Course outline

University of Gondar

Faculty of Social Sciences & humanities.

Department of Geography and Environmental Studies (GeES)

Course Title: Cartography (3 Cr. Hours) **Academic Year**:201/10-2011
Course Number: GeES **Semester**: 1st
Instructor :Wagaw L

Course objective:

This course is a preparatory discussion on the principal concepts, techniques and method of the science cartography and map-making process. The intention in this course is to impart understanding on the importance of mapping as a means of communication and the steps of mapping involved. Cartography is an **"Art of accurately-scaled Maps and Charts";** concerned with the organization and communication of geographically-related information in either graphic or digital form. The name by itself encompasses all germane stages from data acquisition to presentation and use. More of the focuses of the course is on analogue, than digital, cartography. Therefore, the course assumes to offer you the fundamental concepts about the construction, interpretation, use and application of paper maps. The course seeks a continuous follow, so that students are advised to remain dynamic in lectures and engage in practical lab exercises.

1. Chapter One: **Introduction part: Basic Concepts**
   - 1.1 What is Map?
     - 1.1.1 Basic definition
     - 1.1.2 Types and uses of Map
     - 1.1.3 Map Language and Marginal information on Maps
     - 1.1.4 Drafting topographic features using symbols and colors
   - 1.2 What is Globe?
     - 1.2.1 Parallels and Meridians
     - 1.2.2 Latitude and Longitude & Graticule
     - 1.2.3 Shape and size
     - 1.2.4 The earth objects to be mapped
     - 1.2.5 Basic Geodesy

2. Chapter Two: **Measurements on Maps**
   - 2.1 Measurement of distances and areas
   - 2.2 The problem of Map scale
3. Chapter Three: **Map Making (projection)**
   - 7.1 Globe-Map relationship, Reference and scale factor
   - 7.2 Large scale Maps
   - 7.3 Enlargement and Reduction of Maps
   - 7.4 Coordinate systems
   - 7.5 Basic concepts of Transformation (False Northing and False Easting)

4. Chapter Four: **Bearings and Directions on Maps**
    - 3.1 Cardinal direction
    - 3.2 Geographic, magnetic and Grid North
    - 3.3 Measurement of direction on Maps
    - 3.4 Azimuth
    - 3.5 Bearing
5. Chapter Five: **Position on Maps**
    - 4.1 Position by place names
    - 4.2 Position by bearings and Azimuth
    - 4.3 Position by geographic grid
    - 4.4 Position by National grid
6. Chapter Six: **Relief on Maps**
    - 5.1 Ways of showing relief on Maps
    - 5.2 Contours and their properties
    - 5.3 Ways of showing altitude on contour Maps (Indexing)
    - 5.4 Drawing of contours
7. Chapter Seven: **Slopes and Gradients on Contour Maps**
    - 6.1 Slopes & Gradients
    - 6.2 The drawing of sections and profiles
    - 6.3 Intervisibility

Evaluation:
Attendance and Assignments 30%
Final Exam 70%
Attendance is mandatory

References:
Birch, T.W. 1949. Maps: Topographical and Statistical, Oxford Clarendon Press.
Bygott, John 1957 An introduction to Map Work and Practical Geography, 6th ed., University Press Ltd., London.
Campbell, John 1991 Map use and Analysis, Wm. G. grown Publishers.
Garnett, Alice 1955 The Geographical Interpretation of Topographical Maps, George G. Harp & Co.Ltd., London.
Jennis, J.H. 1973 AnElementary Map Interpretation, Ungman, London.
Maling, A.H. 1973 Coordinate Systems and Map Projections, Ungman, London.
Mankhouse, F.J.1973 Maps and Diagrams, Methene Co., London.
Raisz, Erwin 1941 General Cartography (2nd ed.), McGraw Hill Book Company, London.
Robinson, Arthus H Elements of Cartography (4th, 5th, 6th, ed.), John Willy and Sons.
Steers, J.A. 1956 An Introduction to the Study of Map Projections, University of London.
Campbell, John 1998 Map Use and Analysis, Chapter 5, pp 86-89.
Tyner, J. (1992) Introduction to Thematic Cartography, Chapter 3, pp 43-66.

What is Map? It is a reduced model of the earth

- Cartography is Concerned with reducing the spatial characteristics of a large area, a portion or all of the earth – and putting it in a **map** to make it observable
  - Cartography is "the conveying of spatial information by means of maps" or "The science, technology and art of map-making"
- Map is neatly drawn bird's eye view of the earth's surface – places spatial data i.e. data about objects or phenomena for which the location on the earth is known, in their correct relationships to one another
- A map is a spatial information system that gives the answers to many questions concerning the area depicted: the distance between points, the positions of points in respect of each other, the size of areas and nature of the distribution patterns
- It is a picture of a place that is usually drawn to scale on a flat surface
- It is used as a tool to record and store, retrieve spatial data
- It is, also, used for making measurement, analysis and interpretation of spatial patterns of distributions of both cultural (human or man-made) and natural features
- A map is an abstract representation and portrayal of the reality (physical features of a portion of the Earth's surface) by graphically displaying on a planar surface ➔Maps display signs, symbols, and spatial relationships among features – Or represent an abstract characteristics such as political or administrative boundaries, population density, mean annual precipitation, or climate which are not visible in the landscape
- Is a pictorial representation of earth's features on a paper or sheet – Maps are drawn using graphic symbols to depict features on the Earth's surface
- Most usually, a Map is a two-dimensional, geometrically accurate representation of a three-dimensional space –
- It is a two-dimensional (2-D) representation (Eg: paper, tracing sheet, cloths …) of three-dimensional (3-D) earth features using proper symbols and colors.
- A well-designed map should include:

  - **Clarity:** Suppose, to produce an effective Geomorphological map (Eg. an effect of glaciation on a landscape), the map-maker need to deeply understand about that geomorphologic action
  - **Order:** Sequenced as Title, overall pattern, map legend, peripheral data
  - **Balance:** refers to the overall layout of the map elements (title, legend, scale, north arrow or Graticule to indicated orientation, inset maps and border)
  - **Visual Contrast:** The clarity of the map derives in part from clear visual contrast between symbols used to represent different features – It gives the eye a focal point and makes the map more interesting/attract map-reader's attention ➔A map that contains only lines of the same color and weight is unlikely to attract the map

reader's attention ➔Visual contrast can be based on any of the graphic variables (shape, size, color, value/intensity, pattern/texture, direction)

- ❖ **Unity and Harmony**: The map shouldn't be too complex, but even if it represents a complex spatial patterns, the map-reader must understand it at a glance – use related/consistent symbols, colors and patterns
- ❖ **Visual Hierarchy:** According to the purpose of the map, unnecessary information should be eliminated entirely – Information that is relevant to the purpose of the map should be symbolized in a way that makes more important information visually more prominent

Tasks of cartography

Map compilation-data collection, data Processing, symbolization, standardization, assembling, and categorization to make it manageable.

Map production (construction)-it could be mechanical or computerization

Map reproduction-which is editing, printing, processing, marketing & distribution.

Map revision-map revision is the process of updating the already existing ma depending on change of the place, technology, budget i.e. it varies from place to place

At times people were consider cartography as mechanical drawing & as part of mathematical geography. Of course, cartography is a multi disciplinary subject which serves as a bridge b/n different discipline & need the contribution of each. It is an auxiliary subject.

Art Vs Cartography

It is well known that the ultimate aim of cartography is representing part/all parts of the earth & other celestial body on graphic scale. This is the artistic nature of cartography

But to what extent cartography is an art is difficult to answer it .It is because of the fact that there are cartographers with artistic knowledge and there are also cartographers with out artistic skill.

Artists have freedom to come up with piece of workBut cartographer its own aim, purpose, area, standardization of symbols, e.t.c. A cartographer need to have background knowledge of geography especially location& spatial distribution of features &know hw to represent real objects on the earth onto map.

Cartography as a science of human communication

Cartography has

-articulacy nature—verbal, words of speech

-literacy—reading

-Numeric—numbers on map can indicate –altitude, number of people, ----

-Graphic-visual

-Body language—

Human communication involves 5 stages

Source→transmitter→Channel→Receiver→Destination

Noises are errors that affect communication/disturbances. These errors arise due to poor drawing, over crowding situation, & complexity & simplicity of the information the map carries.

Types of Maps:

Cadastral Maps:

- Drawn on a large scale
- Show the boundaries of every field and plot of land or a particular area – The map that indicates the legal boundaries and ownership of the property

Thematic Map:

- Concentrates on the distribution of a single attribute or the relationship among several themes **(**E.**g.** Soil type, vegetation, Population, average annual income, precipitation….)
- A map that displays the spatial distribution of an attribute that relates to a single topic, theme, or subject of discourse
- This includes **Univariate or single variable maps** (show the spatial distribution of a single variable such as precipitation, population or crop yields), S**pecial purpose maps** (designed for use by skilled users within a discipline such as geological maps, hydrological maps or for some specific actions like electoral map of elections) and **Derived maps** (are based on statistical data E.g. Maps which represent proportion maps, rate maps, mean/average maps or density maps)
- The **dissymmetric map** is a method of thematic mapping, which uses areal symbols to spatially classify volumetric data – Cartographers use dissymmetric mapping for population density

Topographic Maps:

- Drawn on a large scale
- Are survey maps, or general reference maps – A map depicting terrain/relief showing ground elevation, usually through either contour lines or spot elevations
- Represents the horizontal (Relative location) and vertical (elevaton) positions of the features represented – It is a graphic representation delineating natural and man-made features of an area or region in a way that shows their relative positions and elevations
- Show details of both physical and man-made features (hills, forests, canals, wells, rail roads, bridges, churches, mosque etc…)

Atlas Maps:

- Provide general information of physical, climatic and economic conditions of a particular place
- Useful for educational purpose

Wall Maps:

- Boldly drawn for better visibility in a classroom of conference hall.
- Are meant for display
- Show various physical and man-made features.
- Supply information about relief, climate, vegetation, population, town, cities etc…

Choropleth Map:

- Maps showing variation…how the amount of a phenomenon varies from one area to another area (Eg. Population densities of countries)

Isarithmic (Isoline) Maps:

- Isolines are lines connecting points having equal value
- Isolines are referred to as **isometric lines** if the data are based on sample points from a continuous surface or as **isoplethic lines** when the data are based on arbitrary points such as the centre points of administrative units used for data collection purposes
- Isotherms connect points having equal temperatures, Isobars connect points having equal barometric pressures, Isohyets connect points having equal amounts of rainfall, Isobaths connect points having equal depth below sea level

Bathymetrical Maps:

- Show the depth of seas and oceans

Uses of Maps:

Broadly speaking, **Visualization, Navigation, Codification** and **Measurement** are the basic functions of a map

- Maps represent and portray a part or whole of the earth's surface on a reduced scale ➔**Visualization**
- Helps to find out the way from one place to another – aids to orientation or **navigation** (road maps, bus route maps, tourist maps, hydrographic charts and aeronautical charts)– it indicates direction to travelers especially @ unfamiliar areas
- Physical planning purpose – A map inventories the present situation, defines the development processes and contains propositions for a future situation – E.g. future land use ➔**Measurement**
- Management tasks or monitoring – generally large scale maps –Eg. Management and maintenance of roads, railways, forests, canals….➔**Measurement**
- **Codification** – showing legal situation as regards to property rights – cadastral maps are produced for codifying land ownership – records political boundaries
- Maps may also be subdivided according to themes: show physical features, or weather/climate map, vegetation map, population map, geological map, language map…different maps serving different **t**hemes ➔**Visualization and Measurement**
- The common among all the maps – show position of places and things in relation to the earth Absolute location and in relation to one another (Relative location) – maps are used to record, present and analyze the location and distribution of points, lines or objects ➔**Visualization**

- **Surveying**:
  - Is the process of determining the location, form and boundaries of a piece of land by measuring its bounds and features
  - The data collected in a survey provide the essential source (database) from which maps are prepared

- **Engineering**:
  - Engineering field **(**particularly **Civil Engineering)** relies heavily on the information provided in maps.
  - Surface topography is important in engineering projects such as those involved in construction of buildings, bridges, roads, dams, tunnels etc. (i.e. maps give the basic idea and location where these construction works to be carried out

- **Hydrology:**

- Maps related to hydrograph supplies information pertaining to harbors, rivers, and other water bodies

- **Geodesy:**
  - Geodesy is a branch of science and mathematics that determines the exact position of figures, points and areas along with the curvature of the earth surface

- **Geological:**
  - Give information about the geological features like rock type, waterways and structures etc…

- **Forestry:**
  - Give the information related to forest cover and type in a particular area
- **Urban Planning:**
  - Maps Pertaining to detailed information of city can be used for various planning purposes – like location for new colonies, construction of roads, power line, waterline, flyovers, drainage etc…
- **Natural Resource Analysis:**
  - Qualitative and quantitative analysis of natural resources (Eg. Fertility analysis, access to water… can be done by using information from maps like types of land, water, forest, minerals etc.
  - These information are very useful in estimation and optimal utilization of natural resources in any area

Marginal Information on Maps

- Maps give detailed information of an area through symbols and colors
- There are some basic formats that every map contains, which make maps to look similar to each other and only theme of the map changes
- These information are:

Title:
- All map should contain a suitable title
- Title
  - identifies the map
  - convey **meaning** and **purpose** for creation of the map

The date of compilation:

- Things change with time, so the map reader must know the date of the map under review

Legend:

- Each map or each series of maps have their own symbols or colors for different objects
- These symbols or colors are described in the form of small boxes containing the same symbol and description or meaning of that symbol/color usually at the bottom right part of the map
- The legend communicates the meaning of the symbols on a map

Scale:

- The scale is the ratio between the distance of any two points on the map and the distance representing the same two points on the ground
- The scale can be represented in either of the three ways:
  - Word statement
  - Representative Fraction
  - Graphical Scale

Word statement (verbal Scale):

1. Expressed in a phrase such as **"Ten centimeters to one kilometer"** which means that 10cm on particular map is equivalent to 1 km on the ground)
2. It is more appropriate to use word statement that indicates the map is at a scale of 10, 100, 1000, etc… (E.g. Ten centimeters to one kilometer —

   Map scale= 10 cm to 1 km)

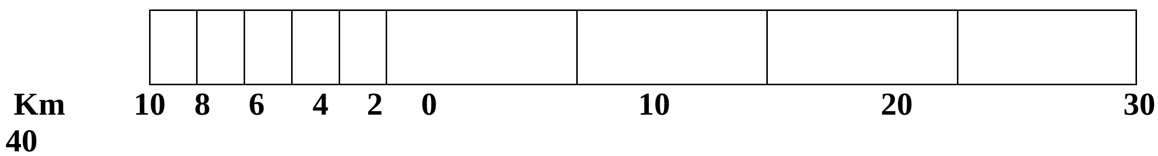
Scale Ratio (R F):

- expressed as the ratio between two distances :
  - The distance between two points as measured on the map
  - The actual distance between the same two points as measured on the earth's surface
  - This ratio is always presented with the map units listed first
- E.g. Distance between two points on the map is 10cm and the distance between equivalent points on the earth is 1km (100,000cm). Then the ratio is 10:100,**000** –which is reduced to 1:10,000 for listing on map.
- Scale ratios are not expressed in any specific units of measurements (Are unit less) – i.e. both sides of the ratio must be specified in the same units
- E.g. 1: 10,000 means 1cm on map represents 10,000 cm on the ground

- Frequently the scale ratio is written as a fraction called representative fraction – Eg. 1: 10,000 can be written as 1/10,000

☒ **Graphical Scale**:

- Map scales also are represented in graphic form --- dividing the line in to units, each of which represents, at map scale, the actual distance between two points on the earth
- These units generally are chosen to be easily usable, rounded numbers, such as tens or hundreds of kilometers, miles, miles, meters or feet
- Often, part of the scale is subdivided into fractional units to aid in measuring distance more precisely
- Is a usually used scale, because the map may shrink with time and the scale shrinks accordingly



☎ **Map Index Number**:

- Topographical maps need a unique identification number shown in the lower left or upper right part of the map
- This number is used to find the adjoining sheets if required

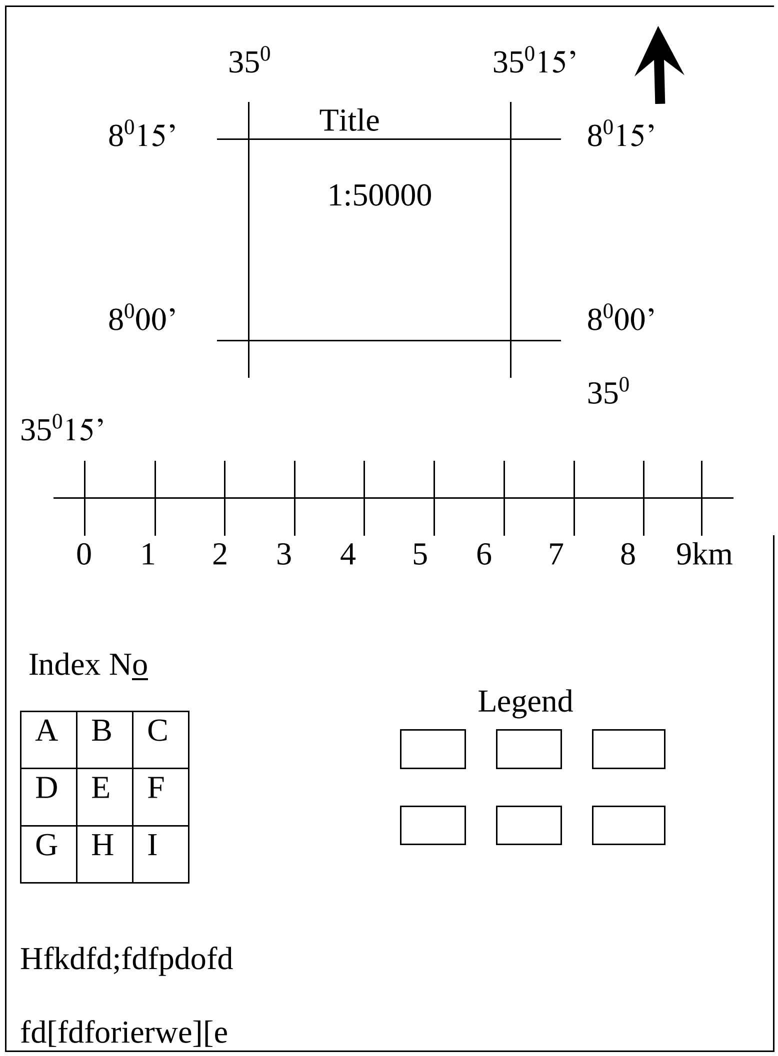
☎ **Coordinate System**:

- Every map is part of a particular portion of the earth, so it contains intersection of latitudes and longitudes
- The values of latitudes and longitudes are shown in the fore corners of the map at intersection points of latitude and longitude

☎ **North Arrow**:

- Every map should have a north arrow pointing towards the north

- So, having the above marginal information on maps, it looks something like below:



A
Map Language

- ✓ To convey its message in a summarized form, a map uses its own language expressed with the help of its conventional symbols and colors
- ✓ A map symbol (language) is a diagram, sign, letter or abbreviation which by convention or reference to key (legend) is understood to represent a specific feature of object
- ✓ Each map or each series of maps have their won symbols, which are explained in key or legend
- ✓ Whenever you are reading a map, consult the legend carefully so that you can understand the complete story told by the map

If you want to be an author of your map, you are, of course, allowed to use your own symbols as on as you give their meaning in a key in the margin of the map. When selecting the symbols for your map, it should satisfy the following requirements:

- **Uniformity** – should be uniform in the entire map
- **Comprehensibility** – should be comprehensive, complete with maximum possible information
- **Legibility** – clear on the map
- Sufficient **preciseness** – in terms of location, space occupied etc

Groups of symbols:

- Symbols for water features – color Blue – Seas, lakes, rivers, water bodies, reservoirs, canals etc …
- Symbols for relief features – color Brown and Black – contours, Hatchers, spot height etc…
- Symbols for vegetations – color Green – forests, woodland, bushes, plantations etc …
- Symbols for communication features:
    - Railways – Black color – (single track, multiple track, normal or narrow gauge)
    - Roads – Red color – (all weather, hard surface, gravel or loose surface, cart track)
    - Aerial ropeways, ferry routs, power line, telephone line etc …-- Black color
- Settlements – Red or pink color – different style and lettering – cities, towns, developed areas etc …
- Miscellaneous symbols – Black or Brown color – administrative boundaries – international, state, district etc … Buildings like church, mosque, school, post office etc… Enterprises like mills, quarries, mines etc…

- You should note that most of these symbols are pictograms
- The variety of symbols used in different parts of the world is enormous. The main duty of a student can only be to make himself familiar with the symbols those are used in his country
- When you face a map with unfamiliar symbol, find the meaning of the symbol in the legend of the map
- Many symbols for common features have already become international… Eg. Bridges, churches, mosques, schools, railways etc, and there is a trend to create a really uniform international map language
- The number of symbols used on a single map depend on:
    - Scale of the map
    - The character of the area mapped (densely or sparsely populated)

Map Classification

- There are many kinds of maps – Some maps show how far one village is from another village, while another map would emphasize physical features like mountains and rivers
- Some maps show weather and climate to the following major groups
- Classification of maps is based upon:

Scale of the Map

- **Large-scale Map**:
  - When a map of a given size covers a relatively small area of the earth's surface, it is called a Large-scale Map
  - Large-scale map can include a considerable amount of information
  - Maps scaled => 1:50,000 / 1:10,000 / 1:5,000 / 1:25,000 are considered as Large-scale maps
  - Convey more information

- **Small-scale Map:**
  - If the map of the same size covers a large area of the earth's surface, relatively little detail can be included and the map is called Small-scale map
  - Scale => 1:500,000 / 1:1,000,000
  - Convey less information

- **Medium-scale Map:**
  - The scale lies between large and small scale i.e. greater than 1:50,000 but less than 1:500,000 are considered as medium-scale
  - Convey intermediate information

The contents of the Map

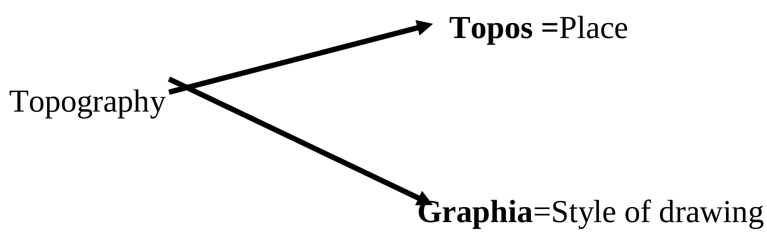
- **General geographical maps** ➔ topographic map – gives information about the topography of an area
- **Topical maps or Thematic maps** ➔ information about a particular theme – soil map, forest map, wasteland map, geology map etc …

The purpose of the Map

- Maps of scientific research
- Maps of educational reference
- Navigational map
- Tourist map

- **Spatial (space) coverage (Aerial extent)**
    - World map
    - Map of continents
    - Map of oceans
    - Regional map
    - Zonal map
    - Country, district maps etc…

- The main difference between these different classes of maps is not only based upon the difference in scale but also upon the uses you can put on maps
- The smaller the scale the less detailed the maps and vice versa
- Another basic difference between maps drawn in different scale is the effect that the scale has on the sizes of the maps covering the whole country when it is drawn in different scale
- Based on the above expression, you should finally remember the important fact that a mapmaker always selects the scale for the map so that it fits the purpose of the map
- Because of the detailed information that can be shown on large and medium scale maps, they are usually called topographical maps



- **Topographic maps –** are general maps which show a selection of natural and man-made features of the landscape within one framework, which results from a systematic survey of the area shown on the map
- **Topical or Thematic maps –** other large or medium scaled maps that deal with only one aspect or theme of the area such as relief, soil, rock type, land use, vegetation etc… are called topical or thematic maps

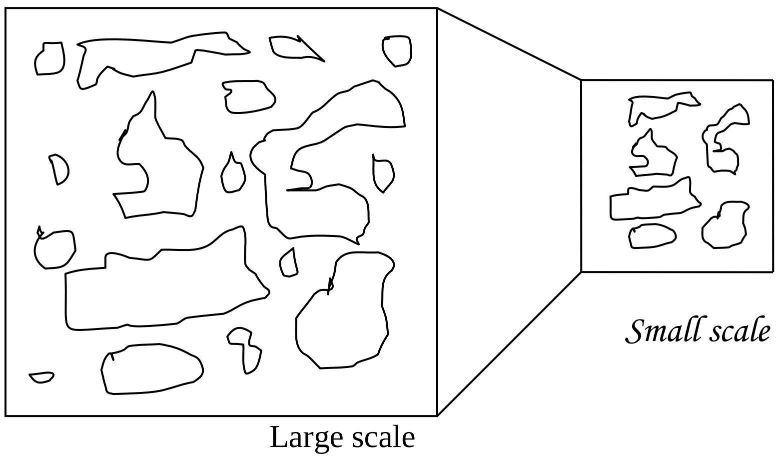
Map Generalization (Cartographic Abstraction)

- Every map has to be generalized or simplified – i.e. maps cannot show each and every detail of the real world they represent

- The smaller the scale of the map, the greater the amount of generalization is required because the amount of space available to show any given feature becomes less
- The following map characteristics can be used for generalization:

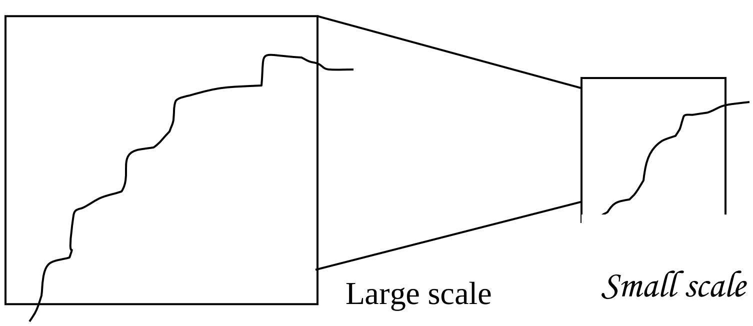
Selection:

- One means of generalization is the selection of and retention of more important features in the area and the elimination of less important ones – no modification but choice
- E.g. If a series of lakes is shown, some of the smaller lakes in the group can be eliminated as the scale reduces



Simplification:

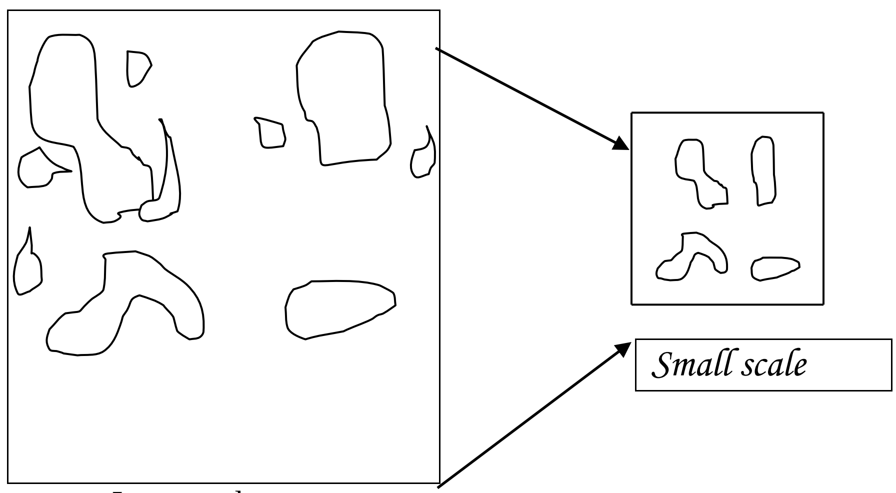
- A second technique of generalization is the simplification of the features retained on the map – eliminate unwanted detail



E.g. district boundary show more detailed information in large scale map compared to small scale map

Combination:

- Another step of generalization is combination of two or more similar features into a single symbol.
- E.g. If there are to many small wooded areas in a region, two or more of small areas of them can be grouped to single wooded area



Large scale

Location shift and size exaggeration:

- The generalization of particular map may also require shift of location of a particular feature to highlight them and gain necessary space
- Sometimes size of a feature also require to be emphasized/exaggerated than actual size to have legibility, visibility on the map

<u>History of cartography</u>

As to the history of cartography no one knows the exact time when it was started. What we know is that, its history is as old as geography, Art, astronomy---

The history of cartography could be dividing

1. Primitive (Ancient) prior to 4^{th} c A.D
2. Middle (medieval) 4-16thc A.D
3. Modern16thc on words

A. **Ancient (Primitive) cartography**

During ancient times people used to express their idea, experience est. through pictures, charts, drawings which we call it "rough sketch maps" these maps were used by ancient people for the purpose of hunting & gathering.(what is found where)

What are the characteristics of ancient maps?

-they carry only localized information
-they are with out scale –all of which were drown on soft ground, clay tablets, stone, bones, on wall of caves,& bronze

What are those ancient areas from where we can find ancient sketch maps?

These are Egypt, Mesopotamia, and Babylon's. Asia,(India & China) central America-the Incas

B. Greek Cartography –the Greeks were the first or pioneer in education, science and technology. This is because they are close to Babylon. Among the Greek scholars the following could be mentioned

What are the contributions of the Greek cartographer for the development of cartography?

1. Anaximander –was who first formed the world map
2. Hicataetus-wrote the first geo.book He believed that the earth as a circular plain or disc

3 Herodotus-was great Greek traveler who rejected that the earth was not circular plain or disc. He also circum navigated Africa
4. Aristotle-(384-322) B.C-who believed the earth is spherical shape.
5. Eratosthenus-the man who coined the word "Geography" and attempted to measure the circumference of the earth. 24662 mile (39459.2km), he also tried to present the spherical shape of the earth on plain surface
6. Hippartus-he compiled the earlier work of Greek scholars
7. Ptolomey-(90-160) AD. It was at his time that the development of geo. & cartography reached at its maximum stage. This man comes up with 8 volumes of geographic books. Emphasizing on the principle of mathematical cartography and methods of representing a spherical surface on a plain surface –place names including their latitude & longitude –location. He was the first man who showed Ethiopia on world map. He was the father of mathematical& cartographic geo.
His ideas were dominant until the 15^{th} c (Dark Age). His problem was, miscalculated the circumference of the earth to the extent 1^0=90.4km in contrast to the Eratosthenes 99.6km. All these mistakes were carried (corrected) by modern cartographer

C. **The Roman Cartography**

What is Globe? Is the best model of the earth

On a **globe,** features from the earth's surface – their **shape, the area** they occupy and **the distance** and **direction between** them – are **correctly shown**

The earth is spherical in shape

Nearly 75% of the earth surface is occupied by water in the form of oceans, rivers, lakes, ponds, etc…..

The remaining 25% of its surface is occupied by lands in the form of mountains, forests, grasslands, marshes, plateau etc…

These together constitute the earth

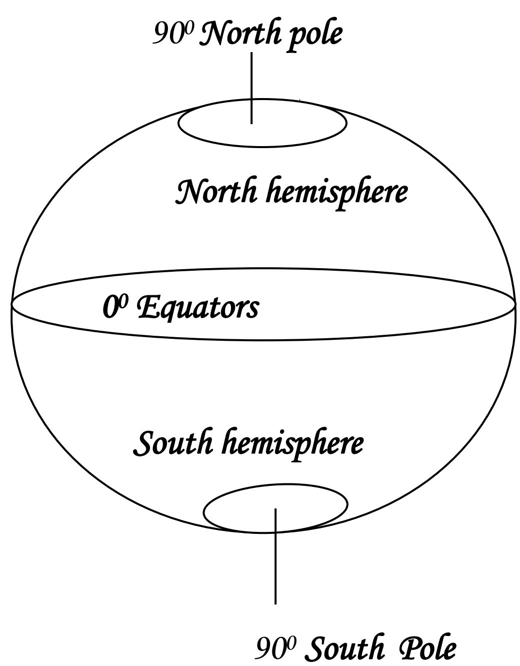
The earth rotates on its axis with respect to pole in westward direction to get day and night on the earth

It also revolves around the sun in a elliptical orbit to get different seasons and months

Depending upon the amount of sunlight received, one complete revolution leads to one year

There are seven continents on the earth – Asia, Africa, Australia, Europe, North America, South America and Antarctica

The oceans are Arctic, Pacific, Atlantic, Indian etc…



To describe the exact location of a particular point on the sphere, we need to establish a reference system called the **Grid System** which consists of a set of imaginary lines drawn across the face of the earth – The key reference points are the **North and South Poles** and the Equator (given by nature) and the prime meridian (agreed upon by cartographers)

Equator:

Is imaginary line drawn on the earth in East-west direction bisecting it into two equal parts

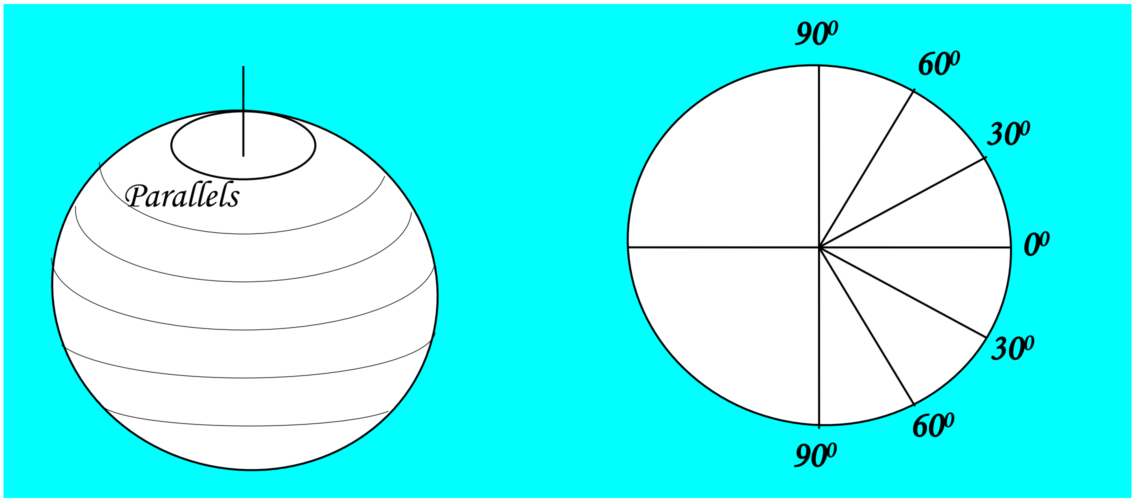
It is the line that encircles the globe halfway between the poles, perpendicular to the axis

The upper part is called North hemisphere – and the lower part is called South hemisphere
The Equator is at 0^0

