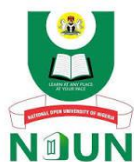


**COURSE
GUIDE**

**ESM 421
ELEMENTS OF SURVEYING**

Course Team Dr. J. C. Udoh (Developer/Course Writer)-Uni Uyo
Prof. K. T. Obidairo (Programme Leader) -NOUN
Ms. C. Medupin (Course Coordinator) - NOUN



NATIONAL OPEN UNIVERSITY OF NIGERIA

© 2025 by NOUN Press
National Open University of Nigeria
Headquarters
University Village
Plot 91, Cadastral Zone
Nnamdi Azikiwe Expressway
Jabi, Abuja

Lagos Office
14/16 Ahmadu Bello Way
Victoria Island, Lagos

e-mail: centralinfo@nou.edu.ng
URL: www.nou.edu.ng

All rights reserved. No part of this book may be reproduced, in any form or by any means, without permission in writing from the publisher.

Printed 2011, 2017, 2025

ISBN: 978- 058-613-1

CONTENTS	PAGE
Introduction.....	iv
What You Will Learn in this Course.....	iv
Course Aim.....	iv
Course Objectives.....	v
Working through this Course.....	v
Course Materials.....	v
Study Units.....	vi
Textbooks and References.....	vi
Assignment File.....	vii
Presentation Schedule.....	vii
Assessment.....	vii
Tutor- Marked Assignment.....	viii
Final Examination and Grading.....	viii
Course Marking Scheme.....	viii
How to Get the Most from this Course.....	viii
Facilitators/Tutors and Tutorials.....	x
Summary.....	xi

INTRODUCTION

ESM 421: Elementary Surveying is a 2-credit unit course for Environmental Science and Resource Management students in National Open University of Nigeria.

The course is broken into six modules and 13 study units. At the end of this course, you are expected to be conversant with the following terms: Surveying, chain surveying, compass surveying, leveling, plain tabling and theodolite survey. This course further provides insight on the contemporary issues in surveying. In the introduction to the course, you will learn about the general overview of surveying, the definition of surveying, the various classes of surveying, the basic principles and processes of surveying. Through this course, you will be equipped to identify key equipments and requirements for the various types of surveying. Issues and terminologies of surveying in a digital age will also be covered in the course.

The course guide, therefore, tells you briefly what the course is all about, the types of course materials to be used, what you are expected to know in each unit, and how to work through the course material. It suggests the general guidelines and also emphasises the need for self-assessment and tutor-marked assignment. There are also tutorial classes that are linked to this course and you are advised to attend.

WHAT YOU WILL LEARN IN THIS COURSE

The overall aim of this course, ESM 421, is to introduce you to the elements of surveying and the variables associated with them. During this course, you will be equipped with definitions of surveying, chain and compass surveying, plain tabling, leveling theodolite surveying, geo-informatics and digital surveying. Meaning, purpose, suitability, and equipment, processes, sources of errors and ways of overcoming them in the various types of surveying will be covered. In this course the importance and influence of the electronics and computers in surveying will be emphasised.

COURSE AIM

This course aims to give you an in-depth understanding of elements of surveying. It is hoped that the knowledge would equip you with the conceptual issues of surveying and also provide practical examples of surveying using different equipments.

COURSE OBJECTIVES

Note that each unit has specific objectives. You should read them carefully before going through the unit. You may want to refer to them during your study of the unit to check on your progress. You should always look at the unit objectives after completing a unit. In this way, you can be sure that you have done what is required of you by the unit. However, below are overall objectives of this course. On successful completion of this course, you should be able to:

- provide an overview and introduction to surveying
- list the classes of surveying
- examine the basic principles and process surveying
- give meaning, purpose, suitability, and equipments for chain survey
- describe the processes of chain survey and the sources of error
- give the meaning and types of compass survey
- examine the bearing and traversing with prismatic compass
- provide the meaning, equipment and principles of leveling
- describe the booking and calculation of reduced levels
- explain the meaning and instruments of plane tabling
- describe the methods of plane tabling
- describe the methods of plane tabling
- give the meaning, equipment and operations of theodolite survey
- describe the adjustment of theodolite
- list and explain contemporary issues in surveying.

WORKING THROUGH THIS COURSE

To complete this course, you are required to read the units, the recommended text books, and other relevant materials. Each unit contains some self-assessment exercises and tutor-marked assignments (TMAS), and at some point in this course, you are required to submit the TMAs. There is also a final examination at the end of this course.

COURSE MATERIALS

The major components of the course are:

1. Course Guide
2. Study Units
3. Text Books
4. Assignment File
5. Tutorials

STUDY UNITS

There are 13 study units and six modules in this course. They are:

Module 1

Unit 1	Overview and Introduction to Surveying
Unit 2	Classification of Surveying
Unit 3	The Basic Principles and Process Surveying

Module 2

Unit 1	Meaning, Purpose, Suitability and Equipment
Unit 2	Processes of Chain Survey and Sources of Error

Module 3

Unit 1	Meaning and Types of Compass Survey
Unit 2	Bearing and Traversing with Prismatic Compass

Module 4

Unit 1	Meaning, Equipments and Principles
Unit 2	Booking and Calculation of Reduced Levels

Module 5

Unit 1	Meaning, Instruments and Operation of Plane
Unit 2	Methods of Plane Tabling

Module 6

Unit 1	Meaning, Equipment and Operations of Theodolite Survey
Unit 2	Adjustment of Theodolite and Contemporary Issues in Surveying

RECOMMENDED TEXTS

These texts will be of immense benefit to this course:

Agor, R. (1993). *Textbook of Surveying and Leveling*. India: Khanna Publishers.

Clark, D. (1983). *Plane and Geodetic Surveying for Engineers*. In: *Higher Surveying*. (6th ed.). CBS Publishers and Distributors.

Chandra, A. N. (2006). *Plane Surveying*. (2nd ed.). New Delhi: New Age International Limited, India.

- Higgins, A. L. (1974). *Elementary Surveying*. Longman Group Ltd.
- Kufoniyi, O. (1999). Education Requirements in Geospatial Information Technology. In: *Proc. Workshop on Surveying and Spatial Information Technology*. Lagos, Nigeria: University of Lagos.
- Ndukwe, N. K. (2001). *Digital Technology in Surveying and Mapping*. Enugu: Rhyce Kerex Publishers, Nigeria
- Okoroigwe, D. S. (2002). *Surveying for Geographers*. Lagos: Mbeyi and Associates (Nig.) Ltd, Nigeria
- Olomo, R. O. (2008). *Modern Comprehensive Practical Geography*. Agbor: Pon Publishers Limited.

ASSIGNMENT FILE

The assignment file will be given to you in due course. In this file, you will find all the details of the work you must submit to your tutor for marking. The marks you obtain for these assignments will count towards the final mark for the course. Altogether, there are 29 TMAs for this course.

PRESENTATION SCHEDULE

The presentation schedule included in this course guide provides you with important dates for completion of each tutor-marked assignment. You should therefore try to meet the deadlines.

ASSESSMENT

There are two aspects to the assessment of this course. First, there are tutor-marked assignments; and second, the written examination.

You are thus expected to apply knowledge, comprehension, information and problem solving gathered during the course. The TMAs must be submitted to your tutor for formal assessment, in accordance to the deadline given. The work submitted will count for 30% of your total course mark.

At the end of the course, you will need to sit for a final written examination. This examination will account for 70% of your total score.

TUTOR-MARKED ASSIGNMENTS (TMAs)

You need to submit all the TMAs as provided in the TMA portal. When you have completed each assignment, submit online and you can access your grades immediately before the deadline. If for any reason you cannot complete your assignment on time, contact your tutor before the assignment is due to discuss the possibility of extension. Extension will not be granted after the deadline, unless on exceptional cases.

FINAL EXAMINATION AND GRADING

The final examination for ESM 421 will be of 2-hour duration and has a value of 70% of the total course grade. The examination will consist of questions which reflect the self-assessment exercise and tutor-marked assignments that you have previously encountered. Furthermore, all areas of the course will be examined. It is also better to use the time between finishing the last unit and sitting for the examination, to revise the entire course. You might find it useful to review your TMAs and comment on them before the examination. The final examination covers information from all parts of the course.

COURSE MARKING SCHEME

The following table gives the course marking scheme

Assessment	Marks
Four TMA (comprising of 20 questions) carries 10marks	Total = $10\% \times 3 = 30\%$ (the best 3, out of 4 TMAs are taken)
Final Examination	70% of overall course marks
Total	100% of Course Marks

HOW TO GET THE MOST FROM THIS COURSE

In distance learning, the study units replace the university lecturer. This is one of the huge advantages of distance learning mode; you can read and work through specially designed study materials at your own pace and at a time and place that suit you best. Think of it as reading from the teacher, the study guide tells you what to read, when to read and the relevant texts to consult. You are provided exercises at appropriate points, just as a lecturer might give you an in-class exercise.

Each of the study units follows a common format. The first item is an introduction to the subject matter of the unit and how a particular unit is integrated with the other units and the course as a whole. Next to this is a set of learning objectives. These learning objectives are meant to guide

your studies. The moment a unit is finished, you must go back and check whether you have achieved the objectives. If this is made a habit, then you will significantly improve your chances of passing the course. The main body of the units also guides you through the required readings from other sources. This will usually be either from a set book or from other sources.

Self-Assessment Exercises are provided throughout the unit, to aid personal studies. Working through these self-tests will help you to achieve the objectives of the unit and also prepare you for Tutor-Marked Assignments and examinations. You should attempt each self-test as you encounter them in the units.

The following are practical strategies for working through this course.

1. Read the course guide thoroughly
2. Organise a study schedule. Refer to the course overview for more details. Note the time you are expected to spend on each unit and how the assignment relates to the units. Important details, e.g. details of your tutorials and the date of the first day of the semester are available. You need to gather together all these information in one place such as a diary, a wall chart calendar or an organiser. Whatever method you choose, you should decide on and write in your own dates for working on each unit.
3. Once you have created your own study schedule, do everything you can to stick to it. The major reason that students fail is that they get behind with their course works. If you get into difficulties with your schedule, please let your tutor know before it is too late for help.
4. Turn to Unit 1 and read the introduction and the objectives for the unit.
5. Assemble the study materials. Information about what you need for a unit is given in the table of content at the beginning of each unit. You will almost always need both the study unit you are working on and one of the materials recommended for further readings, on your desk at the same time.
6. Work through the unit, the content of the unit itself has been arranged to provide a sequence for you to follow. As you work through the unit, you will be encouraged to read from your set books.

7. Keep in mind that you will learn a lot by doing all your assignments carefully. They have been designed to help you meet the objectives of the course and will help you pass the examination.
8. Review the objectives of each study unit to confirm that you have achieved them. If you are not certain about any of the objectives, review the study material and consult your tutor.
9. When you are confident that you have achieved a unit's objectives, you can start on the next unit. Proceed unit by unit through the course and try to pace your study so that you can keep yourself on schedule.
10. When you have submitted an assignment to your tutor for marking, do not wait for its return before starting on the next unit. Keep to your schedule. When the assignment is returned, pay particular attention to your tutor's comments, both on the Tutor-Marked Assignment form and also written on the assignment. Consult your tutor as soon as possible if you have any questions or problems.
11. After completing the last unit, review the course and prepare yourself for the final examination. Check that you have achieved the unit objectives (listed at the beginning of each unit) and the course objectives (listed in this course guide).

FACILITATORS/TUTORS AND TUTORIALS

There are 8 hours of tutorial provided in support of this course. You will be notified of the dates, time and location together with the name and phone number of your tutor as soon as you are allocated a tutorial group. Your tutor will mark and comment on your assignments, keep a close watch on your progress and on any difficulties you might encounter and provide assistance to you during the course. You must mail your TMA to your tutor well before the due date. At least two working days are required for this purpose. They will be marked by your tutor and returned to you as soon as possible.

Do not hesitate to contact your tutor by telephone, e-mail or discussion board if you need help. The following might be circumstances in which you would find help necessary: contact your tutor if you:

- do not understand any part of the study units or the assigned readings
- have difficulty with the self test or exercise

- have questions or problems with an assignment, with your tutor's comments on an assignment or with the grading of an assignment.

SUMMARY

You should try your best to attend the tutorials. This is the only chance to have face to face contact with your tutor and ask questions which are answered instantly. You can raise any problem encountered in the course of your study. To gain the maximum benefit from the course tutorials, prepare a question list before attending them. You will learn a lot from participating in discussion actively. GOODLUCK!

**MAIN
COURSE**

CONTENTS	PAGE
Module 1	
Unit 1 Overview and Introduction to Surveying.....	1
Unit 2 Classification of Surveying.....	5
Unit 3 The Basic Principles and Process of Surveying.....	10
Module 2	
Unit 1 Meaning, Purpose, Suitability and Equipment.....	14
Unit 2 Processes of Chain Survey and Sources of Error.....	22
Module 3	
Unit 1 Meaning and Types of Compass Survey.....	28
Unit 2 Bearing and Traversing with Prismatic Compass.....	34
Module 4	
Unit 1 Meaning, Equipments and Principles.....	37
Unit 2 Booking and Calculation of Reduced Levels.....	43
Module 5	
Unit 1 Meaning, Instruments and Operation of Plane.....	46
Unit 2 Methods of Plane Tabling.....	50
Module 6	
Unit 1 Meaning, Equipment and Operations of Theodolite Survey.....	56
Unit 2 Adjustment of Theodolite and Contemporary Issues in Surveying.....	60

MODULE 1

Unit 1	Overview and Introduction to Surveying
Unit 2	Classification of Surveying
Unit 3	The Basic Principles and Process of Surveying

**UNIT 1 OVERVIEW AND INTRODUCTION TO
SURVEYING****CONTENTS**

1.0	Introduction
2.0	Objectives
3.0	Main Content
3.1	The Meaning/Definitions of Surveying
3.2	Object of Surveying
3.3	Primary Divisions of Surveying
4.0	Conclusion
5.0	Summary
6.0	Tutor-Marked Assignment
7.0	References/Further Reading

1.0 INTRODUCTION

This unit provides the overview of surveying. Most scientists do not spend all their working hours inside air conditioned rooms but in most cases, they depend on data gathered in the field to enable them do their work successfully. Surveying is one of those courses whose practitioners depend on data gathered either by themselves or their agents to enable them take vital decisions that will make the society function properly. It is pertinent to ask: What is surveying? What is the main relationship between surveying and mapping? Why do we have to survey? What are the primary divisions of surveying? These and related questions will be answered in this unit.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- define the meaning and definitions of surveying
- explain the main objectives and relevance of surveying
- describe the primary divisions of surveying.

