MAP READING MANUAL FOR
GRADE 9-10 GEOGRAPHY
TEACHERS

Written by: Tamrat Fitie
Reviewed by: Addishiwot Abebe
              Alemnaw Koyachew
              Geda Horka
              Mihirotu Walie
              Tesfaye Tadele
              Yemaruwa Atsibiha

Ministry of Education; CURRICULUM PREPARATION AND
IMPLEMENTATION DIRECTORATE (MoE)

ADDIS
ABABA

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INTRODUCTION

Map reading is a basic skill that geographers should master and make the geography lesson more relevant to the students and stimulate a greater interest to apply it in their daily life activities.

It is meaningful to point out the great importance of basic map reading skills in the study of geography. This was strongly suggested by famous educationists, that a map is a tool of the geographer and therefore, no lesson in geography can be called complete without the use of a map. Specifically it is imperative to mention that a geography teacher should appreciate that the lessons delivered without a map will be groundless. Rather, more can be expressed in a single map: than by volumes of speech or writing. (Wikipedia, the free encyclopedia)

In geographical studies, maps occupy the central position and are imperative tools for researchers, cartographers, teachers, students and others to examine the whole earth or a specific of it.

This manual is intended to guide geography teachers in the first cycle of secondary education (grades 9-10) and structured in such a way that they can use it as a prominent tool for lesson planning. The contents discussed and the minimum learning competencies listed in this manual including the unit outcomes are comparable with the student text book, since the main emphasis is to elaborate or give more detail by explaining the concepts in depth and provide workable and attractive exercises.

The first unit of this manual deals with the map reading contents of grade 9 geography, which include (meaning of map, historical development of map, uses of map, classification of maps, marginal information on maps, the relationship between linear and areal scale, finding the scale of the map, measuring regular and irregular shaped areas and statistical diagrams).

The second unit of the manual deals with the map reading contents of grade 10 geography, which embrace (identification of direction, measurement of direction and bearing, position on maps, map enlargement and reduction, methods of showing relief on maps, slopes and gradients and field distance).
Unit 1: THE CONCEPT OF MAP READING

Unit Outcome

After completing this unit, you will be able to:

- Express the meaning, historical development, uses and types of maps
- Compute field distance and areas of regular and irregular shaped figures, construct and interpret statistical diagrams

Main Contents

1.1 Meaning of Map
1.2 Historical development of Maps
1.3 What are Maps used for?
1.4 Classification of Maps
1.5 Marginal Information on Maps
1.6 The Relationship between Linear and Areal Scale
1.7 How to find the Scale of a Map
1.8 The Measurement of Regular and Irregular Shaped Areas
1.9 Statistical Diagrams

Competencies

At the end of this section, you will be able to:

- explain the meaning of a map
- appreciate the historical development of maps
- state the basic uses of maps
- categorize maps based on scales and purposes
- distinguish the convectional signs and symbols used to represent different features on maps
- identify some of the marginal information given on maps
- convert linear scale to areal scale
- calculate the scale of a map
- calculate the areas of regular and irregular shaped figures by referring to the scale of a map
• construct statistical diagrams using simple line graphs, bar graphs and pie charts based on the provided data

1.1 Meaning of Map

Activity 1.1

Discuss the following questions in your group.

a) What is a map?
b) What does the map represent?
c) What is the shape of the earth?
d) What are the different views used to observe objects from different angles?
e) What does the term diminish mean? And why all maps show things reduced in size?
f) What are the two methods used by a map maker to simplify the map?

A map is a visual depiction of all or part of the earth’s surface on a flat piece of paper that can be carried and transported easily. It is a symbolic representation of useful information that communicates ideas and designs and appears as if it were drawn from the view of someone sitting in a flying object. It shows how things are related to each other in terms of distance, area, direction and position.

A map is a graphic representation or scale model of spatial concepts. It is a means for conveying geographic information. Maps are a universal medium for communication, easily understood and appreciated by most people, regardless of language or culture. Incorporated in a map is the understanding that it is a "snapshot" of an idea, a single picture, and a selection of concepts from a constantly changing database of geographic information.

Old maps provide much information about what was known in times past, as well as the philosophy and cultural basis of the map, which were often much different from modern cartography. Maps are one means by which scientists distribute their ideas and pass them on to future generations (Merriam 1996).

Generally maps are produced to symbolize the Earth’s surface, showing how things are correlated to each other by distance, direction, area and position. They are a way of presenting different features about all or a portion of the spherical surface on a flat piece of paper that is portable. A map is not a simple photograph of the Earth’s surface, but can illustrate many things that a picture cannot show, and as a result, a map gives the impression of being different in many ways from a photograph of the Earth’s surface. So it is a visual representation of an area — a symbolic depiction highlighting relationships between elements of that space such as objects, regions, and themes.
Maps can be prepared in many different ways each screening different expression of the same subject and allowing us to visualize the world in a convenient, educational or exciting way. To use maps effectively, be aware of the following important facts:

(1) No map is just right or perfect. People create maps from data they gather with certain tools. Even computer-made maps depend on programs intended or designed by people and on data collected by human-made machines. People make mistakes and machines are by no means totally perfect all the time, nor can any device record every detail of a landscape. Therefore, maps can be full of errors and inaccuracies. Due to data errors or cartographic errors, a certain town may not be exactly where the map shows it or a mountain peak may not be exactly as high as it appears on the map.

Cartographers using traditional tools such as the recording of ground data by hand or the use of high-altitude photography is limited by how many objects and how small an object they can record. Very small features may not be exactly placed on the map or they may not appear at all.

Contemporary tools such as high-resolution satellite photography can record fine points to a resolution of several meters. Most surface objects of practical significance can be recorded with such imagery and translated into highly accurate maps or photographs, but they are still question to analysis and data error. Cartographers sometimes intentionally or knowingly limit the details they present in a map in order to make the map functional and less confusing.

(2) A map might have been produced accurately as a plan of the ground, but however, it is a plan of the ground at a definite time span. If it is a long time since it was produced or revised, much might have been changed. For instance, towns grow, roads and railways are built and forests grow and are cut down. No map can be taken as being absolutely consistent or reliable except as regards the main physical features. Even they may change slowly; coast lines wear away and in some places rivers have a tendency to change their course. It is therefore very imperative to note the date on which the map was produced or revised and to judge its reliability. This is because the world is persistently or constantly changing both physically and culturally, so maps can become obsolete or out-of-date and no longer showing the world accurately. Modern technology has provided a partial solution—computers have made it promising to renew maps easily without redrawing them. On the other hand appropriate information reflecting changes in the world must still be composed or collected periodically and used to adjust the maps’ database or record.

(3) Maps are biased. This shows that they do not demonstrate every single feature of a chosen geographic area like each individual tree, house, and road. Therefore the cartographer must decide the projection and scale for the map and decide how much information to present.
As indicated, above, different definitions have been provided for a map. Furthermore, a simple, precise and logical definition of a concept is always required. Below we can see the simplest definition given to a map.

“A map is a simplified, diminished, plain representation of all, or part, of the surface of the earth as viewed from vertically above.” Kurt Roselius, (1991)

In order, to get a clear picture of the concept; the terms used in the meaning of a map need further clarifications.

**Simplified**: This proves that maps are never exact, defining features of the earth’s surface, not even of a small segment of it and a map maker cannot show all the small elements in his map. For instance if you consider the plan of your school compound a map maker cannot portray or depict all the necessary details of the school compound like relief, vegetation or human made features. This forces the map maker to make the following decisions.

a) The map maker should decide on the type of information he would like to depict on the map that whether he wishes to demonstrate the relief, the vegetation, the buildings, the play grounds, the gardens, the rocks etc. of the area he is mapping. This refers to the selection of the information in the process of simplifying.

b) In order to summarize the information, the map maker uses conventional signs and symbols. This means that the information he would like to portray or put down on the map, should be summarized by making use of a special language or convention. Therefore employing the characters of an alphabet to communicate a message shows that a map utilizes a supplementary conventional secret codes and symbols.

**Diminished**: By this we mean that all maps demonstrate things reduced in size. This shows that there would be no need or rationale to illustrate, for example the map of Ethiopia which is equal in size to a country itself. Such a map is unmanageable and would have no use at all. It is true that even though photographs also show images of objects smaller than their real size. The disparity between the photograph and a map is that with regard to a map the amount or degree of diminution or reduction is indicated in the scale that is expressed in different ways and attached to the map.

**Plain**: It is already customized that our planet earth is spherical in shape. Maps are all plain illustrations or representations of this spherical surface. As we all know, there is no mechanism or device in geometry that enables us to accurately transfer the spherical shape of the earth on to a plain sheet of paper. This is because there is no simple scheme or a systematic plan of action to cut up the surface of the spherical shape and allow it to lie flat on a sheet of paper. Therefore, it is possible to generalize that all maps show inaccurate pictures of the earth. You can prove this by wrapping a sheet of
paper around a globe. All maps are therefore deformed, that is they are not correct in one respect or another depending on the size of the area shown on the map.

So the task of transferring a spherical surface on to a plain surface is becoming a complex phenomenon. The other problem that the map makers are facing is that the earth’s surface is not plain or smooth but full of ups and downs exhibiting or displaying different altitudes.

On the other hand map makers have already devised different methods to depict these ups and downs or the three dimensional nature of the earth’s surface on a two dimensional plain surface.

**Viewed from vertically above:**

By this we mean that things can be viewed from different angles or view points and they all appear being completely different. Take for example, the view of your school building. You can see the building from the side as you do when you enter the gate of the school compound. Now you view it from the side which forms the *side view* of the building. Then you can climb a tree or a higher ground some distance away from the school compound and you then get an *oblique* or *slanting* view of the building. Lastly you can imagine yourself in an aero plane vertically above the school building. This is the *bird’s eye view* /vertical view of the building needed to portray it on the map. So objects are depicted on maps as viewed from vertically above.

### 1.2 Historical development of Maps

**Activity 1.2**

Discuss the following questions in pairs

a) What is the most important tool for a geographer?
b) Mention the two major stages in the historical development of map?
c) Compare and contrast the traditional map making and the modern map making.
d) Who was Eratosthenes?
e) How map makers acquire spatial information nowadays?
f) Who are the Cartographers and what is Cartography?
g) What is GIS?
h) What is GPS?

**Cartography** is the art and science of creating maps. It requires the gathering of geographical information, the storage, processing, and editing of this information, and the arrangement of the data in a map form. Cartography is based on sound geographical knowledge of the surface being mapped, as well as the many skills and tools helpful to the mapping process.

Maps are prepared in many different forms. The earliest maps made by ancient people were possibly lines drawn in sand or small pebbles or stones and sticks arranged on the ground.

The first map of the world was drawn by Anaximander-ancient Greek geographer, who is considered by many to be the first map maker. Even though, the shortage of archaeological and written evidences limited the assessment of his map; it is taken for granted that he portrayed land and sea in a map form.

An important contribution to the development of mapping was made by Eratosthenes (275-195 BC), who was credited for the scientific estimate of the earth's circumference. His work has been described as the first scientific attempt to offer geographical studies a mathematical basis.

**Stages in the development of Maps**

**Early Maps**

The oldest known maps are those preserved on the clay pieces of Babylonians from about 2300 B.C. This is the initial positive verification of graphic demonstration of the earth; it may be understood that map making goes back much further and it began among non literate peoples.

It is reasonable to guess that humans very early made attempts to communicate with each other concerning their environment by scratching routes and locations on the ground.

Markings on cave walls that are associated with paintings by primitive human have been distinguished by some archaeologists as efforts to show the game trails of the animals portrayed, though there is no general agreement on this.
Similarly, networks of lines scratched on certain bone tablets could possibly represent hunting trails, but there is obviously no conclusive proof that the tablets are indeed maps.

Next to the works of the Babylonians, mapping and the perception of a spherical shape of the earth were well known by Greek philosophers and have been accepted by all geographers by the time of Aristotle since 350 B.C.

**Cartography** (the art of map making) had been practiced since ancient times. For many centuries its highest relevance was the production of hand-drawn flat maps and charts pulled together from information composed visually by explorers, and other individuals. As a result, they were not as accurate as modern maps, but are fascinating as a record of the stage of knowledge and thought at the time.

Map reproductions in the early ages were also of great worth because they were copied by hand, which made their distribution tremendously limited.

It is doubtless to say that, the earliest maps must have been based on personal understanding and familiarity with local features to show directions to their tribes, where to search for water and other requirements, such as the relative locations of pasture lands, springs and wells including the locations of enemies and other hazards. Wandering life encouraged or stimulated such mapping efforts by recording ways to cross different environments, like deserts and mountains.

Some early maps were often deliberate for specific purposes, usually for military campaigns or for boundary delineation. The ancient Romans and Egyptians, who created maps for these purposes, were among the most scholarly map makers of their time.

**Medieval Maps**

The Medieval period European maps were dominated by religious views in which Jerusalem was portrayed at the center and east was tilted or oriented toward the map top. Meanwhile, North Atlantic explorations have been gradually integrated into the world view beginning in the 12th century. Similarly, mapping developed along more practical and reasonable lines in Arabic lands, including the Mediterranean region. The main peculiarity of medieval maps is that all of the maps were drawn and decorated by hand, which made their distribution extremely limited.

**Renaissance Maps**

The development of printing, first in China in the 12th century and then in Europe in the 15th century using curved wooden blocks made maps much more commonly available.

Printing with carved copper plates came into view in the 16th century and continued being the standard or normal awaiting the development of camera-friendly techniques. Major
progress in mapping appeared during the Age of Exploration in the 15th and 16th centuries, with navigation maps which illustrated coast lines, islands, rivers, harbors and other features of interest.

Maps both promoted and smoothed the progress of exploration, which in turn inspired or stimulated cartographers to make more extensive and more accurate maps. The interaction between mapping and exploration can be seen in the rapidly increasing detail filling the maps made by Spanish adventurers in North America as they explored the continent between the 15th and 17th centuries. The growing aspiration for spreading out and trade, together with the advances in ship building and money-making techniques, promoted mapping activities of the period.

Modern Maps

Nowadays, cartographers look for ways to make more precise maps, methods to reproduce them more professionally and guide to allocate them more conveniently. During the history of cartography, map-making has evolved with technology.

The application of scientific methods in map makings, during the 17th, 18th, and 19th centuries, enabled maps to be more accurate and realistic. However, much of the world was inadequately known until the widespread use of aerial photography following World War I. Modern map is generally based on the combination of both ground observation and remote sensing.

The creation and modification of modern printing techniques towards the end of the 19th century especially lithography, which allowed delicate detail and shading made available the means to easily duplicate complex and accurate maps.

The materialization of the field of statistics which allowed map makers to translate complicated mathematical generalizations into figurative geographic features and the development of public infrastructure in and around major urban centers during the late 1800s and early 1900s enhanced the development of modern maps.

In our modern era, technology known as remote sensing has assisted professionals to chart the depths of ocean or the border line of the outer space and experience a rapidly accelerating change. Cameras have been taken into orbit to provide vast image collections of earth and other planets, and also galaxies by space programs.

The far-reaching development in map making has emerged into sight from progress in electronic communication and various computer applications which can store and transmit enormous amounts of mapping data and produce maps using sophisticated digitizers, plotting machines and electronic typography.
Geographic information system (GIS) is a means of collecting, storing, integrating, analyzing, and presenting geographic data. It incorporates five important components which form part of a whole. These include hardware, software, data technical expertise and methods.

Hardware: GIS hardware is the computer or central processing unit for operating the GIS and ranges from centralized computer servers to desktop computers manipulated in stand-alone or networked computer system’s setup. It provides the space for storing data and programs.

Software: GIS software provides the functions and tools needed to input and store, analyse and display geographic information. Key software components include:

- Tools needed to input, manipulation and store geographic information.
- A database management system (DBMS).
- Tools that hold up geographic query (question), analysis and visualisation
- A graphical user interface (GUI), software that links a computer with another device or the set of commands, messages, and other features allowing communication between computer and user.

Data: The most essential constituent of a GIS is the data, geographic and related tabular data. Geographic data and related tabular data can be collected in house, compiled to custom specifications and requirements, or purchased from a commercial data provider. GIS will integrate spatial data with other data resources and use DBMS to organise and maintain the spatial data.

Each theme is a layer of data that is connected geographically to other data layers of different themes. A GIS can be used to project combinations of geographical interrelationships of the various data layers onto a single map. On the other hand individual themes can be separated from the overall prevailing conditions and considered individually.

Technical Expertise: People are responsible for the day-to-day operations of the GIS. Users include technical experts, managers, administrators and end users. Today GIS is being used by people, in many different fields, as a tool that enables them to perform their jobs more effectively.GIS technology is of limited value without trained technical experts who manage the system and develop plans for applying it to real-world problems. GIS users range from technical specialists who design and maintain the system to those who use it to help them perform their everyday work.
Global Positioning System (GPS) is a device that provides an earth coordinate position based on the reception of special satellite transmissions. The location is worked out, by triangulation, based on the relative locations of at least three satellites. Modern GPS units—some as small as cellular telephones—have a simple LCD screen similar to that on an electronic calculator, and a simple keyboard for entering codes. These hand-held devices can be programmed to record and put on view the exact position of the element.

The contemporary system used for GPS is administered by the United States, although the European Space Agency has plans for a similar system. Due to military security, the US government regulates the resolution of satellite transmissions available to the public for GPS use. The main problem associated with using GPS to collect map data is that trees and steep terrain block the reception of satellite transmissions. Currently, the most common and rapidly growing use of GPS is in aircraft and ship navigation, and some vehicle manufacturers are beginning to install GPS in their cars. In Oslo, Norway, for instance, a taxi company is installing GPS in all its taxis to help track individual cars and offer security oversight for its drivers.

Despite its current limitations, cartographic use of GPS is on the increase. Among other purposes, it is being used to verify or confirm the location of boundary lines. GPS and related technology will play increasingly important roles in cartographic data collection as
the accuracy of satellite-based positioning technology increases.
(http://ces.iisc.ernet.in/energy/monograph1/Gispage6.html)

1.3 What are Maps used for?

Activity 1.3

Discuss the following questions in small groups.

a) What are the four basic uses of a map?
b) What are the two types of location?
c) Tell the absolute location of Ethiopia.
d) Which maps show distribution of features?
e) What do topographic maps show?
f) How maps offer visual comparisons?
g) How maps help in planning?

