or in external data collectors. Data can be uploaded and can be downloaded to a computer. It can also perform basic co-ordinate geometry functions like area and perimeter calculations.



Precautions:

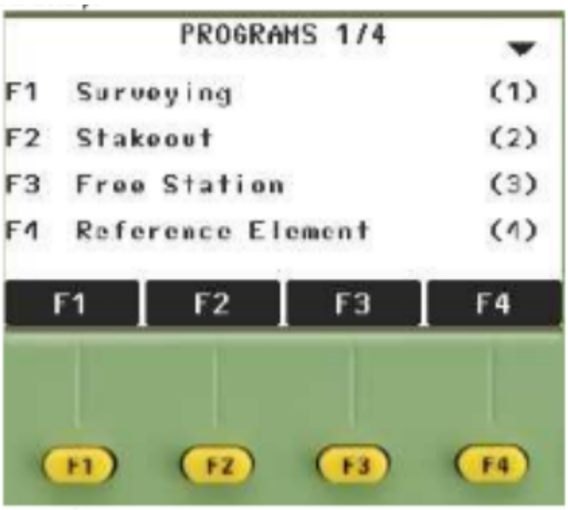
Total stations are very expensive and can be damaged by forcing or dropping the equipment. Please be extremely careful with this expensive equipment and make sure it does not get wet.

1. Never Place the Total Station directly on the ground.
2. Do not aim the telescope at the sun.
3. Protect the Total Station with an umbrella.
4. Never carry the Total Station on the tripod to another site
5. Handle the Total Station with care. Avoid heavy shocks or vibration.
6. When the operator leaves the Total Station, the vinyl cover should be placed on the instrument.
7. Always switch the power off before removing the standard battery.
8. Remove the standard battery from the Total Station before putting it in the case.
9. When the Total Station is placed in the carrying case, follow the layout plan

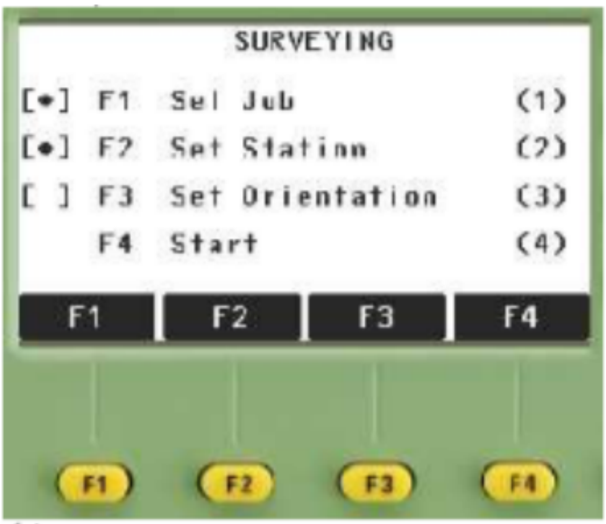
BASIC STEPS INVOLVED IN SETTING UP A TOTAL STATION

1. **SETTING UP A TOTAL STATIN OVER A POINT FOR THE FIRST TIME (Aligning to North)**

1. Switch on the instrument.
2. Press **USER** Key for Laser Beam for centering and leveling.
3. Press **MENU.**
4. Press **F1 (PROGRAMS).**