3.0 MAIN CONTENT

3.1 Meaning/Definitions of Surveying

Various definition of surveying exists. According to Agor (1993), surveying is the art of determining the relative position of distinctive features on the surface of the earth or beneath the surface of the earth, by means of measurements of distances, directions and elevations Okoroigwe (2002) define surveying as the art of determining relative positions of objects on the earth's surface by taking measurements and drawing them to convenient reduced size on papers it may be horizontal or vertical.

Surveying is define as the art of making (such) measurements of the relative positions of points on the surface of the earth that on drawing them on to scale, natural or artificial features are exhibited in their current relative horizontal and vertical positions (Chandra, 2006).

In his own view, Ndukwe (2001) defines surveying as the art and science of determining the relative positions of earth's features and their representation in form of maps, plans and charts.

From the above definitions, it can be deduced that surveying deals with the measuring of distances, directions and elevations to determine the relative positions of features on the earth's surface. These are then represented in the form of maps, plans and charts.

3.2 Object of Surveying

The main object of surveying is the gathering of data and the preparation of plans, maps and charts of a specific area with such data. From ancient times, man had been interested in demarcating and recording property boundaries hence early surveying efforts were geared towards that direction. In contemporary times, modern life is made possible by the efforts of surveyors and the plans, maps and charts they help to create. This is because, the first step for the execution of most projects is surveying. Note that before the construction of roads, building, railways, etc, the surveyor makes detailed measurements in the field and prepares the detailed plans and charts that help the engineers to layout the alignments of such projects.

It should be noted that since surveying developed from ancient times, the science, methods and instruments of surveying have been greatly influenced by the level of technological development of any era. Because of the importance of surveying to modern man, the training of

engineers, environmentalists, planners, architects, geographers, etc, is not complete without instructions on various aspects of surveying.

3.3 Primary Divisions of Surveying

The curative of the surface of the earth, based on its being close to ellipsoid in shape – forms the basis of surveying being divided into plane and geodetic surveying.

(a) Plane Surveying

Plane surveying is survey in a small extent. Here the earth's surface is assumed to be a plane and the curvature of the earth is ignored. Since small areas are involved, the lines connecting any 2 points on the surface of the earth are treated as straight lines and the angles between them as plane angles. Plane surveying involves areas that are up to 260 square kilometer (260 km^2) to determine the relative position of individual features at a sufficiently large scale.

Surveys for engineering projects falls under plane surveying. Knowledge of plane geometry and trigonometry are necessary for plane surveying.

(b) Geodetic Surveying

Geodetic surveying takes place in a national scale which takes into consideration the curvature of the earth. It requires higher levels of accuracy in linear and angular observations than plane surveys hence; it is used to provide widely spaced control points for subsequent detailed plane surveys. Geodetic surveys extend over large areas of 1000 km^2 and above. Hence, lines connecting any two points are treated as arcs and not straight lines and the angles as spherical angles.

4.0 CONCLUSION

The art and science of surveying has evolved over the years to reflect changes in technological development in any era. You should have this at the back of your minds in the process of studying this course. You should also take particular note of how these changes in science and technology has affected the tools and methods used in surveying.

5.0 SUMMARY

Surveying concerns the measurement of vertical (height) and horizontal (distances and bearing) distances of features on the earth's surface to determine their relative positions. These are then represented in the form of maps, plans and charts. Based on the curved nature of the earth, surveying can either be plane or geodetic. While plane surveying is

carried out in a local scale, geodetic surveying takes place in a national scale.

6.0 TUTOR-MARKED ASSIGNMENT

1. What is surveying?
2. Explain the primary divisions of surveying.

7.0 REFERENCES/FURTHER READING

Agor, R. (1993). *Textbook of Surveying and Leveling*. India: Khanna Publishers.

Chandra, A. N. (2006). *Plane Surveying*. (2nd ed.). New Delhi: New Age International Limited, India.

Okoroigwe, D. S. (2002). *Surveying for Geographers*. Lagos: Mbeyi and Associates (Nig.) Ltd, Nigeria.

Ndukwe, N. K. (2001). *Digital Technology in Surveying and Mapping*. Enugu: Rhyce Kerex Publishers, Nigeria.

UNIT 2 CLASSIFICATION OF SURVEYING

CONTENTS

- 1.0 Introduction
- 2.0 Objective
- 3.0 Main Content
 - 3.1 Classification of Surveying
 - 3.1.1 Classification Based on the Basis of Instruments Used
 - 3.1.2 Classification Based on the Surface and the Area Surveyed
 - 3.1.3 Classification Based on the Basis of Purpose
 - 3.1.4 Classification Based on Instrument Used
 - 3.1.5 Classification Based on the Method Used
- 4.0 Conclusion
- 5.0 Summary
- 6.0 Tutor-Marked Assignment
- 7.0 References/Further Reading

1.0 INTRODUCTION

This unit introduces you to the various ways of classifying surveying. This will help you to have an understanding of surveying and the various components of the subject.

2.0 OBJECTIVE

At the end of this unit, you should be able to:

- explain the various ways of classifying surveying.

3.0 MAIN CONTENT

3.1 Classification of Surveying

Various authors have attempted the classification of the different types of surveying that exist (Agor, 1993). Based on these, in this unit surveying will be classified according to certain criteria including the instruments used; purpose; the area surveyed, and the methods used.

3.1.1 Classification on the Basis of Instruments Used

Based on the instrument used, surveying can be classified into:

- Chain tape surveys
- Compass surveys
- Plane table surveys
- Theodolite surveys.

3.1.2 Classification based on the Surface and the Area Surveyed

i) **Land Surveying:** Land surveys are done for objects on the surface of the earth. They can be subdivided into:

- **Topographic Survey:** This is for depicting the physical (hills, valleys, mountains, rivers, etc.), and, manmade features (roads, houses, settlements, etc.) On the surface of the earth.
- **Cadastral Survey:** This kind of survey is used in determining property boundaries including those of fields, houses, plots of land, etc.
- **Engineering Survey:** This is used to acquire the required data for the planning, design and execution of engineering projects like roads, bridges, canals, dams, railways, buildings, etc.
- **City Surveys:** City surveys involve the construction and development of towns including roads, drainage, water supply, sewage street network, etc.

ii) **Marine or Hydrographic Survey:** These are surveys of large water bodies for navigation, tidal monitoring, the construction of harbors, etc. The taking of soundings on shores and banks, aid the determination of water depths. This helps in the production of topographic maps and the survey of bathymetric controls.

iii) **Astronomical Survey:** Astronomical survey uses the observations of the heavenly bodies (sun, moon, stars etc.) to fix the absolute locations of places and graticules (lines of longitude and latitude) on the surface of the earth.

3.1.3 Classification on the Basis of Purpose

- i) **Engineering Survey:** As mentioned earlier in the last unit, this is used to get the necessary data used in the design and construction of most engineering projects.
- ii) **Control Survey:** Control survey uses geodetic methods to establish widely spaced vertical and horizontal control points.

- iii) Geological Survey: Geological survey is used to determine the structure and arrangement of rock strata. Generally, it enables one to know the composition of the earth's constituents.
- iv) Military or Defense Survey: This is carried out to map places of military and strategic importance
- iv) Archeological Survey: This is carried out to discover and map ancient relics of antiquity.

3.1.4 Classification Based on Instrument Used

- i. Chain/Tape Survey: This is the simple method of taking linear measurements using a chain or tape with no angular measurements made.
- ii. Compass Survey: Here horizontal angular measurements are made using magnetic compass with the linear measurements made using the chain or tape.
- iii. Plane Table Survey: This is a quick survey carried out in the field with the measurements and drawings made at the same time using a plane table.
- iv. Leveling: This is the measurement and mapping of the relative heights of points on the earth's surface showing them in maps, plane and charts as vertical sections or with conventional symbols.
- vi. Theodolite Survey: Theodolite survey takes vertical and horizontal angles in order to establish controls

3.1.5 Classification Based on the Method Used

- i. Triangulation Survey: In order to make any survey manageable, the area to be surveyed is first covered with series of triangles. Lines are first run round the perimeter of the plot, then the details fixed in relation to the established lines. This process is called triangulation. The triangle is preferred as it is the only shape that can completely cover an irregularly shaped area with minimum space left.
- ii. Traverse Survey: If the bearing and distance of a place of known point are known, it is possible to establish the position of that point on the ground. From this point, the bearing and distances of other surrounding points may be established. In the process, positions of points linked with lines connecting them emerge. The process of establishing these lines, is called traversing, while the connecting lines joining two points on the ground is known as a traverse. A traverse station is each of the points of the traverse, while the traverse leg is the straight line between consecutive stations. Traverses may either be open or closed.

- **Open Traverse:** An open traverse terminates in a point that is not predetermined as it neither returns to its starting station nor closes on any point whose bearing and height is known as show in Figure 1.1.

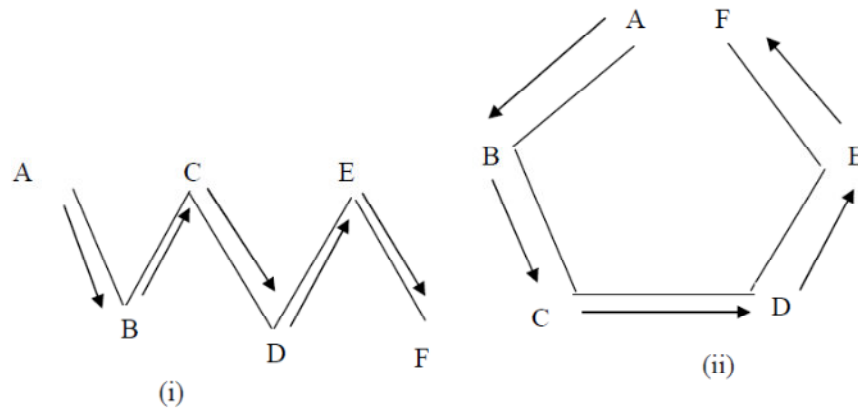


Figure 1.1: Open Traverse – A and F are Positions of Unknown Coordinates and Heights in (i) and (ii)

- **Closed Traverse:** In a closed traverse, a traverse originates from a point whose bearing and height is known and terminates in another point whose bearing and height are also known. The terminal point may either be its starting point (Fig.1.2i) or any point of known coordinate (Fig. 1.2ii).

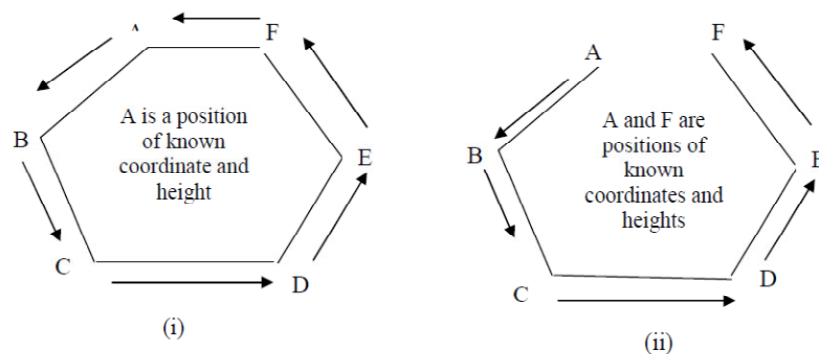


Figure 1.2: Close Traverse – (i) and (ii)

4.0 CONCLUSION

Surveying is a means to an end and not an end in itself. Various types of surveying therefore emerge as there are need to solve problems in the society. Classifying the various types of surveying, presents some challenges which this section has tried to solve.

5.0 SUMMARY

This section has presented the various ways of classifying surveying. These include classifications based on the instruments used; purpose; the area surveyed, and, the methods used. These methods are not mutually exclusive hence; you should take note of surveys that under more than one class.

6.0 TUTOR-MARKED ASSIGNMENT

Explain the classifications of surveying based on:

- the instruments used
- purpose
- the area surveyed
- the methods used.

7.0 REFERENCES/FURTHER READING

Agor, R. (1993). *Textbook of Surveying and Leveling*. New Delhi: Khanna Publishers, India.

Chandra, A. N. (2006). *Plane Surveying*. (2nd ed.). New Delhi: New Age International Limited, India.

UNIT 3 THE BASIC PRINCIPLES AND PROCESS OF SURVEYING

CONTENTS

- 1.0 Introduction
- 2.0 Objectives
- 3.0 Main Content
 - 3.1 Basic Principles of Surveying
 - 3.2 The Process of Surveying
- 4.0 Conclusion
- 5.0 Summary
- 6.0 Tutor-Marked Assignment
- 7.0 References/Further Reading

1.0 INTRODUCTION

So far in this course, we have discussed the meaning, object and major classifications of surveying. In this unit, we will move further to discuss the basic principles and process of surveying.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- state and explain the basic principles of surveying
- discuss the process of surveying.

3.0 MAIN CONTENT

3.1 Basic Principles of Surveying

Surveying is based on simple fundamental principles which should be taken into consideration to enable one get good results (Agor, 1993). These are discussed below.