Maps are perhaps the most important tools and vital sources of information for a geographer. This is because they record definite facts of positions, relief, climate, vegetation, materials and their distribution broadly over the earth.

Wall maps in the geography class rooms should be displayed by using a specially constructed wooden frame. In the absence of wall maps the teacher can draw sketch-maps on the blackboard, whenever a particular item has to be illustrated.

Pupils should be encouraged to use atlases outside classes and make a habit of searching physical and cultural features, the rivers, towns, capitals, harbors etc. It is indispensable that geographic education should involve the use of maps as a source of geographical information and the methods of teaching geography in schools should lay emphasis on the wider use of map.

Though maps are limited in scope, yet they are of enormous use in the teaching and learning of geography. It was strongly suggested by a famous educationists, that a map is a tool of the geographer and therefore, no lesson in geography can be called complete without the use of a map. A geography teacher should appreciate that the lessons without a map are meaningless. Rather, more can be expressed in a single map: than by volumes of speech or writing. (Wikipedia, the free encyclopedia)

The initial use of maps was to guide people how to get from one position to another. Before the introduction of the modern paper, primitive people were drawing simple map sketches in the sand to show their fellow people the location of a water hole and a hunting ground.
Today, maps are used for many other purposes. Some of the basic uses of maps are listed as follows:

**Location:** Maps show the exact site and the general situation of places.

**Distance:** By using the map and the scale properly, one can calculate the actual distance between two points.

**Area:** The size of a certain point or a country can be calculated from most maps correctly through accurate measurements on maps and proper utilization of scale.

**Direction:** The direction or bearing from one point or place to another can be obtained correctly from most maps.

In addition to aforementioned indispensable basic information obtained from almost every map and essential for every map user, map can be used for the following special purposes.

1. Most maps are produced in the practice of trying to understand how phenomena are distributed spatially over the land surface. For example the spatial distribution of the natural vegetation and wild animals.

2. We can also use maps to study the relationships that exist between various phenomena. For instance the relationship between climate and natural vegetation.

3. Maps can be used to identify social and environmental problems. For example to differentiate areas subject to potential hazards and develop plans for controlling problems such as, abandon those in danger and providing services. Maps that show the distribution of diseases can be used in planning for public health services.

4. Distribution maps are also important sources for statistical studies, like land use studies, population studies, etc.

5. Route Planning — Movement on land, at sea, or in the air rely heavily on maps to plan our routes and to maintain our course.

6. Planning- Urban and regional planning depend heavily on maps for the location of schools and public facilities.

7. Storage of Information - Some maps are produced to present a consistent register of features that are believed to be important, such as boundaries, hydrographic, topography, and place names. For instance the topographic maps that are produced by most countries are good examples of this type of map use.

8. **Jurisdiction, Ownership, Assessment** - Maps are used as legal documents showing who has rights to property- the ownership of land and boundaries. Taxes are based on property ownership and evaluators rely heavily on maps. In more
traditional societies where boundaries have been understood but not documented, efforts are now being made to produce maps showing agreed-upon boundaries. These maps are permitting indigenous societies to hold on to rights to their land against outside forces wanting access to resources.

9. **Forecasting and Warning** - Maps are an important part of the prediction processes and are equally important in forewarning potential victims. The weathercaster on television is one component of the use of maps to predict the future of events that play out over the Earth’s surface and that have the potential for significant damage to systems important to humans. Such forecasting and the dissemination of warnings is done at many scales, ranging from quite localized flash flooding, wildfires, and tornado touchdowns to larger features like hurricane landfalls, severe storms, volcanic eruptions, insect infestations, tsunamis, and sea level rise and high tides.

1.4 **Classification of Maps**

**Activity 1.4**

Discuss the following questions in pairs

a) What are the two criteria used in classifying map?

b) What is a general purpose map? Give example.

c) What is the advantage and disadvantage of a general purpose map?

d) What are thematic maps?

e) What does specific purpose map show?

f) What is scale?

g) Name the types of map based on scale.

h) Compare and contrast large scale, medium scale and small scale maps.

Since maps can exhibit manifold or diverse levels of information, the division between different types of maps is not always clear. In addition, maps have uses in diverse fields, and as such, sometimes terminology may seem incompatible. However, the key purpose of this manual is to introduce you to the most commonly used type’s of classification.

Maps can be classified based on the purpose and the scale. Many maps are intended and fashioned to provide very specific uses while other maps enclose so much information that they are used by a variety of users for a great range of activities.

1.4.1 **Classification based on the purpose**

Maps can be categorized based on their functions or purposes. These include the general purpose maps and the specific purpose maps.

1. **General purpose Maps**: The fundamental type of map used to symbolize land areas is the topographic map. These maps demonstrate the natural features of the area covered as well as certain non-natural features, known as cultural features. Among these are Political boundaries, such as the extents of towns, countries, and states are also shown.
Due to the great range of information included on them, topographic maps are most frequently used as all-purpose reference maps. They are maps regularly used for reference purposes and can exhibit a variety of information including both natural and human made features. The two major groups of the general purpose maps are physical and cultural maps.

**Physical Map:** A physical map is one that illustrates the physical landscape features of a place. They generally depict things like mountains, plains, rivers and lakes. In these maps, water features are always shown with blue. Mountains and elevation changes are usually shown with different colors and shades to show relief. Normally on physical maps green represents lower elevations while browns show high altitudes.

The most familiar type of general purpose map is a topographic map. Topographic maps are frequently used as reference maps, and typically demonstrate both natural land features (such as coastlines and bodies of water) as well as political boundaries. Topographic maps also exhibit elevation (height above sea level), using either coloring (relief shading) or contour lines. Therefore topographic maps are the same as physical maps in that they show different physical landscape features.

**Cultural Map:** A cultural map does not show any topographic features. It instead focuses solely on the human made features. For instance, an economic or resource map is a type of cultural map that shows the specific type of economic activity or natural resources present in an area through the use of different symbols or colors depending on what is being shown on the map.

A road map is one of the most widely used cultural map types. These maps show major and minor highways and roads as well as things like airports, city locations and points of interest like parks, campgrounds and monuments. Major highways on a road map are generally red in color and larger than other roads, while minor roads are a lighter in color and a narrower in line.

2. **Thematic Maps:** Thematic (special purpose) maps are maps that focus on a particular composition or special topic and they are different from the aforementioned general reference maps because they show information about one specific topic like forestry, soil, geologic, climate, land use, etc. They are typically used to communicate a specific theme to particular map viewers. A thematic map shows how qualitative and quantitative data are distributed geographically. Based on the information they convey, thematic maps could be classified into two groups, i.e. qualitative and quantitative thematic maps.

**Qualitative Thematic Maps:** Qualitative map data states the presence or nonexistence of the subject on a map, like the type of soil or vegetation occupying an area and is not expressed in the form of numerical value. Therefore, qualitative thematic maps show the areal distribution of phenomena without any quantitative or numerical indication. E.g. chorochromatic and chroschematic maps.
**Quantitative Thematic Maps**: Quantitative thematic maps are also known as statistical maps and display spatial distributions of geographical elements representing quantitative values. E.g. dot maps and isoplethic maps.

### 1.4.2 Classification based on the scale

Most maps are made at a scale that is much smaller than the area of the actual surface being portrayed. The degree of reduction that has taken place is normally acknowledged somewhere on the map. This measurement is universally referred to as the map scale. Theoretically we can think of map scale as the ratio of the distance between any two points on the map as compared to the actual ground distance represented.

Maps are frequently described in a comparative sense, as being small scale, medium scale or large scale. We have maps representing an area of the world at scales of 1:100,000, 1:50,000, and 1:25,000. Of this group, the map drawn at 1:100,000 has the smallest scale relative to the other two maps. The map with the largest scale is the map which is drawn at a scale of 1:25,000. The smaller the number on the bottom (denominator) of the map scale, the more detailed the map will be. A 1:10,000 map will show objects ten times as large as a 1:100,000 map but will only show 1/10th the land area on the same sized piece of paper. Therefore we can make a distinction between:

- a) Large scale maps > 1: 50,000
- b) Medium scale maps 1:50,000-1:250,000
- c) Small scale maps ≤ 1: 250,000

The main difference between these different groups of maps is not only the variation in scale but the use to which we can put the maps. As a rule, smaller scales show less details and their presentation becomes more generalized. For example, if we want to find our way inside Addis Ababa, we have to use a map with a scale large enough to give us with all the necessary details. If the main purpose is to show the sub divisions of Ethiopia into administrative or physical regions, a map with much smaller scale is desirable, since all the unnecessary details have been omitted. Therefore, it is obvious that when we want to deal with the geographical problems with reference to the whole of the country; only maps made in small scales can be utilized.

### 1.5 Marginal Information of Maps

**Activity 1.5**

Discuss the following questions in small groups.

- a) What is marginal information?
b) What does the title of a map explain?

c) Why a year of publication of the map is necessary?

d) What is the purpose of legend or key?

e) What is True North?

f) What does magnetic variation show?

g) What are conventional signs and symbols?

h) What are the most important requirements to be fulfilled by the symbols?

i) What is a map grid?

j) Mention the two major map grid systems.

k) What is geographic or international grid?

l) Explain the terms: parallel, meridian, latitude, longitude, equator, prime meridian.

m) What is a national grid system?

n) Explain the terms: eastings, northings, verticals, horizontals.

o) What are the two geographic poles of the earth?

p) What is a magnetic compass?

q) What is a gyrocompass?

People use a map depending on the type of map they have and what kind of information they desire from it. In the case of simple maps, only one or two types of information may be accessible and few or no map skills are necessary to utilize it. For instance, a sketch of a locality may only illustrate what connection a particular house has to the street corner or whether it is farther from there to the market or to the school. Even those who cannot read the neighborhood language can use such maps. But complex maps can show actual distance, the accurate location of many important land features, elevation, vegetation, political divisions, and many other features of the world. Reading information from a map necessitates certain abilities or skills. **Reading a map is just like reading a book and one should know where to start.**

The initial activity for a map reader after obtaining the map is not to study the map itself or appreciate the colors, but referring to the information provided in the margin of the map. All maps have guides in their margins to convey information for the users. Therefore
in reading the map you should begin by referring to the information integrated in the margin or edge of the map.

The information presented comprises the following vital facts in the margin of each map or map series.

**Title**: The heading or title of the map enables us to choose the map depending on the purpose of the study. For example, soil map, vegetation map, climate map, economic map, etc.

**Date**: The year of compilation of the map and accuracy anticipated or expected in terms of areas, distances, directions, etc. Due attention should be given to the date of completion when selecting the map, since geography as a subject is dynamic dealing with the changing world. Therefore to obtain the correct information about a definite region one should make use of the most recent possible version or edition of a map.

**Key**: The key to the signs and symbols used on the map is important information without which it is difficult to understand and use the map correctly.

**Scale**: The scale to which a map is drawn is one of the crucial or indispensable elements included in the marginal information. Without the scale it is impossible to make any form of calculation.

**Grid references**: The two major grid references used on the map. In order to locate a feature on a map or to describe the relative and absolute location of the mapped area, it is necessary to refer to the map's geographic grids. These are the International or geographic grid (Latitudes and Longitudes in degrees) and the National grid (Eastings and Northings in kilometers).

**Magnetic declination or variation**: This shows the angular difference between true north and magnetic north. It is necessary information for those who would like to use the map together with the magnetic compass for correct navigation or orientation in the field.

**Conventional signs and symbols**

We know that map contains a large quantity of easily read information; a system of symbols should be utilized. Many commonly used symbols have become generally accepted or are readily or easily understood.

In order to communicate or convey its message in a summarized form a map uses its own language, expressed or articulated with the help of its conventional signs and symbols. A map symbol could be a diagram, letter or abbreviation which by convention or reference to a key is understood to symbolize a specific feature or object. All maps have their own symbols which are clarified or explained in a key also called legend or
reference. So when you are reading a map, you should refer or consult the key provided in the marginal information with awareness or carefully so that you can understand or comprehend the full message conveyed by the map.

In the practice to draw a map of your own, you are free to design your own signs and symbols, but never forget to give their meaning in a key attached to your map. It is also recommended to use symbols that satisfy the following requirements:

- Each symbol should be consistent or uniform all over the map or a series of maps.
- The symbols should be comprehensible or understandable so as not to guide to speculation or guesswork.
- The symbols should be legible or readable so as to easily distinguish them on the map.
- The symbols should be sufficiently or adequately accurate in terms of location, space occupation, etc.

A cartographer may devise a great variety of symbols to suit various needs. Below is the list of some group of symbols that we can find on topographic maps.

**Symbols for Water Features:** These include symbols for water features such as rivers, marshes, lakes, seas, oceans and human made wells, springs, reservoirs, irrigation canals, etc. These features are usually printed in blue including their names.

**Symbols for Relief Features:** Relief maps are three-dimensional models of the terrain in an area and symbols representing them are usually printed in brown color.

**Symbols for Vegetation Features:** On relief maps different kinds of vegetation or wood lands are shown in green prints. The map maker depicts vegetation features by using symbols known as *pictograms/pictographs*, which are graphic symbols or pictures representing words or ideas as opposed to a symbol such as a letter of the alphabet. These symbols are dissimilar from most others so far stated or mentioned because they try to show features as they appear when viewed from the side. To portray or depict the differences in the density of the vegetation in different forests, the map maker spaces the pictographs closer or further apart from one another on the map.

**Symbols for Communication Features:** These features include the different types of rail ways comprising single track, multiple track, and normal gauge or narrow gauge; roads of different classes including all weather, hard surface, gravel or loose surface, dry weather roads, cart tracks, and trails, ropeways, power transmission lines, telephone lines, air ports, etc. These symbols are frequently printed in black color apart from the major classes of roads which are printed in red color.
Symbols for Settlement Features: Comprises a group of symbols used to represent features like scattered settlements, villages, road sides, towns, and cities which are usually printed in black color.

Miscellaneous/Various Features: This group consists of symbols most of which are pictograms that do not fit into any of the aforementioned groups. They include symbols for different types of boundaries of international and internal administration; symbols for unusual or special buildings such as mosques, churches, schools, post and telephone offices and symbols for human enterprises or projects like mills, quarries and mines.

Generally there are varieties of symbols being used in different parts of the world. Therefore student of geography should be familiar with the symbols commonly used on topographic maps, specifically those symbols used on maps of once own nation state or country. If a student occasionally or irregularly faced with a map that is utilizing unfamiliar symbols should make a quick reference to find the meaning of a symbol from the key of the map.

The other fact that should be understood is that the different number of symbols used on most maps depends on the scale of the map. For instance a great variety of symbols can be shown on large scale topographic maps, while the symbols depicted on small scale maps might be very few in number. Below are the lists of natural and human made features depicted on the 1:250,000 series topographical map of Ethiopia:

Water Features: land subjected to inundation (floods), temporary river, water fall, dam, water hole, spring, etc. (printed in blue).

Relief Features: contour lines, escarpment, cinder cones, etc. (printed in brown).

Vegetation Features: wood lands, forests, scattered trees, etc. (printed in green).

Communication Features: all weather roads-hard and loose surfaces (printed in red), dry weather roads, tracks and trails (printed in black), rail ways, single track, multiple track (printed in black), power transmission line, ropeway (printed in black) and air ports: I class, II class, heliports (printed in black).

Settlement Features: buildings, village, scattered settlement, farms and industries, church, mosque, school, etc. (printed in black).

Boundaries: international (printed in red with black center line), internal (printed in black).

Miscellaneous Features: road number, bridge, road distance, trigonometrical point, spot height, etc. (printed in black).
MAP SYMBOLS AND SIGNS

1. WATER FEATURES: (printed in blue)
   Land subjected to inundation:
   Temporary river:
   Permanent river, waterfall, dam:
   Well (water hole), spring:

2. RELIEF FEATURES: (Printed in brown)
   Contour lines:
   Escarpment, cinder cones:

3. VEGETATION: (Printed in green)
   Woods, brush wood scattered trees:

4. COMMUNICATION FEATURES: (Printed in red or black)
   All weather roads: hard and loose surface:
   Dry weather roads, tracks, trails:
   Rail roads: single track, multiple track
   Power transmission line, ropeway:
   Airports: I class, II class, heliports:

5. SETTLEMENTS, BUILDINGS, ENTERPRISES: (Printed in black)
   Village, scattered settlements, farms and industries;
   Church, mosque, school:
   Quarry, (mine):

6. BOUNDARIES:
   International: (Red with black center line)
   Internal: primary administrative: (black)

7. MISCELLANEOUS:
   Road number, bridge, road distance:
   Trigonometrical point, spot height:

Figure 2A: Symbols and signs
Figure 2B: Symbols and signs

Map scale
As already mentioned scale is one of the most important things given in the marginal information of each map. We also know that scale is the ratio between the distance of any two points on the map and the real distance of the same points on the land. Though, maps show features diminished in size, scale gives us the exact degree to which the map maker has reduced the size of each feature. All topographic maps are much smaller in size than the real world they represent. The landscape features depicted must be greatly reduced to fit the map. In order to be able easily to measure areas and distances on the map, the map maker also called cartographer should diminish all the actual distances and areas on the ground to the much shorter lengths illustrating them on the map represents the scale of the map. Each map is a simplification of reality. This generalization comes as a result that maps naturally demonstrate the earth at a smaller size that it really is.

Maps represent areas and features, but not at their actual size. A large scale map covers a small area while a small scale map covers a large area. The reduction of an area is known as the scale of a map. To effectively use maps you need to convert measurements from map units to ground units.

The relationship between ground and map distance can be expressed by either a linear or areal measurement. Linear measurement is expressed in three ways: as a word statement, as a graphic scale, and as a representative fraction (RF). Areal measurement most often is expressed by a graphic scale such as a circle or square of a proportionate size.