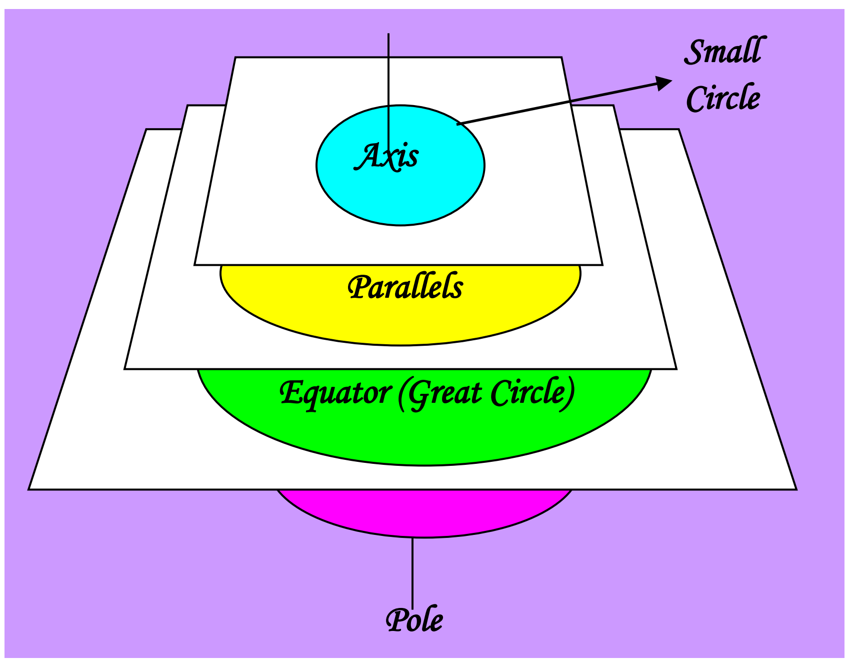
Poles:
The North and South most part of the earth are called poles
The North and South poles are the end points of the axis about which the earth spins
The poles are at 90^0 N & S – and the distance between the two poles is 180 degrees, because a full circle contains 360 degrees

Parallels and Meridians (Geographical Coordinates)
Parallels:
Are Imaginary lines drawn and run East-West direction, parallel to the equator and parallel to one another at right angles to the meridians
These are numbered in degrees North and South from the equator, which is given a value 0^0 with the maximum value 90^0 assigned to each pole – Parallels increasingly become smaller and smaller (so that Small Circle) closer towards the pole
On the globe, the 60^{th} parallel (60^0) is only half as long as the equator)
Parallels are used to define locations of points in the North-South direction – in terms of distance measured as an angle from the earth's center (Equator)
These are also called **Lines of Latitudes –** defined as the measure of distance in degree North and South of the equator – or the angular distance from the equator
The polar circumference of the earth (assume a full circle) is 24,899 miles (app. 40,000 kms … 1km=0.6214 miles if 1 mile = 1.61 kms) – Thus, the distance between each degree of latitude ➔➔24,899 miles/360 = app. **69 miles** or 40,000/360 = app. **111 kms**
But, even though we assume, the earth is not a perfect circle, has a slight flattening near poles (see Geodesy part), therefore all degrees of latitude are not equally long ➔➔i.e. degrees of latitude are slightly longer near poles (111.70 km; 69.41 mi) than near the equator (110.56km; 68.70 mi)
To record the latitude of a place in a more precise way degrees are subdivided into 60 Minutes (') and each Minutes also into 60 second ("), exactly like an hour of time
1 minute of latitude is about 1.85 kms (1.15 mi) and one second of latitude about 31 meters (101 ft…1ft=0.000189mi)

Imaginary line drawn parallel to equator at 23 ½ ^{0} north is called Tropic of Cancer and line drawn 23 ½ ^{0} south is called Tropic of Capricorn.



Great Circle:
Which is the Equator, located midway between the poles
Is the line defined by the intersection of the plane with the earth's surface, by visualizing a plane passing through the center of the earth
The Arc of the Great Circle is the shortest distance between two points
Each half of a great circle (Arc of a Great Circle) that joins the poles is defined as meridians
A Small Circle is created when a plane passing through the earth divide into two unequal portions
Lines of Latitude or Parallels, placed parallel to the Great Circle (Equator) are series of small circles



Meridians:
Are each half of a Great Circle (Arc of the Great circle) that pass through and join the poles @ right angles to the parallels

Imaginary lines drawn in North-South direction, since the distance North or South of the Equator is not enough to locate a point in space

Meridians are farthest apart @ the Equator and come closer and closer together as latitude increases and totally converge @ the North and South poles

Unlike parallels of latitude, all meridians are of the same length

Since all the meridians are identical, one must be selected as a starting point called **Prime meridian** – The Prime Meridian is an arbitrary line and the starting point for East-West measurement

It could have been assigned to any North/South line which circles the globe

Most maps use the Greenwich England as the Prime Meridian – which is an imaginary line passing through the Royal Observatory @ Greenwich – selected as 0^0 longitude

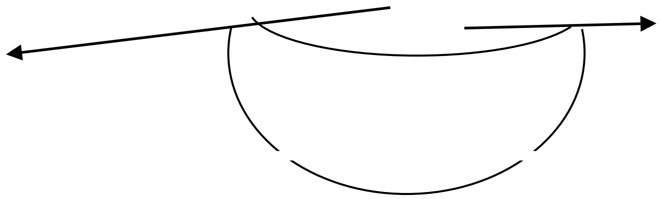
The Prime Meridian given a value of $0^0$and remaining meridians are numbered in degrees east or west of the prime meridian

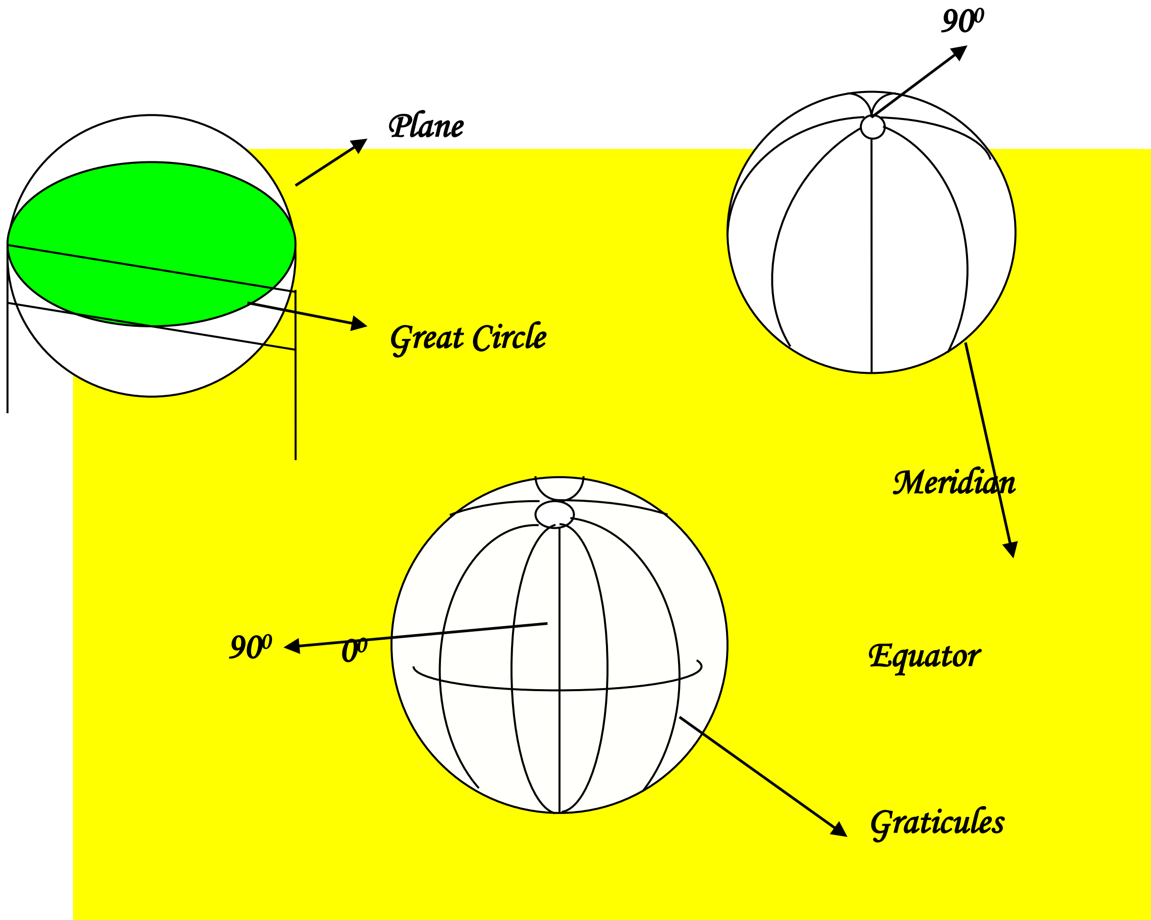
This gives the values of Longitudes – defined as the angular distance East or West of a prime meridian and changes in East-West direction

East-West measurements range from0^0 to 180^0 from meridian to 180th meridian in each direction on the opposite side of the Prime Meridian

Like parallels of latitude, degrees of longitude can be subdivided into minutes and seconds – However, distance between adjacent degrees of longitude decreases away from the equator because the meridians converge @ poles

Time depends on longitude – The earth, which makes a complete 360^0 rotation once 24 hours, is divided into 24 time zones roughly centered on meridians at 15^0 interval – Greenwich Mean Time (GMT) is the time at the Prime Meridian





aticules:

* The imaginary network of the lines of Meridians and Parallels upon which the map is drawn

Characteristics of Graticules :

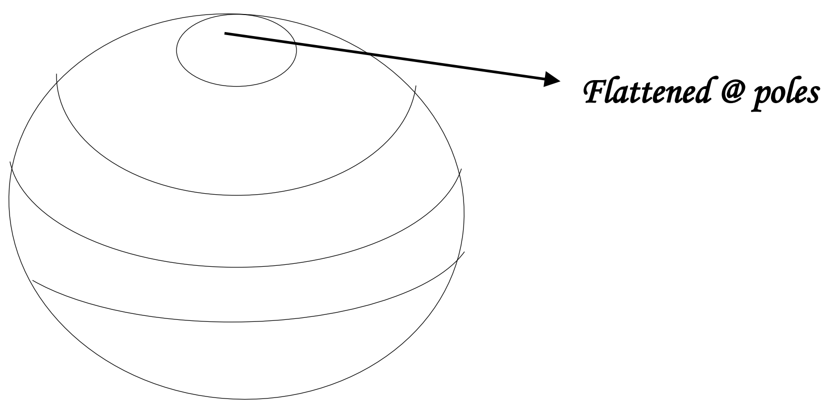
* **The Arc of the Great Circle** is the shortest distance between two points
* Meridians are arcs of the great circle that meet @ the poles
* The Equator is a Great circle, located midway between the poles – Parallels (Lines of Latitude) are concentric small circles that are parallel to the equator

- Parallels are true East-West lines
- Parallels are equally spaced between the equator and poles
- Parallels are always parallel to one another, so that any two parallels are always the same distance apart
- Meridians are spaced farthest apart on the equator and converge to a single point at the poles
- Parallels and Meridians cross one another at right angles

The Earth Objects to be mapped

- **Natural features** – forest, mountain, hills, rivers, grassland, relief features, wasteland, soil, rock, water bodies etc …
- **Cultural features or man-made feature** – features created by man Eg. Roads, rail, bridges, canals, buildings/dams etc…

Basic Geodesy – Shape and Size of the Earth
Spherical Earth:
The basic shape of the earth is spherical but somewhat flattened at poles
But, a more detailed examination reveals that the earth's shape is not exactly spherical

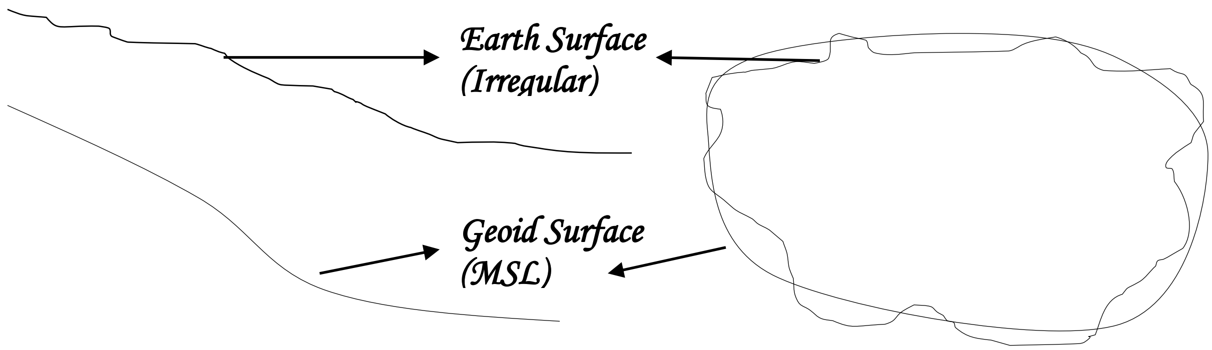


Geoidal Surface (Geoids – meaning **Earth-like):**
Reveals that the earth's shape and size is not a regular ellipsoid, but somewhat irregular
The precise shape of the earth is represented by a figure called Geoid, which is defined as a theoretical surface on which the **potential of the gravitational force** of the earth is perpendicular and equal at all points to its strength at mean sea level
If the earth were of same geological composition and devoid of mountain ranges, ocean basins, and other vertical irregularities, the Geoid surface would match the **ellipsoid** exactly
The earth's surface undulates, and thus there is variation in gravity ➔Vertical distance (From deepest part of the ocean to the highest mountain peak of the earth) = 19, 880

meters ➔But the diameter of the earth = 12, 756,370 meters, excluding the Vertical distance

The Geoid is three-dimensional shape and corresponds approximately with the Mean Sea Level (MSL)

This surface of the earth is not suitable for mathematical calculations



Ellipsoidal Surface (Ellipsoid):

Since Geoid is not suited for mathematical computations, an ellipse that best fits the

The earth revolves easterly on its axis ➔this rotation generates centrifugal force, which causes the earth to bulge slightly @ the middle and to flatten slightly @ the poles ⇨resulting in a shape called **Ellipsoid**

An Ellipsoid has a slightly greater radius @ right angles to the axis of rotation and slightly smaller radius along the axis ➔This is what we call **Polar Flattening**

The flattening ratio is not so great (averaged to be **1/298**), this means that the earth is so close to the true Spherical shape that results from a full circle

i.e. If we sliced the earth from pole to pole through its center, we would see slightly elliptical cross section

The size and shape of the ellipse is specified by its semi-major and semi-minor axes and its flattening is designated by the letter ‘f’

It is the difference between the lengths of the semi-major and semi-minor axis divided by the length of the semi-major axis

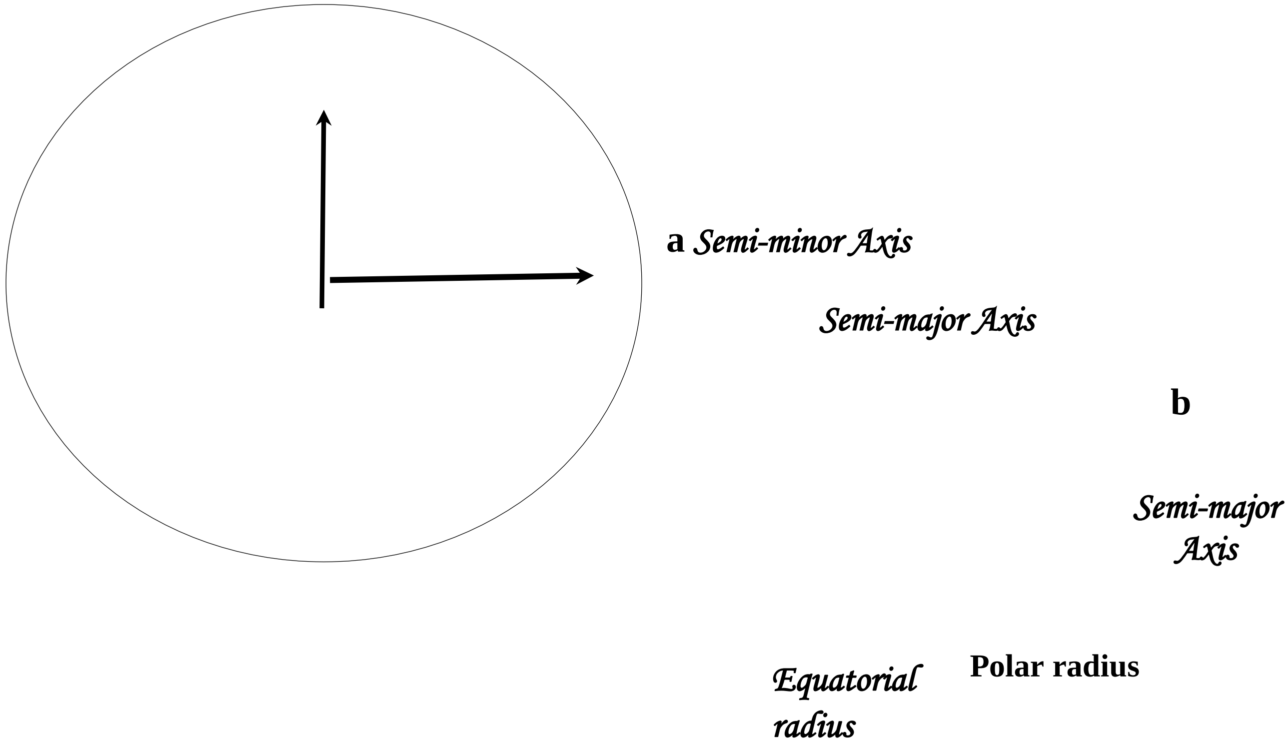
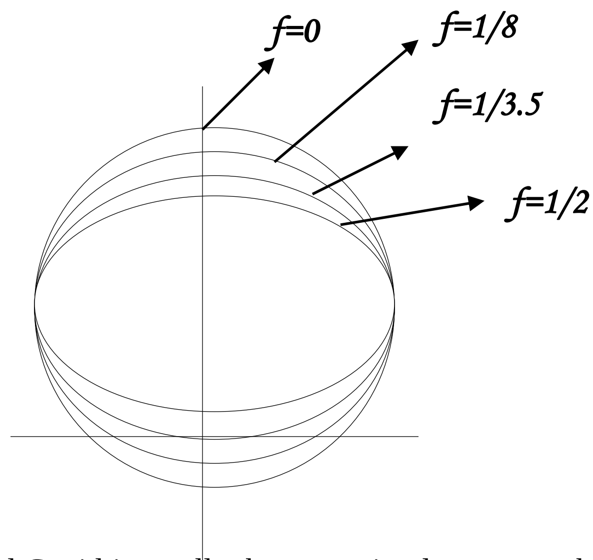