Working from the Whole to the Parts: This is achieved by covering the area to be surveyed with a number of spaced out control points called primary control points whose heights and bearings have been determined with a high level of precision using sophisticated equipments. Based on these points as controls, a number of large triangles are drawn. Secondary control points are then established to fill the gaps with lower precision than the primary control points. At a more

detailed and less precise level, tertiary control points at closer intervals are finally established to fill in the smaller gaps.

The main purpose of surveying from the whole to the parts is to localise the errors as working the other way round would magnify the errors and introduce distortions in the survey. In spatial terms, this principle involves covering the area to be surveyed with large triangles. These are further divided into smaller triangles and the process continues until the area has been sufficiently covered with small triangles to a level that allows detailed surveys to be made in a local level. Error in the whole operation is minimised as the vertices of the large triangles are fixed using higher precision instruments.

Using measurements from two control parts to fix other points: Given two points whose height and bearings have been accurately determined, a line can be drawn to join them hence, surveying as control reference points. The locations of various other points and the lines joining them can be fixed by measurements made from these two points and the lines joining them. For an example, if A and B are the control points, the following operations can be performed to fix other points as shown in Figure 1.3

- i) Using points A and B as the centers, ascribe arcs and fix where they intersect (Fig. 1.3i).
- ii) Draw a perpendicular from D along AB to a point C (Fig. 1.3ii).
- iii) To locate C, measure distance AB and use your protractor to equally measure angle ABC (Fig. 1.3iii).
- iv) To locate C the interior angles of triangle ABC can be measured. The lengths of the sides AC and BC can be calculated by solving the triangle (Fig. 1.3iv).

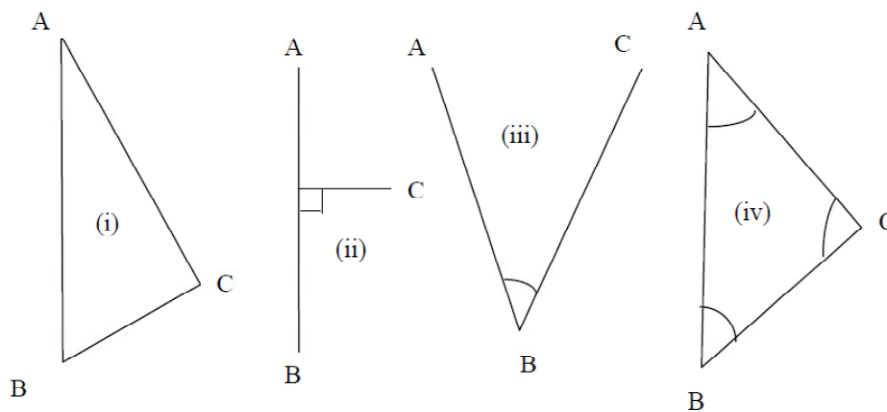


Figure 1.3: Fixing the Third Points using Two Points

3.2 The Process of Surveying

The survey process passes through three main phases – the reconnaissance, field work and measurements, and the office work. Details of these processes are given in the next modules where the specific types of surveys are treated.

(a) Reconnaissance Survey: This is a pre-field work and pre-measurement phase. It requires taking an overall inspection of the area to be surveyed to obtain a general picture before commencement of any serious survey. Walking through the site enables one to understand the terrain and helps in determining the survey method to be adopted, and the scale to be used. The initial information obtained in this stage helps in the successful planning and execution of the survey.

(b) Field Work and Measurement: This is the actual measurements in the field and the recordings in the field notebook. To get the best results in the field, the surveyor must be acquainted with the functions of the equipments and take good care of them.

(c) Office Work: This is the post-field work stage in which data collected and recordings in the field notebooks are decoded and used to prepare the charts, plans and maps for presentation to the clients and the target audience.

4.0 CONCLUSION

As a scientific endeavour, surveying has a set of principles and procedures which if rigorously followed leads to high level of precision in the results derived. This unit has introduced you to some of these. As the study progresses, you should take note of these and apply them in the survey process.

5.0 SUMMARY

This unit dealt with the basic principles and process of surveying. By covering the area to be surveyed with a network of triangles, one can therefore be working from the whole to the parts. In this way errors are minimised in the surveying. The survey process passes through 3 main phases – the reconnaissance, field work and measurements, and, the office work.

6.0 TUTOR-MARKED ASSIGNMENT

1. State and explain the three main processes of surveying.
2. List and explain the principles of surveying.

7.0 REFERENCES/FURTHER READING

Agor, R. (1993). *Textbook of Surveying and Leveling*. New Delhi: Khanna Publishers, India.

Clark, D. (1983). *Plane and Geodetic Surveying for Engineers*. In: *Higher Surveying*. (6th ed.). CBS Publishers and Distributors.

Chandra, A. N. (2006). *Plane Surveying*. (2nd ed.). New Delhi: New Age International Limited, India.

Higgins, A. L. (1974). *Elementary Surveying*. Longman Group Ltd.

Okoroigwe, D. S. (2002). *Surveying for Geographers*. Lagos: Mbeyi and Associates (Nig.) Ltd. Nigeria.

MODULE 2

Unit 1	Meaning, Purpose, Suitability, and Equipment
Unit 2	Processes of Chain Survey and Sources of Error

UNIT 1 MEANING, PURPOSE, SUITABILITY, AND EQUIPMENT

CONTENTS

- 1.0 Introduction
- 2.0 Objectives
- 3.0 Main Content
 - 3.1 Meaning of Chain Survey
 - 3.2 Purpose and Suitability of Chain Survey
 - 3.3 Principles of Chain Survey
 - 3.4 Equipment of Chain Surveying
- 4.0 Conclusion
- 5.0 Summary
- 6.0 Tutor-Marked Assignment
- 7.0 References/Further Reading

1.0 INTRODUCTION

In this unit, we shall begin with an in-depth study of one of the various types of surveys – the chain survey. The different types of survey depend on the equipment used and the desired level of accuracy. Chain survey introduces you to surveying generally hence; it will greatly benefit you if the concepts introduced by are taken seriously.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- explain the meaning, purpose, suitability of chain survey
- highlight various equipment used in chain survey.

3.0 MAIN CONTENT

3.1 Meaning of Chain Survey

This is the simplest form of survey where only the linear measurements are made while the angular measurements are ignored. It is named after the principal instrument previously in use for survey operation – the

chain. Although a more flexible tape now replaces the chain, the name is still commonly used to refer to the type of survey that involves the taking of linear measurements in the field.

Chain survey is well suited for small areas that need the filling of geographical details.

3.2 Purpose and Suitability of Chain Survey

Agor (1993) examines the purpose, suitability of chain survey as follows:

- a) Purpose: Chain survey is carried out to:
 - obtain data further accurate description of property boundaries
 - prepare an accurate plan of a plot of land and determine its area
 - delineate the boundary of a piece of land in a previously surveyed location
 - share a piece of land into smaller units
 - obtain data for engineering project (e.g. road and rail alignment).
- b) Suitability: Chain survey is suitable on an open and well level piece of land with non-simple details; where large scale plans/maps are need (e.g. site of a housing estate); and, where the area is small in extent. Chain survey is not suitable for large areas that are crowded with many details; wooded and undulating areas.

3.3 Principles of Chain Survey

The principles of chain surveys follow the general principles of surveys already explained under Unit 3 of Module 1. You are advised to revised it.

3.4 Equipments of Chain Surveying

Chain survey is mainly concerned with the measurement of distances hence the main equipments used include:

- Chain
- Tape
- Arrows
- Ranging poles
- Optical Square
- Cross Staff
- Trough compass.

1) Chain

A chain is made up of steel or iron pieces of wire known as links which are joined together with circular or oval rings that make for flexibility. It has a brass handle at both ends which is part and parcel of the total length of the chain known as chain length. A typical chain is made up of 100 links and has a bran tag at every 10th link called a teller. This makes for operating of length as the letters are numbered and differentiated from the next one for easy identification. Different kinds of chains exist including Gunter's chain, Engineers' chain and metric chains. Generally, chains have been replaced with tapes for linear surveys. Chains are now being studied to get the historical perspective of the development of survey equipments over the years.

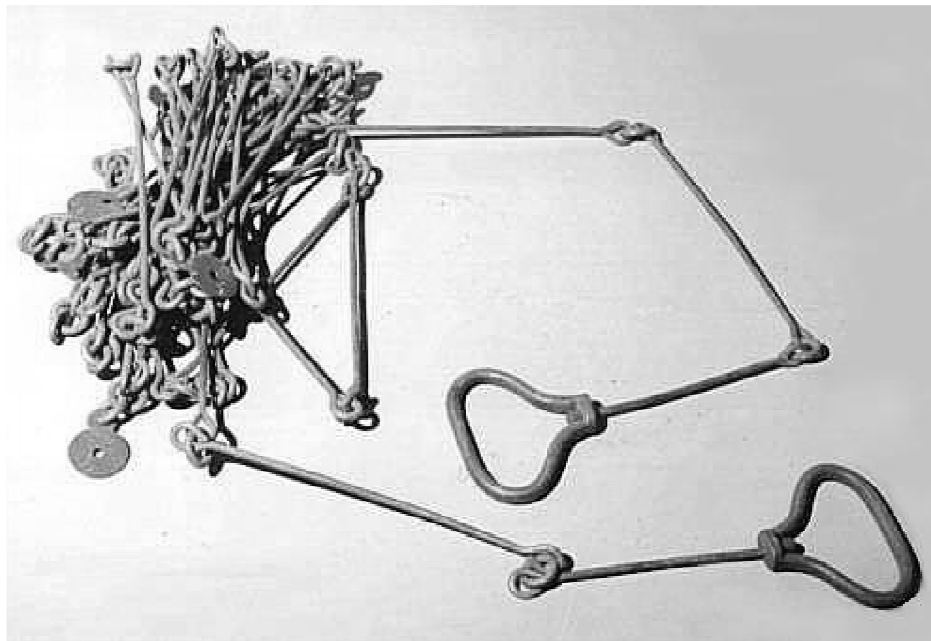


Figure 2.1: Survey Chain
(Source - www.vannattabros.com)

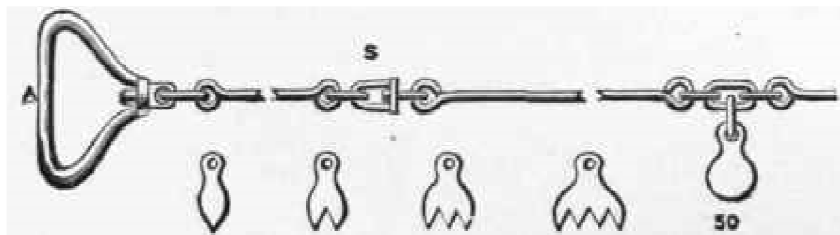


Figure 2.2: Surveying chain showing Brass Markers in Position
(Source: chestofbooks.com)

2) Tape

Tapes have replaced chains in recent years because they are light, portable and flexible. Different types of tapes exist and they are classified according to the materials they are made of hence we have cloth or line tape, metallic tape, steel tape; etc.

- i) Cloth Tape or Linen Tape: Generally between 10m to 30m in length, these are made of linen cloths that are varnished to resist moisture. It has a ring at the end of the tape that has its length included in the total length of the tape. The main limitation of cloth tape is that the stretching of the length can introduce errors in measurements. It is not as heavy and strong as a chain or steel tape hence; is likely to twist and tangle and does not remain straight in strong winds. Continuous usage can erase the figures.
- ii) Metallic Tape: This is more durable than cloth tapes as it is made up of cloth that is reinforced with brass or copper wire. Usually, between 20 to 30m, it comes in a leather case with a winding mechanism. Metallic can be used to take accurate measurements as each meter is divided into decimeters which are equally subdivided into centimeters.
- iii) Steel Tape: This is a fine steel ribbon used to provide measurement of superior accuracy than cloth or metallic tapes. With a brass ring at the end, whose length is included in the length of the tape, steel tape is available in lengths of 10, 20, 30 and 50 meters.
- iv) Invar Tape: This is made up of nickel and steel alloy and is used primarily to obtain a high degree of precision. Invar tapes are more expensive and softer than steel tapes. Also, it needs to be handled with great care to avoid bending.
- v) Steel Bands: Also called a band chain, it is made up of ribbon of steel with brass swivel handle at each end. The steel band is wound on either an open cross of metal reel. The steel band is used to obtain accurate measurements, it is lighter to handle than the chain, and its length is not stretched due to usage. However, it requires proper care as it can easily break. Also, it must be oiled and cleaned regularly to avoid rust.

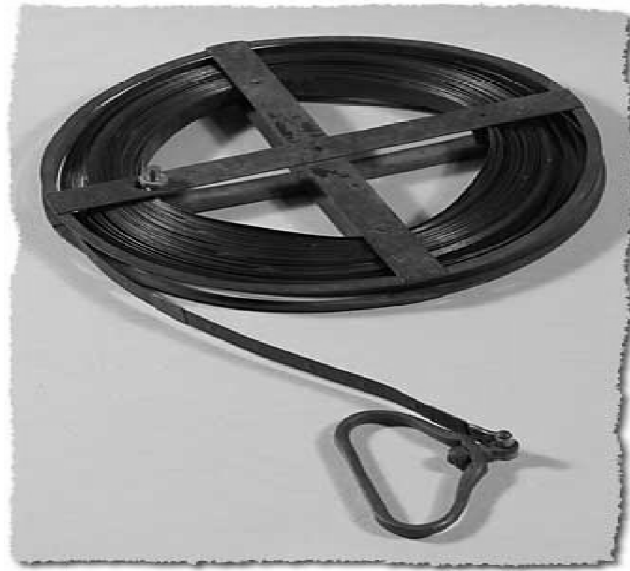


Figure2.3: Steel Tape (Source: derm.qld.gov.au)

3) Arrows or Chain Pins

An arrow is a piece of steel and iron of about 0.4 - 0.5 meters in length bent at the top into a circle and with a posited end allow for easy penetration into the ground. It is used primarily for marking the end of chaining and temporary stations.