Map scales can be expressed in any one of the following ways:

**As a ratio or fraction**, such as $1:100,000$ or \( \frac{1}{100,000} \), which means that one unit of measurement on the map represents 100,000 of the same units on the earth's surface. According to this scale type, the larger the denominator and the smaller the fraction, the more of the earth are represented on a single map. Therefore, small-scale maps demonstrate a large piece of the earth, and large-scale maps illustrate a relatively small piece. The ratio or the representative fraction scale has advantage not commonly shared by the other methods in that it is never tied to any system of measurement. For instance, the English student can convert a ratio into inches and miles, while those students using the metric system can convert it into metric units. Because of its unique character, the ratio scale is qualified as the most universal method and can be understood and utilized everywhere. The assigned measurement unit must be the same for the numerator and the denominator. The numerator is always one and represents the distance as measured on the map; the denominator represents the ground distance. The advantage of the same units is that map measurements may be made in whatsoever unit you choose.
A Graphic Scale portrays scale by means of a line, with partitions marked by smaller intersecting lines, similar to a ruler. One side of the scale stands for the distance on the map, while the other side represents the actual distances of places in real life. By measuring the distance between two places on a map and then referring to the graphic scale, it is easy to calculate the actual distance between those same items.

The other peculiar character of a graphic scale is that, the scale does not start from zero but has one unit, divided into quarters, to the left of zero. This gives us an opportunity to read fractions of a kilometer as well as full kilometers.

As a phrase in words and figures, such as “1 cm represents 100 km” (that is, 1 cm on the map represents 100 km on the earth’s surface). But in a statement do not write as ‘one centimeter equals 100 kilometers’; this is both ridiculous or silly and untrue.

All the above scale types illustrate significant relations, that the larger the scale of a map, the closer it approaches the actual size of features on the earth’s surface. Small-scale maps usually show larger portions of the earth’s surface and have less detail than large-scale maps. Another way to consider of map scale is that objects in small-scale maps emerge small, whereas the same objects in large-scale maps appear large.

Practical example of a map scale: if we consider a map with scale 1:50,000 also can be written as $\frac{1}{50,000}$. This fraction reads as follows: 1 unit as measured on the map represents 50,000 equal units as found on the earth’s surface. For instance, if we measure one cm. on the map, then according to the map scale, this corresponding distance equals 50,000 cm. on the earth’s surface. Once the representative fraction is known, various measurements can be made on the map. For example, assume we have a map where the representative fraction is stated as 1:100,000. On such a map, we know that one cm. on this map measures 100,000 cm. on the earth’s surface. Therefore, if we measure a distance of 10 cm. between two points, we will arrive at a distance on the earth’s surface as $(10 \times 100,000 = 10,000,000 \text{ cm})$.

Obviously, this value can be converted into a more logical unit such as kilometers. Since there are 100,000 cm. in one kilometer, we can take 1000,000 cm. and divide by 100,000 cm. which gives 10 kilometers, which is the distance between these two points on the earth’s surface. The table below shows how meters are related to five other measures of length.

Table 1: Metric system vs. Imperial system

<table>
<thead>
<tr>
<th>Metric length</th>
<th>Imperial/USA Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 millimeters</td>
<td>= 1 centimeter</td>
</tr>
<tr>
<td>10 centimeters</td>
<td>= 1 decimeter</td>
</tr>
<tr>
<td>12 inches</td>
<td>= 1 foot</td>
</tr>
<tr>
<td>3 feet</td>
<td>= 1 yard</td>
</tr>
<tr>
<td>Metric area</td>
<td>Imperial/USA area</td>
</tr>
<tr>
<td>-------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>10 decimeters = 1 meter</td>
<td>22 yards = 1 chain</td>
</tr>
<tr>
<td>10 meters = 1 decameter</td>
<td>10 chains = 1 furlong</td>
</tr>
<tr>
<td>10 decameters = 1 hectometer</td>
<td>8 furlongs = 1 mile (5280 feet)</td>
</tr>
<tr>
<td>10 hectometers = 1 kilometer (1000 meters)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Metric area</th>
<th>Imperial/USA area</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 square mm = 1 square centimeter</td>
<td>144 square inches = 1 square foot</td>
</tr>
<tr>
<td>10000 square cm = 1 square meter</td>
<td>9 square feet = 1 square yard</td>
</tr>
<tr>
<td>100 square m = 1 acre</td>
<td>4840 square yards = 1 acre</td>
</tr>
<tr>
<td>100 acres = 1 hectare</td>
<td>640 acres = 1 square mile</td>
</tr>
<tr>
<td>100 hectares = 1 square kilometer</td>
<td></td>
</tr>
<tr>
<td>= 1000000 square meters</td>
<td></td>
</tr>
</tbody>
</table>

**Grid References:**

**Grid references** define locations on maps using Cartesian coordinates (numbers showing position of points on a plane). Grid lines on maps define the coordinate system, and are numbered to provide a unique reference to features.

The two major grid systems are the Geographical or International Grid and the National Grid.

**Geographical Coordinate System:**

Beginning from the ancient times, people have made an attempt to come up with the dependable or reliable systems which enable them to measure their location on earth's surface. For centuries, both Greek and Chinese scientists tried many different methods but a consistent one did not build up until the ancient Greek geographer, astronomer and mathematician, **Ptolemy**, launched the geographical grid of parallels and meridians for location purposes on his map of the world drawn in the year 150 A.D. In order to perform this, he divided a circle into $360^\circ$, each degree into 60 minutes ($60'$) and each minute into 60 seconds ($60''$). He also applied this method to locate places on the earth’s surface by expressing their position in degrees, minutes and seconds and published the geographical coordinates in his book Geography.

Even though, Ptolemy made the best effort in defining the position of places on Earth's surface at the time, the accurate or precise length of a degree of latitude was unanswered for about 17 centuries.
Nowadays, if a globe is studied carefully we can find that two sets of lines form a network on the surface of this spherical object.

The geographical coordinate system measures location from only two values, in spite of the fact that the locations are described for a three-dimensional surface. The two values used to describe location are both measured relative to the polar axis of the Earth. The two measures used in the geographic coordinate system are called latitude and longitude.

Lines of latitude or parallels are drawn parallel to the equator shown as circles that span or cover the Earth’s surface. These parallels are measured in degrees, minutes and seconds. There are 90 angular degrees of latitude from the equator to each of the poles. The equator has an assigned value of 0°. Measurements of latitude are also defined as being either north or south of equator to distinguish the hemisphere of their location. Lines of longitude or meridians are circular arcs that converge at the poles. There are 180° of longitude either side of a starting meridian which is known the **Prime Meridian**. The Prime Meridian has an assigned value of 0°. Measurements of longitude are also defined as being either west or east of the Prime Meridian.

Latitude measures the north-south position of locations on the Earth’s surface relative to a point found at the center of the Earth. This central point is also located on the Earth’s rotational or polar axis. The equator is the starting point for the measurement of latitude. The equator has a value of zero degree. A line of latitude or parallel of 30° north has an angle that is 30° north of the plane represented by the equator (the maximum value that latitude can attain is either 90° North or South). These lines of latitude run parallel to the rotational axis of the Earth.

Geographical grid is made up of meridians of longitude and parallels of latitude. The geographic grid is used to locate a feature on a map or to express the coverage of an area. Through established rule (convention) longitude is measured 180° east and 180° west from 0° at Greenwich, England. Latitude is also measured 90° north and 90° south from the 0° parallel of the equator. Position on a map can be accurately delineated or demarcated by giving degrees, minutes, and seconds for both latitude and longitude.

Latitude and Longitude being system of geometrical coordinates are used in defining location of places on the surface of the earth.

**Latitude**: is the angular distance that provides the location of a place north or south of the equator and is expressed in degrees, minutes, and seconds. The latitude of a point on the surface of the earth is equal to the angle between the radius through the point and the equatorial plane. The number of latitude degrees cannot exceed 90° and ranges from 0° at the equator to 90° at the poles. Areas described as having low latitude are those expressed with lower coordinates or are nearer to the equator, while those with higher latitudes are those expressed with higher coordinates and are far from the equator.
Degrees of latitude are equally spaced, but due to the slight flattening of the earth at the poles the length of a degree of latitude varies from 110.57 km at the equator to 111.70 km at the poles.

In addition to easily locating places on earth, latitude is very crucial to geography because it helps navigation and researchers comprehend or understand the various patterns observed on earth. We know that high latitudes for example have cooler climates than low latitudes. It is much colder and drier in the Arctic than in the tropics. This is a direct effect of the unequal distribution of solar radiation between the tropics and the other temperature zones.

It is also important to stress that latitude also results in extreme seasonal variations in climate, because the angle of the sun varies at different times of the year depending on latitude. This can in turn affect the types of flora and fauna that can survive in an area. Equatorial rainforest for example is the most biodiversity place in the world while the difficult temperature conditions in Arctic and Antarctic regions make it difficult for many species to survive.

**Important Lines of Latitude**: when referring to latitude, there are three different important lines to remember. One of these important lines of latitude is the equator. The **equator**, being located at $0^\circ$, is the longest line of latitude with a length of 40,075.16 km. It is an important line of latitude; the great circle which shows the exact center of the Earth and divides that Earth into two Northern and Southern Hemispheres and also receives the most direct sunlight on the two **equinoxes** (March 21 and September 23). It passes through Indonesia, Somalia, Kenya, Uganda, Democratic Republic of Congo, Congo, Gabon, Brazil, Colombia, and Ecuador.

The **Tropic of Cancer** found at $23\frac{1}{2}^\circ$N runs through Mexico, Egypt, Saudi Arabia, India and southern China.

The **Tropic of Capricorn** is located at $23\frac{1}{2}^\circ$S and runs through Chile, southern Brazil, South Africa and Australia. These two parallels of latitude are important since they receive direct vertical rays on the two **solstices** (June 21 and December 22). These two parallels of latitude are momentous or important in delineating the area known as the **tropics**.

Lastly, the **Arctic** and **Antarctic** circles are also important lines of latitude. They are located at $66\frac{1}{2}^\circ$N and $66\frac{1}{2}^\circ$S respectively. These demarcate places experiencing 24 hour sun light and 24 hour darkness in the world.
**Longitude:** is the angular distance of any point on Earth measured east or west of the prime meridian and is expressed in degrees, minutes, and seconds.

Even though the **equator** was a clear preference as the prime parallel, being the largest; no one meridian was exceptionally qualified as prime meridian. Until a single prime meridian could be agreed upon, each nation was free to choose its own prime meridian. As a result, most maps of the 19th-century lacked a standardized grid. This problem was resolved in 1884, when an international **prime meridian**, passing through London’s Greenwich Observatory, was officially selected and a metallic marker was designed to indicate its exact location. Because of this designation, longitude had begun to be measured in degrees east or west of the $0^\circ$ Prime Meridian. For instance, $40^\circ$ E, the line passing through Eastern Africa, is an angular distance of $40^\circ$ measured east of the Prime Meridian. On the other side the $40^\circ$ W, which is in the middle of the Atlantic Ocean, is an angular distance of $40^\circ$ W of the Prime Meridian. The number of longitudes never exceeds $180^\circ$ ranging from $0^\circ$ at the prime meridian to $180^\circ$ at the **International Date Line**. This is where the eastern hemisphere and the western hemisphere meet. It also marks the line where each day officially begins. The west side of the International Date Line is always one day ahead of the east side, no matter what time of day it is when the line is crossed. The main reason for this event is that the earth rotates from west to east on its axis.

A new concept to measure longitude was emerged when Galileo determined that the possibility of measuring with two clocks. He stated that any point on earth took 24 hours to complete the full $360^\circ$ rotation of the earth. He discovered that if $360^\circ$ is divided by 24 hours a point on rotating earth took $15^\circ$ of longitude to travel in an hour. Because of this with an accurate clock at sea, a comparison of two clocks is found possible to determine longitude. Accordingly, one clock would be at the port and the other on the sailing ship. Then the time difference was easily identified as one hour represented a $15^\circ$ change in longitude.

Nowadays, longitude is well accurately or precisely measured with atomic or tiny clocks and satellites. As the earth is divided equally into $360^\circ$ of longitude with $180^\circ$ east and $180^\circ$ west of the prime meridian, the longitudinal coordinates are also divided into 60 minutes and the minutes further divided into 60 seconds.

Each degree of latitude and longitude is divided into 60 minutes, and each minute divided into 60 seconds, which enables us to assign a precise numerical location to any point on earth. At the equator, meridians of longitude which are one degree apart are separated by a distance of 111.32 km and converge at the poles.

Latitude and longitude should not be confused with the terms of parallel and meridian also called parallel of latitude and meridian of longitude.
Halfway between the poles, lays the **equator**, a great circle, divides the earth into northern and southern hemispheres. It is valued a latitude of $0^\circ$.

Parallel to the equator and north and south of it are a series of imaginary circles that become lesser and lesser the closer they are to the poles. This series of east-west-running circles, known as the **parallel** of latitude, is an imaginary (unreal) line joining points with equal latitude degrees. Latitude lines are also called parallels because they are parallel and equidistant from each other.

Similar to the equator, parallels are also identified as circles of latitude or lines that ring or circle the whole earth. Unlike the other parallels, the equator divides the earth into two equal parts and its center corresponds with that of the earth. Therefore it is the only line of latitude that is a great circle while all other parallels are forming small circles.

The degree measure of latitude is the value of the angle from the equator whereas the parallel values the actual line along which degree points are measured. For instance, $40^\circ$N latitude is the angle of latitude between the equator and the $40^\circ$th parallel. This parallel is the line along which all latitudinal values are $40^\circ$. The line is also parallel to the $41^\circ$th and $39^\circ$th parallels.

The other series of half-circles extending north and south from one pole to the other, called the **meridian** of longitude is also an imaginary line connecting all points with equal longitude degrees. The other important thing to be mentioned here is that the meridians by converging towards the North Pole indicate the **Geographic** or **True North**.

**Distance between Lines:** If you divide the circumference of the earth, which is approximately 40,000 km by 360 degrees, the distance on the earth’s surface for each one degree of latitude or longitude is just over 111 km. As you move north or south of the equator, the distance between the lines of latitude and longitude gets shorter until the meridians actually meet at the poles. At the equator, one degree of longitude is the same length as one degree of latitude and at the north and south poles, the distance between degrees of longitude becomes zero. The following figures illustrate lines of latitude and longitude.
The National Grid Systems:

The national grid is a system of metric coordinates, shown as vertical and horizontal lines on maps, used for map reference purposes. They are usually printed on almost all topographic maps to be utilized in locating and describing position.

Horizontal and vertical lines drawn on a map make a net work of a grid. These lines form perfect squares and are divisible into smaller and smaller squares, like squares with sides of 100 km, 10 km and 1 km. The bigger and smaller squares use lines with different thicknesses and forms. Each line is numbered from a particular point which is usually, by convention or agreement, the south-western of the whole grid for the country. From this origin all vertical lines are numbered eastwards forming eastings, while all horizontals are numbered northwards by forming northings. Therefore on topographic maps the geographic grid is supplemented with a national or regional grid composed of squares of different sides depending on the scale of the map. For example squares with the sides of 100 km have been used on the Ethiopian 1:500,000 topographic maps and these have been divided into smaller squares with sides of 10 km. The 1:250,000 topographic map of Ethiopia is based on a basic grid composed of squares with sides of 10 km. The other maps with larger scale like 1: 20,000 have squares with 1km side.

It is worth mentioning that the lines forming net works in the national grids system should not be confused with the parallels of latitudes and meridians of longitudes. In order to make a distinction between them Horizontals or Northings can be used for a set of lines running from east to west and Verticals or Eastings for the lines that run from north to

Figure 3: latitude and longitude together with parallels and meridians (Microsoft Encarta 2009)
south. Unlike the meridians, the verticals do not indicate true north. The direction shown by the verticals is called the **Grid North**.

The other difference between the geographical grid and the national grid is that the national grid measures distances in kilometer from the “grid origin” located in the south western most corner of each country; while the geographical grid is based on degree distances measured from the point where the great circle, the equator crosses the prime meridian. (D.N.McMASTER, Map Reading for East Africa, 1967).

The grid origin used on Ethiopian maps, is located outside the country being a regional grid rather than a national, at a point in North West Kenya, where the 34° 30' E meridian crosses the equator.

The position of Addis Ababa in this grid system will approximately be 470 km east and 1000 km north of the grid origin.

In this grid system, a small part of Western most Ethiopia remains outside of the national grid. Therefore, for this part another grid origin should be used (Kurt Roselius, 1991).

![Figure 4: The grid origin for Ethiopia, where the 34°30'E meridian crosses the equator.](image)

**Magnetic Declination**

The earliest identification of magnetic declination was completed by the Chinese in about 720 AD. But the Europeans perception of declination was known in the early 1400s. However, the first accurate measurement of declination was achieved in 1510, when Georg Hartman for the first time determined the declination in Rome. The significance of
declination for navigation was understandable. Mariners quickly worked out methods for determining it and started to compile declination values from various locations around the world. In 1700 Edmund Halley appeared with the idea of depicting declination as contour lines on a map; he used this novel idea by producing the first declination chart of the Atlantic Ocean. Starting from this novel work declination charts have been produced on a regular basis.

Magnetic declination also undergoes changes that are much more rapid than the other variations as a result of magnetic activity. Changes in declination increase as one approaches the North Magnetic Pole. The number of times per year that a compass user will be influenced by changes in declination caused by magnetic storms will depend both on the user’s application and position.

It is also important to know that the declination shown in the diagram on the topographic map is not the true declination. Declination is defined as the angle between magnetic north and the true north. However, the diagram on the topographic map sheet gives the value of the angle between magnetic north and grid north, which is referenced to the grid lines shown on the map. This angle is properly called grid declination. The angle between grid north and true north is called the convergence angle. To obtain the true declination it is necessary to add or subtract the convergence angle to the Grid Declination. The diagram below illustrates four possible combinations.

![Diagram illustrating four possible combinations of declination angles](image)

Figure 5: Illustrates four possible combinations
In figure 5:

- the star indicates true north;
- the square indicates grid north;
- the arrow indicates magnetic north;
- G refers to grid declination;
- C is the convergence angle;
- D refers to the declination.

All quantities are considered positive. Four cases are illustrated:

1. Magnetic north west of true north; grid north west of true north;
2. Magnetic north west of true north; grid north east of true north;
3. Magnetic north east of true north; grid north west of true north;
4. Magnetic north east of true north; grid north east of true north

Magnetic declination is the angle between compass north (the direction the north end of a compass needle points) and true north (the direction indicated by the meridians towards the geographic North Pole). Generally magnetic declination or variation refers to the difference between Magnetic North and True North. The declination is positive when the magnetic north is east of true north. Magnetic declination does not vary only from place to place, but also differs from time to time in one and the same place.