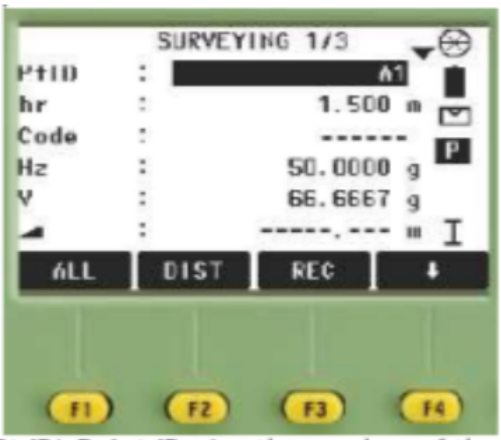


5. Press **F1(SURVEYING)**

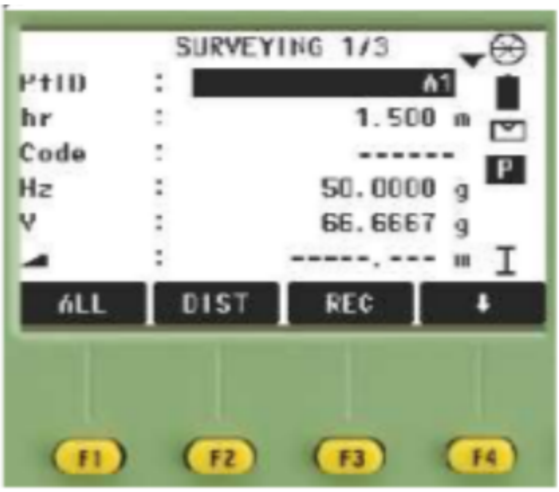


6. Press **F1(Set Job)**

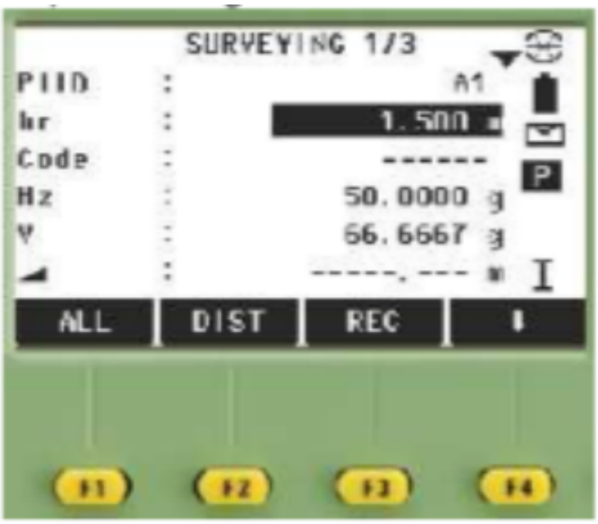
7. Press **F1(New)** to give a new job name
8. To write the name of the job. Press **F1(INPUT)** and then using the Function keys **F1 to F4** give the name. then Press Enter.
9. Press **F4(OK)**
10. Press **F2(Set Station)** to give the station No. Press **F1(INPUT)** to give the station number using the Function Keys from **F1** to **F4**.
11. Press **F2 (FIND)**
12. Press **F4 (ENH)**
13. Enter the Easting, Northing and Elevation for the point and Press **F4 (OK)**
14. Now in front of **hi (Instrument Height) give the height of the instrument.**
15. Press **F4(OK)**
16. Press **F3(Set Orientation).**



17. Press **F1 (Manual Angle Setting)**
18. Point the instrument in the North direction and Press **F1(Hz=0).**
19. Press **F3 (REC).**
20. Press **F4(START).**



21. In front of the **(Pt ID) Point ID** give the number of the point to shoot.



22. In front of the **hr (Reflector height)** give the height to which the reflector is opened.

2. FOR SHIFTING THE STATION BY ALIGNING TO THE BACK POINT (Known Co-ordinates)

1. Switch on the instrument.
2. Press **USER** key for Laser Beam for centering and leveling.
3. Press **MENU**.
4. Press **F1 (PROGRAMS).**
5. Press **F1 (SURVEYING).**
6. Press **F2 (Set Station)** to give the station No.
7. In front of station: Enter the station Number where you are standing. Press **F1(INPUT)** to give the station number using the function keys from **F1 to F4.**
8. Press **F2 (FIND)**
9. Press **F4 (OK)**
10. Now give in front of **hi** (height of Instrument) and Press **F4(OK).**
11. Press **F3(Set orientation).**
12. Press **F2(Coordinates).**
13. In front of **BS(Back Sight)** give the number of the Back Point to which the Instrument is being aligned. By Pressing **F1(INPUT**)
14. Press **F2 (FIND)**
15. Press **F4 (OK).**
16. Press **PAGE.**
17. Now Sight the back point and press **F1 (DIST).**
18. The value in front of Δ = will give the relative error in station shifting.
19. Press **F3(REC).**
20. Now Press **F (OK).**
21. Press **F4 (START)**
22. And we can continue with the surveying.
23. To see the Easting, Northing and Elevation for a Point Press PAGE until you see East, North, Elevation.

<u>FINDING THE RL OF TARGET OBJECT</u>

***Aim*:**

To determine remote height of a point on an target object using Total Station.