Figure 2.4: An Arrow (Source: surveyantiques.com)

4) Ranging Pole

This is a pole of about 2 meters in length alternatively painted white and red and is pointed at one end. They are used stations and for ranging (it can get out straight lines). To do this two poles are fixed at the two stations or points and this enables one to measure along straight lines by

placing a series of ranging poles along the route in order to get the straight lines.



Figure2.5: Ranging Pole (**Source:** [www. cgsr.ie](http://www.cgsr.ie))

5) Optical Square: This is an optical instrument used to take offsets at right angles from the chain lines. Offsets are measurements made from outside the survey line of triangulation or traverse skeleton to a property boundary or fence or wall offsets enable one fix point's details in relation to the chain line.



Figure 2.6: Optical Square (www.geo-fennel.de)

6) Cross Staff: This is a simple form of optical squares used for the same purpose of fixing off sets. It is constructed in the form of a wind vane, consisting of a cross with vertical ends with slits. Offsets are taken using the lines of sight which cross at right angles.

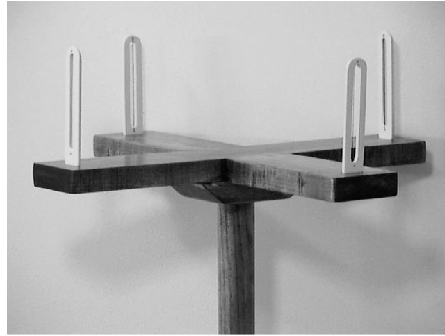


Figure 2.7: A Cross Staff ([www. orbitals.com](http://www.orbitals.com))

(7) Trough Compass: It is used to determine the North – South line.

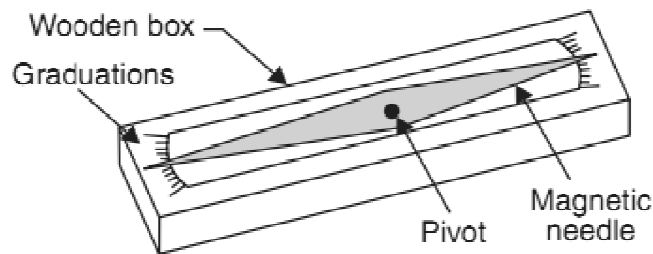


Figure 2.7: A Trough Compass (source: www.theconstructor.org)

4.0 CONCLUSION

Chain surveying, like most types of surveying, is named after the major equipment used – the chain. Despite the fact that the tape has now replaced the chain as the major equipment used, the name chain surveying is still maintained to describe this type of surveying.

5.0 SUMMARY

The meaning, purpose, suitability, principles and major equipment of chain surveying were explained in this unit. The main focus of this type of surveying is linear measurement. The equipments used here also reflect this fact – chain/ tape, arrows, ranging pole, optical square, cross staff and trough compass.

6.0 TUTOR-MARKED ASSIGNMENT

1. Explain the meaning of chain survey. What is the purpose and suitability?
2. List the various equipment used in chain survey.

7.0 REFERENCES/FURTHER READING

- Agor, R. (1993). *Textbook of Surveying and Leveling*. New Delhi: Khanna Publishers, India.
- Clark, D. (1983). *Plane and Geodetic Surveying for Engineers*. In: *Higher Surveying*. (6th ed.). CBS Publishers and Distributors.
- Chandra, A. N. (2006). *Plane Surveying*. (2nd ed.). New Delhi: New Age International Limited, India.
- Higgins, A. L. (1974). *Elementary Surveying*. Longman Group Ltd.
- Okoroigwe, D. S. (2002). *Surveying for Geographers*. Lagos: Mbeyi and Associates (Nig.) Ltd.

UNIT 2 PROCESSES OF CHAIN SURVEY AND SOURCES OF ERROR

CONTENTS

- 1.0 Introduction
- 2.0 Objectives
- 3.0 Main Content
 - 3.1 Processes of Chain Survey
 - 3.2 Sources of Errors in Chain Survey and their Correction
 - 3.2.1 Cumulative Errors
 - 3.2.2 Compensating Errors
 - 3.2.3 Gross Errors
 - 3.3 Overcoming Obstacles during Chaining
- 4.0 Conclusion
- 5.0 Summary
- 6.0 Tutor-Marked Assignment
- 7.0 References/Further Reading

1.0 INTRODUCTION

The meaning, purpose, suitability, principles and major equipments of chain surveying were explained in the previous unit. In this unit, we will move ahead to show the processes involved in a chain survey operation, then explain the main sources of errors and ways of overcoming them.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- explain the processes of chain surveying
- identify and explain the sources of error of chain surveying and ways of overcoming them.

3.0 MAIN CONTENT

3.1 Processes of Chain Survey

The chain survey process follows the procedure already explained in Module 1 Unit 3. These include: Reconnaissance survey, field work, and office work.

Reconnaissance Survey: This is the preliminary inspection of the area to be surveyed and in the process choosing the main triangles by taking

note of corners and intersections. Furthermore, secondary lines of the survey framework are noted. Also, the scale is determined by getting an estimate of the maximum dimensions of the area by pacing and measurements.

Field Work: The major operations involved in the field work of chain surveying include:

- **Ranging:** Ranging involves placing ranging poles along the route to be measured so as to get a straight line. The poles are used to mark the stations and in between the stations.
- **Running a Chain Line:** As explained earlier, the use of tapes have now replaced the chain, the chaining is still being used to mean the process of measurement of the sides of the triangles. To measure, two team leaders called a leader and a follower are chosen. Taking a number of arrows and holding the handle of the tape, the leader starts the chaining process by walking along the line towards the end of the line leaving behind the follower holding the tape. With signals from the follower, the leader extends the tape along the line; aid placing an arrow where the tape ends. The procedure is continued until the whole line is covered.
- **Measurement of Offsets:** As the chaining progresses, the leader leaves the tape on the ground for the offset and booking teams to do their work. Offsets are measurements made outside the main survey line. Where the appropriate equipments (optical square and cross staff) are not available, a simple method of taking measurements along the survey line at two points to the object is used.
- **Booking:** In order to avoid confusion after the measurements in field, care must be taken to record neatly in a field notebook. Where the original field notebook cannot be accessed, an improvised version can be made by ruling 2 lines about 1cm apart in the middle of an ordinary exercise book. Booking takes place as measurement is done along the line from the bottom of the page to the top. Right and left entries on the page are made to correspond with the right and left measurements on the ground. It is advisable that each chain line should be recorded in a separate page.

Office Work: Generally, office work in surveying involves the computation of coordinates, data processing, preparing plans and maps to suitable scales; and the computation of areas and values (Chandra,

2006). According to Okoroigwe (2002), plotting – representing on paper to a suitable scale the previously surveyed objects – central to office work of chain survey.

3.2 Sources of Errors in Chain Survey and their Correction

The errors can be divided into three groups:

- a. Cumulative (systematic) errors
- b. Compensating (accidental) errors
- c. Gross errors

3.2.1 Cumulative Errors

Cumulative errors are said to be systematic errors as they are one-directional hence keep on accumulating as the survey progresses. If not checked they have serious implications to the accuracy of the survey. Errors in this class include incorrect length of the tape, page of the tape or the tape not being in line. Since the sources of these errors are known, they can be eliminated. They can either be positive or negative errors. While positive errors shortens the measurement (e.g. where the tape length is shorter than what it should be), negative errors elongates the measurements (e.g. where the tape is longer than what it should be). Checking the equipment can eliminate these errors.

3.2.2 Compensating Errors

Compensating errors are said to be accidental errors hence, they cancel out and do not pose serious problem to the accuracy of the survey. They arise as a result of not being perfect in the use of the equipment or in the whole survey process. For example, if the pull exerted on the tape is either more than or less than what should be the case, faulty results be gotten. The effect can either be positive or negative.

3.2.3 Gross Errors

These are mistakes that can be attributed to the inexperience of the team leaders. These are very serious errors which although are random in accordance but may lead to faulty plans and maps if not checked. They include discontinuing the chain length (e.g. where some arrows are lost or misplaced); misreading of the tape; reading tape upside down (e.g. taking 6 to be 9), etc. By taking the necessary precautions, these errors can be corrected.

3.3 Overcoming Obstacles during Chaining

Various types of obstacles encountered in the course of chaining can be classified into different groups (Agor, 1993). These include:

A. Obstacles which Obstruct Ranging but not Chaining: These include obstacles like water bodies for instance, lakes, ponds and rivers. It is possible to chain around these obstacles by using the following methods:

By Constructing Rectangles: Chaining had reached A, and encountered an obstacle. To get to B mark A and B with an arrow. Set of perpendiculars AC and BD high enough to clear the obstacles. Join and measure DC which now equals AB. This allows chaining to continue from B.

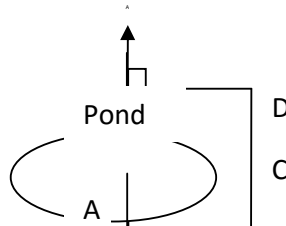


Figure 2.8: Overcoming Obstacles by Constructing Rectangles

By Constructing Similar Triangles: To continue chaining from B, fix a point C away from the obstacle. Range a pole at D to align with AC hence $AC = CD$. In line with BC range another point E in line with BC. Hence $BC = CE$. Measure ED which equals AB hence chaining can continue from B.

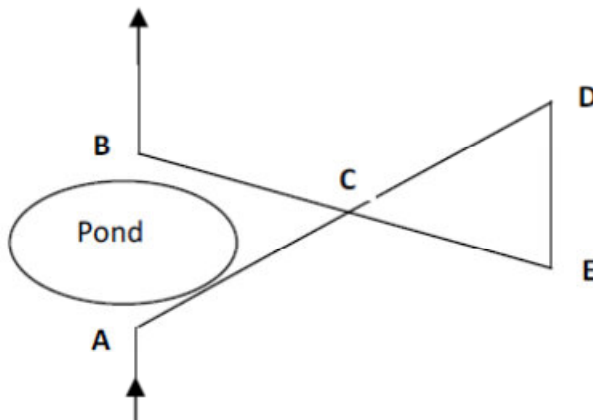
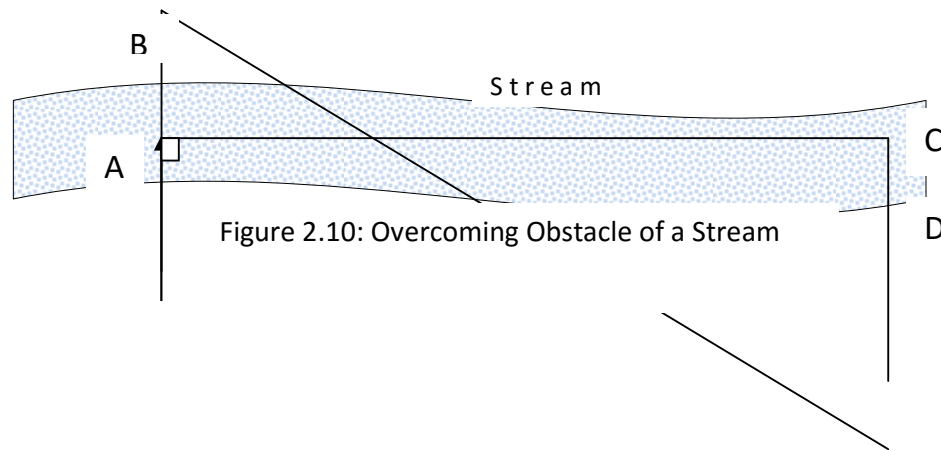


Figure 2.9: Overcoming Obstacle of a Pond

In another scenario, similar triangles can be constructed to overcome an obstacle created by a stream. In this case, chaining had reached A and there is the need to overcome the obstacle created by the stream to reach B. Set out a perpendicular AC and mark the midpoint E. set out another perpendicular CD so that D, E and B are in a straight line. The 2 triangles created are congruent. Therefore, $CD = AB$ which is the required length. Chaining can now proceed from B.



B. Obstacles which Obstruct both Ranging and Chaining: Chaining has reached B from A where an obstacle like a building has been reached. Erect equal perpendiculars AC and BD from A and B along the chain line. Along CD, range E and F beyond the obstacle. Set off perpendiculars EG and FH from E and F equal to AC. As G and H are in line with AB, then CE equals AG.

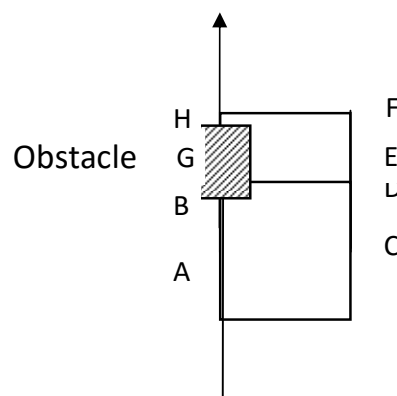


Figure 2.11: Overcoming Obstacles that Obstruct Ranging and Chaining

4.0 CONCLUSION

Errors and obstacles will be encountered by students in the course of carrying out a chain surveying operations. In this case one does not have to abandon the project but proceed after identifying them and the procedure of overcoming them. This unit has equipped you to handle these problems.

5.0 SUMMARY

This unit had discussed the major processes of chain surveying include reconnaissance survey, field work and office work. The three major types of errors in chain survey were equally covered. Finally, the various types of obstacles and how to overcome them were explained.