In order to use any map for navigational purpose, the correct magnetic declination for the area in the year when the map was printed and the annual magnetic variation should be given in the marginal information. Most navigational maps demonstrate magnetic declination by using Isogonic lines. These are imaginary lines joining points with the same magnetic declination. The other set of lines are referred to as Agonic lines, which join points that have a zero declination. For instance, in Ethiopia, the agonic line in 1975, passed through L. Tana-Addis Ababa-Ginnir. The annual declination from the true north for Ethiopia is 2' (minute) towards east per year. This shows that the points that were on the agonic line in 1975, for instance Addis Ababa, will have a magnetic declination of 2' (minute )to the east in 1976. But it is important to remember that the annual change does not remain constant with time. Therefore, using the annual change to update the declination on an old map is likely to result in an error in the updated declination.

When using a map and a compass jointly for navigational purposes the necessary corrections should be taken into consideration. Simply speaking, true north is the direction in which the North Pole is located along the Earth’s rotational axis, while magnetic north is the direction toward which the compass needle points and the direction indicated by this north seeking magnetic needle is referred to as Magnetic North.
Figure 6: Example of magnetic declination showing a compass needle with a "positive" (or "easterly") variation from geographic north.

Source: http://en.wikipedia.org/wiki/Magnetic_declination)

**Earth’s magnetic field** (also known as the geomagnetic field) is the magnetic field that extends from the Earth’s inner core to where it meets the solar wind (a stream of energetic particles emanating from the Sun). Earth’s magnetic field changes over time because it is generated by the motion of molten iron alloys in the Earth’s outer core. The Earth’s magnetic field changes, at random intervals, which averages about several hundred thousand years. This causes the north and south magnetic poles to change places with each other. The magnetic field of the Earth largely deflects most of the charged particles emanating or originating from the sun, thus protecting it from this solar wind. These particles would strip away the ozone layer, which saves the Earth from harmful ultraviolet rays.

**Gyrocompass** is a navigational compass fitted with a gyroscope instead of a magnet. It is used in marine vessels and merchant fleets all over the world. They are free from the vagaries or unpredictable changes of the magnetic compass; they indicate true, geographic north instead of magnetic north, and they have sufficient directive force to make practicable the operation of accessory equipment. The gyroscopes transmit electrical signals to an electronic computer that combines and amplifies them. In the gyrocompass the controlling forces are applied automatically in just the right direction and proportion to cause the
gyro axle to seek and hold the true meridian, that is, to point north and south. (Microsoft Encarta 2009)

![The Earth's Magnetic Field](image)

Figure 7: Earth’s magnetic field

1.6 The Relationship between Linear and Areal Scale

Activity 1.6

Do the following questions in your geography group

a) What is linear scale?

b) What is areal scale?

c) What is the relationship between the areal and linear scales?

All the three types of scale, so far mentioned are “linear” scales, since they give the relationship between linear quantities or distances on the map and linear quantities on the ground.

The areal scale is usually not provided on a map since it can easily be found by squaring the linear scales. This also leads to the fact that as the linear scale is doubled the areal scale would be four times as big as the initial one. Therefore, after obtaining a linear scale for a map, the areal scale can easily be obtained by simply squaring the linear scale. This shows that the areal scale can be expressed as the square of linear scale. For example, the areal scale for a linear scale;
1: 10,000 would be \( \left( \frac{1}{10000} \right)^2 = 1:100,000,000 \).

The linear scale could also be obtained from the areal scales by simply finding the square roots of the areal scales. For example, if the areal scale given is \( 1\text{cm}^2 \) to \( 9\text{km}^2 \) (the square root for \( 1\text{cm}^2 \) is \( 1\text{cm} \) and the square root for \( 9\text{km}^2 \) is \( 3\text{km} \)), then the linear scale will be \( 1\text{cm} \) to \( 3\text{km} \).

1.7 How to find the Scale of a Map

Activity 1.7

Discuss the following questions in pairs

a) What are the two ways of finding the scale of a map?

b) What are the steps used to find the scale of a map when distance between the two points is known?

c) What steps are employed to calculate the scale of a map based on latitude information?

As already described, the scale of a map is the ratio of a distance on the map to the corresponding distance on the ground. Because of this every map must demonstrate this relation by providing scale. But sometimes maps purposely miss scales. This is in the case of aerial photographs or in the case of maps prepared for exercise purposes. In the absence of the scale it is impossible to make any sort of calculation. Therefore measurement of distances and areas in this case is only possible if some additional information is available that could be utilized in finding the scale of the map. Below we shall discuss two important cases in which scales could be obtained when not provided.

Case I: When distance information is given between two points.
Figure 8: How to find scale, with given distance information

Given: The straight line distance between points A and B on the exercise map is measured 4cm and the corresponding real distance between the aforementioned points is 80km. Then based on this information you can obtain the ratio scale of the map, since the information has already provided you with one type of scale, i.e. the verbal scale, which is 4cm to 80km.

Therefore: 4cm: 80km, 1cm: 20km, 1cm: 2,000,000cm. Leave the units and write the scale as a ratio.

R.F. 1: 2,000,000 or \( \frac{1}{2,000,000} \)

Case II: When distance information is not available on the exercise map instead the map is provided with latitude and longitude markings, the scale of a map can also be roughly calculated.
Figure 9: How to find scale, with given degree information

Given: The distance between the two points on the exercise map is 5cm and the corresponding degree distance is $\frac{1}{2}^\circ$. Since $1^\circ$ latitude is roughly 111km, then $\frac{1}{2}^\circ$ will be $\frac{111}{2} = 55.5$km. Therefore 5cm: 55.5km, 1cm: 11.1km=1,110,000cm. Leave the units and write the scale as a ratio.

R.F. 1:1,110,000 or \[ \frac{1}{1,110,000} \]

1.8 The Measurement of Regular and Irregular Shaped Areas

Activity 1.8
Do the following questions in your geography group.

a) Give examples of regular shaped geometric figures.

b) What are the steps used in calculating the areas of regular shaped figures.

c) Show the methods used for calculating areas of irregular shaped figures.

One of the most important uses of map is to find areas of both regular and irregular shaped figures. Area and distance have direct relations. In map exercises one might be asked to find areas of both regular and irregular shaped pieces of land. The procedure of finding areas of regular shapes and irregular shapes is not the same.

**Regular shaped areas**: These include squares, rectangles and triangles. In mathematics you know the formulae for calculating the areas of these geometric figures. The only thing required here is to know the necessary facts about them, like sides, base, height, etc. and applying the formulas designed. It is possible to obtain these facts through measurement on the maps by using accurate rulers.

<table>
<thead>
<tr>
<th>Area of Rectangle: Length x Breadth</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Area of Square: Length x Length</td>
<td></td>
</tr>
<tr>
<td>Area of Triangle: 0.5 x Base x Height</td>
<td></td>
</tr>
<tr>
<td>Area of Circle: ( \pi r^2 )</td>
<td></td>
</tr>
</tbody>
</table>

**Area of a rectangle**: If the area of the piece of land to be calculated is somewhat rectangular in shape, measure its width and length on the map. Then convert these distances in to kilometers by using the scale properly, before carrying out the computation or calculation required in finding the areas of rectangular shapes.

Scale: 1: 50,000, length: 4.4cm, width: 3.6cm, formula: L x scale x W x scale

Steps:
• Measure length in cm and convert to km.
• Measure width in cm and convert to km.
• Apply formula — L x W.
• Write the answer in km².

\[
L = 4.4 \times \frac{50000}{100000} = 2.2 \text{ km.}
\]

\[
W = 3.6 \times \frac{50000}{100000} = 1.8 \text{ km}
\]

Area = 2.2 km x 1.8 km = 3.96 km²

**Area of square**: If the area to be calculated has a square shape you can measure one side of the square and multiply by the scale of the map and convert the centimeter distance into kilometer by dividing by 100,000 (1km=100,000cm). Then you can apply the formula used for finding the area of the square, i.e. \( S^2 \).

Example: The side of a square having a length of 2.5cm on a map with the scale 1:250,000, then the area will be:

\[
2.5 \text{ cm} \times 250,000 = \frac{625000}{100000} = 6.25 \text{ km.}
\]

Area: 6.25 km x 6.25 km = 39.06 km².

**Area of a triangle**: In the case of the area of a triangular figure, the steps used in relation with the other figures are also to be applied except the formula.

Example: The area of triangular figure that has 3 cm base and 5 cm height on a map with scale 1:50,000 will be:

\[
B = 3 \text{ cm} \times 50,000 = \frac{150000}{100000} \text{ cm} = 1.5 \text{ km.}
\]

\[
H = 5 \text{ cm} \times 50,000 = \frac{250000}{100000} \text{ cm} = 2.5 \text{ km.}
\]

Area: 1.5 km x 2.5 km x \( \frac{1}{2} \) = 1.9 km².

**Irregular shaped areas**: Most areas to be measured on maps are, usually irregular in shape. These areas can be obtained from maps:
By using **plani meter**: This is a small device used for measuring areas of both regular and irregular shaped figures by simply moving over the perimeter.

![Planimeter](https://www.google.com.et/search?q=planimeter&tbm)

**Figure 10: planimeter**


**By covering the area with a rectangle**: If the area to be calculated is regular to some extent, you can cover the area by a rectangle that is approximately drawn. The rectangle should be drawn approximately in such a way that the parts of the area that are excluded by the rectangle should be compensated by including approximately equal parts that are not necessarily form part of the area. After covering the area in question with the rectangle, it is now easy to calculate the area by measuring the length and the width of the rectangle. The actual area can now easily be obtained through use of scale and the formula applied in finding the area of the rectangle. See the figure below.

![Area calculation](https://example.com/area_calculation.png)

**Figure 11: How to find the area of an irregular shape**

**By using Graph paper**: In this method the map is superimposed or covered with a suitable sized graph paper and clamped or attached firmly. As the area of each square of a graph is known counting the approximate number of squares and multiplying by the scale
of the map can give you the area of the irregular shaped figure. For example, if the square used to cover the area in question has a side of \( \frac{1}{2} \) cm you can count all squares that are totally within the shape. Then count the remaining approximate half squares and quarter squares. Then sum up your pieces of squares and multiply them by the scale of the map to obtain the area of the figure.

How to proceed:

Scale of the map: 1: 200,000

Area of the square with the side of \( \frac{1}{2} \) cm = \( \frac{1}{2} \) cm \( \times \) \( \frac{200000}{100000} \) = 1 km and its areal scale will be: 0.25 cm² to 1 km², considered to be full squares. The number of full squares with the sides of \( \frac{1}{2} \) cm by \( \frac{1}{2} \) cm is counted to be 35 and when multiplied by the areal scale, it gives you 35 km². If the number of half squares counted is 12 and when this is multiplied by the areal scale it becomes 6 km². Then the area of the figure will be 41 km².

1.9 Statistical Diagrams

Activity 1.9

Discuss the following questions in your geography group.

a) What is the term statistics?

b) Give examples of statistical information.

c) In geography how are statistical figures presented?

d) What are statistical diagrams?

e) Give examples of statistical diagrams.

f) What is a line graph?

g) What is a bar graph?

h) What is the pie chart?

i) What are the main uses of a pie chart?
Statistics is a branch of mathematics and deals with analysis and interpretation of numerical data in terms of samples and population. Some of the statistical diagrams used in geography include line graph, bar graph and pie chart.

Line graphs: These provide a diagrammatic demonstration of the relationship between variables and how that relationship changes. For example, you might make a line graph to show how population growth rate varies over time, or how a temperature of a certain place varies from month to month. It is also possible to graph more than one data set on the same line graph, as long as it relates the same two variables. For example: You could graph the average monthly high temperature and the average monthly low temperature for a given city on the same graph, because all the data still apply to the same two variables: temperature and month.

Steps to draw a line graph:

1) Draw a large cross in the middle of your graph paper

2) Label each axis with the variable it represents. To continue the temperature-time example from the introduction, you would label the x-axis as months during the year, and the y-axis as temperature.

3) Identify the range of data you have to include for each variable. To continue the temperature-time example, you'd select a range that was large enough to include the highest and lowest temperatures you plan to graph.

4) Decide how many units every line on the graph represents for each of your variables. You might designate a scale of 5 degrees Celsius per line to measure temperature along the Y-axis, and a scale of one month per line to measure time along the X-axis

5) Plot your data on the graph. For example: If the high temperature in your hometown was 30 degrees Celsius in June and July, locate the months on the X-axis and the "30 degrees" line on the Y-axis. Trace both lines to the point where they intersect. Place a dot on the intersection. Repeat for all your other data.

6) Connect the left-most dot and the dot to its right with a straight line. Continue connecting the dots, one by one, working from left to right.

7) Write the graph’s title at the top of the page.
Figure 12A: Example of a line graph

Temperature Graph of your Home Town
Bar graph: This is a chart that uses either horizontal or vertical bars to show comparisons among groups with rectangular bars having lengths proportional to the values that they represent. The bars can be plotted vertically or horizontally. This vertical bar chart is also identified as a column bar chart.

A bar graph is a chart in which one axis of the chart illustrates the specific categories being compared, and the other axis represents a separate value. Some bar graphs present bars clustered in groups of more than one (grouped bar graphs), and others show the bars divided into subparts to show cumulate effect.

Steps to draw a bar graph

1) Determine the discrete or separate range.

2) Examine your data to find the bar with the largest value. This will help you determine the range of the vertical axis and the size of each increment.

3) Then label the vertical axis.
4) Examine your data to find how many bars your chart will contain. Use this number to draw and label the horizontal axis.

5) Determine the order of the bars. Normally, bars showing frequency will be arranged in chronological (time) sequence.

6) Draw the bars. If you are preparing a grouped bar graph, remember to present the information in the same order in each grouping. In a column bar chart, the categories appear along the horizontal axis; the height of the bar corresponds to the value of each category.

Bar graphs are a great way to visually display your data in order to compare items or show how they change over time. Making a bar graph and plotting your data is a simple process once you understand the basic components of all bar graphs.

**Components of bar graphs:** All bar graphs have 4 basic elements.

The first is a title, which is a critical component of the bar graph because it clarifies the overall significance of the data.

The second element of a graph is the x (horizontal) axis, which can also be called the grouped data axis because it represents the data groups.

The third element is the y (vertical) axis (or frequency data axis), which represents the frequency at which the data occurs.

The final graph component is the bars themselves, which are rectangular blocks. Each bar represents the data for one data group, and the height of the bar corresponds to the frequency of the data.

![Average rainfall in mm per month](image)

Figure 13: Average rainfall in mm per month
A pie chart also called a circle graph is more appropriate to illustrate samples of the whole population, production, area, etc. In this respect the total population or quantity is by a circle of any size. The whole circle is being equivalent of 100% or 360°. Therefore a pie graph is a circular chart divided into sectors or components parts illustrating numerical proportion or part of whole. In a pie chart, the arc (section of a circle) length of each sector is proportional to the quantity it represents.

Pie charts are very widely used in the business world and the mass media. However, they have been criticized, and many experts recommend avoiding them, pointing out that research has shown it is difficult to compare different sections of a given pie chart, or to compare data across different pie charts. Pie charts can be replaced in most cases by other plots such as the bar chart.

**Steps to draw a pie graph**

1. Compute the percentage share of every sector.
2. Change all data into sectoral values by using the formula given below.
3. Draw a circle of any suitable size, like 1 cm, 2 cm, 3 cm, 4 cm, and etc. radius.
4. Mark all the sub divisions with a protractor on a circle starting from the highest value from the top and marking the other values in descending order.
5. Finally, write the name and percentage value of each sector.

\[
\text{sectoral value} = \frac{\text{component value}}{\text{total value}} \times 360°
\]
A map is a visual depiction of all or part of the earth's surface on a flat piece of paper that can be carried and transported easily.

It is a symbolic representation of useful information that communicates ideas and designs and appears as if it were drawn from the view of someone sitting in a flying object.

Generally maps are produced to symbolize the Earth's surface, showing how things are correlated to each other by distance, direction, and size.

Cartography is the art and science of creating maps.

The first map of the world was drawn by Anaximander-ancient Greek geographer, who is considered by many to be the first map maker.

The oldest known maps are those preserved on the clay pieces of Babylonians from about 2300 B.C.

The Medieval period European maps were dominated by religious views in which Jerusalem was portrayed at the center and east was tilted or oriented toward the map top.

Geographic information system (GIS) is a means of collecting, storing, integrating, analyzing, and presenting geographic data. Important components of GIS include combination of computers, databases, and software.

Global Positioning System (GPS) is a device that provides an earth coordinate position based on the reception of special satellite transmissions.

Some of the basic uses of maps are listed as follows:

- **Location**: Maps show the exact site and the general situation of places.
- **Distance**: By using the map and the scale properly, one can calculate the distance between two points.
- **Area**: The size of a certain point or a country can be calculated from most maps correctly through accurate measurements on maps and proper utilization of scale.
- **Direction**: The direction or bearing from one point or place to another can be obtained correctly from most maps.

Topographic maps demonstrate the natural features of the area covered as well as certain non-natural features, known as cultural features.

A physical map is one that illustrates the physical landscape features of a place. They generally depict things like mountains, plains, rivers and lakes.

A cultural map does not show any topographic features. It instead focuses solely on the human made features.

Thematic (special purpose) maps are maps that focus on a particular composition or special topic.
Quantitative thematic maps are also known as statistical maps and display spatial distributions of geographical elements representing quantitative values.

As a rule, smaller scales show less details and their presentation becomes more generalized.

The initial activity for a map reader after obtaining the map is not to study the map itself or appreciate the colors, but referring to the information provided in the margin of the map.

Magnetic declination or variation shows the angular difference between true north and magnetic north.

In order to communicate or convey its message in a summarized form a map uses its own language, expressed or articulated with the help of its conventional signs and symbols.

A large scale map covers a small area while a small scale map covers a large area.

Geographical grid is made up of meridians of longitude and parallels of latitude.

Latitude is the angular distance that provides the location of a place north or south of the equator and is expressed in degrees, minutes, and seconds.

Longitude is the angular distance of any point on Earth measured east or west of the prime meridian and is expressed in degrees, minutes, and seconds.