***Equipment and accessories*:**

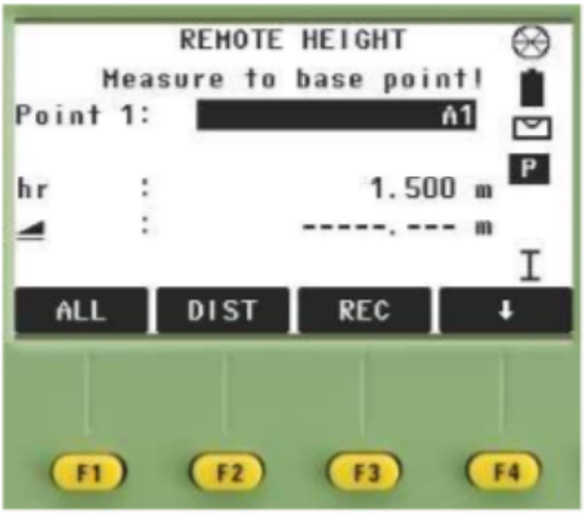
1. Total Station
2. Tripod
3. Prism and Pole
4. Arrows
5. Field Book

***Procedure*:**

The Remote height program is used to find the elevation of the remote point where it is possible to place the prism directly below the point the point whose remote elevation is to be found.

1. Identify the point whose elevation has to found out.
2. Choose a point for the Total station set up such that from this point both the point under consideration and its projection on the ground are visible, then set up the station over this point.
3. Press **MENU.**
4. Press **F1 (Programs)**
5. Press **PAGE** button.

6. Press **F3 (Remote Height).**
7. **The First three steps (F1, F2 and F3) for station setup and orientation (refer to Step1 and Step2).**
8. Press **F4 (Start).**



9. Focus on the required point and turn telescope towards ground and guide the prism man for properly placing the prism on the ground.
10. Now put the prism on the base point and Sight it and press **F3(ALL).**
11. Now move the telescope and focus the top point whose elevation is to be found.
12. The height Value will be displayed on the screen.

Result:

The R.L of the remote point is ……………………………m

EXPERIMENT NO.9

TOTAL STATION AND APPLICATIONS: DETERMINATION OF AREA ENCLOSED IN A CLOSED TRAVERSE HAVING MINIMUM 5 STATIONS

***Aim*:**

To find the area enclosed in a closed traverse using Total Station.

***Equipment and accessories*:**

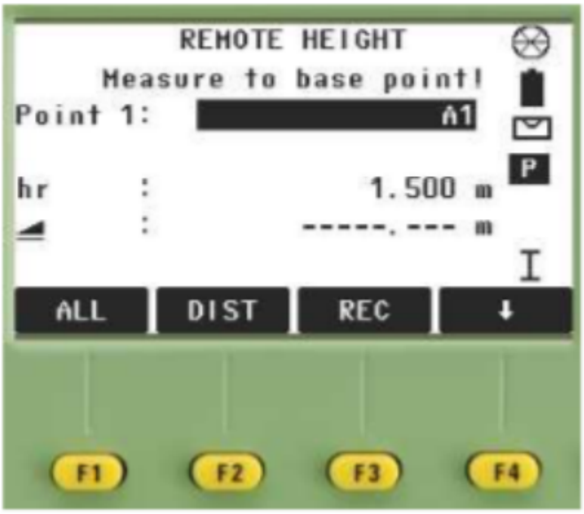
1. Total Station
2. Tripod
3. Prism and Pole
4. Arrows

***Procedure*:**

1. Select a suitable location and setup instrument and do all necessary stationery adjustments.
2. Sight the first point on the line enclosing the area
3. Press **MENU.**
4. Press **F1 (Programs)**
5. Press **PAGE** button.

6. Press **F2 (Area & Volume).**

7. Press **F4 (Start).**
8. Measure all co-ordinates of the points around the enclosed area.



9. After all the points which are necessary to calculate the surface area have been observed press [CALC] to display calculated area.

***Result*:**

The area of the given plot is ……………………………sq.m

EXPERIMENT NO.10

GLOBAL POSITIONING SYSTEM (GPS): DETERMINATION OF LATITUDE AND LONGITUDE OF ANY FOUR STATIONS AND COMPUTATION OF THE AREA

***Aim*:**

To find the area enclosed in a closed traverse using Handheld GPS.