6.0 TUTOR-MARKED ASSIGNMENT

1. List and explain the sources of errors.
2. What are processes of chain survey?

7.0 REFERENCES/FURTHER READING

- Agor, R. (1993). *Textbook of Surveying and Leveling*. New Delhi: Khanna Publishers, India.
- Clark, D. (1983). *Plane and Geodetic Surveying for Engineers*. In: *Higher Surveying*. (6th ed.). CBS Publishers and Distributors.
- Chandra, A. N. (2006). *Plane Surveying*. (2nd ed.). New Delhi: New Age International Limited, India.
- Higgins, A. L. (1974). *Elementary Surveying*. Longman Group Ltd.
- Ndukwe, N. K. (2001). *Digital Technology in Surveying and Mapping*. Enugu: Rhyce Kerex Publishers, Nigeria.
- Okoroigwe, D. S. (2002). *Surveying for Geographers*. Lagos: Mbeyi and Associates (Nig.) Ltd, Nigeria

MODULE 3

Unit 1	Meaning and Types of Compass Survey
Unit 2	Bearing and Traversing with Prismatic Compass

UNIT 1 MEANING AND TYPES OF COMPASS SURVEY

CONTENTS

1.0	Introduction
2.0	Objectives
3.0	Main Content
3.1	Meaning and Types of Compass Survey
3.2	Instruments
3.2.1	The Compass
3.3	Strengths and Weaknesses of Compass Survey
3.3.1	Strengths
3.3.2	Weaknesses
3.4	Sources of Error and Ways of Overcoming Them
3.4.1	Sources
3.4.1.1	Ways of Overcoming the Errors
4.0	Conclusion
5.0	Summary
6.0	Tutor-Marked Assignment
7.0	References/Further Reading

1.0 INTRODUCTION

Compass is another type of survey instrument. In this unit, we will explain the meaning, types of compass survey and also introduce and discuss the concept of bearing.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- explain meaning and types of compass survey
- describe the concept of bearing.

3.0 MAIN CONTENT

3.1 Meaning and Types of Compass Survey

In compass survey, the direction of the survey line is measured by the use of a magnetic compass while the lengths are by chaining or taping. Where the area to be surveyed is comparatively large, the compass survey is preferred, whereas if the area is small in extent and a high degree of accuracy is desired, then chain survey is adopted. However, where the compass survey is used, care must be taken to make sure that magnetic disturbances are not present.

3.2 Instruments

3.2.1 The Compass

The two primary types of survey compass are: the prismatic compass and surveyors compass.

- **Prismatic Compass**

Invented in 1814, the prismatic compass consists of a small circular box of about 100mm. It can either be used as a hand instrument or mounted on a tripod; and is very useful in a situation where rough surveys are needed i.e. where the accuracy of the survey is not the main consideration but the speed. The main parts of a prismatic compass are: compass box, lifting lever, needle, Agate cap, Glass cover, magnetic needle, graduated ring, prism, prism cap, sighting slit, lifting pin, coloured glasses, focusing screw, object hair – vane; horse hair, reflecting mirror, brake pin and spring brake.

Prismatic compass is useful for filling in details in a survey and in places where the ground does not allow the use of chaining. It is used by the military for reconnaissance survey, night mobility and for sketching along roads or rivers. However, while making observation with a prismatic compass care must be taken to avoid local attractions. Also, keys, pins and other metallic substances must not be brought near the compass.



Figure3.1: Prismatic Compass (**Source:** www.surveyinginstrumentindia.com)

- Surveyor's Compass

Similar to the prismatic compass but with few modifications, the surveyors compass is an old form of compass used by surveyors hence the name. It is used to determine the magnetic bearing of a given line and is usually used in connection with the chain or compass survey.

Difference between the Prismatic and Surveyor's Compass

Prismatic Compass	Surveyors Compass
1. The magnetic needle and the graduated dial are attached together while the prism and the box rotate.	1. The magnetic needle remains stationary while the graduated dial rotates with respect to the needle.
2. Readings are taken by looking through the prism eye hole from the south end of the compass.	2. Readings are taken by looking on the dial immediately between the North ends of the magnetic needle.
3. The graduations are marked in a clockwise direction.	3. The graduations are marked so as to increase in the counter clockwise direction.
4. The zero of the graduated scale is marked.	4. The zero is fixed below the North end.
5. The position of the East and West are in their correct positions.	5. The positions of East and West are interchanged.
6. It gives whole circle bearings.	6. The surveyor's compass usually indicates the reduced bearings.

Source: Okoroigwe, (2002)

3.3 Strengths and Weaknesses of Compass Survey

Olomo (2008) and Okoroigwe (2002) enumerated the strengths and weaknesses of the compass survey which can be summarised as follows:

3.3.1 Strengths

- It is useful in filling in survey details, determining the magnetic bearings of lines and calculation of angles between them. It is useful in running rapid traverse without regard to preceding lines.
- Compass surveying comes in where chain survey cannot be carried out as the land cannot be divided into triangles as a result of the presence of many obstacles. For an example, running lines through forests where obstructions impede line of sight are easily overcome than with other methods.
- Unlike the theodolite, the compass is light and easy to carry about; hence the bearing can be taken easily. This forms the basis for quick survey. Most reconnaissance survey are carried out in this way (for an example for military purposes) are carried out in this way.
- As the bearing for each leg is determined independently, error is generally reduced as the error for the bearing is confined to each traverse leg,
- It is suited for exploratory work hence safest in the forest where local attractions are few.

3.3.2 Weaknesses

- The degree of accuracy is low especially as the compass readings can be affected by local attractions (magnetic properties) of iron railings and watches.
- Survey of high accuracy can only be achieved using a telescope where the line is of great length.
- Unreliable compass needle and local attractions may mean that quick survey work is either impossible or unreliable.

3.4 Sources of Error and Ways of Overcoming Them

Based on Olomo (2008) these can be summarised as follows:

3.4.1 Sources

- Magnetic effect of iron railings, poles wristwatches, and eye glasses on prismatic compass.
- Improper handling and focusing of the compass; and, poor booking of readings.
- Faulty prismatic compass.

3.4.1.1 Ways of Overcoming the Errors

- Avoid areas (and things) with magnetic attraction
- Proper booking and plotting of field data
- Proper handling and usage of the compass.

4.0 CONCLUSION

Compass surveying, like most types of surveying, is named after the major equipment used – the compass. Compass survey becomes useful to compensate for the limitations of chain survey. For an example, running of triangles may not be possible as a result of the presence of many obstacles.

5.0 SUMMARY

In this unit, the meaning and types of compass survey were highlighted. In compass surveying, the main equipment – the compass – is used to measure the direction of the survey line. The prismatic compass and surveyors compass are the major types of survey compass. The unit ends by stressing the weaknesses and strengths of compass survey, and, pointing out the errors involved and ways of overcoming them.

6.0 TUTOR-MARKED ASSIGNMENT

List and explain the two types of compass survey.

7.0 REFERENCES/FURTHER READING

Agor, R. (1993). *Textbook of Surveying and Leveling*. New Delhi: Khanna Publishers, India.

Olomo, R. (2008). *Modern Comprehensive Practical Geography*. Agbor: Pon Publishers, Nigeria.

Okoroigwe, D. S. (2002). *Surveying for Geographers*. Lagos: Mbeyi and Associates (Nig.) Ltd.

Rabenhorst, T. D. &McDermott (1989). *Applied Cartography: Source Materials for Mapmaking*. Columbus: Merrill Publishing Company.

UNIT 2 BEARING AND TRAVERSING WITH COMPASS SURVEY

CONTENTS

- 1.0 Introduction
- 2.0 Objectives
- 3.0 Main Content
 - 3.1 Bearing
 - 3.2 Back and Fore Bearing
 - 3.3 Traversing and plotting with the Compass Survey
 - 3.4 Error of Closure
- 4.0 Conclusion
- 5.0 Summary
- 6.0 Tutor-Marked Assignment
- 7.0 References/Further Reading

1.0 INTRODUCTION

In this unit, we will examine the back and fore bearing; and, the steps to be taken when traversing with compass survey.

2.0 OBJECTIVES

At the end of this unit, you should be able:

- demonstrate back and fore bearing
- describe traversing with compass survey.

3.0 MAIN CONTENT

3.1 Bearing

The bearing is the angular direction measured clockwise starting from north with reference to the observer. The reference north may be true or magnetic. While the true bearing is the angular direction measured in a place with the direction of true or geographical north; the magnetic bearing is the angle which it makes with the direction of magnetic North measured in the clockwise direction.

3.2 Back and Fore Bearing

Fore bearing (FB) is the compass bearing of a place taken from one station to the other in the direction that the survey is being carried out. The back bearing (BB) in the other hand is the bearing in the opposite

direction i.e. the bearing taken backwards from the next station to its preceding station that the fore bearing was taken. The difference between BB and FB is always 180° as shown in Figure 3.2.

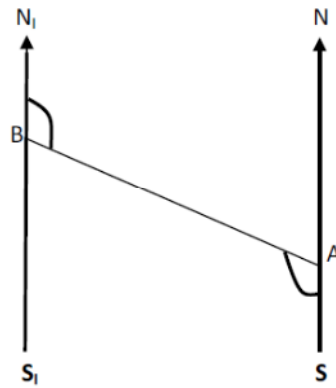


Figure 3.2: The Back and Fore Bearing

If B is sighted from an observer at A, and the N/S and N_1S_1 are the magnetic NS lines, then:

$$\begin{aligned}\text{Forward bearing (FB)} &= \angle N A S + \angle S A B \\ \text{Back bearing BA} &= \angle N_1 B A \\ \text{Therefore back bearing BA} &= \text{forward bearing AB} - 180^\circ\end{aligned}$$

If the observer relocates to B and observes B, then forward bearing (FB) $BA = \angle N_1 B A$ and back bearing (AB) $= \angle N A S + \angle S A B$. Hence, we can conclude that forward bearing $= N_1 B A + 180^\circ$. As a general rule, if the fore bearing is less than 180° , add 180° to get the back. Bearing, and if the fore bearing is greater than 180° , then subtract 180° to get the back bearing.

3.3 Traversing and Plotting with the Compass Survey

Traversing with the compass involves taking the bearing along a series of connecting straight lines and at the same time measuring the distances with the tape. The compass is read at each point and a back bearing is equally taken to serve as a check. This continues until the traverse closes. Choosing a suitable scale, the traverse is then plotted taking into consideration the general shape of the area.

3.4 Error of Closure

A closed traverse when plotted from field observations may not close due to some errors including that of observations, measurements or drawings. As a result, the last station does not coincide with the starting

point. This discrepancy is called error of closure or closing error. This can be adjusted using the following procedure derived from Agor (1993).

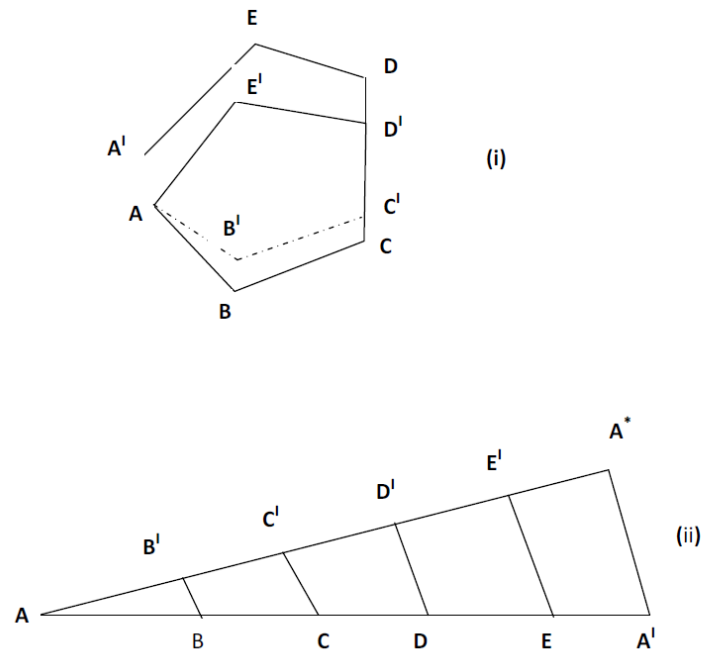


Figure 3.3: Error of Closure – the Error (i) and Correction (ii)

Procedure:

1. Draw a straight line $A A^1$ equal to the perimeter of the traverse to any suitable scale. Set off along it the distances AB , BC , CD , DE and EA^1 equal to the lengths of the sides of the traverse.
2. Draw $A^1 A^*$ parallel and equal to the closing error $A^1 A$.
3. Draw parallel lines through points B , C , D , and E to meet $A A^*$ at B^1 , C^1 , D^1 and E^1 .
4. Draw parallel lines through the plotted stations B , C , D , E and plot the errors equal to $B B^1$, $C C^1$, $D D^1$ in the direction $A^1 A$.
5. Join the points $A B C^1 D^1 E^1 A$ to get the adjusted traverse.

4.0 CONCLUSION

It is important that you understand the processes needed to successfully undertake a compass survey, the error likely to be encountered in closing the traverse and how to overcome it. These had been covered in the unit.

5.0 SUMMARY

This unit examined the meaning and types of compass bearing. It also discussed the process of traversing with compass survey. The unit ended with a highlight on error of closure and ways of overcoming it.

6.0 TUTOR-MARKED ASSIGNMENT

What do you understand by traversing with compass survey?

7.0 REFERENCES/FURTHER READING

Agor, R. (1993). *Textbook of Surveying and Leveling*. New Delhi: Khanna Publishers, India.

Olomo, R. (2008). *Modern Comprehensive Practical Geography*. Agbor: Pon Publishers, Nigeria.

Okoroigwe, D. S. (2002). *Surveying for Geographers*. Lagos: Mbeyi and Associates (Nig.) Ltd, Nigeria

Rabenhorst, T. D. & McDermott (1989). *Applied Cartography: Source Materials for Mapmaking*. Columbus: Merrill Publishing Company.