Table1: Official Ellipsoids

Name	Radius (a) in meter	Radius (a) in meter	Polar flattening
WGS 84	6,378,137.0	6,356,752.3	1/298.26
GRS 80	6.378,137.0	6,356,752.3	1/298.26
WGS 72	6,378,135.0	6,356,750.5	1/298.26
Australian	6,378,160.0	6,356,774.7	1/298.25
Krasovskiy	6,378,245.0	6,356,863.0	1/298.30
Hayford 1909 (International)	6,378,388.0	6,356,911.9	1/297.00
Clarke 1880	6,378,249.1	6,356,514.9	1/293.46
Clarke 1866	6,378,206.4	6,356,583.8	1/294.98
Bessel 1841	6,377,397.2	6,356,079.0	1/299.15
Airy 1830	6,377,563.4	6,356,256.9	1/299.32
Everest 1830	6,377,276.3	6,356,075.4	1/300.80



The difference between Spheroid and Geoid is small when mapping large area; therefore spherical shape of the earth is taken for most of the mapping purposes E.g. Atlas Map etc…

Spherical shape is the reference surface for small-scale maps of countries, continents and large area

But, with detailed large-scale maps of small areas (such as Topographic maps), the difference between locations on the spherical and ellipsoidal approximations is significant, therefore Ellipsoid is used as reference surface of these large-scale maps

Geoid Surface is used for Geodetic Control Survey (for ground surveyed horizontal and vertical positions)

Ellipsoid surface is considered for Topographic Mapping

Location

For any mapping, position of point on the earth is required

Positioning is done with reference to the imaginary lines drawn in East-West and North-South direction on the earth surface

❋ **Direction**

The determination of direction requires a frame of reference

A baseline must be established first and direction is expressed in terms of angular measurement in relation to baseline

The baseline usually used for direction finding is North-South line that passes through the viewer's position and establishes north

Because more than one north reference can be established, the viewer must decide which one to be used:

A reference is required to determine the direction

First a baseline is established

Direction is expressed in terms of angular measurement with respect to baseline

Baseline is usually North-South line to establish north

More than one north can be established

True North:
Direction towards the North pole
Magnetic North:
A north arrow of magnetic compass needle points towards the north magnetic pole
Grid North:
Any map may have more specialized grids such as UTM (Universal Transverse Marketer) and SPC (Slate Plane Coordinate Systems) superimposed on it
The Grids North is the direction of north trending lines of such grids

UNIT TWO

Measurements on Maps

A variety of information about the earth, and about the features distributed on its surface, is obtained by direct measurements from maps

Two measurements of primary importance:

The distance between locations

The area of a region

Measurement of distance

Map distance measurement assume that one of the two conditions is met so that the measurements taken are valid

First condition is that the distances are short so that the earth's curvature is not an important factor

The second is that the map is on equidistant projection and the measurements are taken along appropriate

For E.g. it is not appropriate to directly measure the distance between New York and London. However, to measure the distance between the downtown and suburbs of a city is valid

Before starting any measurement on map, it is advisable (necessary) to consider the following three points

If you are asked to measure a distance between two points A and B, it is the real distance (ground distance) that is wanted not distance on the map

Therefore, don't give answer like this, "the distance from A to B is 30 cm"

To obtain the real answer it is required to change the distance obtained through measurement on map (map distance) to real distance (ground distance) with the help of scale of the map

Distance on map is measured in centimeters but distance on field is given in kilometers

Therefore it is meaningless to say that, "the distance from Addis Ababa to Asmara by road is 10740000 cm=1074 km

All distance obtained through measurements on maps called map distance don't consider the ups and downs on the field

In the real world the routes between locations almost always involve ups and downs

The actual surface distance between two objects, therefore is longer than the map distance, except in exceptional case where ground surface is perfectly flat

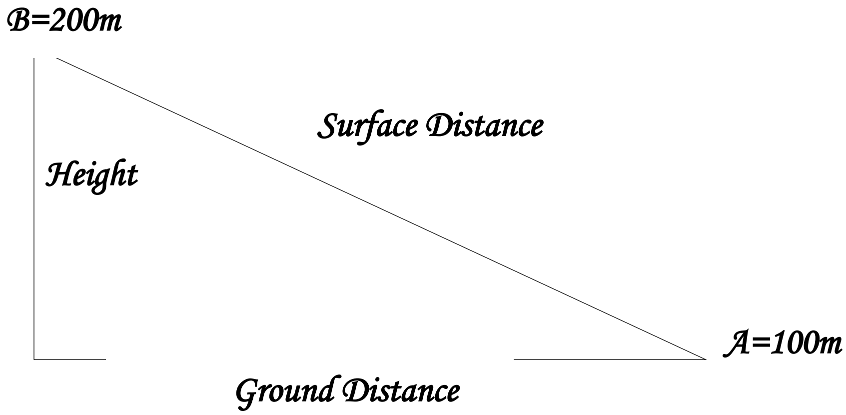
Assuming that there is relatively uniform slope between two points, the calculation of the distance correction for elevation involves simple application of the Pythagorean Theorem

Suppose two points A and B have map distance of 30 cm and elevation is 100m and that of is 200m. The scale of the map is 1:50,000

Then map distance=cm

Scale 1cm=0.5 km

Ground distance= 30 x 0.5= 15 km



Now **Height difference** between A and B is 200m-100m=100m

The field or surface distance= $\mathbf{\sqrt{(1500)^2} + \sqrt{(100)^2}}$=

In distance measurement exercise, you will be asked to find three types of distance

Opisometer – is an instrument having route measuring wheel

The wheel is allowed to move along the route whose distance is required

The length traversed by the wheel is indicated on the instrument

The total length recorded by the instrument is converted into ground distance

Accurate measurements along bending lines like roads are possible only on large-scale map

On small and medium scale maps, roads are shown in such a generalized way that all small bends of roads are eliminated

In such case accurate road distance measurement is not possible

Measurement of Areas

The normal scale of a map usually is defined in linear dimensions

The aerial scale of a map in contrast is defined in aerial units

The scale of a map is sometimes used to describe the relationship between the area of a feature plotted on a map and area of the same feature on earth's surface

The ratio between area of a region on a map and the area of the same region on the earth is the square of map's linear scale

Arial scale= $(\text{linear scale})^2$

For E.g. if the scale is 1:50,000

Linear scale is 1 cm to 0.5 km

Arial scale = $(0.5\text{km})^2 = 0.25\ \text{km}^2$

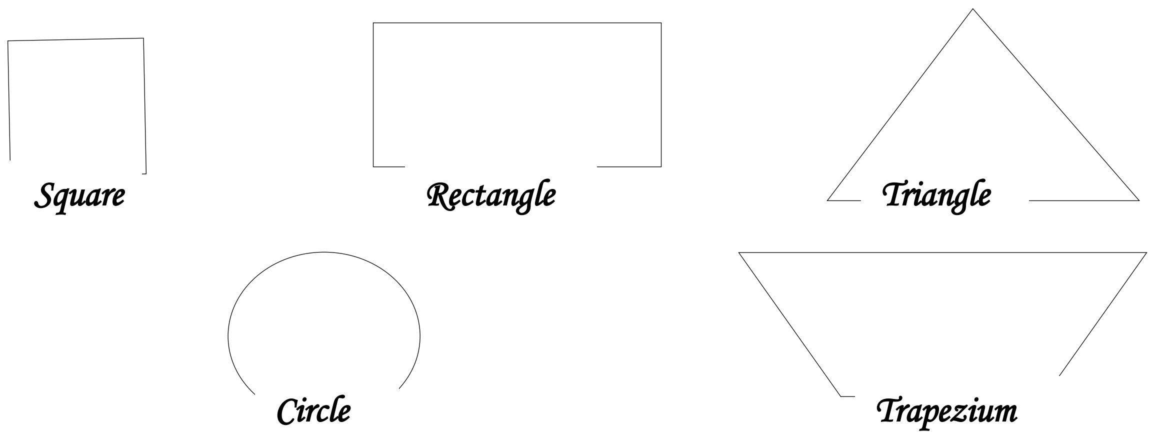
Areas of Regular shapes

Regular shapes include square, rectangles, triangles, trapezoid, etc…

From geometry, areas of regular shapes can be calculated by knowing the necessary parameters like base, height, length, radius etc…

These parameters are obtained through measurements on maps

Using scale of the map, the map area is converted to ground area



- ***Area of Square =*** *(side)*^{2}
- ***Area of circle =*** πr^2
- ***Area of Rectangle =*** *Length x Breadth*
- ***Area of Triangle =*** *½ x base x height*
- ***Area of Trapezoid =*** *½ (side1 + side2) x height etc…*

Areas of Irregular shapes

Most areas to be measured from maps are irregular in shapes

The following methods are used to calculate the area of irregular shapes on maps and then using the scale of the map, it is converted into ground area

Direct Methods of Measurements

Polar Plannimeter:

Is an instrument that measures areas on a map in terms of square inches or square centimeters?

As usual, these measurements are then arithmetically converted to earth measurements

Digital Plannimeter:

Is an instrument to calculate the area on map with high accuracy?

Steps:

The Plannimeter dial is set zero

Scale of the map is entered into the Plannimeter

Tracing point is marked on the area to be measured

Tracing point is placed over the starting point – then carefully moved over the Perimeter of the area in clock-wise direction and returning to the starting point

Note the reading on the dial – at least 3 readings should be taken for an area – measure at least three

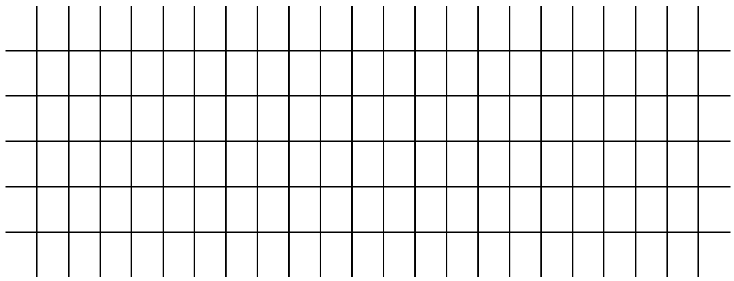
A final area is recorded after taking the average of the readings

Indirect Methods of Measurements of Irregular Shapes

Grid square:

A grid is an array of horizontal and vertical lines intersecting each other at right angles

Each square is called grid cell



Steps:

A grid of known area (generally each cell =1cm^2) is drawn on tracing or transparent sheet

These grids are overlaid on area of interest

Count the full square that completely fall within the area

Count the half or partial cells

Then, Area = [Full Cells + (half cells)/2 + (Quarter cells)/4] etc … X Cell value

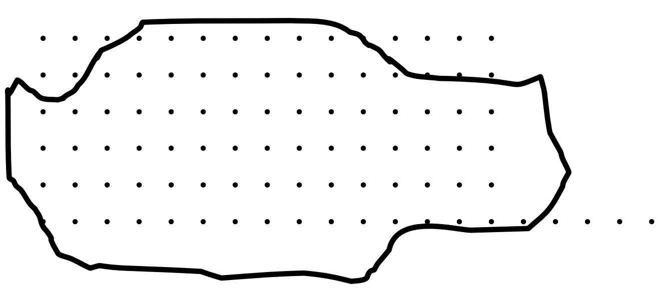
Dot measurement:

With the dot-Plannimeter method of aerial measurement which is a variant of the grid square method, a regularly spaced pattern of dots is placed over the map

This is similar to the grid square method – the only difference is that instead of using grids, dots are used

Dots of known widths (generally 1 cm^2) are overlaid on the shapes

Number of dots within the shape and number of dots at the boundaries are counted



Area = [dots within + (dots @boundary)/2] X dot width

In contrast to grid square method and strip method, which are exhaustive counting methods, the dot Plannimeter method is simple procedure

Strip method:

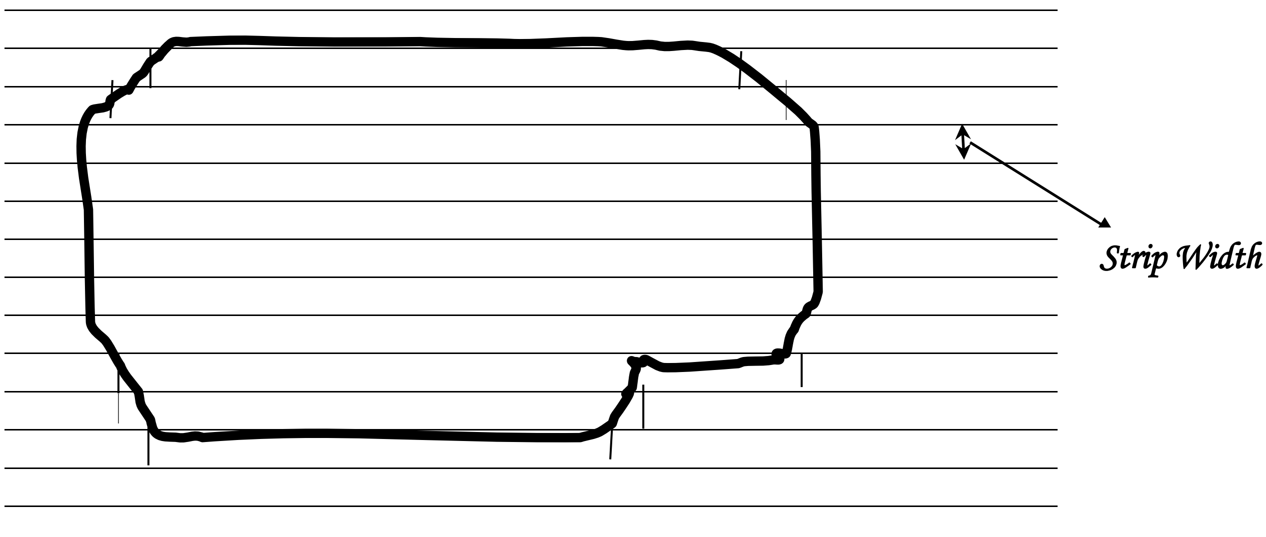
In strip method, a series of parallel lines of known width (generally 1 cm^2) are drawn over the area

The end of each strip is formed by drawn vertical lines at the edge of area being measured

Length of each strip is measured

Sum the individual strip lengths and multiply the total length with strip width to get the area

Area = Total strip length (cm) X strip width (cm)



Polygon method:

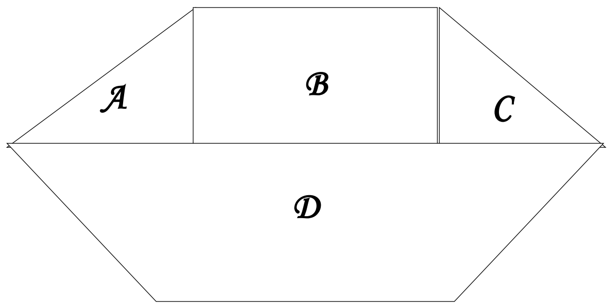
It is based on methods of measurement for regular shapes

Divide the area into number of regular shapes

Measure the required parameters for each regular shape

Calculate the area for each shape

Sum the area to get the area of irregular shape



Area = Area A + Area B + Area C + Area D

Problem of Map scale

1.How to change from one scale to another scale…….

From RF to simple Scale?

1:50000, 1:100000, 1:250000 etc…

From Simple scale to RF?

1 inch to 1 mile, 1cm to 0.5km, 1cm to 5 km etc…

From Simple scale and RF to Graphical Scale?