The national grid is a system of metric coordinates, shown as vertical and horizontal lines on maps, used for map reference purposes.

Magnetic declination is the angle between compass north (the direction the north end of a compass needle points) and true north (the direction indicated by the meridians towards the geographic North Pole).

Isogonic lines are imaginary lines joining points with the same magnetic declination.

Earth’s magnetic field (also known as the geomagnetic field) is the magnetic field that extends from the Earth’s inner core to where it meets the solar wind (a stream of energetic particles emanating from the Sun).

Gyrocompass is a navigational compass fitted with a gyroscope instead of a magnet.

Planimeter: is a small device used for measuring areas of both regular and irregular shaped figures by simply moving over the perimeter.

Statistics is a branch of mathematics and deals with analysis and interpretation of numerical data in terms of samples and population.

Answers for Unit 1 activities:

Activity 1.1

a) A map is a simplified, diminished, plane representation of all or parts of the earth’s surface as viewed from vertically above.
b) A map represents all or part of the earth’s surface.

c) Spherical.

d) Side view, oblique or slanting view, vertical or bird’s-eye view.

e) Reduced in size. It is impossible to draw objects with their true size on a piece of paper.

f) Selecting the information and summarizing the information.

**Activity 1.2**

a) Map.

b) Traditional map making and modern map making.

c) Most traditional maps were made by traditional materials like sticks, clays, shells and etc. Measurement was made by hand and was inaccurate. But modern map making uses modern instruments like computers, cameras, satellite imagery, GIS, etc.

d) Eratosthenes was a Greek mathematician, geographer and astronomer.

e) Nowadays computers play roles in the collection, storage, analysis and presentation of data, and even in the mapping and reproduction of maps.

f) Cartographers are map makers and cartography is the art and science of making maps.

g) Geographic information system (GIS) is a means of collecting, storing, integrating, analyzing, and presenting geographic data. It consists of a combination of computers, databases, and software. The first step in developing a GIS is to create the geographic data from sources like specially designed airplanes, remote sensors and the Global Positioning System.

h) Global Positioning System (GPS) is a device that gives an Earth coordinate position based on the reception of special satellite transmissions. The position is worked out, by triangulation, based on the relative positions of at least three satellites.

**Activity 1.3**

a) Maps are basically used for identifying location, distance, area and direction.

b) Relative and absolute.

c) 3°N-15°N, 33°E-48°E.
d) Distribution or thematic maps.

e) Human made and natural features.

f) Maps show the whole world on a plane surface which makes easy for a map user to make visual comparison.

g) Maps can provide planners with vital information to plan for the future.

**Activity 1.4**

a) Purpose and scale.

b) A general-purpose map is a map that shows a wide range of information about the place it represents. Topographic maps.

c) Their ability to provide different information is their advantage and their disadvantage is that they show limited details.

d) Specific-purpose or topical maps.

e) Shows detail information of a single topic.

f) Scale is a ratio that shows the degree to which the area that is mapped has been reduced. **Map scale** is defined as the distance on a map compared to that same distance on the earth's surface.

g) Large scale maps, Medium scale maps and Small scale maps.

h) A large scale maps present a relatively small area with greater details. Medium scale maps cover wider areas than large scale maps, but cover smaller areas than small scale maps. The small scale maps cover wider areas than large and medium scale maps.

Comparison of scale: \[
\frac{1}{10} \Rightarrow \frac{1}{100} \Rightarrow \frac{1}{1000} \Rightarrow etc
\]

**Activity 1.5**

a) Information presented in the map's margins.

b) The type of information provided by the map.

c) To judge whether the map is current or old. Date is important, because geographic information is very dynamic.

d) Explains the meaning of the signs and symbols used on the map.
e) A north direction indicated by geographic grids or meridians.

f) The angular difference between magnetic north and true north.

g) Signs and symbols used on maps through the agreement of all map-makers of the world.

h) They should be uniform, easy to understand and consistent in space occupation and orientation.

i) A set of imaginary lines that divides the earth’s surface into regular grids.

j) International or Geographic Grid System and National Grid System

k) International (Geographic) Grids give absolute location with latitude and longitude degrees.

l) Parallels are imaginary lines that join all points with the same latitude degrees. Meridians are also imaginary lines that join all points with the same longitude degrees. Latitudes are angular distances measured to the north and south of the equator. Longitudes on the other hand are angular distances measured to the east and west of the prime meridian. The equator, being located at 0°, is the longest line of latitude with a length of 40,000 km. It is an important line of latitude; the great circle which shows the exact center of the Earth and divides that Earth into two Northern and Southern Hemispheres. Prime meridian (0°), which passes through London’s Greenwich Observatory, divides the earth into two eastern and western hemispheres.

m) National or regional grid made up from squares with 100 km, 10 km and 1 km sides and gives position of points.

n) Eastings are imaginary lines that run from north to south (Verticals) joining points having the same distance from the National grid origin. They are referred as eastings, since they measure distances to the east of the grid origin. Northerings are the horizontals that measure distances to the north of the grid origin.

o) North Pole and South Pole.

p) A device for finding directions, usually with a magnetized needle that automatically swings to magnetic north.

q) A navigational compass fitted with a gyroscope instead of a magnet is used in marine vessels and merchant fleets all over the world.

Activity 1.6

a) Scale that expresses the ratio of the distance measured on a map to ground distance.
b) Areal scale shows the relationship between map area and ground area.

c) Areal scale is simply the square of linear scale.

**Activity 1.7**

a) By using the known distance between two points on the map and by using latitudes.

b) Measuring the distance between the points on the map with a ruler and equating this with the ground distance known between the two points.

c) Measuring the distance on the map between the latitudinal marks, equating this with the degree distance and converting it to a kilometer then to centimeter unit to obtain the scale.

**Activity 1.8**

a) Circle, rectangle, square, triangle, etc.

b) Measuring the lengths on a map and multiplying with the scale and apply the formulae for calculating areas.

c) By using a device called planimetre, covering the figure with approximately drawn rectangle and by using graph paper.

**Activity 1.9**

a) Statistics is a branch of mathematics that deals with the collection, organization, and analysis of numerical data.

b) Information about crop production, population growth, industrial growth, etc.

c) By using statistical diagrams.

d) Pictorial representations of numerical information.

e) Charts, graphs and diagrams.

f) A graph that uses lines to show changes over time.

h) Pie charts are circle graphs.

i) They are primarily used to show the sizes of parts in relation to a single whole and in relation to each other.
Unit 2: DIRECTION AND POSITION ON MAPS

Unit outcome

After completing this unit, you will be able to:

- Develop the skills of identifying direction and measuring distances on map, and practice, map enlargement and reduction
- Acquire basic skills of locating places and objects on maps using different methods
- Understand the different ways of representing relief on maps

Main Contents

2.1 Identification of Direction
2.2 Measurement of Direction and Bearing
2.3 Position on Maps
2.4 Map enlargement and reduction
2.5 Methods of showing Relief on Maps
2.6 Slops and Gradients
2.7 Field Distance

◆ Unit Summary
◆ Answers for Unit 2 Questions

2. DIRECTION AND POSITION ON MAPS

Competencies:

At the end of this section, you will be able to:
- Acquire the skill of finding direction on a map
• Show direction of a given place on a map by means of compass direction and bearings
• Explain the use of magnetic compass
• Practice how to find direction and bearings of points on maps
• Define what geographical grid system means
• Demonstrate the position of a given place by means of geographic grid system
• Define what national grid system means
• Show the position of places on maps using national grid references (four and six digits grid)
• Demonstrate the national grid origin of Ethiopia
• Enlarge and reduce maps using a pantograph or square methods
• Compute the scale of enlarged or reduced map
• Describe methods of showing relief on maps
• Define the term contour lines
• Discuss the properties of contour lines
• Distinguish contour lines and isolines
• Identify the different ways of showing specific height on contour map
• Compute the altitude of points between contour lines
• Explain the term slope
• Demonstrate types of slope
• Describe the term gradient of slope
• Compute gradient of slope
• Express gradient in different ways
• Calculate field distance

2.1 Identification of Direction

Activity 2.1
Discuss the following questions in small group.
a) Define the geographic term direction.

b) What is a landmark?

c) How the landmarks are used to indicate direction?

d) Which tools are used to find direction?

e) What are the four cardinal points of a compass?

f) Which points of a compass are used to indicate direction?

g) Mention the point midway between the cardinal points.

h) What is the starting point to measure direction?

i) How much is the degree distance between NE and SW?

j) What is the degree difference between NNE and NNW?

Direction is the way somebody or something goes, points or faces. It is defined as an imaginary straight line on the map showing the angular position of various maps with relation to a common base direction.

Many kinds of features are shown on some maps, although omitted from others, because of the landmark character of the features. A landmark is an object of sufficient interest in relation to its surroundings to make it outstanding. For example, buildings may be considered landmarks when they are used as schools or churches or mosques or when they have some other public function. They may be landmarks also because of their outstanding size, height, or design; or they may be landmarks because of their history, such as old forts or the birthplaces of famous men. The same principle is applied to features other than buildings, but the adjacent area always is considered in relation to the object. Where map features are few, objects that would not be shown in more congested districts may be mapped as landmarks. Most maps provide a reference or orientation point to indicate how a direction on the map corresponds to a direction in the real or actual world. This is crucial or decisive when using the map to travel between points. A map indicates a cardinal direction for such point of reference usually by an arrow pointing north. Maps from past centuries used different cardinal directions. The cardinal direction could be anyone. For instance some older European maps placed East at the top, pointing to the area then known as the Orient, the term latter replaced by orientation. The reason for the selection of East as a cardinal direction in Medieval Europe was that Jerusalem, which was believed to be the centre and as the same time the most important place on the Earth, was located to the East of Europe. The ancient Chinese selected south as their cardinal direction. The main reason for the Chinese maps to use south as starting point to measure direction was that especially to the people in the northern China, the rich fertile southern China
was the place to move to during times of starvation or famine. Though, as inventors of
the magnetic compass, the Chinese adjusted their compass needles to point to the south.
The old Muslim maps also placed south pointing upward. Nowadays North is
internationally considered to be the cardinal direction. As a result modern maps usually
adopt the convention or principle that the top of the map corresponds to North, the
bottom to South, the left edge to West, and the right edge to East. Therefore all views
are oriented with North as up except when the map is centered on the North Pole or
South Pole.

The North and the South Poles symbolizing the rotational axis of the earth do not
correspond to the magnetic poles, the direction a compass points. This is because the
magnetic poles constantly vary from place to place and from time to time. The north-
pointing arrow on many accurate maps is divided into two parts, one indicating true north
and one indicating magnetic north. The angular difference between the true north (the
direction indicated by the meridians) and the magnetic north (the direction indicated by a
compass) is known as the map’s magnetic declination or variation. For example, according
to a 1987 map of Moscow, the compass points to magnetic north at 7° 46’ to the right
of true polar north, so the magnetic declination according to this map is 7° 46’ east. The
declination changes with a change of location on the globe and it also changes with the
change of time as the magnetic poles move. Some localities have a change in magnetic
declination of several minutes per year. Lines of longitude or meridians are oriented
toward the rotational axis of the earth. Digital maps are produced in reference to this
axis and usually ignore magnetic north.

**Compass** is a device that indicates direction and used by mariners, aviators or pilots,
campers, hunters, and other travelers to assist them to get from one place to another.

Two fundamental types of compass are used: the magnetic compass, which probably
originated in ancient China; and the gyrocompass, a device developed at the beginning
of the 20th century.

In the magnetic compass, directions are obtained by means of one or more magnetic
needles pointing in the general direction of the magnetic North Pole under the influence
of the magnetic field of the earth.

The gyrocompass (compass with gyroscope inside) which is unchanged by the magnetism
or pull of the earth, consists of a gyroscope, with the rotating wheel on an axis restricted
to the horizontal plane so that its axis aligns itself with the north-south line parallel to
the axis of the rotation of the earth, consequently indicating true north. A gyroscope is a
self stabilizing tool consisting of a rotating heavy metal wheel pivoted inside a circular
frame whose movement does not affect the wheel’s direction in space. (Microsoft Encarta
2009).
2.2 Measurement of Direction and Bearing

Activity 2.2

Discuss the following questions in pairs

a) What is the difference between direction and bearing?

b) What do you mean by basic direction?

c) What are the two ways of giving direction?

d) What is the difference between the traditional method and the modern method of indicating direction?

e) How is the wind direction named?

f) What does a bearing of an object mean?

g) How do you measure bearing?

h) How do you calculate a back bearing?

A direction or bearing of one point from another can be given in two different sets of units. One is the traditional system which uses the cardinal compass points north, east, south, west and the subdivisions of them. This system can indicate 32 different direction points. The other one is a more modern and accurate method and provides directions in degrees, minutes and seconds.

Direction can be expressed or measured from the true north by the compass points. The compass points include N (0°), NNE (22.5°), NE (45°), ENE (67.5°), E (90°), ESE (112.5°), SE (135°), SSE (157.5°), S (180°), SSW (202.5°), SW (225°), WSW (247.5°), W (270°), WNW (292.5°), NW (315°) and NNW (337.5°).
There are more compass points than aforementioned. But they become more difficult to use and remember them. Therefore it is much better to measure or to describe direction with accuracy in degrees by using a protractor and to state it in figure.

It is known that there are 360 degrees for a square. In this measurement the direction north becomes $0^\circ$, east is $90^\circ$, south $180^\circ$ and west $270^\circ$.

A "bearing" is a term used (for example) in navigation, although it can also be used to refer to simply our direction of motion. In navigational terms, "bearing" is perhaps more usually the angle between our forward direction, and the direction from us to another object. It typically refers to the direction of, some object, as seen by us, compared to our current heading. In other words, it's simply the angle between our forward direction, and a line towards the object in question. The term can also be used to mean the "absolute" compass direction of an object, as seen by us.

In aerial terms, "bearing" means the actual compass direction of the forward course of our aircraft. In land navigation, bearing means the angle between a line connecting us and another object, and a north-south line. (Meridian)
The bearing of a point is the number of degrees in the angle measured in a clockwise direction. Bearing is a more accurate measurement than direction, because it is expressed as an ANGLE.

All bearings are taken to the right (clockwise) from NORTH by means of a protractor.

The easiest way to determine bearing from one point to the other in the field is by using a protractor. If you have a protractor with you, put it on the map with the center of the protractor on point ‘A’ or on a line drawn between points ‘A’ and ‘B’ so that it is tilting parallel to a north-south gridline. Once you have done this, it will be easy to read the bearing of point ‘B’ from point ‘A’. In figure 16 below, point B is roughly south east of A or point B bears south east from A.

Figure: 16, measurement of directions and trends on maps

How to proceed:

1) Draw a line with a pencil to join the two points (A-B);

2) Draw an arrow indicating the true north that runs through the point ‘A’ from which the bearing of point ‘B’ is required.
3) Put the protractor at point ‘A’ and measure the angular distance between the arrow drawn through the point and the line connecting point ‘B’ reading clockwise from north (0°).

4) Finally verify or state the bearing in compass points or in degrees clockwise from north.

In the absence of a protractor with you, it is possible to find the bearing you require using your compass. To do this, put your compass on the map so that the center of your compass will be on the line between points A and B. Then the edge of your compass is tilting parallel to a north-south gridline. Now rotate the map and compass together until the north arrow on the compass points to 0° and this enables you to determine a bearing between the two points.

In addition to the aforementioned measurements of direction, the other exercise involves the finding of the trend or alignment of certain extensive features like mountain ridges, coast lines, roads or rivers. In this case, the steps to be followed are:

1) Draw a pencil line, to indicate the general trend or alignment of the feature.

2) Draw an arrow indicating the true north approximately half-way along this line.

3) Set a protractor, at the point where the two lines (the line indicating the north Pole and the one drawn to show the general trend of the feature) cross one another and measure the general alignment.

In the case of a river, the procedure used to find the trend or alignment is different since the trend of the river is always downstream and as a result only one angle is supposed to be measured. (See fig. 16 above)

**Some more examples of finding position:**

a. The position of a point $P$ on a bearing of 076° is shown in the following diagram.

![Diagram showing point P on a bearing of 076°](image)

The position of the point $P$ is 76° east of north. So, the direction is N76°E.

b. The position of a point $P$ on a bearing of 150° is shown in the following diagram.
The position of the point $P$ is $180^\circ - 150^\circ = 30^\circ$ east of south. So, the direction is $S30^\circ E$.

c. The position of a point $P$ on a bearing of $225^\circ$ is shown in the following diagram.

The position of the point $P$ is $225^\circ - 180^\circ = 45^\circ$ west of south. So, the direction is $S45^\circ W$.

d. The position of a point $P$ on a bearing of $290^\circ$ is shown in the following diagram.

The position of the point $P$ is $360^\circ - 290^\circ = 70^\circ$ west of north. So, the direction is $N70^\circ W$.

2.3 Position on Maps

Activity 2.3

Discuss the following questions in your geography group.
a) What is position?

b) What are the two ways of giving position on maps?

c) What are meridians and parallels?

d) What is the difference between a parallel and latitude?

e) What is the difference between a meridian and longitude?

f) What is a national grid reference?

g) Where is the grid origin of Ethiopia?

h) What are eastings?

i) What are northings?

In unit one it has been mentioned that one of the most important uses of maps is indicating position or location of a certain point. Therefore the earliest and still the most vital use of maps was and is to demonstrate or display the position of a point as related to other points. **Position** refers to the spatial location (rather than orientation) of an entity. Generally cartographers use four conventional or socially accepted techniques to provide the position of a place. These methods vary from one another mainly in terms of exactness or accuracy required in locating a certain point in the field. The method or technique used for showing position on maps also depends on the educational level of the map user which enables her/him to understand what the cartographer has in mind when making that map. These four methods include:

I) Position by the use of place names

II) Position by the use of bearing and distance

III) Position by the use of International Grids

IV) Position by the use of National Grids. Each method will be discussed as follows.

**1. Position by the use of place names:**

A place can be located approximately by its name and where it is found; for example, Accra in Ghana, Cairo in Egypt, and Algiers in Algeria and Lake Tana in Ethiopia etc. Printing place names is the most universal and easiest way of providing the accurate position of a place on a map. This involves the marking of a place with a dot on a map and then printing its name. When finding the location of such places on a map, one
should look all over the map until the place is identified by the name attached to the dot. Example, •Addis Ababa.