MODULE 4

Unit 1	Meaning, Equipment and Principles
Unit 2	Booking and Calculation of Reduced Levels

UNIT 1 LEVELLING: MEANING, EQUIPMENT AND PRINCIPLES**CONTENTS**

- 1.0 Introduction
- 2.0 Objectives
- 3.0 Main Content
 - 3.1 Meaning of Levelling
 - 3.2 The Instruments
 - 3.3 Principles of Leveling
 - 3.4 Major Terms
- 4.0 Conclusion
- 5.0 Summary
- 6.0 Tutor-Marked Assignment
- 7.0 References/Further Reading

1.0 INTRODUCTION

We have so far been dealing with survey in a horizontal scale. We know that phenomena in space also exist in a vertical scale. Levelling enables survey in a vertical scale. In this unit, we will examine the meaning, instruments and principles of levelling.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- explain the meaning of leveling and highlight some of the equipment used in leveling
- explain the basic principles of and terms used in levelling.

3.0 MAIN CONTENT**3.1 Meaning of Levelling**

From most engineering surveys like road or rail construction, it is necessary to measure the elevation of points along the project. The act of establishing the elevation of points on or below the surface of the

earth is called levelling. Levelling is therefore surveying in a vertical plane. An elevation of a point on the surface of the earth is actually the difference in altitude between the point and some datum or base level. Hence, levelling makes use of a base level to determine the height of any point. The sea level is the base level of topographic maps.

3.2 The Instruments

3.2.1 The Level

The level is an instrument used to accurately determine the difference in elevation between two points on the earth's surface. By itself, it does not read or register heights but gives a horizontal line of sight so that in looking along it, places lying along the same height can be seen. Varieties of levels exist and their difference lies in the level of complexity. Examples include water level and Surveyor's level (Dumpy level) and Abney level (Figures 4.1, 4.2 and 4.3). The surveyor's level consists of a bubble tube with a telescope attached.

The water level is made up of 2 glass tubes half-filled with coloured water fitted and a tripod. When the two water levels are in line and one looks along a horizontal line of sight passing through the water surfaces, anything one sees along this line are of the same level with one's eye and the water surface. Figure 4.3 show a simple version of a water level that can easily be constructed by the student to demonstrate how levelling works.

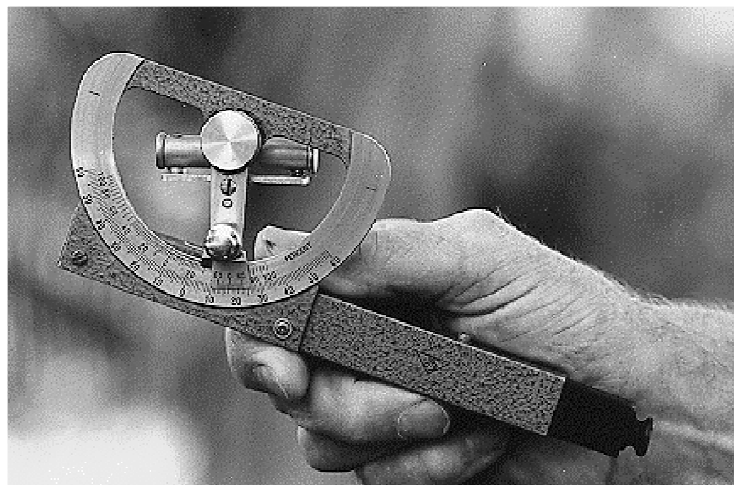


Figure 4.1: Abney Level(Source: www.fennerschool-associated.anu.edu.au)



Figure 4.2: Abney Level (Source: dreamstime.com)

3.2.2 Levelling Staff

This is a graduated wooden staff for reading vertical heights. Different types exist. Generally, the bottom of the staff represents the zero reading.

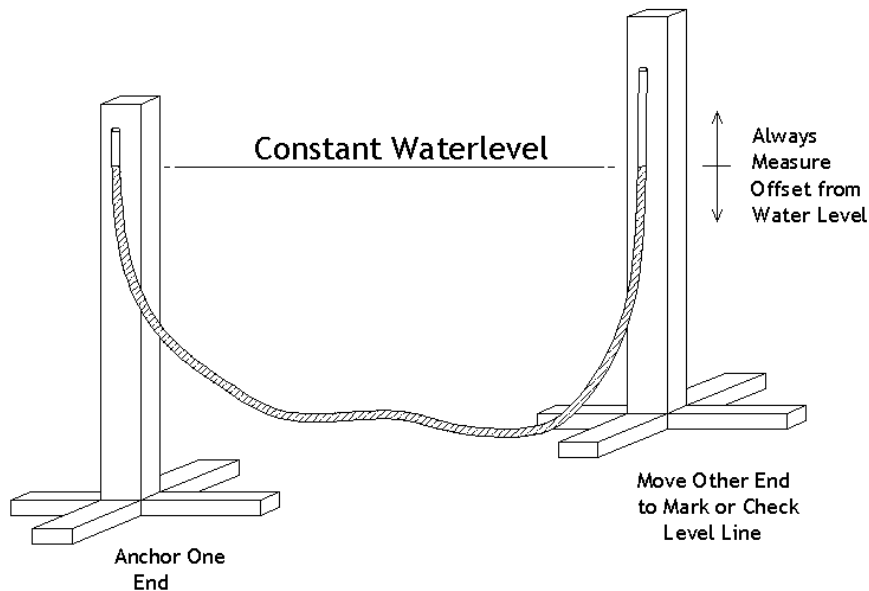


Figure 4.3: Water Level (glacierboats.com)

The type of staff that allows readings to be read directly is called the self-reading staff; while the long type that allows a more accurate reading to be made but which is long and cumbersome to handle (about 3m) is called solid staff. The folded or hinged are double 2m long staff that are hinged or folded together.



Figure 4.4: Automatic Level with a Leveling Staff (Source: benmeadows.com)

3.3 Principles of Levelling

The principle of levelling is based on the fact that “if a level is placed between 2 points A and B, measurements obtained on a staff placed on these two points would mean the difference in height between the two points”. This is because the readings are made from the same position along the same line of sight.

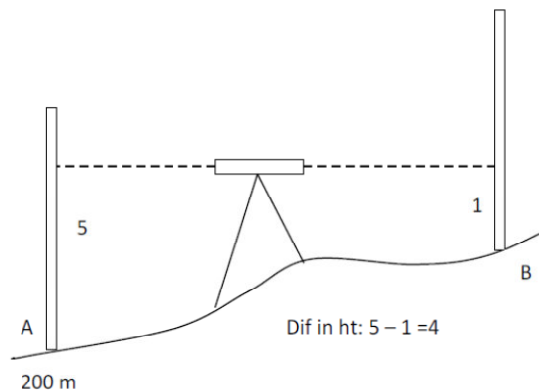


Figure4.5: Taking Measurements using a Level (1)

In this case, the difference is 4m (5-1). Lower readings are usually made at higher grounds while higher figures are made at lower grounds. If the distances between the two points are long, it means the reading of the staff will not be done once but in stages. If A is 200m above sea level, B will be $200 + 4 = 204\text{m}$.

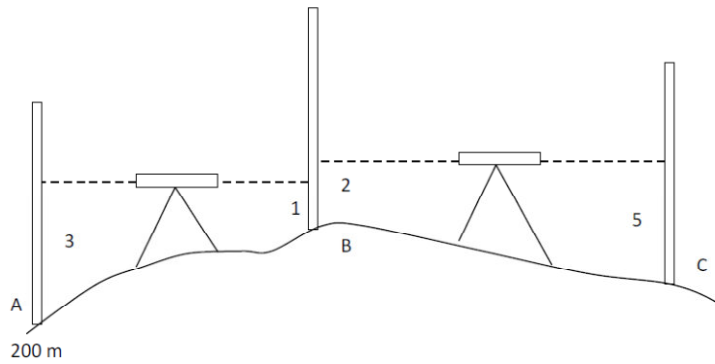


Figure4.6: Taking Measurements using a Level (2)

If the level is set between points A and B, the difference in height is 2m (i.e. 3-1m). The height of point B is then $200 + 2$ (202) as B is in a higher elevation than A. One can remove the level and place it in between B and C. The new height of the staff is now 2m at B and 5m at C making it a difference of 3m. It means that the height of point C will be height of B (202m). The difference in height = $202 - 3\text{m} = 199\text{m}$.

3.4 Major Terms

Meanings of major terms used in leveling are discussed as follows:

- (1) **Datum:** This is an imaginary level surface to which all elevations are measured or referred to. The mean sea level is often used as the datum
- (2) **Bench Mark (B.M):** This is a mark of a point of known elevation which serves as a starting point of determining the elevation of other places. It is usually points that have been correctly surveyed and approved by appropriate government agencies. It is indicated by the letters BM and the height in meters (e.g. B.M. 203) cut in fixed materials.
- (3) **Back Sight:** This is the first reading on the staff placed on a benchmark at the commencement of levelling operation. It is the first reading taken to a point whose height is either known or can be calculated.
- (4) **Fore Sight:** Foresight is the reading taken at a point where the elevation is not yet known. It is the reading taken at a point

whose height is required in order for the levelling operation to continue.

- (5) Reduced Level: This is also called reduced height and is the calculated elevation of a place above or below sea level.

4.0 CONCLUSION

Unlike the other kinds of surveying studied so far, levelling is involved with surveying in a vertical plane. Levelling is necessary as it enables heights of features to be calculated and represented in maps.

5.0 SUMMARY

The meaning, equipments and principles of levelling had been the focus of this unit. Levelling makes use of a base sea level to determine the height of any location on the plane. The major terms used in levelling were also explained. These include datum, bench mark, back and fore sight, and reduced level.

6.0 TUTOR-MARKED ASSIGNMENT

1. State the principle of levelling.
2. What do you understand by the term levelling?
3. Explain the meaning of the following terms as applicable in levelling:
 - Datum,
 - Bench mark
 - Back sight
 - Fore sight
 - Reduced level.

7.0 REFERENCES/FURTHER READING

- Agor, R. (1993). *Textbook of Surveying and Leveling*. New Delhi: Khanna Publishers, India.
- Clark, D. (1983). *Plane and Geodetic Surveying for Engineers*. In: *Higher Surveying*. (6th ed.). CBS Publishers and Distributors.
- Chandra, A. N. (2006). *Plane Surveying*. (2nd ed.). New Delhi: New Age International Limited, India.
- Higgins, A. L. (1974). *Elementary Surveying*. Longman Group Ltd.
- Okoroigwe, D. S. (2002). *Surveying for Geographers*. Lagos: Mbeyi and Associates (Nig.) Ltd.

UNIT 2 BOOKING AND CALCULATION OF REDUCED LEVELS

CONTENTS

- 1.0 Introduction
- 2.0 Objective
- 3.0 Main Content
 - 3.1 Booking and Calculation of Reduced Levels
 - 3.1.1 Rise and Fall Method
 - 3.1.2 Collimation (Height of Instrument) Method
- 4.0 Conclusion
- 5.0 Summary
- 6.0 Tutor-Marked Assignment
- 7.0 References/Further Reading

1.0 INTRODUCTION

This unit concludes this module. In this unit, we shall be examining the booking and calculation of reduced levels.

2.0 OBJECTIVE

At the end of this unit, you should be able to:

- explain the procedure of booking and calculation of reduced levels.

3.0 MAIN CONTENT

3.1 Booking and Calculation of Reduced Levels

Two methods are used to book and calculate the reduced level. These are: Rise and fall method and India:

3.1.1 Rise and Fall Method

The rise and fall method uses differences in level between two consecutive points to obtain the rise or fall in elevation at that point.

In Figure 4.7, supposing the level is set up not X between points A and B. If A is located at a point 200 meters above level and the difference in height is 2m, then the location B is 202m the covered. To book and calculate the level in a level notebook, 6 columns are drawn for the station, back sight, foresight, rise, fall reduced level and remarks.

The calculation is performed step by step as shown and represented in Table 4.2. Hence, the level at D is 201m.

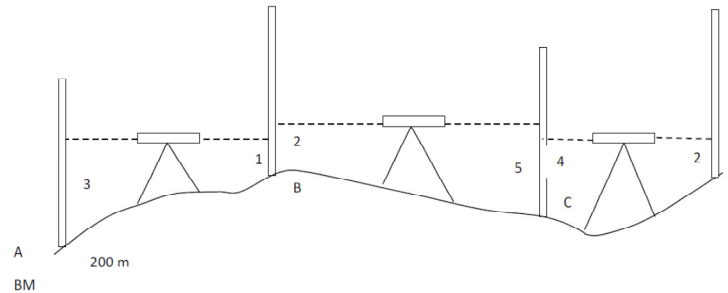


Figure 4.7: Reduced Levels

Table 4.1: Calculation of Reduced Level using Rise and Fall Method

Stations	(BS) Back sight	(FS) Foresight	(R) Rise	(F) Fall	(RL) Reduced level	Remarks
A	3	-	-	-	200	BM
B	-	1	2	-	202	-
C	2	5	-	3	199	-
D	4	2	2	-	201	End of line

To check the accuracy of the tabulation, the formula is used as follows:

$$\sum BS - \sum FS = \sum R - \sum F = \text{First Reduced Level} - \text{Last reduced level}$$

$$= 9 - 8 = 4 - 3 = 200 - 201$$

$$= 1 = 1 = 1$$

NOTE: The sum of the back sight minus the sum of the foresight must be equal to the sum of the rise minus sum of fall, and must be equal to first reduced level minus last reduced level. In the above example, they are all equal meaning that the Table 4.1 was correctly compiled.

3.1.2 Collimation (Height of Instrument) Method

In this method, the back sight is added to the known elevation of the point to get the height of instrument. The foresight of the second point is then subtracted from the height of the instrument to obtain the reduced level or the elevation of the second point.