1 inch to 1 mile, 1 cm to o.5 km, 1:250,000, 1:500,000 etc …

2.How to find out scale when it is not given:

We need to **deduce** scale when it is either not given on the map or the scale given on a foreign map shows distances in unknown units to us

Map without scale is called Drawing or Sketch

Case I – When some ground distance is given:

Eg – Distance between A and B on ground is 5 km

Then measure the distance between A and B on the map (Map distance) – Let us say it is 50 cm

Hence 50 cm to 5 km = 50 cm to 500,000 cm

1cm to 10,000 ➔RF = 1: 10,000

Case II – When nothing is known about the distance on the map but map is provided with Latitude and Longitude:

The map distance between two latitude and Longitude lines can be compared to the earth distance between them

Average length of degree of latitude is 110.5 km near equator and 111.7 km near poles

So depending upon the place, we can calculate ground distance between two latitude degrees

Measure the same distance between two latitude lines on map

Calculate the scale using the formula:

Scale = Map distance/Ground distance

- If length of Longitude is used then distance between Longitude degrees is Cosine of latitude multiplied by 111.3 km
- i.e. if longitude is measured at 45^0 latitude, then

Cos (latitude degree) X 111.3 km = Ground distance between Longitudes

The distance between the two longitude degrees = Cos 45^0 X 111.3 km = 78.7 kms = **Ground distance between Longitudes** measure the map distance between the same points and calculate the scale using the formula above

Case III – By comparison with other map:

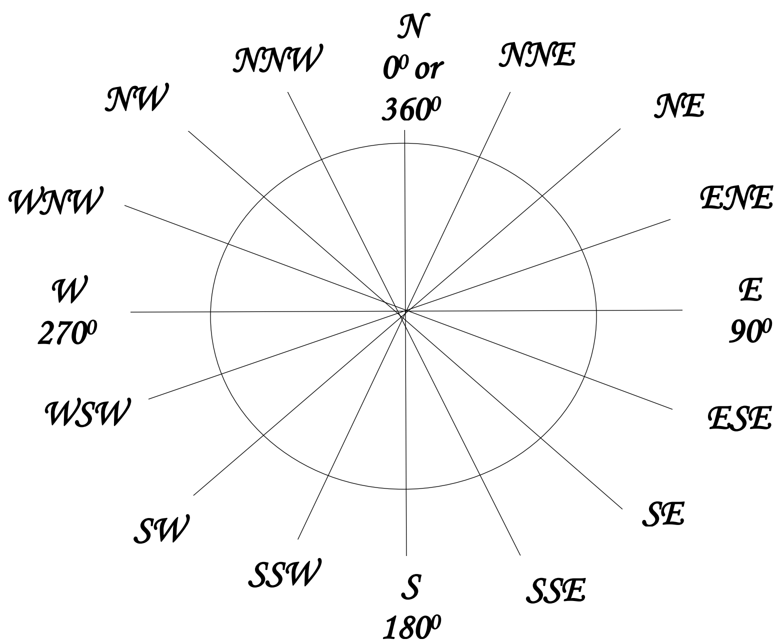
The map distance between points A and B on map X is 50 cm and the scale is 1:50,000
The same points A and B are present on another map Y where the map distance between AB is 25 cm, what will be the scale of the other map
On map X, 1cm = 0.5 km
➔ 50 cm is 50 x 0.5 = 25 km
Now on map Y, AB = 25 cm
➔ 1cm on map Y = 25/25km = 100,000
Scale of Y is 1:100,000

Bearing and Direction on Maps

North, South, East and West are the four cardinal directions – the angle between two adjacent points is 90^0
The four cardinal positions can be further subdivided into eight points – The angle between two adjacent pints will now be 45^0
To be more accurate, the directions can be again be subdivided into sixteen points – the angles between two adjacent points is $22½^0$
Even with sixteen compass points we cannot cover all directions accurately – so we have to take help of direction finding system, which will give us the exact direction in terms of degrees
When we start from North which is 0^0, move clock wise till you come to East, which will be 90^0
Likewise, move clockwise further till you come to South which is 180^0
Again, move clockwise from South till you get 270^0, which is west
And, finally, come back to North when you have completed 360^0 or made a complete circle.
Thus, when you take north as point of reference, you can find direction in terms of degrees

Cardinal direction

On mariner's compass, there are 32 points showing different directions
Points marked North, South, East and West on a mariner's compass are known as Cardinal directions
And the remaining points are known as Intermediate points
Normally only 16 directions out of the 32 are shown below as we use only these directions
The 16 directions are drawn @ an interval of $360^0/16 = 22^0 30'$



The other 16 directions are as follows:

North by East = the direction halfway between N and NNE

North-east by East = the direction halfway between NE and ENE
North-east by North = the direction halfway between NE and NNE
East by North = the direction halfway between E and ENE
East by South = the direction halfway between E and ESE
South-east by East = the direction halfway between SE and ESE
South-east by South = the direction halfway between SE and SSE
South by East = the direction halfway between S and SSE
South by West = the direction halfway between S and SSW
South-west by South = the direction halfway between SW and SSW
South-west by west = the direction halfway between SW and WSW
West by South = the direction halfway between W and WSW
West by North = the direction halfway between W and WNW
North-west by West = the direction halfway between NW and WNW
North-west by North = the direction halfway between NW and NNW
North by West = the direction halfway between n and NNW

Geographic, Magnetic and Grid North

The determination of direction requires a frame of reference

The baseline must be established first and direction is expressed in terms of angular measurement in relation to baseline

The baseline usually used for direction finding is North-South line that passes through the viewer's position and establishes North

Because, more than one North reference can be established, the viewer must decide which one to be used

A reference is required to determine the direction

First a baseline is established

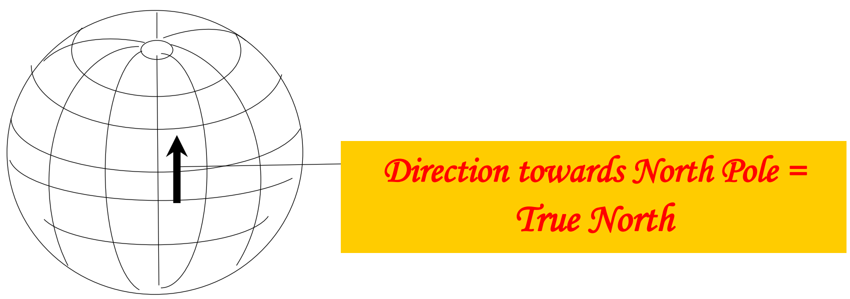
Direction is expressed in terms of angular measurement with respect to baseline

Baseline is usually N-S line to establish North

More than one North can be established

True or Geographic North

The most commonly used north for finding direction is True North (sometimes called Geographic North)



True North is the northerly direction along a line on Longitude (Meridian Direction)

Determination of True North

True north is easily determined, on clear night in northern hemisphere, by sighting POLARIS, which is a star located almost directly over the Geographical North Pole

A **Gyrocompass** provides another means for determining true North – it has an advantage that it can be used at any time of the day or night

Gyrocompass aligns itself with the spin of the earth's axis

Its North arrow points towards True North and it is not affected by the variation of the earth's magnetic field

Magnetic North

A north arrow of magnetic compass points towards the North Pole – a direction called Magnetic North

The North magnetic Pole is currently located in the northern hemisphere near Canada nearly 1440 km from the Geographic North

The Magnetic North coincides with the True North in some parts of the earth's surface

The line joining these two points is known as **Agonic Lines**

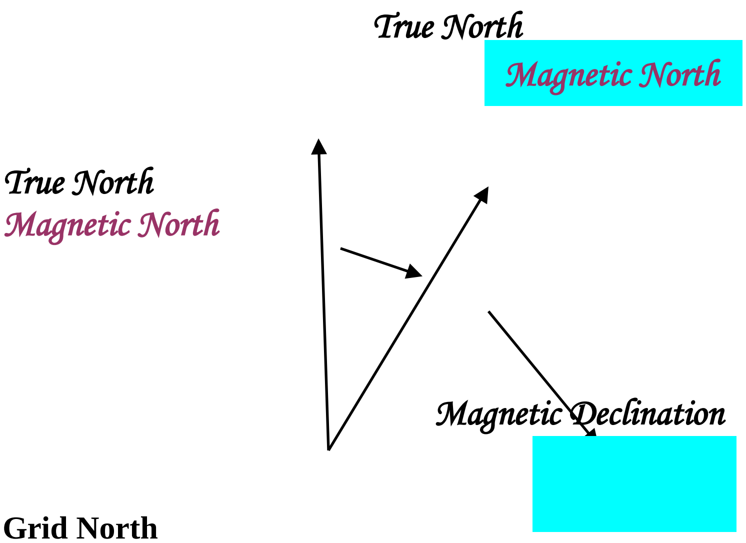
However, the two poles are not same to most of the location on the surface

As a result the Magnetic compass does not usually point towards the Geographic north, and therefore not directly indicate true North

The difference between True North and Magnetic North at any given location is called **Magnetic Declination**

A line joining points with the same magnetic declination is called **Isogonic Lines**

A direction measured from the Magnetic North, the one indicated by the magnetic compass is referred to as the Magnetic bearing or Azimuth with respect to the True or Geographic North



Grid North

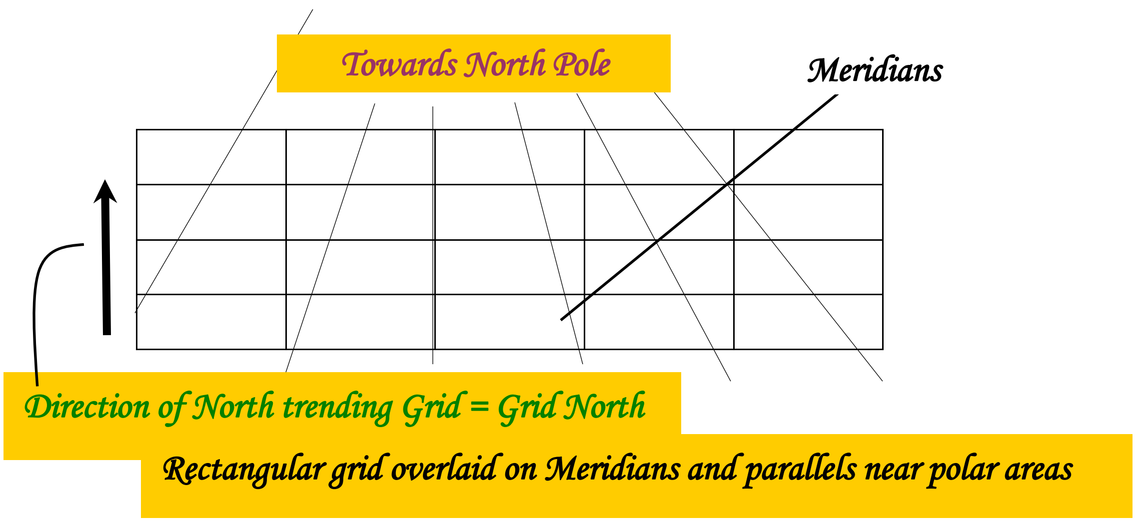
Any map may have more specialized grids such as UTM (Universal Transverse Mercator) and SPC (State Plane Coordinate Systems) superimposed on it

The direction of north trending lines of such grid is called Grid North

Meridians which are aligned with True North, converge as one moves away from the equator towards the either poles

Whereas the grid lines of rectangular grids do not

Therefore, although the North-South lines of the rectangular grids may coincide with the True North at the grid origin (some other special point), they usually don't align at other locations

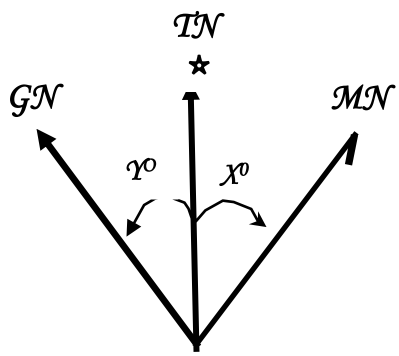


Thus, there is always a difference between the direction of north-South line of particular grid and either True or Magnetic North

In addition, Grid North of two or more grids seldom matches, so there may be more than one Grid North on a given map

Declination Diagram

A declination diagram is placed on the map to show the relationship between the three North's



True North is usually marked by a line with a star (*****) at the end (and letter **TN**)

Magnetic North is shown by a line with a partial or half arrow head and letter **MN**

Grid North is shown by line with abbreviation **GN**

The angular difference between the three North's is indicated on the face of the diagram (X^o and Y^o)

A date of the diagram is usually indicated as Magnetic declination changes with time

Direction Designation

Directions are usually designated as either Azimuth or Bearing based on True, magnetic and Grid North's

Measurement of Directions on Map

Using traditional system – directions can be measured using North, South, East and West, and subdivision of them like NE, SE, NW etc…

Using more modernized system – the direction in degrees and fractions of degrees East or North

Azimuth

An Azimuth is an angle usually measured clockwise in degree, minute and second from north to the target

It ranges from 000^0 North through 090^0 East to 180^0 South to 270^0 West to 360^0 North again

Depending upon the reference direction, Azimuth can be:

True Azimuth – measured with respect to TrueNorth

Magnetic Azimuth – measured with respect to magnetic North

Grid Azimuth – measured with respect to Grid North

Back Azimuth

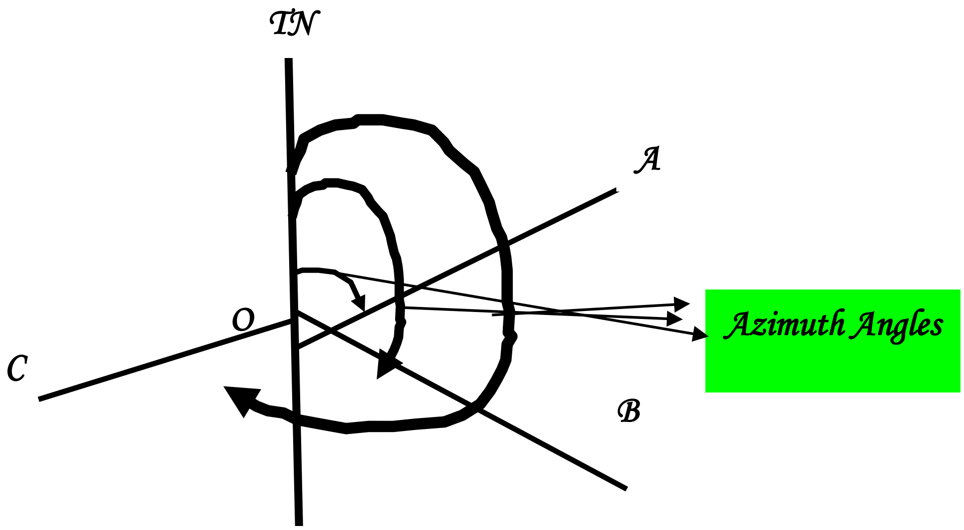
A back Azimuth is exact reverse of an Azimuth and determined from target to observation point

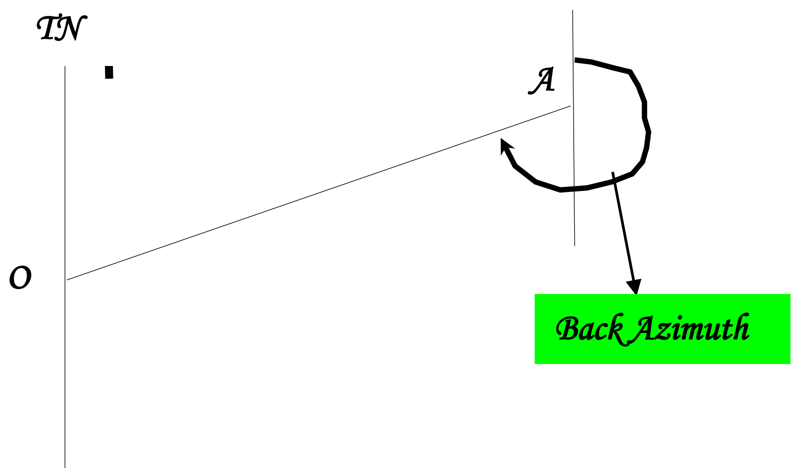
Value of Back Azimuth is determined by adding 180^0 to an azimuth that has a value less than 180^0

E.g.: If Azimuth is 45^0, Back Azimuth is = $45^0 + 180^0 = 225^0$

Or subtracting from azimuth that has a value of 18^0 or more

E.g.: If Azimuth is 245^0, Back Azimuth is $245^0 – 18^0 = 65^0$





Bearings

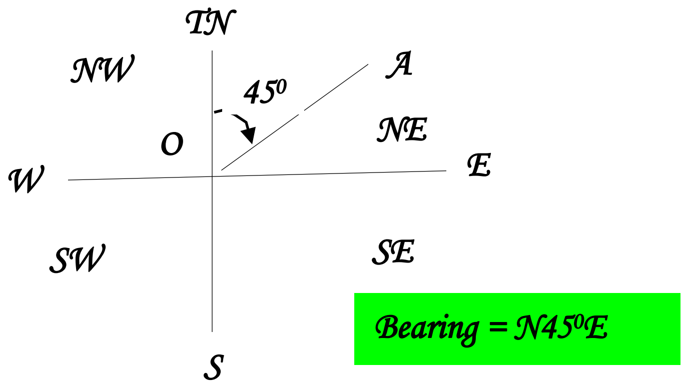
Bearing is an angle measured from North-South baseline, whichever is nearer to the target

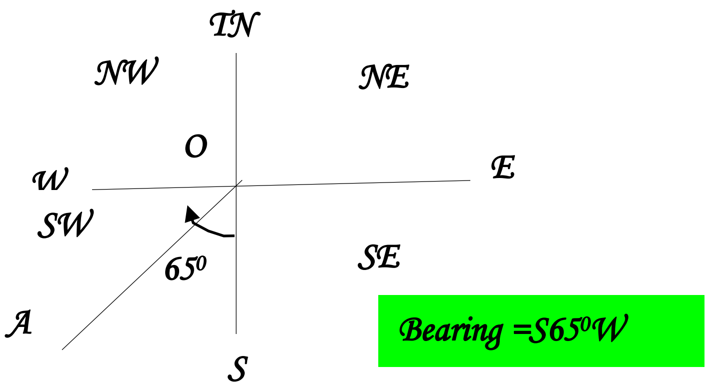
Bearing angle never exceeds the value 90^0