***Equipment and accessories*:** Hand held GPS Garmin etrex 10

***Theory*:** GPS is a navigation system for measuring a position by receiving information from GPS satellites. It is a constellation of 24 satellites in 6 orbital planes at a distance of 20,000 kms from the surface of the earth.

Device Overview

①	Zoom keys. Press to zoom in and out.
②	Back key. Press to return to the previous menu.
③	Thumb Stick™ controller. Move directionally to scroll or highlight an item. Press to select an item.
④	Menu key. Press to open the menu for a page. Press twice to return to the main menu.
⑤	⏻ Press to adjust the backlight. Hold to turn the device on or off.
⑥	Mini-USB port (under weather cap).
⑦	Battery cover.
⑧	Battery cover locking ring.
⑨	Mounting spine.

Turning On the Device

Hold ⏻.

Acquiring Satellite Signals

It may take 30 to 60 seconds to acquire satellite signals.

1 Go outdoors to an open area.
2 If necessary, turn on the device.
3 Wait while the device searches for satellites.
   ? flashes while the device determines your location.
   shows the satellite signal strength.

Turning On the Backlight

Select any key to turn on the backlight.

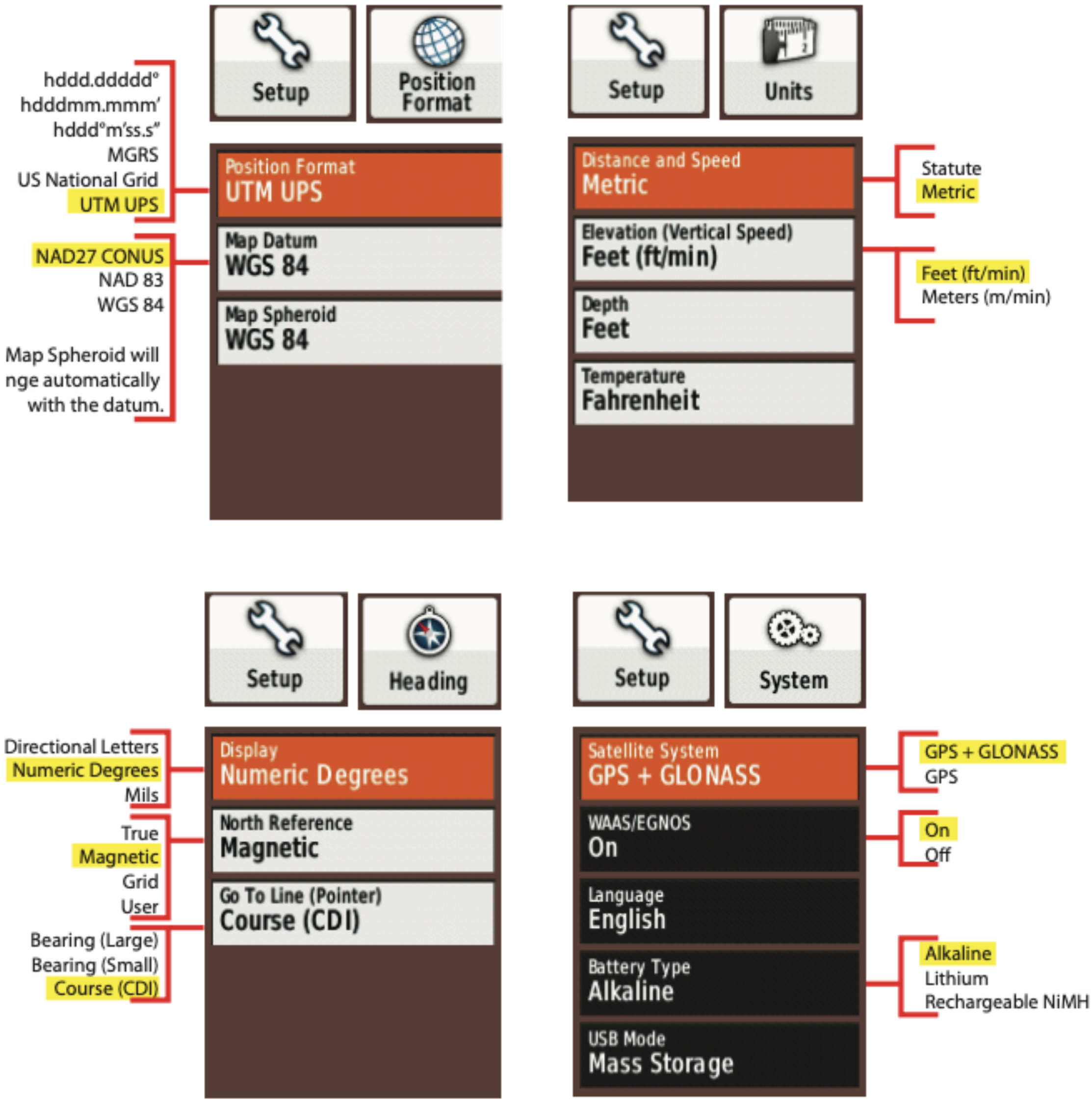
The backlight turns on automatically when alerts and messages are displayed.