Table 4.2: Calculation of Reduced Level using Collimated Method

Level Station	BS	FS	Height of Instrument	RL(M)	Remark
A	3	-	203	200	BM
B	-	1	-	201	
	2	-	204	-	

C	-	5	-	199	
	4	-	203	-	
D	-	2	-	201	End of station

4.0 CONCLUSION

This unit concluded Module 4 by examining the booking and calculation of reduced levels. These step by step easy to follow procedure enable one obtain the reduced level – the calculated elevation a place.

5.0 SUMMARY

Two methods are used to book and calculate the reduced level. These are: Rise and Fall Method, and Height of Instrument or Collimation method. The rise and fall method uses differences in level between two consecutive points to obtain the rise or fall in elevation at that point. In collimation method, the back sight is added to the known elevation of the point to get the height of instrument. The foresight of the second point is then subtracted from the height of the instrument to obtain the reduced level or the elevation of the second point.

6.0 TUTOR-MARKED ASSIGNMENT

Explain the procedure of booking and calculation of reduced levels.

7.0 REFERENCES/FURTHER READING

- Agor, R. (1993). *Textbook of Surveying and Leveling*. New Delhi: Khanna Publishers, India.
- Clark, D. (1983). *Plane and Geodetic Surveying for Engineers*. In: *Higher Surveying*. (6th ed.). CBS Publishers and Distributors.
- Chandra, A. N. (2006). *Plane Surveying*. (2nd ed.). New Delhi: New Age International Limited, India.
- Higgins, A. L. (1974). *Elementary Surveying*. Longman Group Ltd.
- Ndukwe, N. K. (2001). *Digital Technology in Surveying and Mapping*. Enugu: Rhyce Kerex Publishers, Nigeria.
- Okoroigwe, D. S. (2002). *Surveying for Geographers*. Lagos: Mbeyi and Associates (Nig.) Ltd, Nigeria.

MODULE 5

Unit 1	Meaning, Instrument and Operation of Plane Tabling
Unit 2	Methods of Plane Tabling

**UNIT 1 MEANING, INSTRUMENTS AND OPERATION
OF PLANE TABLING****CONTENTS**

- 1.0 Introduction
- 2.0 Objectives
- 3.0 Main Content
 - 3.1 Meaning of Plane Tabling
 - 3.2 Instruments for Plane Tabling Survey
 - 3.2.1 Drawing Board or Plane Table
 - 3.2.2 Sight Rule or Alidade
 - 3.3 Plain Table Operations
- 4.0 Conclusion
- 5.0 Summary
- 6.0 Tutor-Marked Assignment
- 7.0 References/Further Reading

1.0 INTRODUCTION

So far, we have dealt with survey methods in which measurements and recordings are done in the field, with transcription and drawings being done in the office. In plane tabling, the map is plotted in the field the same time measurements are done.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- explain the meaning of plane tabling and major instruments used to carry it out
- discuss the meaning of plane table operation.

3.0 MAIN CONTENT

3.1 Meaning of Plane Tabling

In this method of surveying, observations and the plotting are done simultaneously on a plane table. The plane table combines a sighting device with a plotting scale.

Agor (1993) defines plane tabling as a graphical construction of straight lines, angles and triangles for plotting the ground detail points. It is based on the principle that the lines that join points on the plane table can be made to lie parallel to the corresponding lines that join points on the ground.

A plane tabling eliminates the field notebook and it is suitable for putting in details in a survey where the survey methods have been accurately fixed using theodolite or any other survey methods.

3.2 Instruments for Plane Tabling Survey

The following are the main instruments used for plane tabling.

3.2.1 Drawing Board or Plane Table

A plane table is a wooden drawing board mounted on a tripod in such a way that it can be rotated in its vertical axis and can also be clamped into any required position. Plane tables come in different shapes and sizes but most have some refinements for levelling the table and a compass. The plane table equally comes with a plumbing fork used to accurately centering the table on a location.



Figure 5.1: Plane Table (Source: www.nptel.iitm.ac.in)

3.2.2 Sight Rule or Alidade

This is a straight edge fitted with sighting device that allows one to have the line of sight. It is used for sighting objects and drawing rays along the edges. Two types of alidade are commonly in use: plain alidade and telescopic Alidade. Plain alidade is made up of a wooden or metallic rule of about 50-75cm long, with vanes at the ends. While, one of the vanes has a narrow slit, the other is open with a fine wire or horse hair. The alidade sometimes comes with a circular bubble attachment for levelling the table.

The alidade that comes with a telescope to increase the accuracy and the range of sighting is called telescopic alidade.



Figure 5.2: Telescopic Alidade on Tripod with Plane Table
(Source: [www. library2.vicu.utoronto.ca](http://www.library2.vicu.utoronto.ca))

3.3 Plain Table Operations

The tripod is unfolded and the plane table is clamped safely on it. The table is then set up using the following operational steps:

- **Leveling:** Here, the table is placed and levelled over the station with the legs of the tripod spread out although eye estimate can be used for levelling for rough and small scale work; a spirit level is needed for accurate and large scale work.
- **Orientation:** In this operation, the table is placed in such a way that all the lines of the paper are parallel and corresponds to the lines on the ground. This is achieved by the use of a magnetic needle and by back-sighting.
- **Centering:** The operation which allows the point on the paper representing the station is made to be vertically over the point on the ground is called centering. Centering may not be necessary in

a rough and the table is only required to be over the ground position.

4.0 CONCLUSION

This unit has demonstrated the fact that it is possible to do all the processes of surveying in the field without carrying out part of it in the office. You should be encouraged to experiment the facts learnt here using homemade equipments.

5.0 SUMMARY

In a plane survey, observations, measurements and plotting are done the same time in the field. The major equipments used are the drawing board (plane table and the sight rule (alidade). It is based on the principle that the lines that join points on the plane table can be made to lie parallel to the corresponding lines that join points on the ground.

6.0 TUTOR-MARKED ASSIGNMENT

1. What is plain tabling?
2. What are the instruments for plane tabling survey?

7.0 REFERENCES/FURTHER READING

- Agor, R. (1993). *Textbook of Surveying and Leveling*. New Delhi: Khanna Publishers, India.
- Clark, D. (1983). *Plane and Geodetic Surveying for Engineers*. In: *Higher Surveying*. (6th ed.). CBS Publishers and Distributors.
- Chandra, A. N. (2006). *Plane Surveying*. (2nd ed.). New Delhi: New Age International Limited. India.
- Higgins, A. L. (1974). *Elementary Surveying*. Longman Group Ltd.
- Ndukwe, N. K. (2001). *Digital Technology in Surveying and Mapping*. Enugu: Rhyce Kerex Publishers, Nigeria.
- Okoroigwe, D. S. (2002). *Surveying for Geographers*. Lagos: Mbeyi and Associates (Nig.) Ltd, Nigeria.
- Rabenhorst, T. D. & McDermott (1989). *Applied Cartography: Source Materials for Mapmaking*. Columbus: Merrill Publishing Company.

UNIT 2 METHODS OF PLANE TABLING

CONTENTS

- 1.0 Introduction
- 2.0 Objective
- 3.0 Main Content
 - 3.1 Methods of Plane Table Surveying
 - 3.1.1 Radiation Method
 - 3.1.2 Intersection Method
 - 3.1.3 Traversing Method
 - 3.1.4 Resection Method
 - 3.2 Strengths, Weaknesses and Sources of Errors in Plane Tabling
 - 3.2.1 Strengths
 - 3.2.2 Weaknesses
 - 3.2.3 Sources of Error
- 4.0 Conclusion
- 5.0 Summary
- 6.0 Tutor-Marked Assignment
- 7.0 References/Further Reading

1.0 INTRODUCTION

This unit concludes this module. In this unit, we shall be examining the various methods of plane tabling.

2.0 OBJECTIVE

At the end of this unit, you should be able to:

- demonstrate the various methods of plane tabling.

3.0 MAIN CONTENT

3.1 Methods of Plane Table Surveying

Four classes of plane tabling surveys are recognised:

- Radiation method
- Intersection method
- Traversing method
- Resection method.

3.1.1 Radiation Method

Here, the plane table is set up at one station which allows the other station to be accessed. The points to be plotted are then located by radiating rays from the plane table station to the points. After reducing the individual ground distances on the appropriate scale, the survey is then plotted. This method is suitable for small area surveys. It is rarely used to survey a complete project but is used in combination with other methods for filling in details within a chain length.

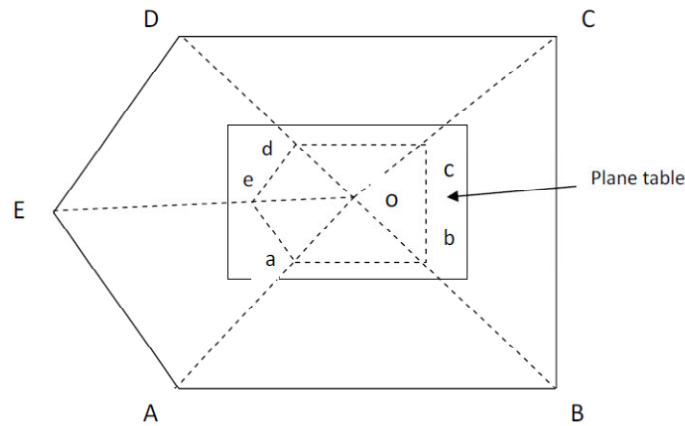


Figure 5.1: Plane Tabling using Radiation Method

The following steps are taken:

1. Select at point O such that all the points are visible
2. Set up and level the instrument at O
3. From O, align the alidade and draw radial lines towards. The stations are from A, B, C, D and E.
4. Measure the distances OA, OB, OC, OD and OE: scale and draw Oa, Ob, Oc, Od and Oe on the paper.
5. Join the point a, b, c, d, and to give the outline of the survey.

3.1.2 Intersection Method

In this method, two instrument stations are used with the distance between them called based line serving as the base to measure and plot the other locations:

1. 2 points A and B are selected from which the rest of the stations can be seen.
2. Set up and level the plane table at A and mark it as a in the paper to coincide with A on the ground.

3. Sight B, C, D and E with the alidade from A and draw rays forwards them.
4. Measure AB, AC, AD and AE and using appropriate scale draw the corresponding paper distance.
5. Remove the equipment from A to B and repeat the procedure using B as the measuring station.

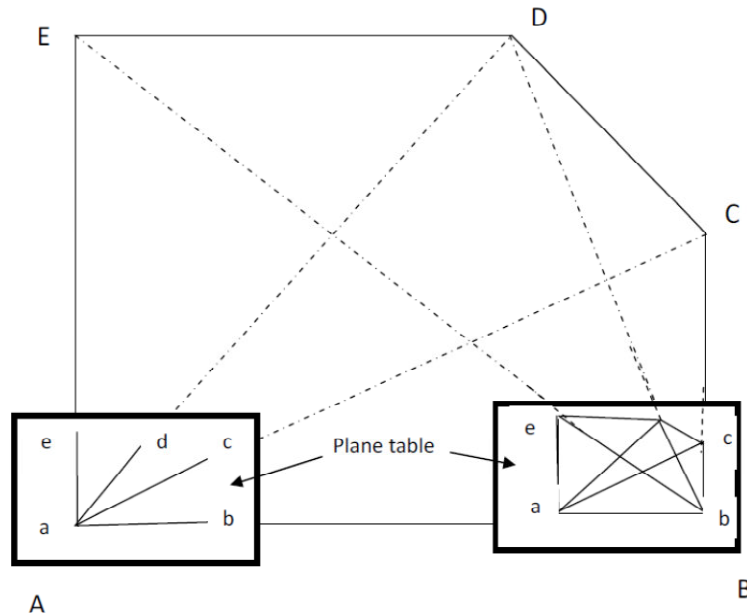


Figure 5.2: Plane Tabling using Intersection Method

3.1.3 Traversing Method

This method resembles the compass traversing in which the plane table is set up at each successive and the back sight taken station until all the stations are covered.

PROCEDURE:

1. You should set up the plane table over station A
2. With the alidade at a sight B, measure AB and using appropriate scale draw the distance ab to correspond with ground distance AB.
3. Transfer the table to B and position b to B. from b sight, measures scale AB and insert as ab on the paper.
4. Relocate the station to C and sight D from there. Continue the procedure until all the stations are covered as shown in the diagram.

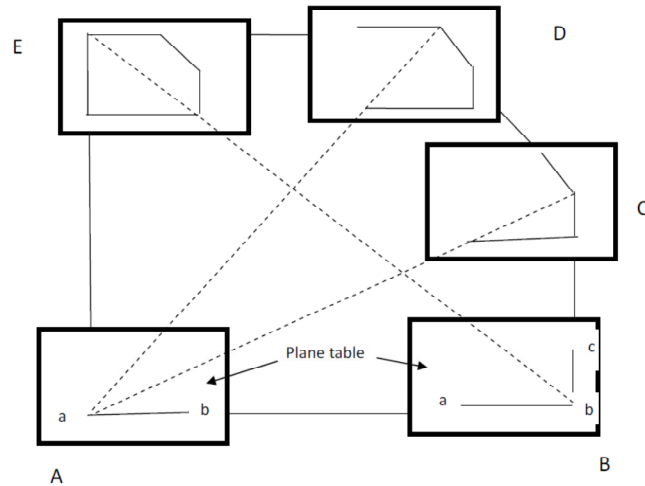


Figure 5.3: Plane Tabling using Traversing Method

3.1.4 Resection Method

The resection method is used for locating the station points by means of drawing rays from the stations whose locations have already been plotted on the sheet. This carried out using various procedures:

- In the simplest method, select a base line AB on the ground, measure and plot ab on paper. Set up the plane table at B in a position where b corresponds to B.
- From b sight C and draw a ray to represent the approximate location of C locate this position as C.
- Set up the instrument at C and draw a ray to A, the true position of C is the point of intersection made between the ray and that made from b.