A bearing is designated as – North 45^0 East or N45^0 E

the base direction is stated first (North or South), then the number of degrees and finally the direction of bearing in East or West with reference direction

Therefore, bearings are given according to the four quadrants – North-East, North-West, South-East and South-West





Depending upon the reference directions, Bearings are:

True Bearing – measured with respect to True north

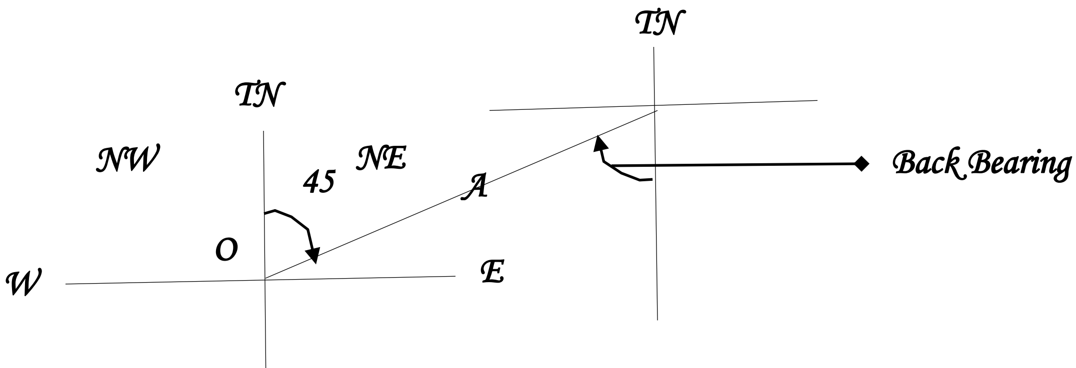
Magnetic Bearing – measured with respect to Magnetic North

Grid Bearing – measured with respect to Grid North

Back Bearing

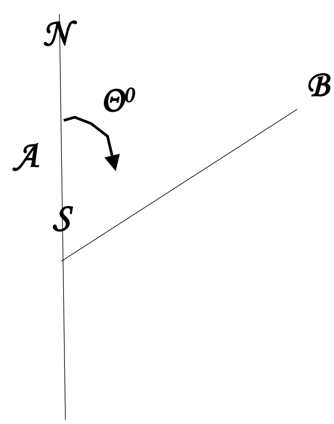
It is the opposite of Bearing

The value of back Bearing is Obtained by changing both of the directional reference and measured from target to the observation point



The relation between Azimuth and Bearing can be calculated on the basis of the Quadrant in which the point lies – What is the relationship between Azimuth and Bearing in different quadrants?

Suppose you have to calculate the Azimuth between A and B with respect to True North
Draw a line joining the two points A and B (Traverse line or Course)
Draw a pencil line parallel to the true North (or other North which is required) through the point A from which the direction of other point B is to be determined
Using the two lines (line of direction of North-South and line joining A and B), set the protractor at 0^0 North and measure the angle between the two lines in clock-wise direction…say 75^0



State the direction in terms of Azimuth
Measure the distance AB on the map and convert it into ground distance…say AB= 5 km
Then, B is at Azimuth 75^0 and 5km from A

Step for Calculating Bearings on Map

Suppose, if you have to calculate the Bearing of town points A and B on a map with respect to True North, then the following steps should be followed

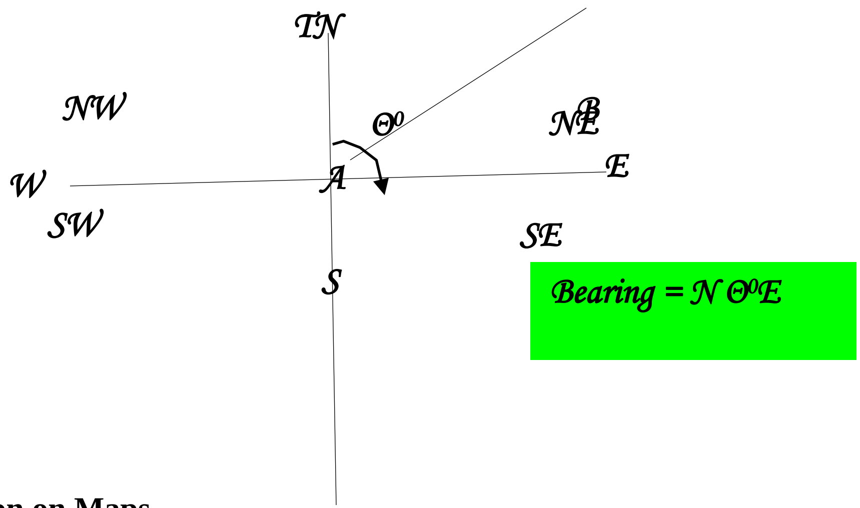
Draw a line joining the two points A and B

Draw a pencil line parallel to the True North line passing through point A from which Bearing of B has to be measured

Draw another line perpendicular to the True north line passing through A to get four set of quadrants

Measure the angle between North-South line whichever is nearer to B and line AB sing protractor

State the Bearing



Position on Maps

- Sowing position or location of a certain point is one of the earliest and still one of the most important uses of maps
- How to show position of point as related to other points that might be familiar to the map-reader
- "Where is the lake? Where is that mountain? Where is that town or village located? What is the general trend or coastline of river? Etc… are the frequently asked questions – How does a map answer these questions?
- There are four conventional methods to give the position of a place:
  - ❶ Position by the use of place names
  - ❷ Position by the use of Bearing and Distance
  - ❸ Position by the use of Geographical Grid
  - ❹ Position by the use of National Grid Reference

Position by the Use of Place Names

- The place is marked with dot on the map in its accurate position and its name is attached to it
- It is commonly used and simplest way for positioning
- If you are interested to find any place on the map, look over the map until you find that place

- The first thing you have to do when the map shows the whole country in your hand is…
  - Locate the town or village you live, and then use the map to find other town, village, rivers, hills etc…
  - If you are supplied with a World Map, then locate your country and capital city – then try to find other important places like London, Paris, Moscow etc…

Short Comings:

- Place name used on a map must be suited to the scale of the map used…
  - On small scale map only importance and major places are printed – the bigger the scale becomes, the more minor place names can be added
  - It is meaningless to use the town map of Nazareth to locate the town itself
  - It is impossible to use the map of whole Africa to locate the places such as Saris, Arat Kilo, Sidist Kilo, Piazza, Shola etc…
- The place name should be meaningful to the person who uses the map to find them…
  - All educated people in Africa will know about Addis Ababa, therefore they would also like to know about the exact position of Addis Ababa – hence it can be shown on the Continental Map
  - However, places like Saris, Arat Kilo, etc… only have meaning to people living in Addis Ababa –thus, it would be useless to print them on continental Map
- place names used on map should not be ambiguous
  - for example – there are several Combolchas, Piazzas, Neghellies, Sarises, and Robes in Ethiopia ⇨ it you use these places in a text that refers to whole country, it causes confusion to the one who wants to locate them on the map of Ethiopia
  - the same is true with other places in the world – for example, there are 10 towns called Paris, 8 of them are in USA, 7 Athens, 3 Cairo and so on… so it is confusing that which of the Paris you are talking about
  - To avoid ambiguity, one should write like this – Paris in France, combolcha in Wello…
- place names do change from time to time
  - place names on old Italian Map – Adama (in past)

- place name in Ethiopian Topographic Maps – Nazareth during the last repines
- If somebody writing about Ethiopia, today wants to make it possible for the reader to make use of those old maps for the purpose of locating place, he/she should provide information like this:

✓ Nazareth formerly Adama (in past)
✓ Adama now Nazareth (at present)

Position by the Use of Bearing and Distance

- As it is Aforementioned, Bearing is an angle measured form North-South baseline, whichever is nearer to the target ➔ Bearing angle never exceeds the value 90^0 – A Bearing is designated as Eg… North 45^0 East or N 45^0 E ⇨ the base direction is stated first, then the number of degrees and finally the direction of bearing in East or West with reference direction
- Therefore, Bearings are given according to the four quadrants – North-East, North-West, South-East and South-West
- It is common and simple method for positioning
- It avoids the ambiguity like the same name of different places
- The position of the place is given with reference to Bearing or Azimuth and distance from major places
  - Debrezeit is 45 Km South-East of Addis Ababa
  - Kombolcha is 10 Km North of Harar
  - Kombolcha is 25 Km South-East of Dessie
- You should not specify like Addis Ababa is 70 Km NNW of Mojo

Short Comings of the above Two Methods:

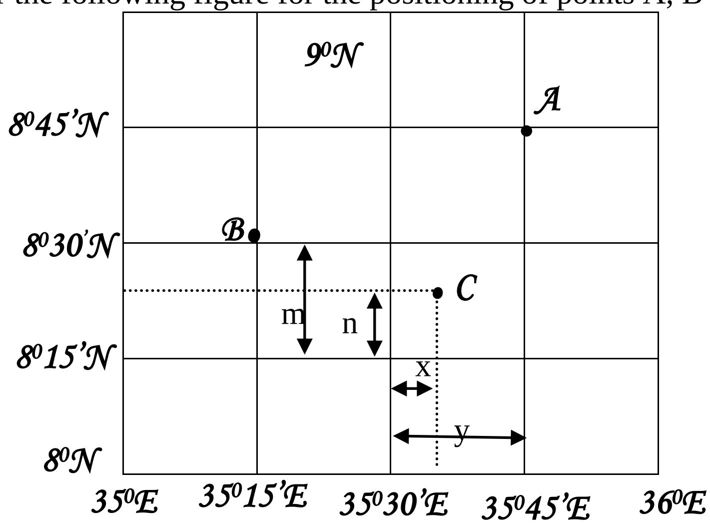
- Both methods do not give a definite location of a certain place
  - In the first method ➚ the map-reader will suffer in finding a place among thousands of place names
  - In the second method ➚ the map-reader must know the location of major places given for reference
    - Example – Harar, Addis Ababa, Dessie
- If you want to refer certain spot in the field and if spot does not have name on your map, you cannot refer to it at least by first method

Position by the Use of Geographic Grid

- In this method, the position is given accurately with the help of a grid composed of a network of lines known as Parallels and meridians
- One set of lines run from North Pole to the South Pole – these imaginary lines are called Meridians and join all the points with the same longitude
- The other set o lines run around the globe parallel to the equator and called Parallels – these lines join all the points with the same Latitudes

- Latitude is angular measurements from the center of the earth northwards and southwards – longitude is angular measurements from the center of the earth in eastwards and westwards
- The parallels give the position in degree (^{0}), minutes (‘) and seconds (“) north or south of the equator – this is the Latitude of the place ➔The meridians also give position of a point in degree, minute and seconds east or west of the zero degree (Prime Meridian) – this is the Longitude of the point
  - 1^0 = 60’ and 1’ = 60”
-

Consider the following figure for the positioning of points A, B and C



- Position of A ➔➔$8^0$45’ N and $35^0$45’ E
- Position of B ➔➔$8^0$30’ N and $35^0$15’ E
- Position of C ➔➔is determined as follows …
  - Measure the distances x, y, m and n on the map in cm
  - Say E.g. x=5 cm, y=15cm, m= 20cm and n=8cm
  - Now for 15 cm, Longitude difference= $35^0$45’E – $35^0$30’ E = 15’ … Therefore for 5 cm, Longitude difference = (15’x5)/15 =5’E…Therefore Longitude of C ➔➔ ➔$35^0$30’ E + 5’ = $35^0$35’ E
  - Now for 20 cm, Latitude difference = $8^0$30’ N – $35^0$15’ N = 15’ N … Therefore for 8 cm, Latitude difference = (15’x8)/20 = 6’ N… Therefore Latitude of C ➔➔➔ 8^0 15’ N + 6’ = $8^0$21’ N
  - Thus position of C ➔➔$8^0$21’ N and $35^0$35’ E
- The great advantage of this method for positioning over the above two methods is that you can find the place by simply referring the Latitude and Longitude value given on the map

Shortcomings

- The shape of grid lines on the globes are curved lines while the shape of grid lines on the most maps are almost straight lines
- No simple relationship between degrees and the actual distance we use (i.e. Not convenient for calculation) – and the length of degree also vary from latitude to latitude and from longitude to longitude
  - Longitude @ equator = 111.1 km
  - Longitude @ the poles is almost 0 km

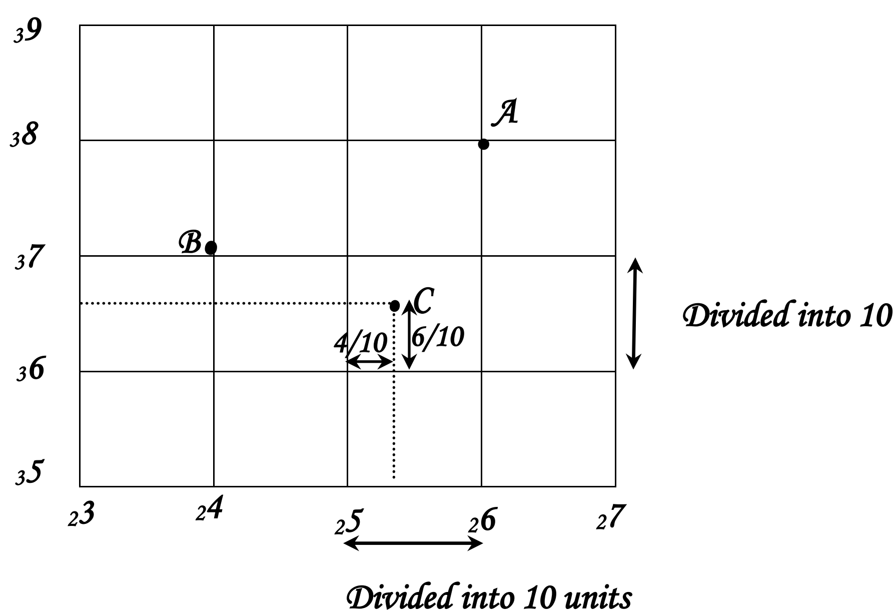
Position by the Use of National Grid Reference

- The cri-cross reference lines on a map is called Grid
  - The grid provides a frame of reference for locating points on a map
- The vertical and horizontal lines of the grid cross at the points called Co-ordinates – Each of these lines are numbered
- The lines that run horizontally are called Nothings
- The lines that run vertically are called Easting
- These lines are the basis for reference to landmarks and places shown on the map
- There are two types of grid references:
  - The four figure grid reference
  - The Six figure grid reference
- When reading grid references, Easting are given first and then the Nothings
- Position on maps can be given in Kilometers and meters by using a set of lines forming grid

- The lines forming the sides of the squares are horizontal (called Northing – run from West to East) and vertical (called Easting – run from North to South)
- Since verticals are parallel to each other, they do not indicate true North as Meridians – the kilometer distance is measured from the grid origin
- The grid origin used on Ethiopian maps is located in North-Western Kenya where the $34^0 30'$ E meridian crosses the equator

Four Digits Grid Reference System

- On a map drawn on a small scale. The 10 Km sides of the square are marked with numbers that increases towards East and North
- One digit is printed bigger than the other digit EG. $3^{\mathbf{10}}$, $4^{\mathbf{7}}$ and like that
- This digit gives the tens of kms from the origin
- The Northing and Easting are numbered at every 10 Km interval
- Again, each side of the square is divided into 10 units (I unit represents 1 Km)



Steps for positioning A		Easting	Northing
1	Locate the vertical grid line left to the point	6	

	A and read the large number		
2	Measure the tenth of the side of the square from this grid line to the point	0	
3	Locate the horizontal gridline below the point A and read the larger number		8
4	Measure the tenth of the side of the square from the gridline to the point		0

- Therefore the position of A is ➔➔➔6080

	Steps for positioning A	Easting	Northing
1	Locate the vertical grid line left to the point B and read the large number	4	
2	Measure the tenth of the side of the square from this grid line to the point	0	
3	Locate the horizontal gridline below the point B and read the larger number		7
4	Measure the tenth of the side of the square from the gridline to the point		0

- Therefore the position of B is ➔➔➔4070

	Steps for positioning A	Easting	Northing
1	Locate the vertical grid line left to the point C and read the large number	5	
2	Measure the tenth of the side of the square from this grid line to the point	4	
3	Locate the horizontal gridline below the point C and read the larger number		6
4	Measure the tenth of the side of the square from the gridline to the point		6

- Therefore the position of C is ➔➔➔5466

Representation of Relief Features on Map

- The height of the surface of the earth varies from place to place
- Land features like plains, hill, plateau, valleys, ridge etc…, which make the earth's surface uneven, are known as relief features
- The relief features have three dimensions namely length, breadth and height but map on which they are represented has only tow dimensions namely length and breadth
- Therefore, one needs to get a specialized training in the art of representing relief features on maps and considerable experience and skill to visualize features on the map

Methods of representing relief features on maps

Hachure:

They are short disconnected lines drawn in the direction in which water flows – that is down the direction of steepest slope

Is earliest method for showing relief features

They are of the same thickness

For slopes, Hachure are close together and wider apart for the gentle slope

Hachure is not drawn for the area which is lever like plateau top, plains etc…

They are drawn in rows – Each row is disconnected from others

They are short and equal length for the slopes of the same steepness – But are relatively long for gentle slopes