Opening the Main Menu

The main menu gives you access to tools and setup screens for waypoints, activities, routes, and more

Setup

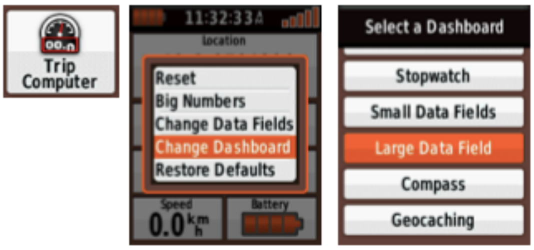
Access the Setup Menu by selecting the **Setup** icon in the Main Menu. The most commonly changed setup pages are picture below with their most common options. At the beginning of class, set you GPSr to the options highlighted in yellow.



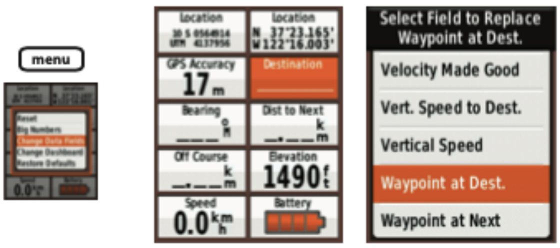
The **Trip Computer**, **Compass**, and **Map** each have user configurable data fields.

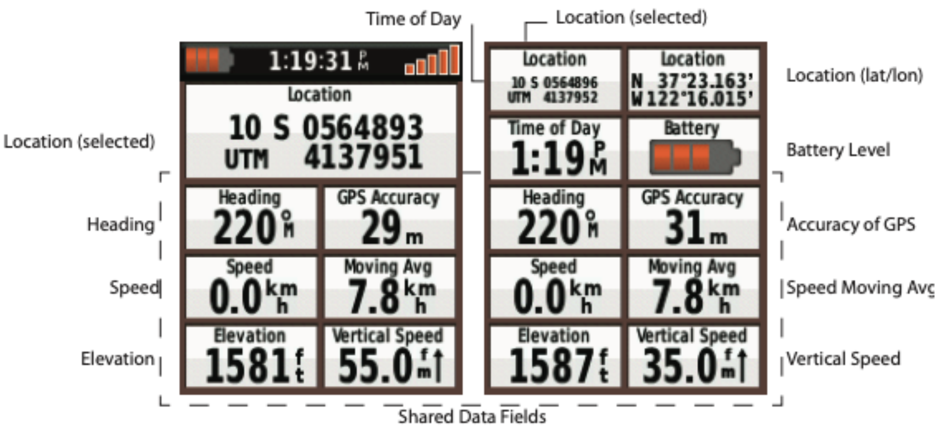
The top of the Trip Computer is called the Dashboard, which can also be configured.

From the **main menu** select the **Trip Computer**, press the **menu** button, select **Change Dashboard**, and select **Large Data Field**.



Then press the **menu** button, select **Change Data Fields**, select the individual data fields, and configure the data fields as shown below.