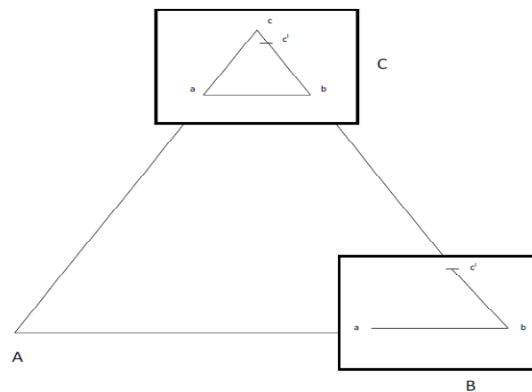


Figure 5.4: Plane Tabling using Resection Method

3.2 Strengths, Weaknesses and Sources of Errors in Plane Tabling

Olomo (2008) enumerated the strengths, weaknesses and sources of errors in plane tabling which can be summarised as follows:

3.2.1 Strengths

- This is a rapid method of surveying where all the steps are carried out in the field.
- Mistakes and chances of omitting some lengths are minimised as the final product – the map is produced in the field.
- Using a plane table does not require specialised knowledge although time and effort is needed to master the skill.
- It is useful for filling in details where the survey skeleton has been surveyed.

3.2.2 Weaknesses

- Plane tabling is ideal only in a dry environment hence the operation is difficult in a wet and windy region.
- This is not an accurate method of surveying.
- As the plotting is done in the field, the scale must be determined before the operation commences.

3.2.3 Sources of Error

- Where the table is not on a levelled terrain, error is introduced.
- The warping and shrinking of the paper used can equally introduce errors.

4.0 CONCLUSION

Not all survey methods follow the procedure of reconnaissance, field work proper and office work. In plane tabling, all the three steps are carried out simultaneously in the field. You have followed the steps provided so as to appreciate the rationale behind this method.

5.0 SUMMARY

The major methods of plane tabling: radiation; intersection; traversing; and, resection methods are presented in this unit. The strengths; weaknesses and sources of errors in plane tabling were also discussed in this unit.

6.0 TUTOR-MARKED ASSIGNMENT

1. List and explain the various methods of plane tabling.
2. What are the strengths and weaknesses of plane tabling?
3. Explain source of errors in plane tabling.

7.0 REFERENCES/FURTHER READING

- Agor, R. (1993). *Textbook of Surveying and Leveling*. New Delhi: Khanna Publishers, India.
- Clark, D. (1983). Plane and Geodetic Surveying for Engineers. In: *Higher Surveying*. (6th ed.). CBS Publishers and Distributors.
- Chandra, A. N. (2006). *Plane Surveying*. (2nd ed.). New Delhi: New Age International Limited, India.
- Higgins, A. L. (1974). *Elementary Surveying*. Longman Group Ltd.
- Okoroigwe, D. S. (2002). *Surveying for Geographers*. Lagos: Mbeyi and Associates (Nig.) Ltd, Nigeria.
- Olomo, R. O. (2008). *Modern Comprehensive Practical Geography*. Agbor: Pon Publishers Limited.
- Rabenhorst, T. D. & McDermott (1989). *Applied Cartography: Source Materials for Mapmaking*. Columbus: Merrill Publishing Company.

MODULE 6

Unit 1	Meaning, Equipment and Operations of Theodolite Survey
Unit 2	Adjustment of Theodolite and Contemporary Issues in Surveying

UNIT 1 MEANING, EQUIPMENT AND OPERATION OF THEODOLITE SURVEY**CONTENTS**

- 1.0 Introduction
- 2.0 Objective
- 3.0 Main Content
 - 3.1 Meaning and Uses of Theodolite Survey
 - 3.2 The Instruments - The Theodolite: Meaning and Classification
 - 3.2.1 Meaning
 - 3.2.2 Classification of Theodolites
 - 3.2.2.1 Parts of a Typical Theodolite
- 4.0 Conclusion
- 5.0 Summary
- 6.0 Tutor-Marked Assignment
- 7.0 References/Further Reading

1.0 INTRODUCTION

This module introduces you to theodolite – an instrument that is more sophisticated than other instruments that have been presented so far.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- enumerate the meaning and uses of the theodolite survey
- list the major equipment of theodolite survey
- explain the major classification of the theodolite.

3.0 MAINCONTENT**3.1 Meaning and Uses of Theodolite Survey**

Theodolite survey is the most accurate of all the types of surveying we have so far examined. It is different from other types of surveying

studied so far as it measures both horizontal and vertical angles. Theodolite survey is named after the main equipment used, theodolite. The theodolite is primarily used for the accurate measurement of angles in the horizontal and vertical planes. The theodolite is primarily used for the accurate measurement of angles in the horizontal and vertical planes. Agor (1993) adds that the theodolite can also be used for prolongation of survey lines, measurement of magnetic bearing of lines, finding differences in elevation and setting out engineering works that require high precision like the ranging of highway and railway curves.

3.2 The Instruments - The Theodolite: Meaning and Classification

3.2.1 Meaning

Okoroigwe (2002) defines a theodolite as an angular instrument, fitted with a telescope that facilitates the sighting of distant objects; and, which can measure both horizontal and vertical angles with great precision. Various types of theodolites exist, but they all operate using the same principle; although there may be slight differences in the mode of reading the vernier.



Figure 6.1: A Theodolite (**Source:** www.indiamart.com)

3.2.2 Classification of Theodolites

Two major classifications of theodolites can be identified:

- Transit and non transit theodolite
- Vernier and Glass arc theodolite.

a. Transit and Non Transit Theodolite

A theodolite is said to be transit when the telescope of a theodolite can be revolved about its horizontal axis (through a complete revolution in the vertical plane). This transited type of telescope is found only in modern theodolites. In a non transit theodolite, the telescope cannot be revolved about its horizontal axis (through a complete revolution) in the vertical plane. This non transit telescope type has now become obsolete and is much inferior when compared to the transit (revolving) type.

b. Vernier and Glass Theodolite

In a vernier theodolite, verniers are provided for reading horizontal and vertical graduated circles; while in the glass arc micrometers are provided for the reading of graduated circles.

3.2.2.1 Parts of a Typical Theodolite

It is normally difficult to describe a theodolite in general terms. Therefore, it is advisable to describe a specific type/class of a theodolite. This section summarizes the parts of a typical transit theodolite (Higgins, 1975; Agor, 1995; Okoroigwe, 2002).

- a. The Trivette Stage: This is the lower triangular plate of the theodolite hinged to the tripod.
- b. Leveling Head: This consists of 2 circular parallel plates fixed apart by the ball and socket arrangements by which a plumb bob can be suspended for centering the transit
- c. The Spindles: These form the vertical axis of the transit - one attached to a vernier plate, and the other one to the lower horizontal plate.
- d. Horizontal Plates: These are made up of the lower plate (or scale plate) which is graduated in a clockwise direction; and, the upper horizontal plate (or the vernier plate) which carries two verniers with magnifiers for reading accurately the horizontal angles.
- e. The Spirit Level: This is used to levelling the instruments.
- f. Standards: these are 2 frames for supporting the horizontal axis
- g. Compass: This is used to guide the telescope towards the magnetic north.
- h. Telescope: This is fixed to the horizontal axis at right angle.
- i. Vertical Vernier: This is used to measure the vertical angle. It is attached to the telescope and graduated from 0^0 to 360^0 .
- j. Index Bar or T- frame: This is centered on the horizontal frame of the telescope. It carries a bubble called altitude bubble tube.

4.0 CONCLUSION

You should take note of the fact that the theodolite has a higher degree of accuracy than other surveying equipments so far discussed. In surveying, the desired level of accuracy and precision determines the equipment thus the type of surveying method deployed.

5.0 SUMMARY

This unit discussed the meaning, uses of theodolite survey. The major classes and parts of a typical survey were equally discussed.

6.0 TUTOR-MARKED ASSIGNMENT

Explain theodolite survey.

7.0 REFERENCES/FURTHER READING

- Agor, R. (1993). *Textbook of Surveying and Leveling*. New Delhi: Khanna Publishers, India.
- Clark, D. (1983). Plane and Geodetic Surveying for Engineers. In: *Higher Surveying*. (6th ed.). CBS Publishers and Distributors.
- Chandra, A. N. (2006). *Plane Surveying*. (2nd ed.). New Delhi: New Age International Limited, India.
- Higgins, A. L. (1974). *Elementary Surveying*. Longman Group Ltd.
- Ndukwe, N. K. (2001). *Digital Technology in Surveying and Mapping*. Enugu: Rhyce Kerex Publishers, Nigeria.
- Okoroigwe, D. S. (2002). *Surveying for Geographers*. Lagos: Mbeyi and Associates (Nig.) Ltd, Nigeria

UNIT 2 ADJUSTMENT OF THEODOLITE AND CONTEMPORARY ISSUES IN SURVEYING

CONTENTS

- 1.0 Introduction
- 2.0 Objectives
- 3.0 Main Content
 - 3.1 Adjustment of the Theodolite
 - 3.1.2 Temporal Adjustments
 - 3.1.2 Permanent Adjustment
 - 3.2 Contemporary Issues
 - 3.2.1 Analogue and Digital Technology
 - 3.2.2 Terminology and Nomenclature
- 4.0 Conclusion
- 5.0 Summary
- 6.0 Tutor-Marked Assignment
- 7.0 References/Further Reading

1.0 INTRODUCTION

This unit deals with an important element in the use of the theodolite which is its proper adjustment. It concludes by examining the current issues in surveying.

2.0 OBJECTIVES

At the end of this unit, you should be able to:

- list and explain the major methods of adjusting a theodolite
- enumerate the major contemporary issues in surveying.

3.0 MAIN CONTENT

3.1 Adjustment of the Theodolite

Two types of adjustment operations are carried out in a theodolite. These are: temporal and permanent adjustments

3.1.1 Temporal Adjustments

These are carried out in any station before making any observation. Adjustments under this group, according to Okoroigwe (2002) are designed to:

- center the theodolite over the station point by means of the tripod legs of the stand and the plum bob
- make the vertical axis of the instrument truly vertical
- set eyepiece so as to get a clear vision of the diaphragm
- remove parallax with the help of the focusing screw so that there is relative motion between the object of the eye piece and the object glass
- set the magnifying glasses so that graduating scale can be read clearly
- set the vertical arc vernier to read zero when the collimation is truly horizontal.

3.1.2 Permanent Adjustment

This is carried out when the axis of the theodolite is out of order. This can happen because while carrying out adjustments, other adjustments can be disturbed (Agor, 1993). This includes the adjustment of the:

- horizontal plate level
- horizontal axis
- telescope and telescope level
- vertical circle index

3.2 Contemporary Issues

As mentioned earlier, the theodolite is more sophisticated than other equipments discussed earlier in this course. In this part of the unit, we will discuss some of the issues that have emerged that revolve around changes in equipments and approaches.

3.2.1 Analogue and Digital Technology

Generally, contemporary surveying have been greatly altered by recent developments in electronics and computer capabilities, digital technology and survey instrumentations. These have resulted in new and modern methods of surveying replacing conventional and old methods. Digital technology in surveying refers to the application of modern digital equipments and computer aided devices in performing surveying operations. This has made possible the automation of surveying operations. For an example, digital theodolite has replaced the traditional micrometer theodolites. Field notebooks have now been replaced by electronic storing devices that enable field measurements to be downloaded to the computer for precessing. Most digital surveying equipments come with automatic storage devices hence, can be connected directly to the computer. Digital technology have brought

more flexibility, higher levels of efficiency and processing capabilities to surveying operations.



Figure 6.2: Digital Theodolite (Source: www.indiamart.com)

3.2.2 Terminology and Nomenclature

To accommodate changes that have taken place in surveying in recent years, new scientific terms and acronyms have evolved. These include Geoinformation, Geoinformatics, Geographic Information System; etc. These terms have become necessary as the expanding scope of surveying has meant that the term surveying does no longer adequately describe the profession thus the addition of these terms. Therefore, most tertiary institutions in Nigeria now bear the name Geoinfomatics and Surveying. Kufoniyi (1999) quoted by Ndukwe (2001) defines geoinformatics as a body of knowledge that deals with the acquisition, processing and management of geo-information. Geo-information is an integrated approach to the acquisition, analysis, distribution, managements and application of spatially referenced data (Ndukwe, 2001). Geoinformatics is inherently multidisciplinary therefore includes concepts from remote sensing, geography, cartography, computer science, etc.

4.0 CONCLUSION

You should take note of the fact that the theodolite has a higher degree of accuracy than other surveying equipments so far discussed. In surveying the desired level of accuracy and precision determines the equipment thus the type of surveying method deployed.

5.0 SUMMARY

This unit discussed the adjustment of that are carried out on a theodolite. It concludes by examining the contemporary issues that have emerged in surveying.

6.0 TUTOR-MARKED ASSIGNMENT

1. List and explain the major methods of adjusting a theodolite.
2. Enumerate the major contemporary issues in surveying.

7.0 REFERENCES/FURTHER READING

- Agor, R. (1993). *Textbook of Surveying and Leveling*. New Delhi: Khanna Publishers,. India.
- Clark, D. (1983). Plane and Geodetic Surveying for Engineers. In: *Higher Surveying*. (6th ed.). CBS Publishers and Distributors.
- Chandra, A. N. (2006). *Plane Surveying*. (2nd ed.). New Delhi: New Age International Limited, India.
- Higgins, A. L. (1974). *Elementary Surveying*. Longman Group Ltd.
- Kufoniya O. (1999): "Education Requirements in Geospatial Information Technology". In: *Proc. Workshop on Surveying and Spatial Information Technology*, University of Lagos, Lagos, Nigeria
- Ndukwe, N. K. (2001). *Digital Technology in Surveying and Mapping*. Enugu: Rhyce Kerex Publishers, Nigeria.
- Okoroigwe, D. S. (2002). *Surveying for Geographers*. Lagos: Mbeyi and Associates (Nig.) Ltd, Nigeria