Disadvantages

Hachure are drawn close together to represent steep slope and hence obscure many other useful details of the map

Hachure do not represent height above Mean Sea Level

They do not show the uphill or downhill direction of slope without the presence of streams and spot height

Hill-shading:

Hill shading represents the relief of the ground on the map vividly and effectively

Hill shading with contours gives more satisfactory results

To understand this more easily, suppose

A relief model is prepared and illuminated obliquely from North-South

Its photograph is taken from above then that photograph is relief map of the ground

Slopes facing North and West are in light and Slopes facing East and South are in shadow

The North-Western and Western slopes are shaded with light color and slopes facing Eastern and South-Eastern where shadow is cast are shaded dark, as slope becomes steeper and steeper

The level areas (plains, ridge-top etc…) are not shaded

Disadvantages

Absolute height above Mean Sea Level not given

Whether the un-shaded areas are low level or high level, it doesn't tell

Layer Tinting:

This method is used to represent relief features on small-scale maps by coloring with different tints of colors

A color legend is given so that the height above Mean Sea Level is represented by different colors

Blue is used to represent sea and other water bodies – the deeper the water, the darker the shade of blue is used

The tint of green is used to represent different height under 500 m – the shade of green varies as green to light green to yellow green as height increases

For height between 500 m to 5000 m, different shades of brown are used – the shades vary from light brown to brown to dark brown to reddish brown to Crimson red as height increases

The areas above 500 m are not shaded

Disadvantage

the above coloring scheme is not strictly followed but still is used in many low scale maps to represent relief

this method is used to show relief on Atlas and Wall maps but not on Topographical maps

Spot Height and Bench Mark:

These methods are used to represent height above Mean Sea Level on the map

Spot Height – is the height above Mean Sea Level (MSL) on the ground – it is indicated by a dot on map with a figure written near it – The figure stands for the height of the point above MSL

Bench Mark – is a mark chiseled on a stone pillar a few decimeters above the ground – the height of mark (not ground) above MSL is indicated by **.BM** with a figure representing height – Thus **.BM** 605 means ➔➔➔the Bench Mark is located on the ground where height is 605 above MSL

. 560 – Spot Height

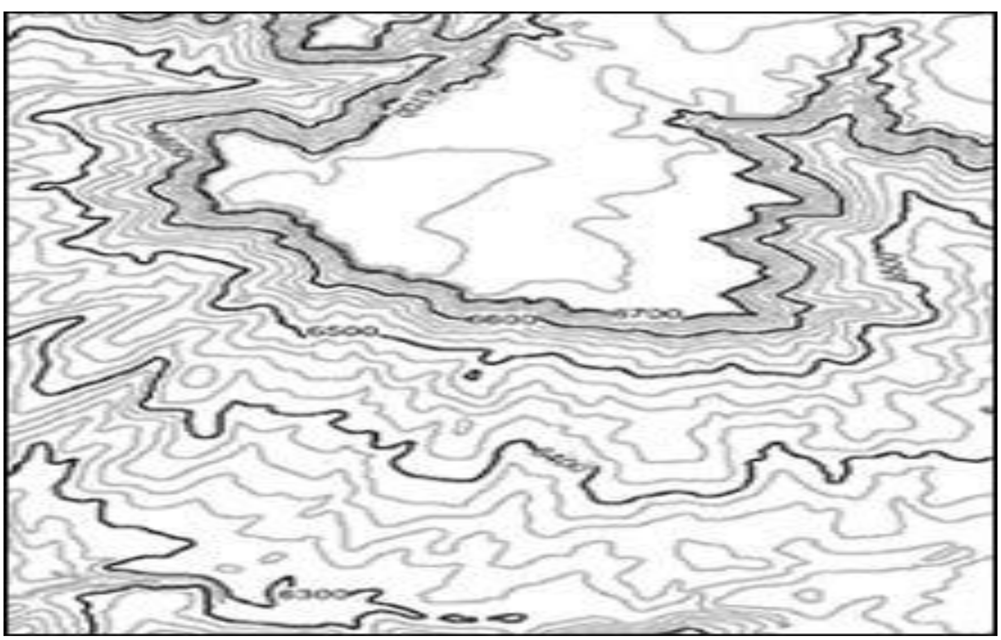
.BM 650 – Bench Mark

Contours:

Representation of relief features on map by contours is a standard and common method

All the possible information regarding the shape of ground can be obtained quite accurately from a contour map

A **CONTOUR** is an imaginary line on a map connecting all adjacent points of the same height above the MSL – thus a line joining all 200 m points on a map is called a **200m Contour**

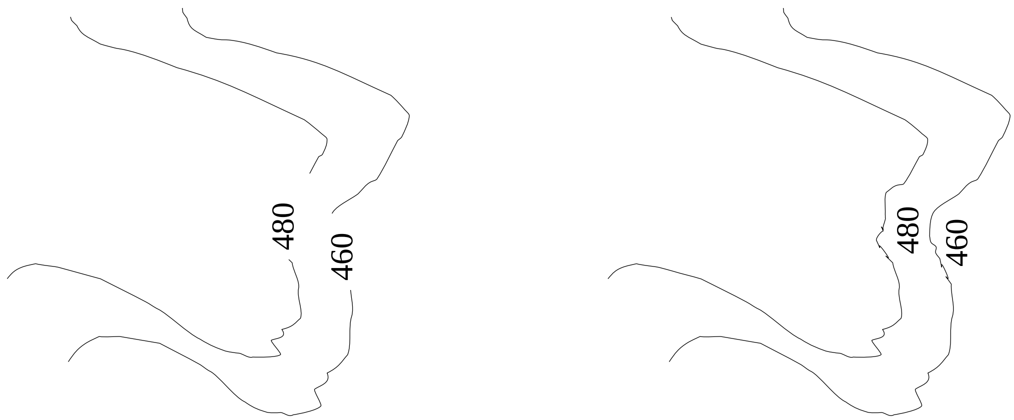


Indexing Contour – Ways of showing altitude on contour Maps

By breaking the line and writing the number along its trend with the height above the figure

By printing the number along the trend of the contour line on the side that is pointing towards higher ground … see the figures below

The closer the contour lines are to one another, the steeper the slope is in the real world



Contour Interval:

The contours are always labeled with a figure showing height above MSL – the figures are written either in gaps or between contours or on the sides of the contours to which height increases

Contours are drawn at a certain interval called

contour interva It is stated in feet or meter and is defined between vertical heights between two contours

Horizontal Equivalence: the horizontal equivalence between two points on a map is in fact the horizontal distance between the same two points on the ground

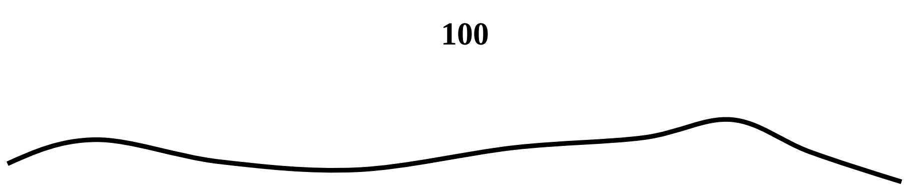
Contour Types

Index Contour

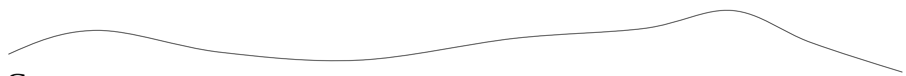
In an area of relatively complex terrain, every fourth or fifth contour needs to be accentuated as wider line weight, called Index contour

Are easier to identify and follow

Have numbers inserted @ intervals along their length to indicate elevation they represent



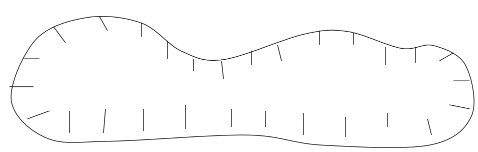
Intermediate Contour
Are regular contours, spaced @ the normal interval and drawn with a finer line weight, lie between the index contours
They may or may not be numbered depending upon space availability



Supplementary Contour
Additional contours, usually drawn @ intervals that are some regular fraction of the basic contour interval
Are appropriate in areas of flat terrain, with a relatively far apart contours
Are usually drawn as dashed or dotted lines to distinguish them from contours drawn @ the basic interval

Depression Contour
When an area lies @ a lower elevation than the surrounding terrain it forms a depression ➔is mapped with contours on its surface called Depression contour

- Distinguished from normal contours by adding short ticks pointing downward towards the bottom of the depression, @ right angles to the contour line

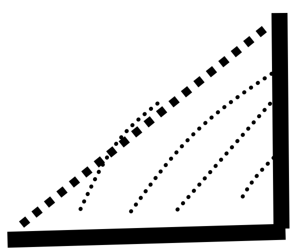


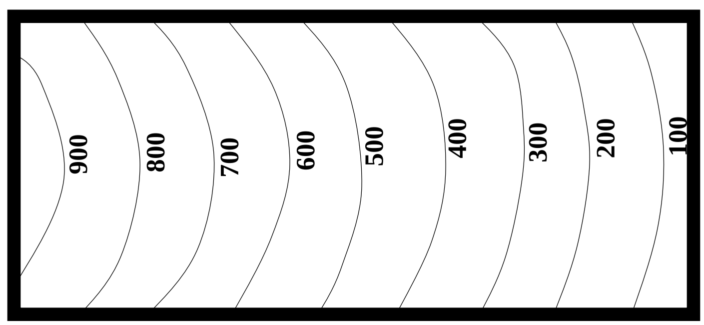
Carrying Contour:
If a series of contours fall extremely close together, they may not all be shown as individual lines
A single contour drawn to represent the several contours that would be drawn if space allowed is the Carrying Contour
Not occur frequently, because a wider interval applied in such cases
Contour Characteristics:
Contour newer branch – No contour will start from any other contour
Contour line does not cross each other (Except in few cases, such as an Over-hanging Cliff)
They always close by returning to its starting point – The closer may take place in another adjacent map
Contour lines can be printed with difference in thickness
Contours are smooth lines without numerous bends

The horizontal spacing of contour lines reveals the nature of the slope that the line represents
The vertical interval between contour elevations is constant

Representation of Relief by Contours:
Some relief features like concave slope, convex slope, valley, spur, ridge, escarpment etc… occur frequently on surface of the earth
Therefore, contours are means to represent these relief features on map and by interpreting the contour patterns the whole landscape can be understood easily

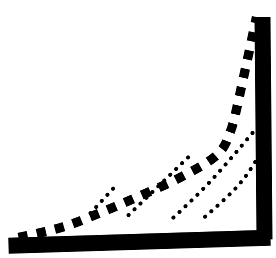
Uniform Slope:
When the rise or fall of the ground per unit horizontal distance is same at every part of the slope
Such slopes are represented by contours, which are spaced at equal distance – i.e. evenly spaced contour lines

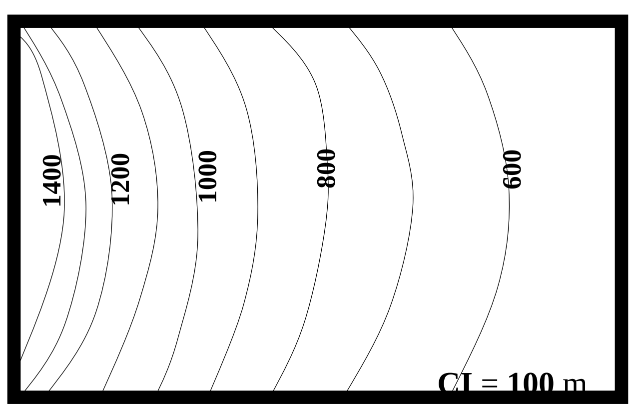




CI = 100 m

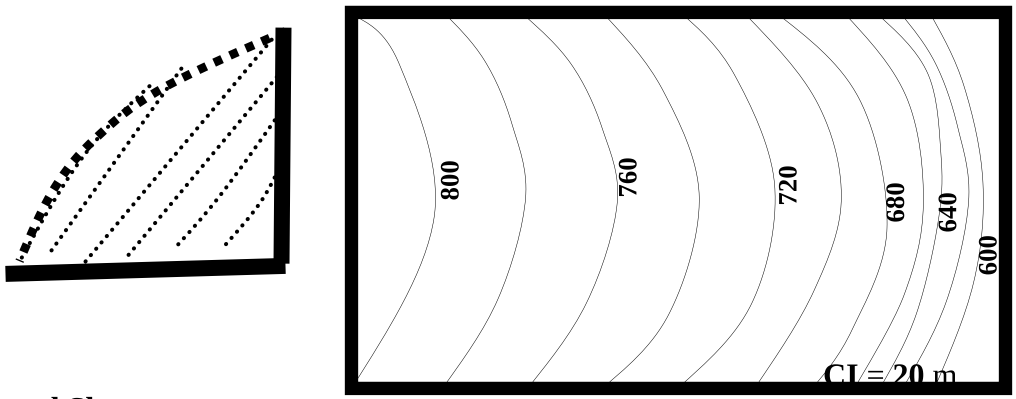
Concave Slope:
A slope which curves inward
Its lower part rises gently but upper part abruptly – therefore, the lower part of concave slope is represented by widely spaced contours but its upper part by closely spaced contours





Convex Slope:
A slope which curves outward

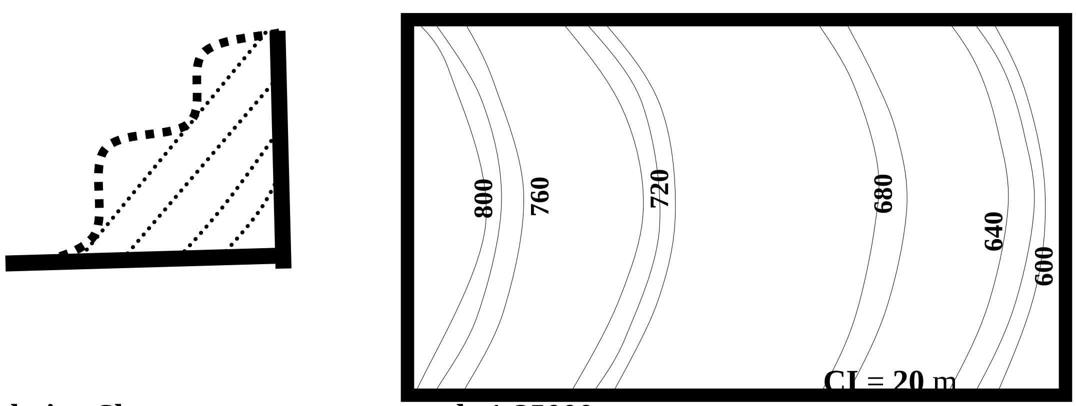
It is steep at bottom but gentle at the top – therefore, contours are close together at foot and wide apart near the top of the convex slope



Terraced Slope:

Rises first gently, then steeply, then gently again and so on

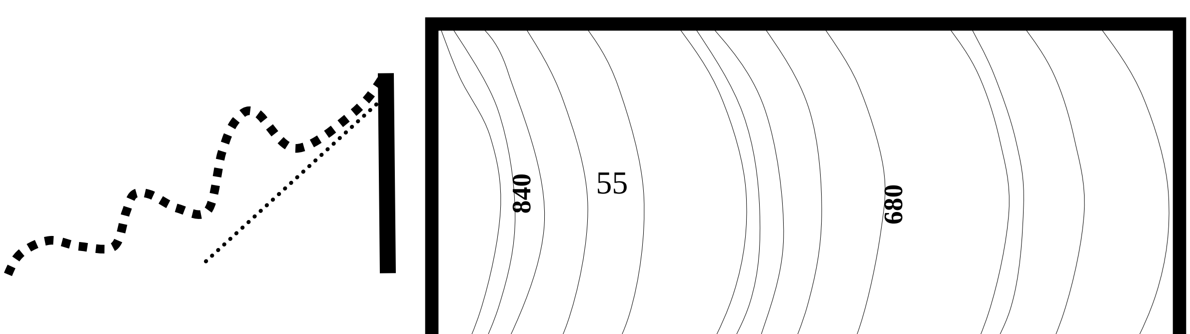
The gently rising section of the slope is represented by widely-spaced contours and the steeply rising section is represented by closely-spaced contours

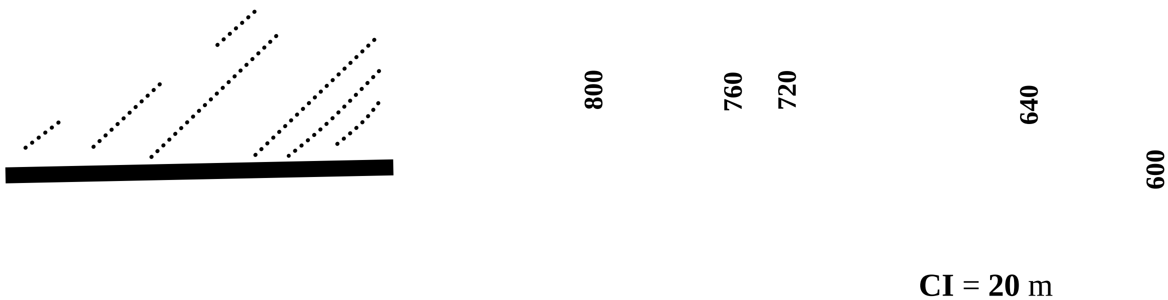


Undulating Slope: **scale 1:25000**

When some part of the slope is convex, then concave and again convex and so on

It generally gives wave appearance – therefore, it becomes wider @ some place and close together @ others