After locating the place, one can use the map to locate other human made and natural features such as villages, towns, mountains, rivers, etc.

As already mentioned locating places by using their names is the simplest and easily understood. However the method exhibits some limitations. Therefore in order to locate places by using this method one should consider the following details about place names in general.

1) Place names printed on a map should be well-matched or suited to the scale of the map. For example, Addis Ababa could be marked with a dot on the map of Africa. But writing the name Addis Ababa on a map of Addis Ababa would be of no value since it is inappropriate to use the city map to locate the city itself. However one can use the map of Addis Ababa to locate different places inside the city like Bole, Arada, Gulele, Markato, Shola, etc. These place names found in Addis Ababa could only be marked on the large scale map of Addis Ababa and not on small scale map of Africa. This is because on small scale map of Africa, all the aforementioned minor places including the city itself would be marked in one and the same dot. This proves that on small scaled maps only major place names are printed, but the bigger the scale the more minor place names could be included.

2) Place names should be significant or momentous to a map user. For instance, all literate people in Africa will recognize Addis Ababa and would also like to be familiar with the exact position of it. On the other hand all the minor place names mentioned here in Addis Ababa only have a denotation or a meaning to people living in that city. Therefore it would be meaningless to print names of minor places on continental maps.

3) Place names used in a text should not be confusing when referring to a map. This is because; there are many towns and cities that share the same name. Though in order to avoid vagueness or ambiguity one should be very specific.

4) Place names may change from time to time; therefore it will be appropriate to use maps with latest edition. For example, Nazerate (currently Adama), Awassa (currently Hawassa), Debre Zeit (currently Bishoftu), etc.

II. Position by the use of bearing and distance

In this method both direction and distance are used in combination to find position on maps. It is also the simplest and the easiest method in which ambiguity could be avoided. But the direction and distance information given to a map user should be accurate and precise. At the same time the places selected as a land mark from which these directions
and distances could be measured should be major and well known so that map users could easily identify them. For instance, Ambo, 100 km west of Addis Ababa.

The two methods discussed above encompass one major deficiency or weakness in common. The major shortcoming they embrace in common is that both of them do not furnish or provide a clear-cut or specific reference to the position of a certain place. The first method offers the map user the task of finding one name among thousands of names marked on the map. The second method takes for granted or assumes that the map user be familiar with the location of the key land marks identified for orientation or reference e.g. Addis Ababa in the above example.

III. Position by the use of International Grids

This is a method that allows the map user to rapidly and precisely locate any place on the map by referring to a grid composed of a network of lines well-known as the parallels and the meridians. As discussed in unit one of this manual, the Greek Geographer Ptolemy was the first to use this net work of parallels and meridians for identifying position of places on maps.

When one makes a careful look at a globe or a wall map she/he views those two sets of lines forming a grid on the surface of a globe or a map. The set of lines that run vertically from the two poles are referred to as meridians also called lines of longitudes. The other set of lines that run horizontally around the globe or on the map parallel to each other are forming the parallels also known as the lines of latitudes.

It is worth mentioning that the core advantage of providing position by geographical grid is that it is very accurate and explicit and at the same time one doesn’t have to search the whole map to locate any place on the map. Giving position of places by the use of these Geographical Grids (latitudes and longitudes) is very valuable for small scale maps of the whole world or larger sections of the world. This is because it is the only method to acquire an international recognition and is also the only method used for transferring points from the surface of a globe to a plain sheet of paper by utilizing different map projections. However the method is not free from limitations since the parallels and the meridians used on most maps, due to the laws of map projections become curved lines and therefore the perfect determination of the location of a point is not straightforward.

In addition to this the method measures in degrees, minutes and seconds; which are not easy in computations and also bear no simple correlation to the real distances that we use in everyday life. Moreover the lengths of longitude and latitude degrees vary between the equator and the poles. For instance, the length of one degree longitude is roughly 111.1 km at the equator and becomes almost zero near the poles. On the other hand the variation in the value of the latitude degree is to the minimum, though it is not accurate enough. The following figures illustrate latitude and longitude degrees.
Figure 17A: International Grids
Figure 17B: Equatorial reference plane

Source: (Microsoft Encarta 2009).

Table 2: Geographic locations of some towns and capital cities in Ethiopia

<table>
<thead>
<tr>
<th>Locations</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Locations</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abaya, L.</td>
<td>06°30'N</td>
<td>37°50'E</td>
<td>Ethiopian Highlands</td>
<td>10°00'N</td>
<td>37°00'E</td>
</tr>
<tr>
<td>Abbe, L.</td>
<td>11°08'N</td>
<td>41°47'E</td>
<td>Genale</td>
<td>06°02'N</td>
<td>39°01'E</td>
</tr>
<tr>
<td>Addis Abeba</td>
<td>09°02'N</td>
<td>38°42'E</td>
<td>Ginir</td>
<td>07°06'N</td>
<td>40°40'E</td>
</tr>
<tr>
<td>Adigrat</td>
<td>14°20'N</td>
<td>39°26'E</td>
<td>Goba</td>
<td>07°01'N</td>
<td>39°59'E</td>
</tr>
<tr>
<td>Adwa</td>
<td>14°15'N</td>
<td>38°52'E</td>
<td>Gonder</td>
<td>12°39'N</td>
<td>37°30'E</td>
</tr>
<tr>
<td>Aksum</td>
<td>14°05'N</td>
<td>38°40'E</td>
<td>Gore</td>
<td>08°12'N</td>
<td>35°32'E</td>
</tr>
<tr>
<td>Arba Minch</td>
<td>06°00'N</td>
<td>37°30'E</td>
<td>Harer</td>
<td>09°20'N</td>
<td>42°08'E</td>
</tr>
</tbody>
</table>
### IV. Position by the use of National Grids

<table>
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<tr>
<th>Place</th>
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<th>Longitude</th>
<th>Place</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asela</td>
<td>08°00'N</td>
<td>39°00'E</td>
<td>Hinna/Imi</td>
<td>06°28'N</td>
<td>42°10'E</td>
</tr>
<tr>
<td>Hawassa</td>
<td>07°02'N</td>
<td>38°28'E</td>
<td>Jijiga</td>
<td>09°20'N</td>
<td>42°50'E</td>
</tr>
<tr>
<td>Awash</td>
<td>09°01'N</td>
<td>40°10'E</td>
<td>Jima</td>
<td>07°40'N</td>
<td>36°47'E</td>
</tr>
<tr>
<td>Bahir Dar</td>
<td>11°37'N</td>
<td>37°10'E</td>
<td>Kebri Dehar</td>
<td>06°45'N</td>
<td>44°17'E</td>
</tr>
<tr>
<td>Batu</td>
<td>06°55'N</td>
<td>39°45'E</td>
<td>Kibre Mengist</td>
<td>05°54'N</td>
<td>38°59'E</td>
</tr>
<tr>
<td>Bure</td>
<td>10°40'N</td>
<td>37°04'E</td>
<td>Lalibela</td>
<td>12°03'N</td>
<td>39°00'E</td>
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<tr>
<td>Chew Bahir</td>
<td>04°40'N</td>
<td>36°50'E</td>
<td>Mega</td>
<td>03°57'N</td>
<td>378°19'E</td>
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<tr>
<td>Danakil Desert</td>
<td>12°45'N</td>
<td>41°00'E</td>
<td>Mekele</td>
<td>13°33'N</td>
<td>39°30'E</td>
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<tr>
<td>Dashen, Ras</td>
<td>13°08'N</td>
<td>38°26'E</td>
<td>Metu</td>
<td>08°18'N</td>
<td>35°35'E</td>
</tr>
<tr>
<td>Debre Markos</td>
<td>10°20'N</td>
<td>37°40'E</td>
<td>Nazret</td>
<td>08°32'N</td>
<td>39°22'E</td>
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<tr>
<td>Debre Tabor</td>
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<td>38°26'E</td>
<td>Negele</td>
<td>05°20'N</td>
<td>39°36'E</td>
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<td>Debre Zeyit</td>
<td>11°48'N</td>
<td>38°30'E</td>
<td>Nekemte</td>
<td>09°04'N</td>
<td>36°30'E</td>
</tr>
<tr>
<td>Dembidolo</td>
<td>08°34'N</td>
<td>34°50'E</td>
<td>Ogaden</td>
<td>07°30'N</td>
<td>45°30'E</td>
</tr>
<tr>
<td>Dese</td>
<td>11°05'N</td>
<td>39°40'E</td>
<td>Omo</td>
<td>06°25'N</td>
<td>36°10'E</td>
</tr>
<tr>
<td>Dila</td>
<td>06°21'N</td>
<td>38°22'E</td>
<td>Tana L.</td>
<td>13°5'N</td>
<td>37°30'E</td>
</tr>
<tr>
<td>Dire Dawa</td>
<td>09°35'N</td>
<td>41°45'E</td>
<td>Tendaho</td>
<td>11°48'N</td>
<td>40°54'E</td>
</tr>
<tr>
<td>Dolo</td>
<td>04°11'N</td>
<td>42°03'E</td>
<td>Ziway L.</td>
<td>8°0'N</td>
<td>38°50'E</td>
</tr>
</tbody>
</table>

The National or Regional Grid is a supplementary reference to the Geographical Grid provided on a large scale or medium scale topographic maps. One important worth mentioning in this respect is that the lines forming the sides of the squares in the case of the National Grid should not be confused with the parallels and the meridians of the Geographical Grid. Therefore the lines of the National Grids could be named differently, being the **HORIZONTALS** or **NORTHINGS** for the lines running from east to west and the **VERTICALS** or **EASTINGS** for those running from north to south. Another significant difference between the two grid references is that unlike the meridians the verticals do not show the true north.

Grid systems vary, but the most common is a square grid with grid lines numbered sequentially from the origin at the bottom left of the map. The grid numbers on the east-west (horizontal) axis are called Northings, and the grid numbers on the north-south (vertical) axis are called Eastings.

Numerical grid references consist of an even number of digits. Eastings are written before Northings. Thus in a 6 digit grid reference 123456, the Easting component is 123 and the Northing component is 456.

Grids may be arbitrary, or can be based on specific distances, for example the United Kingdom Ordnance Survey maps use one-kilometer square grid spacing.

A grid reference locates a unique square region on the map. The precision of location varies, for example a simple town plan may use a simple grid system with single letters for Eastings and single numbers for Northings. A grid reference in this system, locates a particular square rather than a single point.

The National Grid system has a benefit over the International Grid in that it uses kilometer distances instead of degree distances and therefore it is easy for computational purposes.

Example: What is the four digit grid reference for the village marked H on the map? (fig.18A).

**PROCEEDINGS:**

1. Locate the vertical grid line to the left of the point and read the large number only (8).
2. Measure the tenths of the side of the square from this grid line to the point H (4).
3. Locate the horizontal grid line below the point and read the large number only (2).
4. Measure the tenths from the grid line to the point (1).

Grid reference for point H: 8421.
Figure 18A: Four digit grid reference (kurt Roselius, 1986).

Example: What is the six digit grid reference for the village marked H on the map? (fig. 18B).

**PROCEEDINGS:**

1. Locate the vertical grid line to the left of the point and read the large numbers only (63).
2. Measure the tenths of the side of the square from this grid line to the point H (8).
3. Locate the horizontal grid line below the point and read the large numbers only (59).
4. Measure the tenths from the grid line to the point (6).

Grid reference for point H: 638596.

Figure 18B: Six digit grid reference

National Grid reference numbers
The numbers going across the map from left to right are called eastings, and go up in value eastwards, and the numbers going up the map from bottom to top are called northings, because they go up in a northward direction.

There are two main types of grid reference:

- four-figure grid reference, such as ‘19 45’, indicates a 1 km by 1 km square on the map; and
- six-figure grid reference, such as ‘192 454’, indicates a 100 m by 100 m square on the map.

Sometimes you may also come across:

- eight-figure grid reference, such as ‘1926 4548’, indicates a 10 m by 10 m square on the map; and
- ten-figure grid reference, such as ‘19267 45487’, indicates a 1 m by 1 m square on the map.

In practice, it’s the six-digit grid reference number that is most commonly used, although the more digits used gives you a more precise location. GPS devices often specify at least eight-digit grid reference numbers.

**Four-figure grid references**

When giving a four-figure grid reference, you should always give the eastings number first and the northings number second, very much like when giving the reading of a graph in school, where you give the $x$ coordinate first followed by the $y$.

An easy way to remember this is that to get the first number, you go along the corridor (horizontal, $x$ axis, northings) and then up the stairs (vertical, $y$ axis, eastings).

For example, the number 2 in the diagram below is square 19 across and square 45 up and therefore, the four-figure grid reference is ‘1945’.
Figure 19A: Four-figure grid references

The numbered squares on the diagram above have the following four-figure grid references: $1 = 18\ 45$, $2 = 19\ 45$, $3 = 18\ 44$, $4 = 19\ 44$.

**Six-figure map references**

To get the six-figure grid reference, you have to imagine that the four-figure square is further divided up into tenths.

In the example below, the grey box is in the four-figure grid reference square ‘18 44’, but more accurately it is 7 tenths across and 8 tenths up within that larger grid square, therefore the six-figure map reference is ‘187 448’.
The shapes on the diagram above have the following six-figure grid references:

Grey square — 187 448
Red dot — 185 443

To be sure there is no doubt or confusion about which National Grid you’re referring, when you quote the six-figure grid reference you should put the two letters of the area you are in before the numbers.

2.4 **Map enlargement and reduction**

**Activity 2.4**

Discuss the following questions in small groups:

a) Why do you enlarge maps?

b) How do you enlarge maps?

c) Why do you reduce maps?

d) How do you reduce maps?

e) What will happen to the size of a map when the scale of the map reduces?

f) What is the formula for calculating the amount of reduction?

g) What is the formula for calculating the amount of enlargement?
h) If a map with scale 1:1000, 000 is enlarged ten times, the scale of the new map will be____.

i) When a map with scale 1:10,000 is reduced eight times, the scale of the reduced map will be____.

j) If a map with scale 1:250,000 is to be enlarged to 1:50,000, the amount of enlargement is____.

k) When a map with scale 1:20,000 is reduced to 1:80,000, the amount of reduction is____.

l) What are the methods for map enlarging and reducing?

m) What is a pantograph?

n) What are the three operational points of a pantograph?

Enlargement or reduction of maps is primarily done to get the appropriate or suitable size, according to desires. In other words, to acquire a base map on which details may be added later on to get more space for labeling further information. Reduction is done to maps of different scale to merge into one.

The importance of the scale is instantly recognized when enlarging or reducing a map. Enlarging a map is very crucial since a small scale map cannot possibly demonstrate small features. Therefore a small scale map can be enlarged to illustrate more details and on the contrary a large scale map can be reduced for different purposes. For instance, a geography teacher might be interested to make use of a map found in geography text books for the purpose of displaying in the class room as a wall map for teaching aid. In this case she/he should enlarge the map to the required size. Hence map enlargement is frequently advantageous to fabricate a replica of a map, or portion of it, with a larger scale than that of the original. This enlargement or magnification offers a foundation for a more detailed or comprehensive rough draft or sketch and more space for remarks and descriptions.

A straightforward technique of enlarging a map is to make use of the ‘square’ method. First draw a square on the map outlining the particular area to be enlarged. If only one grid square is to be enlarged, then use the existing printed grid lines as the border. On a separate sheet of paper draw a square in the same proportion as the preferred increase in scale. Example, if the preferred scale is doubles that of the original, and then the square on the sheet of paper must be double the size of the square on the map. Divide the areas of both the original and the enlarged square in to similar small geometrical patterns. The detail from the original square is then copied out by eye, to the enlargement being designed in the same relative position as it occupies in the original map square.

Methods of Map Enlargement and Reduction
Generally there are four methods by the help of which map can be precisely enlarged or reduced. These include photographic method, square method, similar triangle method and pantographic method.

a) Photographic Method

b) Square Method

c) Similar Triangle Method

d) Pantographic Method

a) **Photographic Method**

This method is the superb or excellent method for enlargement and reduction. In this process, by the help of Camera, negative is prepared and by the help of negative, suitable size of photograph may be printed.

b) **Square Method**

One very familiar method of enlarging and reducing map is by the use of the square method. This method is an inexpensive or easy on the pocket, low-tech way to reproduce and/or enlarge a map that you want to paint or draw. The grid method is somewhat time-intensive process, depending on how large and detailed your map will be. While the process is not as quick as using a projector or transfer paper, it does have additional advantage of helping to get better your drawing and observational skills. Below are some of the steps to be followed when enlarging a map.

1. To decide the size of the new map you should measure the length and width of the original map. Though, the number of times the original map could be enlarged depends on the size of the paper that is at our disposal.

2. Multiplying the length and width by 2 or 3 correspondingly, if you propose to enlarge the map to twice or thrice its initial size.

For example, if the length and width of a map are 4cm and 2cm respectively, such a map would measure 8cm by 4cm if enlarged to **twice** its size and 12cm by 6cm if enlarged to **thrice** its size and so on.

3. After enlarging the original map, it is uniformly understandable that the scale would change. For instance, during enlargement the scale for the new map is obtained by **multiplying** the original scale with the number of times the scale has been enlarged. Therefore, if a map has a scale of 1:90,000, the scale of the map changes to 1:45,000 if the size has been enlarged **twice** and 1:30,000 if the size of the map has been enlarged to **thrice** its original size.
E.G. Enlarged: Twice: $2x \frac{1}{90000} = 1:45,000$

When thrice: $3x \frac{1}{90000} = 1:30,000$

4. The features to be depicted on the enlarged map should also be proportional to the obligatory size of the enlarged map.

5. Finally you should write the title and the new horizontal scale of the enlarged map. See the following example:

To enlarge to twice the size:

1. Draw the outline or frame for the new map so that the sides are double as of the original map. Cover the original map with a grid of half centimeter squares and number a scale similar to the one in Diagram A. Cover the new map with a similar grid using one centimeter by one centimeter squares. That means the measurement on the left (frame in Diagram A) should be half the size as the one on the right (frame in Diagram B).