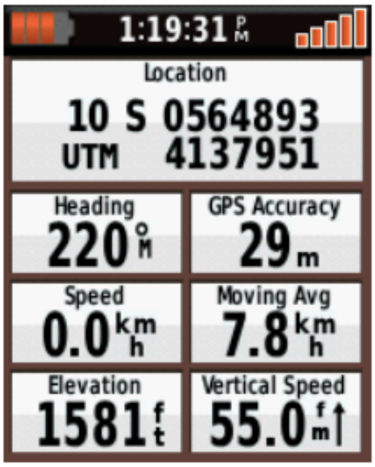


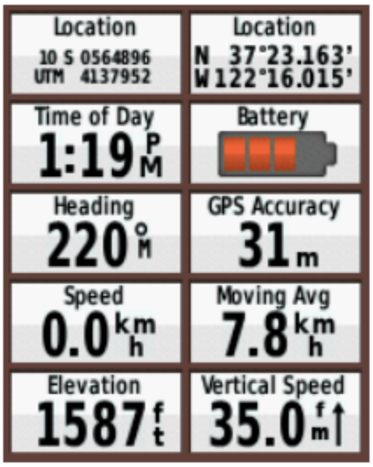


Your Location

The **Trip Computer** will be able to show you the coordinates for your current location.

When I'm using UTM but working with folks that may need lat/lon, I prefer the Small Data Field Dashboard configured to also show lat/lon coordinates.





Calculating the Size of an Area

1 Select **Area Calculation** > **Start**.
2 Walk around the perimeter of the area you want to calculate.
3 Select **Calculate** when finished.

EXPERIMENT NO.11

STUDY OF DIGITAL PLANIMETER

***Aim*:** To measure the area of the plan in the drawing sheet.

***Equipment and Accessories*:** Digital Planimeter

***Measurement Procedure*:**

1. Preparatory Steps:

Level and paste the object on a drawing board placed nearly horizontal. Set the instrument with its roller with and tracer arm placed at right angles to each other and placed the tracer arm on the approximate centre line of area of the object.

2. Power On: Push the on/c key. The display will indicate `O'.

3. Selection of Metric or English scale:

Push the m <= = => ft. key and the unit of metric system are displayed alternately on the right side of display. Select and set either unit symbol. (If no unit symbols appear on power turned on, it means that the instrument is in the pulse count mode. Push the unit key, making the selected unit symbols displayed).

The unit km^2 (or acre) is followed by no unit symbol but the pulse count mode. In this case the pulse is equivalent to 0.1 cm^2 for areas on a 1:1 scale.

Once set, the unit system and it's symbol will be protected even after the power is turned off unless the m <= = => ft. key and the unit key are pushed.

4. Selection of Unit:

Each time the unit key is pushed, the mark shifts to the higher unit [namely cm^2 (in^2)] to m^2 (ft^2) or m^2(ft^2) to km^2 (acre) and eventually returns to the lowest thus repeating that sequence. Set the selected unit when the mark reaches it.

5. Tracing of an area:

Mark the starting point at any position on the outline of area to be measured. Set the pin point of circle in the tracer lens on it. Push the START key and see that `O' appears on the display (with a sound `beep'). Then move the tracer clockwise along the outline of area until it comes to the starting point. The figure displayed indicates the area of object that has been measured.

6. Memory of Measured Figures by HOLD key:

The measured figures on the display are frozen by the HOLD key. In this mode, both the `HOLD' symbol appear on the left side of the display unit. This prevents an inadvertent loss of result when it is memorised.

7. Accumulative Measurement by HOLD key:

The HOLD key may be used to accumulate segments of a large area or measure two or more different areas accumulatively. To measure and accumulate several areas trace the first area and push HOLD key, then trace the second and push the HOLD. Repeat some steps for third, fourth etc...

To start a new measurement during accumulative measurement after releasing the `HOLD' function by the second or any subsequent push on the `HOLD' key, return the tracer to the original starting point and push the ON/C key then the figure frozen at the previous measurement appears on the display unit.

8. Average Measurement by AVER key:

The same area measured repeatedly up to nine times may be averaged to obtain the most reliable results.

Measure an area, push the END key, and measure the same area again. Repeat this procedure continuously several times. Eventually, push the AVER key to obtain the final averaged result.

Pushing the END key causes the display to become "O". This value is not frozen but changes as the tracer moves. If the "O" display changed when the tracer was aligned the starting point to make the second measurement, push the ON/C key to bring the display to "O". In this condition, the data effective before the END key was pushed is stored and only the figure in display is cleared, permitting average measurement to continue.

Result:

The area of the given plan =