2. Connect the original map and the enlarged map with lines, as shown below.

3. Put the original map or map you wish to enlarge on the left side. (See Diagram A.)

4. Trace the major features to be shown on the enlarged map by using the grid as a guide and draw each frame (found on Diagram A) onto the frame found in the same position on Diagram B. For example, frame D7 on each diagram will contain the head and frames C1, D1, and E1 contain the feet in both diagrams.
Figure 20: Square method

Source:http://socialstudies.nelson.com/arnold/skimm/main/items/enlarging

c) **Similar Triangle Method**

This method is mostly employed for reducing or enlarging a narrow or linear area, such as river, railway, road etc.

d) **Pantographic Method**

A pantograph is an uncomplicated mechanical device that uses two pens to duplicate and enlarge or reduce drawings or maps.

There are two or more needles attached to a red in a pantograph. When one needle is moved, the other needle also moves mechanically. One of the needles is moving along the outline of a map, hence the other needle traces a similar outline larger or smaller as desired.

The instrument is generally used for reduction of plans, charts and maps. It can also be used for enlargement. But in case of enlargement a minor mistake in the movement of the tracer point on the original map will be several times multiplied by the enlarging needle, so that in case of enlargement, the element of error increases.
Generally, a map is not enlarged more than four or five times with a pantograph. As such a pantograph works on the principles of the parallelogram or four-sided geometrical figure. (http://books.google.com.et)

**Steps to be followed when reducing a map**

1. Measuring the length and width of the original map.

2. Dividing the length and width by 4 or 5 if you are requested to diminish the map four times or five times of its initial size.

For instance, if the length and width of a map are 20cm and 40cm respectively, such a map should measure 5cm by 10cm if reduced to a fourth of its size and 4cm by 8cm if reduced to a fifth of its size and so on.

3. When reducing the original map, it is evident that the scale would correspondingly change. For instance, during reduction the scale for the new map is obtained by dividing the original scale with the number of times the scale has been reduced. Therefore, if a map has a scale of 1:40,000, the scale of the map changes to 1:160,000 if the size has been reduced by four times, and 1:200,000 if the size of the map has been reduced to a fifth of its previous size.

4. The features to be marked on the reduced map should also be comparative or proportional to the required size of the reduced map.

5. Finally you should write the title and the new horizontal scale of the reduced map. (http://discussionfacts.blogspot.com/2011/09/steps-to-map-reduction-and-enlargement.html)

**How to Make Your Own Pantograph**

Pantograph is indispensible to enlarging or making a copy of an image by hand. Pantographs permit an individual to copy or trace an image with excellent accuracy. This device can be used in art classes and as well as in woodworking classes. The pantograph works by following an original image and tracing a copy on a separate sheet of paper. Pantographs can be purchased at art supply or delivery stores and woodworking stores. Luckily, it is possible to make a pantograph that is as efficient or competent as the manufactured kind.

**Instructions**

1. Cut the cardboard into four strips.
2. Put down the cardboard strips into the standard pantograph design. Drill the pencil into the end of the pantograph design. Lightly push the pencil that will be used for tracing through the cardboard.
3. Connect the pantograph together using the pushpins and locate each pushpin on the four corners of the design. The pushpins move overturned or wrong side up and you can use small pieces of cork to cover the sharp points and keep yourself and others from injury.

4. The drywall screw should be pushed through the cardboard strip, 3 inches away from the pushpin that is parallel to the pencil.

5. Tape the 3/4-inch-thick block of wood to the table and hammer the nail through the cardboard to keep the pantograph stationary or immobile.

The lengths of the four arms are: Arm A - 31.2cm, Arm B 31.2cm, Arm C - 25.2cm and Arm D - 16.2cm
Figure 21A: Pantograph

The arms are assembled as shown using the screws, with various nuts, dome nuts and wing nuts:

- Pivot 1 - This gives free arm movement, but not excessive looseness.
- Pivot 2 - This is the tracing point which used a 40mm long screw inserted from the top, with one nut locking it to Arm D, and two nuts locked together below Arm C to permit free arm movement, but not excessive looseness.
- Pivots 3 and 4 - These are the moveable pivots that influence the magnification or exaggeration. For each 25mm screws inserted from below with a nut and a wing nut locked together to permit free arm movement, but not excessive looseness.

When using the pantograph, the drawing surface should be about 60cm square with the anchor point situated in the bottom left hand corner and taped down. The picture to be copied is placed so that the tracing point (pivot 2) is just on the left hand bottom corner of the picture and the picture is then taped down. The blank
drawing paper is placed so that the pencil sits just on its bottom left hand corner. The end of the pencil moves so that the tracing point also moves to the top right hand of the picture and ensure that the pencil is still on the blank paper. Sometimes, depending upon the size of the picture, it may be necessary to overlap the picture and drawing paper and copy the picture one half at a time.

Figure 21B: Enlarging a map using a pantograph.

2.5 Methods of showing Relief on Maps
Activity 2.5

Discuss the following questions in small groups.

a) What is relief?
b) Give examples of relief features.
c) Mention the different ways of showing relief on maps.
d) How many dimensions do the relief features have?
e) How many dimensions does the map have?
f) What is a physiographic diagram?
g) Which views are used in physiographic diagrams?
h) How objects are viewed on modern maps?
i) Why physiographic diagrams lack accuracy?
j) What are hachures?
k) How do the hachures spaced?
l) What do the shorter and longer hachures show?
m) What are the limitations of hachures?
n) What is hill shading?
o) How does the steeper slope shown in hill shading method?
p) What are the limitations of hill shading method?
q) What is layer coloring or layer tinting?
r) Mention some of the limitations of layer coloring?
s) What are formlines?
t) What limitation do the formlines have?
u) What are contour lines?
v) List the general properties of contour lines?
w) Which contour line exists both on the map and in the field?
x) What is vertical interval?
y) What is cliff?
z) How is cliff indicated on contours?
   aa. How is an overhanging cliff shown on contours?
   bb. How do contour lines numbered?
   cc. What are index contour lines?
   dd. What are spot heights?
   ee. What is the difference between the spot heights and trigonometrical points?
   ff. What are benchmarks?

The varying heights of hills and mountains, and the depths of valleys and gorges as they appear on a topographic map, are known as relief; unless the relief is adequately represented, the map does not give a clear picture of the area it represents.

In Geography, relief refers to the difference in elevation of an area. This variation is usually expressed as the difference between the highest and lowest point. It can also refer to a map that shows the topography of an area. Terrain, or land relief, is the vertical and horizontal dimension of land surface. When relief is described underwater, the term **bathymetry** is used.

Different methods of representing the relief features on a map have been and are still used. Hachures, hill shading and physiographic drawings are the qualitative methods of relief representation while the quantitative methods include contours, spot heights, trigonometrical stations and layer tints. Below we shall see each technique briefly.

**Traditional Techniques:**

A. **Physiographic Diagrams:**

Traditional map making techniques used by ancient map makers included a standardized or consistent set of three dimensional pictures also called physiographic diagrams that represent the physical appearance of landforms as viewed by an observer standing on the ground from the side or oblique direction.

Physiographic diagrams are therefore pictorial methods of representing relief features and are classified as a type of schematic maps that show the basic form or layout of the land features (Robinson et al., 1995).

**Some shortcomings of physiographic Diagrams:**
• Show objects as viewed from the side and an overhead view (a mixture of overhead and side views).

• Important details about the feature will be hidden in the opposite side.

• Lack altitude information.

• Not true to scale.

B. Hachures:

Early map makers existed up to the middle of the nineteenth century made an effort to depict or portray relief features on the map by using a technique of hachuring. Hachures are small non-numeric lines of diverse thickness, running directly down slope to designate the direction water would take when flowing from high ground to low. In this respect they promoted visualization of the physical appearance of the land surface. The using of hachures for representation of relief was standardized or harmonized by the Austrian topographer Johann Georg Lehmann in 1799.

According to this technique, the thickness and lengths of the lines were proportional to angle of the slope, so the steeper slopes were represented by darker, shorter and denser hachures, while the gentler slopes were portrayed with thinner, longer and less crowded hachures. Hachures illustrate the orientation of slope and their thickness and overall density provide the map user with a broader sense of steepness and successfully convey quite specific shape of the land feature.

Some limitations of hachures:

• No indication of absolute heights

• The denser hachures obscure some geographic details

• All high lands look flat topped

• No distinction between the bottom and the top of the slope.
C. Hill shading:

Hachuring has been replaced by the other form of traditional technique identified as hill shading in the early 18th century. Hill shading is the other traditional and incorrect technique for depicting land features on maps in a factual manner. It resembles a light and shadow effect. Hill shading technique can be very useful and the most successful method for portraying hilly areas. It adds to the visual quality of the map by providing an overall view of the landscape. This shows that, hill shading is mainly used for its visual effect and gives a two-dimensional relief map three-dimensional appearance (Robinson, 1995, Slocum, 2008).

Imhof (1982) explains three different types of shading. Slope shading works on the principle that the steeper the slope-the darker or the heavier the shade. Oblique or hill shading relies on the effect of an oblique light source on a land surface. The third one combines the effects of oblique and slope shading.

In this technique, the direction of the light is the most important element for shading the hill slopes. Hill shading simulates the cast shadow thrown upon a raised planetary surface. Accordingly, a light source is imagined to be located over the region and to cast shadow in some parts, to illuminate others. For instance one method visualizes that light source is placed vertically over the land, so that the steepest slopes are lit up or illuminate the least. Based on this the sides of mountains and hills are shaded darker than mountain peaks, plateaus, hill tops and valley bottoms which are shaded in lighter tint. The other
method is when the imaginary source of light is placed obliquely at the upper left corner of the map and shines from the north west of the area, thus casting shadow over the eastern and southern higher slopes. Following this the south and east facing slopes are darkly shaded than the upper and left corner of the map. Generally hill shading grants or provides us with a view that is familiar in our daily lives and portrays a general idea of the relief of any region.

Some draw backs of hill shading:

- The density of the shading obscures important geographical details and also makes the printing of place names impossible.
- It does not preserve any reasonable degree of accuracy.
- It does not provide any altitudinal information.
- Very difficult to determine the upper and lower slopes of the hill.

(http://en.wikipedia.org/wiki/cartographic_relief_depiction)

D. Layer Coloring (Layer Tinting):

A technique called layer coloring or tinting was developed by a map maker to present an overall image of different altitudes. This improves the visual effect of the relief in which the distribution of high and low land could be readily identified. In this method one conventional principle is followed in which a map maker starts tinting from the sea level with deep green colors and makes his way through different shades of green, yellow, and brown and ending with red, purple or even white in the extreme high elevations. Generally layer tinting is an extension of the contouring technique that has been used on maps to convey altitudinal differences.

It should be pointed out here that when using layer tinting method, conventionally green is often used for low land, yellow for higher land and brown for the highest altitude. But this particular color series is entirely conventional and that it by no means designates the actual color of the area portrayed.

Layer tinting or layer coloring is a technique used on some maps to strengthen or reinforce the conception of relief and to make the landforms more easily understood by unskilled users of maps. It relies upon the presence of either contours or form lines to provide the basis for coloring and is not a complete method by itself.

Some draw backs of layer coloring or tinting:

- It does not show the detailed shape of the land.
• Higher elevation tints may be so dense and dark which make the placing of readable details difficult.

• It may give the wrong notion or view of physical boundaries along the edges where the tint is changing.

• It is expensive to produce.

• Gives wrong impression in people’s mind, for instance symbolism of green for fertile lowlands would be misleading for low elevations in arid climates.

E. Form lines:

A form line is an imaginary line that joins all points with an approximate height above the real line marking the edge of the sea against the land. Unlike hachures, form lines do not follow up slope but trend a horizontal course across the surface of all types of land forms. Form lines have no standard elevation and are not measured from any datum plane. Therefore they give the general idea of the relief with indefinite or an approximate height which are never labeled with representative elevations.

Form lines could be distinguished from contour lines on a topographic map by the fact that they are symbolized with dotted or pecked lines and are not always plotted at fixed intervals. They could be used only where demonstration of features with ordinary contours is impossible; but excessive or unnecessary use of form lines should be avoided as this will make the map more complex. As a result only one form line may be used between two successive contour lines.

**Some limitations of formlines:**

• They are not measured from any datum plane;
• Have no standard elevation and give only a general idea of relief;
• They are represented on a map as dashed lines and are never labeled with representative elevations.

F. Contour Lines or Isohyps
es

Contour lines or isohyps are imaginary lines used by cartographers as an effective mechanism or the most accurate way for representing different relief features on standard topographic maps. They are predominantly important to accurately show the altitude, shape and slope of the terrain.

Imhof defines contour lines as “... lines on the map depicting the metric locations of points on the earth’s surface at the same elevation above sea level.”
Contours give vertical rise above mean sea level (M.S.L.) or ordinance datum (O.D.) which is regarded as zero height. It is an average level of the sea calculated by measuring the sea level carefully between the highest and the lowest tide marks.

Too many contour lines would be difficult to manage. Therefore in order to avoid complexity and make contour maps easier to read, topographic maps show contour lines for certain elevations at constant interval of the same numerical value known as the vertical interval (V.I.) or contour interval (C.I.) which represents the height difference between two successive contour lines.

Contour lines always increase or decrease by the same amount. For instance, if one contour line represents a height of 100 meters above sea level and the successive contour line reads 200 meters above sea level, then the third contour line will be 300 meters above sea level. From the given example one can understand that the contour interval used in this case is 100 meters.

The size of the vertical interval used on any topographic map depends up on the type of the terrain shown and the scale of the map. Accordingly, a map depicting very flat areas uses a small vertical interval, while a map showing mountainous areas uses a bigger vertical interval. On the other hand small scale maps use a larger vertical interval while a large scale maps tend to have a small contour interval. For instance, flat areas may be mapped with a 10 meter contour interval and rugged terrain may have a 50 meter contour interval.

**General characteristics of Contours:**

i. All points joined by the same contour line have the same known elevation.

ii. Contour lines cannot superimposed or cross each other except in the case of a cliff or an overhanging cliff.

iii. Closely gaped contour lines represent steep slope.

iv. Widely gaped contour lines symbolize gentle slope.

v. Uniformly separated contour lines indicate even slope.

vi. A closed loop contour with higher altitude towards the center shows hills.

vii. Closed loop contour with lower altitude towards the center signifies depression.

viii. All contour lines cannot dead-end; but must close on themselves within the map boundary or outside.

ix. Irregular contours imply rough or rugged terrain.
x. Contour elevations are marked on the uphill side of lines or by breaking the lines to avoid confusion.

xi. Contours cannot wye or branch.

xii. Contours forming V-shaped bends pointing towards a higher elevation symbolize a valley.

xiii. Contours forming V-shaped bends pointing towards a lower elevation indicate a spur.

xiv. Contours forming U-shaped bends pointing towards a lower ground represent a ridge.

xv. Every fifth contour line is designated as an index contour that is marked with elevation. This makes contour maps easier to read, since it is not viable or impractical to mark the elevation of every contour line on the map and hence the index contour lines are the only ones labeled. The unnumbered contours can be determined by counting up or down from the adjacent index contour line and multiplying by the given contour interval.

**Types of Contour Lines:**

The three types of contour lines found on a topographic map include index contour, intermediate contour and supplementary contour. Following are the essentials of the three types of contour lines.

**Index contour lines:**

As already mentioned, most topographic maps show every fifth contour line in bold print or heavier than the other contour lines. Such bold faced contour lines are referred to as index contour lines. They are regularly marked with numbers indicating their corresponding altitudes measured from the mean sea level. These contour lines will be the first thing to capture one’s eye when looking at a topographic map.

**Intermediate contour lines:**

Between each pair of index contour lines, there prevails a set of four thinner lines called intermediate contour lines. The intermediate contour lines are usually drawn in sets and each line corresponds to an equal amount of altitudinal change between each line. The other thing worth mentioning here is that the altitudinal change between one index contour line and the nearby intermediate contour line will also be the same value as the change between two consecutive intermediate contour lines. For instance if the height difference between two index contour lines is 100 meters, the elevation difference between two adjacent contour lines will be 20 meters (the altitude difference between the two nearby index contours=100 ÷ 5= 20). This shows that the contour interval is 20 meters.

**Supplementary contour lines:**
These are the other type of contour lines usually expressed as a dashed or dotted line drawn between the index and intermediate contour lines where the spacing between the two contour lines becomes very wide. Therefore the supplementary contour lines are more often seen in very flat areas where the change in elevation becomes minimum. In flat areas, supplementary contour lines may be used to present additional information about the topography and assist in identifying minor changes in elevation. The other thing worth mentioning is that the contour interval used for the supplementary contours is generally half the regular contour interval and is indicated next to the regular contour interval in the marginal information. For instance if the regular contour interval is 50 meters, the vertical interval for the supplementary contour line from the closest regular contour line would be 25 meters.

Figure 23A: Contour lines

Source: (http://www.justtrails.com/nav-skills/reading-topographic-maps-contour-lines-and-slope/)
G. Different methods of showing altitudes on contour maps

As already described, the most accurate way of indicating altitude on a topographic map is by the help of contour lines which are drawn at a certain fixed vertical interval. However, altitudes of some important features such as mountain peaks, road intersections, the bottom of valleys, the level of lakes and the altitude of a landing strip or runway in an airport might fall between consecutive contour lines. The altitudes of these important features can be provided by the help of spot heights, trigonometrical points, bench marks, etc.

Spot heights:

These are imaginary points showing precise altitudes of important individual features that lay along roads, on mountain tops or between consecutive contour lines. They are marked on topographic maps with a dot followed by a number that gives the accurate altitude of the individual point in meters.

Trigonometric points or stations:

Unlike spot heights, trigonometric or triangulation points or stations are identifiable on the ground. As a result they are real points existing both on the map and on the ground. Trigonometric points are marked permanently by means of a concrete pillar or a plate fixed on the ground. But on topographic maps they are usually marked by a triangle with adjacent elevation numerals in meters.
Trigonometric or triangulation points occupy the corner in a network of triangles usually on the top of a mountain from where the angular measurements take place. This is because in the preparation of topographic maps, measurement of distances is unusually carried, while angular measurements are made between points.

**Benchmarks:**

The term benchmark is generally applied to a method used to mark any position with accurate elevation. Benchmark is a permanently fixed reference survey station or point with accurate elevation with respect to a standard datum. Usually, they are cut into the brick, stone or concrete, though some are on bronze plates let into the wall. Frequently, bronze or aluminum disks are set in stone or concrete to provide a precise elevation point. The height of a benchmark could be calculated in relation to the heights of the adjacent benchmarks. The altitude and position of each benchmark is normally portrayed on large scale maps. (From Wikipedia, the free encyclopedia).

![Figure 24](image)

**Calculating Altitude:**

As aforementioned, the altitude of any unnumbered or unlabeled contour line can be decided by a simple calculation using the vertical interval provided in the marginal information. The vertical interval represents the vertical distance or the vertical rise between two consecutive or adjacent contour lines. By simply counting the number of intermediate contour lines from an index or a labeled contour line, and multiplying the
number of the contour lines by the value of the vertical interval, one can determine the height of any unnumbered contour line.

For points lying between two consecutive or neighboring contour lines, determining their heights is possible by applying the following two procedures.

**Procedure one:**

i. Identify the point for which the altitude is calculated.

ii. Determine the elevations of the adjacent contour lines found on each side of the point (400 and 500).

iii. Estimate the altitude of the point between the two contours by using the contour interval and the position of the point from the nearest contour. For instance, if a point is half of the way between the 400 meter and the 500 meter contours, its height could be estimated as 400 plus half of the contour interval (in this case 100 m). Accordingly, the altitude of the point occupying half a way between the two contours will be:

\[
\frac{1}{2} \times 100 + 400 = 450m \quad \text{Or} \quad 500(-) \frac{1}{2} \times 100 = 450m
\]

**Procedure two:**

i. Identify the point for which the altitude is calculated.

ii. Determine the elevations of the adjacent contour lines found on each side of the point (500 and 550).

iii. Draw a line through the point for which the elevation is calculated and join the two successive contour lines.

iv. Measure the total length of the line joining the two contours through the point (25mm).

v. The dot indicating the position of the point for which the altitude is calculated divides the line in to two portions (5mm to 20mm). If the vertical interval is 50m, the altitude of the point from the lower contour or from the upper contour will be:

\[
\frac{5}{25} \times 50 + 500 = 510 \text{ meter or } 550 - \frac{20}{25} \times 50 = 510 \text{ meter.}
\]

2.6 **Slopes and Gradients:**

**Activity 2.6**

Answer the following questions in your geography group.
a) Define the term slope.
b) How do the contour lines spaced to show a steep slope?
c) How do the contour lines spaced to show a gentle slope?
d) What type of slope is represented with larger vertical interval?
e) What type of slope is represented with smaller vertical interval?
f) Define an even slope.
g) How do the contour lines spaced to show an even slope?
h) How do the contour lines spaced to show a concave slope?
i) How do the contour lines spaced to show a convex slope?
j) How do the contour lines spaced to show a terraced or stepped slope?
k) What is escarpment?
l) What is scarp slope?
m) What is deep slope?

The main criteria used to determine the steepness of the slope on a contour map include:

a) The space between the contours (the closer together the contours are the steeper the slope is, but the other two criteria should remain the same).

b) The contour interval used on the map (the bigger the contour interval the steeper the slope will be, but the other two criteria should be similar).

c) The size of the scale can be used to determine the steepness of the slope, when the two criteria remain the same. In this case the larger the scale the steeper the slope and vice versa.

To make it more practical, you can make a comparison of the steepness of the following slopes illustrated in figure 25 below. If you compare (a) and (b), the distance between the contours is the same. The scale is also the same. The only difference here is the vertical interval. So slope (a) with a larger vertical interval is steeper than slope (b). If you compare slope (b) and (c), the distance between the contours is the same. Both have the same vertical intervals. But they differ only in scale, as slope (c) is having a
larger scale which makes it to be steeper than slope (b). In the same way if you compare slope (a) and (d) both have the same vertical intervals and scales. But they differ only in the distance between the contour lines. The contours of slope (a) are closer together and that of slope (d) are further apart. As a result slope (a) is steeper than slope (d). Similarly slope (c) is steeper than slope (f).

Figure 25: Relationship between distance between contours, V.I. and scale in deciding the steepness of a slope.

Types of Slopes:

The four types of slopes discussed below separately include even slope, convex slope, concave slope and stepped or terraced slope.

1. Even Slope

Contour lines representing an even slope on a map will be evenly spaced between the foot and the top of the terrain feature.
2. Convex Slope

Contour lines showing a convex slope on a map are drawn closer together at the foot of the terrain feature and farther apart near the top. This shows that a convex slope is steeper at the bottom and becoming gentler near the top.
3. Concave Slope

Concave slope is gentler at the foot and steeper near the top of the terrain feature. Therefore, the contour lines portraying a concave slope are drawn farther apart at the foot and closely spaced near the top of the terrain feature.
4. Stepped or terraced Slope

In the case of stepped or terraced slope the gradient changes several times between the foot and the top of the terrain feature. As a result, the contour lines showing this slope are drawn closer together and farther apart alternatively.
5. Escarpment

An **escarpment** is a steep slope or long cliff that occurs from faulting and resulting erosion and separates two relatively level areas of differing elevations. Usually **escarpment** is used interchangeably with **scarp** (from the Italian **scarpa**, shoe). But some sources differentiate the two terms, where **escarpment** refers to the margin between two landforms, while **scarp** is synonymous with a cliff or steep slope. The surface of the steep slope is called a scarp face. (Scarp refers to the cliff itself.)

An escarpment is an area of the Earth where elevation changes suddenly. Escarpment usually refers to the bottom of a cliff or a steep slope. Escarpments separate two level land surfaces. For example, an escarpment could be the area separating the lower parts of the coast from higher plateaus. One side of an escarpment could be rock from one geologic era, while the other side of the escarpment could be rock from a different geologic era. Escarpments are formed by one of two processes: erosion and faulting. Erosion creates an escarpment by wearing away rock through wind or water. One side of an escarpment may be eroded more than the other side. The result of this unequal erosion is a transition zone from one type of sedimentary rock to another. The other process by which escarpments are formed is faulting. Faulting is movement of the Earth's top layer, or crust, along a crack called a fault. The same process often results in earthquakes. Faulting creates escarpments as it moves pieces of the Earth around. Escarpments are found on every continent, even Antarctica.

**The Measurement of Gradient on a Contour Map:**

Gradient is the rate of change in altitude of a slope. It is generally expressed as a percentage, an angle, or a ratio. The average slope of a terrain can be calculated from contour lines on a topographic map. To calculate the slope of the terrain, the horizontal
The gradient is obtained by dividing the rise by the run.

The formulas used in calculating gradient are the following:

\[
\text{Gradient} = \frac{\text{rise}}{\text{run}} = \text{gradient in ratio or } \frac{AD}{HD}
\]

\[
\text{Gradient} = \frac{\text{rise}}{\text{run}} \times 100 = \text{gradient in percent or } \frac{AD}{HD}
\]

\[
\text{Gradient} = \frac{\text{rise}}{\text{run}} \times 60 = \text{gradient in degree or } \frac{AD}{HD}
\]

According to the above formulae, the comparison of rise (altitude difference) to run (map distance) is mainly applied to determine the percentage of the gradient between two points. For instance, if the altitude of point “A” is 500m and the altitude of point “B” 400m, the height difference between them is simply found by subtracting 400 from 500 (500-400=100). This is the vertical distance (VD or rise). Then the horizontal distance (HD or run) can be calculated by measuring the paper distance between the two points and multiplying by the scale of the map. In this case if the paper distance measured between the two points is 5cm and the scale of the map is 1:50,000 the map distance will be:

\[
\frac{5 \times 50,000}{1000} = 250m.
\]

Lastly the gradient is obtained by dividing the altitude difference or the rise by the map distance or run (\( \frac{100}{250} = 1:2.5 \)). This shows that for every 2.5 unit of horizontal distance there is 1 unit of rise in altitude. This could also be expressed in percentage and degrees.

\[
\text{Gradient in percent} = \frac{\text{rise}}{\text{run}} = \frac{1}{2.5} \times 100 = 40\%
\]

\[
\text{Gradient in degree} = \frac{1}{2.5} \times 60 = 24^\circ
\]

Table: 3, Description of Slopes
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<td>A</td>
<td>Little or none</td>
<td>Little or no slope: 0 - 3 % gradient</td>
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<tr>
<td>B</td>
<td>Gentle</td>
<td>Gentle slopes: 4 - 9 % gradient</td>
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<tr>
<td>C</td>
<td>Moderate</td>
<td>Moderate slopes: 10 - 15 % gradient.</td>
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<tr>
<td>D</td>
<td>Steep</td>
<td>Steep slopes: 16 - 30 % gradient.</td>
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<tr>
<td>E</td>
<td>Extremely steep</td>
<td>Extremely steep slopes: 31 - 60% gradient.</td>
</tr>
<tr>
<td>F</td>
<td>Excessively steep</td>
<td>Excessively steep slopes: &gt; 60% gradient</td>
</tr>
</tbody>
</table>


2.7 Field Distance:

Activity 2.7

Discuss the following questions in your geography group.

a. Mention the three types of distances calculated on maps.

b. What is a field distance?

c. What are the necessary steps to be followed when calculating a field distance?

A map distance is a distance obtained through measurement on a map and the use of scale. This means that, the paper distance measured on the map should be multiplied by the scale of the map to obtain the map distance. Unlike the Field distance the map distance does not take into consideration the differences in elevation between the points.

Field distance: As mentioned above this takes into consideration the differences in altitude between points. The field distance between two points on a map can be obtained through the combination of map distance and altitude difference.

Steps to be followed when calculating a field distance:

The first thing to do when answering distance questions is identifying whether the question is a field distance or a map distance. To make a distinction between the two distances, it is better to read the question very carefully. If the question consists the word “field”, it is the field distance. But if the word “field” is missing from the statement, it will be a map distance that should be calculated through simple measurement on the map and the use of the map scale.

After identifying the field distance, the following steps can be followed:

a. Calculating the map distance (through measurement on the map and the use of scale).

b. Calculating altitude difference between the points (subtracting the lower altitude from the higher).

c. Applying the formula (pythagoras’ theorem), \( FD^2 = MD^2 + AD^2 \).
Unit Summary:

- Direction is the way somebody or something goes, points or faces.
- Maps from past centuries used different cardinal directions.
- Nowadays North is internationally considered to be the cardinal direction.
- Compass is a device that indicates direction.
- Two fundamental types of compass are used: the magnetic compass, which probably originated in ancient China; and the gyrocompass, a device developed at the beginning of the 20th century.
- In the magnetic compass, directions are obtained by means of one or more magnetic needles pointing in the general direction of the magnetic North Pole under the influence of the magnetic field of the earth.
- The gyrocompass (compass with gyroscope inside) which is unchanged by the magnetism or pull of the earth.
- The easiest way to determine bearing from one point to the other in the field is by using a protractor.
- In the absence of a protractor with you, it is possible to find the bearing you require using your compass.
- Printing place names is the most universal and easiest way of providing the accurate position of a place on a map.
- The Greek Geographer Ptolemy was the first to use the net work of parallels and meridians for identifying position of places on maps.
- The National or Regional Grid is a supplementary reference to the Geographical Grid provided on a large scale or medium scale topographic maps.
- The National Grid system has a benefit over the International Grid in that it uses kilometer distances instead of degree distances and therefore it is easy for computational purposes.
- Enlargement or reduction of maps is primarily done to get the appropriate or suitable size, according to desires.
- A straightforward technique of enlarging a map is to make use of the ‘square’ method.
- A pantograph is an uncomplicated mechanical device that uses two pens to duplicate and enlarge or reduce drawings or maps.
- Hachures are small non-numeric lines of diverse thickness, running directly down slope to designate the direction water would take when flowing from high ground to low.
- Hill shading is mainly used for its visual effect and gives a two dimensional relief map three dimensional appearance.
- Layer tinting or layer coloring is a technique used on some maps to strengthen or reinforce the conception of relief and to make the landforms more easily understood by unskilled users of maps.
A form line is an imaginary line that joins all points with an approximate height above the real line marking the edge of the sea against the land.

Form lines have no standard elevation and are not measured from any datum plane.

Contour lines or isohypses are imaginary lines used by cartographers as an effective mechanism or the most accurate way for representing different relief features on standard topographic maps.

A map depicting very flat areas uses a small vertical interval, while a map showing mountainous areas uses a bigger vertical interval.

Contour lines cannot superimposed or cross each other except in the case of a cliff or an overhanging cliff.

Contour elevations are marked on the uphill side of lines or by breaking the lines to avoid confusion.

Every fifth contour line is designated as an index contour that is marked with elevation.

The unnumbered contours can be determined by counting up or down from the adjacent index contour line and multiplying by the given contour interval.

Between each pair of index contour lines, there prevails a set of four thinner lines called intermediate contour lines.

Spot heights are imaginary points showing precise altitudes of important individual features that lay along roads, on mountain tops or between consecutive contour lines.

Unlike spot heights, trigonometric or triangulation points or stations are identifiable on the ground.

The term benchmark is generally applied to a method used to mark any position with accurate elevation.

Slope is the degree of steepness of both natural and human made surfaces as compared to the horizontal plane.

Gradient is the rate of change in altitude of a slope. It is generally expressed as a percentage, an angle, or a ratio.

A map distance is a distance obtained through measurement on a map and the use of scale.

The field distance between two points on a map can be obtained through the combination of map distance and altitude difference.

Answers for Unit 2 activities

Activity 2.1

a) Direction is the way somebody or something goes, points or faces.

b) A land mark is an object that is easily seen from a distance.
c) Landmarks are used to remember where things are.

d) Maps and compasses.

e) North, East, South, West.

f) Sixteen.

g) NE, SW, NW, SE.

h) North.

i) \(180^\circ\).

j) \(315^\circ\).

**Activity 2.2**

a) Direction is indicated by using compass points, while bearing indicates direction in degrees.

b) Cardinal direction.

c) Traditional ways and modern ways

d) Traditional ways use the cardinal compass points and modern ways use degrees.

e) It is named after the direction from which it blows.

f) Refers to its direction and a clock wise measurement in degrees.

g) Clock wise from north.

h) A back bearing is obtained by adding or subtracting \(180^\circ\) to or from a forward bearing.

**Activity 2.3**

a) Location.

b) Geographical grids (latitude and longitude) and National grids (eastings and northings).

c) Set of lines that run from North Pole to the South Pole and the other set of lines that run parallel to the equator.

d) Parallels are imaginary lines, while latitudes are angular distances.

e) Meridians are imaginary lines, while longitudes are angular distances.

f) A net work of horizontal and vertical lines printed on a map.
g) SW Kenya where the 34°30'E meridian crosses the equator (0°).

h) The vertical lines of the National grid, numbered east wards.

i) The horizontal lines of the National grid, numbered north wards.

**Activity 2.4**

a) When we need to show more details about the area it shows.

b) We enlarge a map by enlarging its scale.

c) When we need to be selective and to generalize the information that the map shows.

d) We reduce a map by reducing its scale.

e) The size of the map also decreases.

f) The amount of reduction = denominator of large scale divided by denominator of small scale.

g) The amount of enlargement = denominator of small scale divided by denominator of large scale.

h) 1:100,000.

i) 1:80,000

j) 5 times.

k) \( \frac{1}{4} \) times.

l) Square and pantograph methods.

m) A mechanical device used for enlarging and reducing maps.

n) The three operational points include: the pivot, the tracer and the pencil holder.

**Activity 2.5**

a) Relief refers to the differences in altitude between the highest and the lowest points on the surface of the earth.

b) Plains, hills, plateaus, valleys, ridges, etc.

c) Physiographic diagrams, hachures, layer coloring, hill shading, form lines and contour lines.
d) They have three dimensions (length, breadth and height).

e) Two dimensions (length and breadth).

f) Diagrammatic pictures used by early map makers to represent relief features.

g) Side or oblique view.

h) Vertical or bird’s eye view.

i) It is drawn without scale.

j) Short disconnected lines that show slopes.

k) For steep slopes they are closer together and for gentle slopes they are spaced wide apart.

l) Shorter hachures show steeper slopes and longer hachures represent gentle slopes.

m) Flat areas unshaded, do not indicate height and are laborious to draw.

n) A method of showing relief on a map, assuming an oblique light that illuminates the landscape from the northwestern corner of the map.

o) The steeper the slope is, the darker it is shaded.

p) No absolute height, detailed map information can be obscured by shading.

q) A method of showing relief by using colors.

r) Does not indicate changes in slopes, can obscure details and some colors can create false impressions.

s) An imaginary pecked or broken line joining points with the same approximate height on a map.

t) Not drawn at a fixed interval; they are unnumbered and usually drawn with broken lines.

u) They are the most common and accurate way of showing relief.

v) They are imaginary lines; drawn at a certain fixed height interval; do not merge or cross one another and never branch.

w) Sea level or zero meter altitude.

x) The difference in altitude between two successive contour lines.

y) A vertical mountain wall.
z) Two or more contour lines run together and then separate to show cliff.

aa) When they cross one another.

bb) They are always numbered in the direction towards which altitude increases.

c) Every fifth or tenth contour line printed thicker than the rest.

d) They provide accurate altitude for individual points.

e) The trigonometrical points exist both on the map and in the field, but the spot heights exist only on maps.

ff) They indicate precise heights along highways or railways.

**Activity 2.6**

a) Slope is an upward or downward inclination of a natural or artificial surface.

b) Closely spaced contour lines indicate steeper slopes.

c) Widely spaced contour lines represent gentler slopes.

d) Bigger vertical intervals indicate steeper slopes.

e) Smaller vertical intervals show gentler slopes.

f) An even slope has a constant gradient from the bottom to the top.

g) They are evenly spaced throughout.

h) They are widely spaced at the base and are close together at the top.

i) They are widely spaced at the top and are close together at the base.

j) They are alternatively close together and far apart in a regular pattern.

k) An escarpment is the steep slope of a plateau.

m) The gentler slope of a plateau.

n) Gradient is the degree or rate of change of slope or elevation between two points.

o) Horizontal distance represents map distance, while vertical distance shows the difference in altitude.

p) As a ratio, in percent and in degree.

**Activity 2.7**
a) Straight line distance, bending distance and field distance.

b) The actual distance which takes into account the altitude difference between the points.

c) The map distance and the altitude difference between the two points and applying the Pythagorean Theorem.

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<td><strong>Altimeter</strong></td>
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