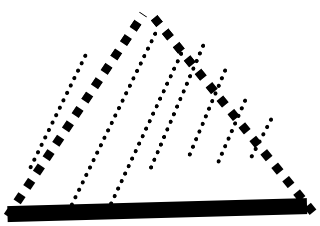


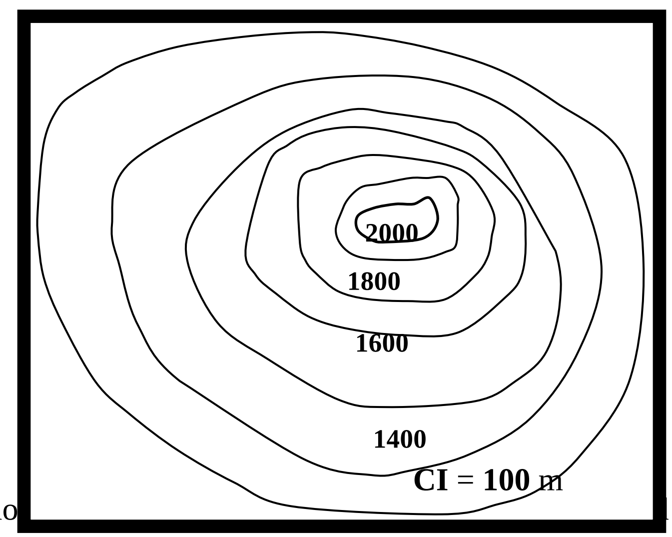
Conical Hills:

A hill, which rises like a cone

It is represented by contours, which are nearly circular

The outer most contour represents minimum height and the inner most contour represents maximum height

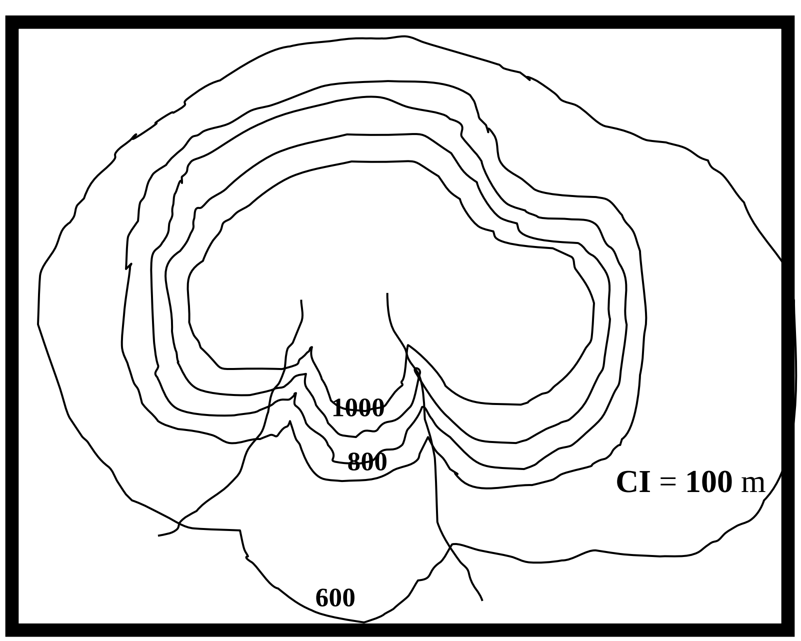


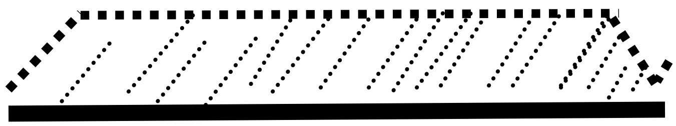


Plateau:

The surface of the plateau, being mo
contours

The slopes surrounding the plateau, being steep, and hence represented by closely spaced contours

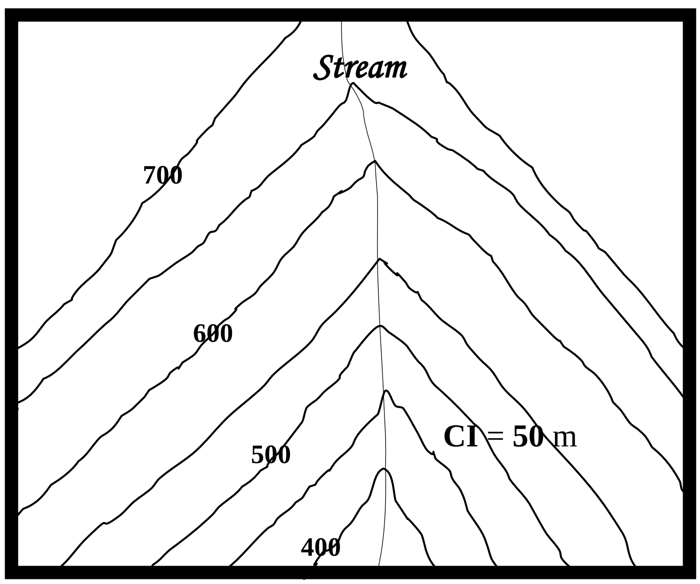


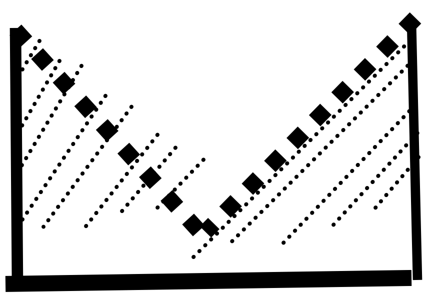


V-shaped valley:

Is shown by V-shaped contours

The outermost contour represents the maximum height and the innermost contour represents the minimum height

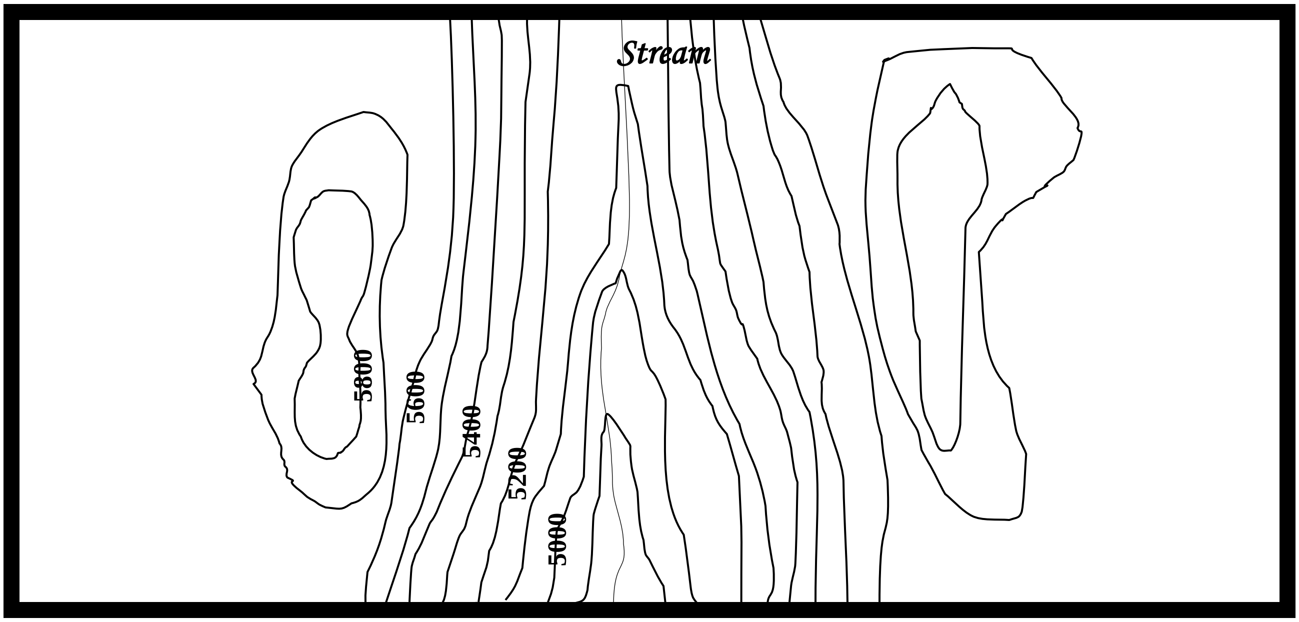




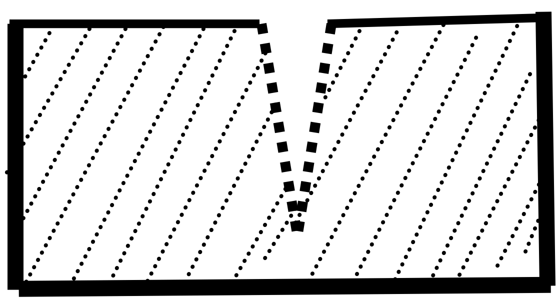
Gorge:

Is a deep narrow valley with precipitous sides

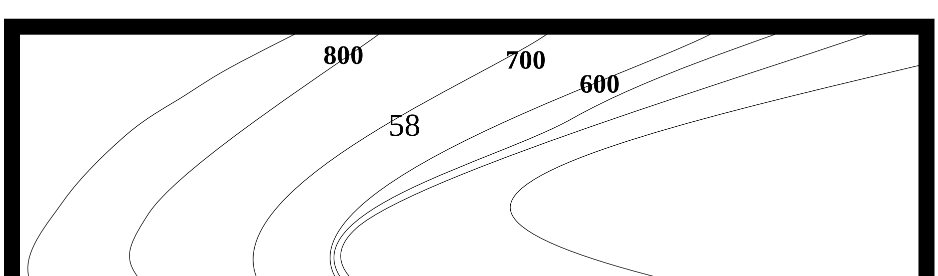
The sides of the gorge are represented by closely spaced contours

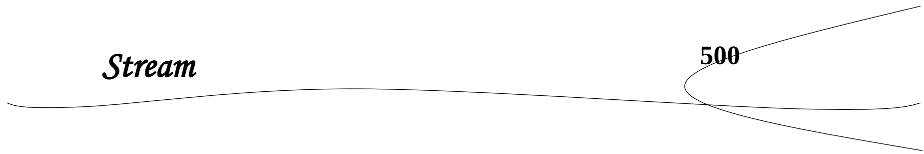


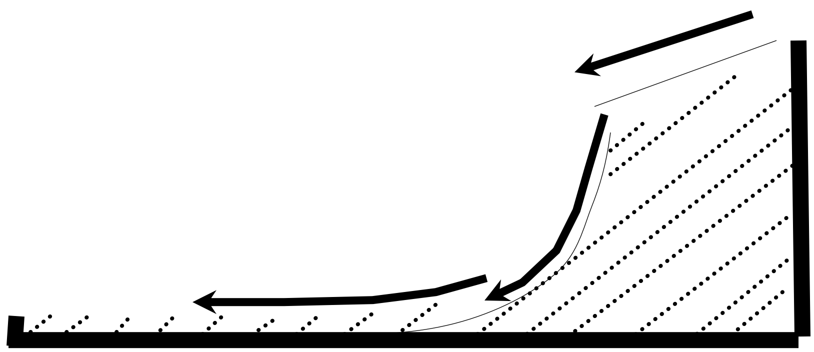
Scale 1:50,000



Waterfall:
In the mountainous area, a section of a valley becomes very steep almost vertical
A stream flowing over a vertical slope makes a waterfall
As waterfall is vertical, it is represented by contours which merge into each other

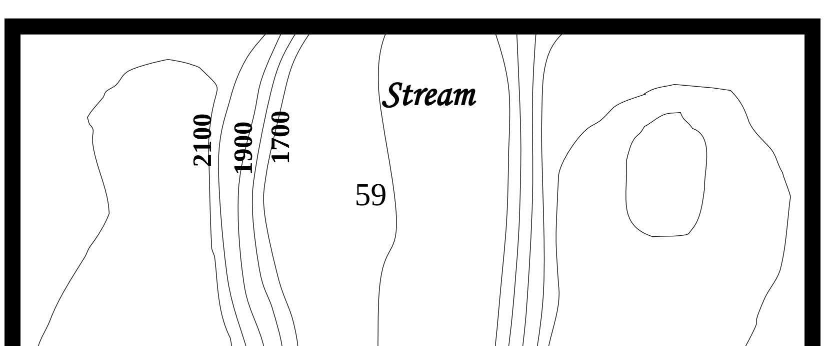


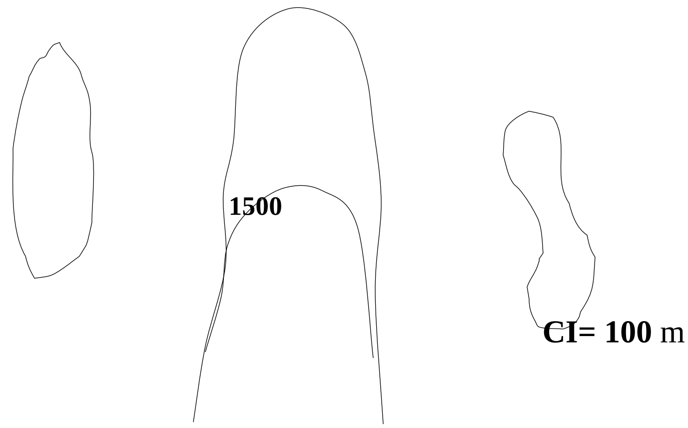


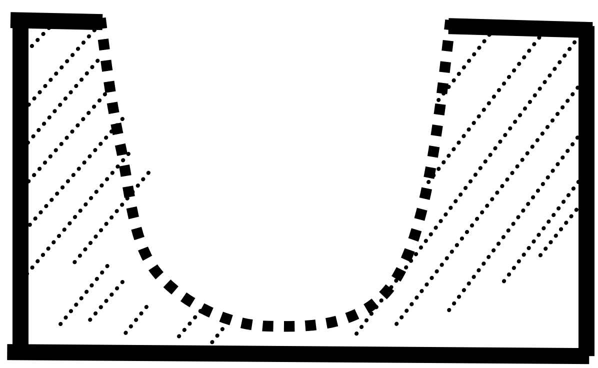


U-shaped Valley:

- The side of U-shaped valley is very steep and bottom is flat
- Therefore, each sides of U-shaped valley are represented by closely spaced contours and its floor by widely spaced contours







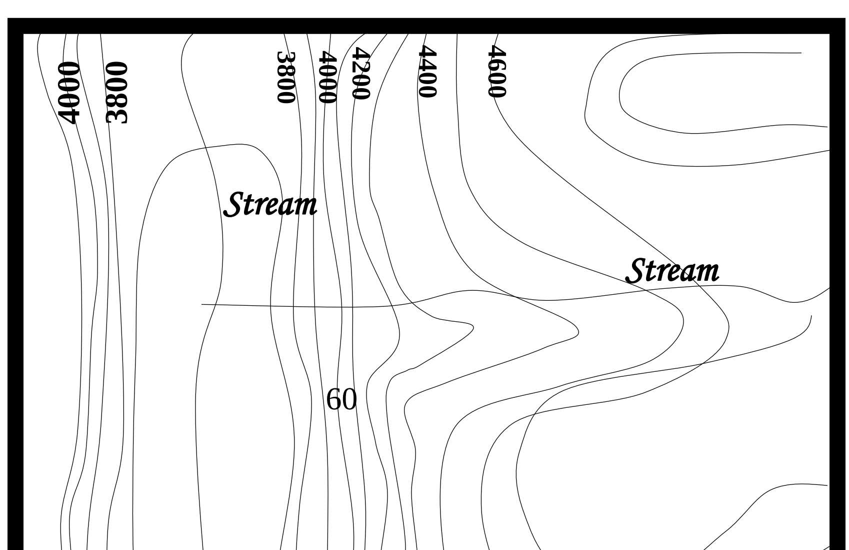
Hanging Valley:

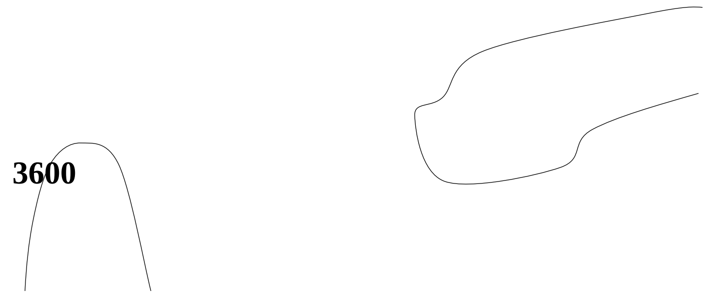
Is a tributary valley at much higher elevation than the main valley

The stream draining a hanging valley flows over a precipitous slope before joining the river of main valley

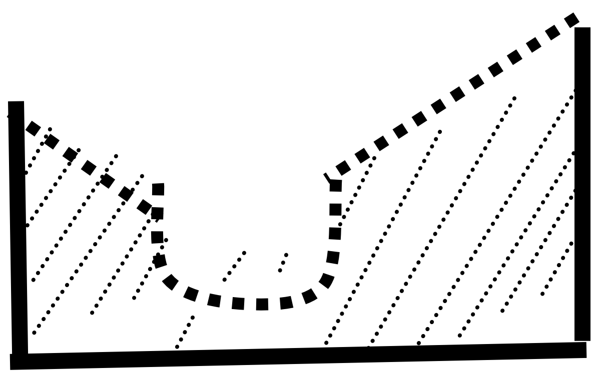
But because of quite cut, the slope of hanging valley are represented by closely spaced contours

The slope becomes very steep where it opens into the main valley





CI= 100 m

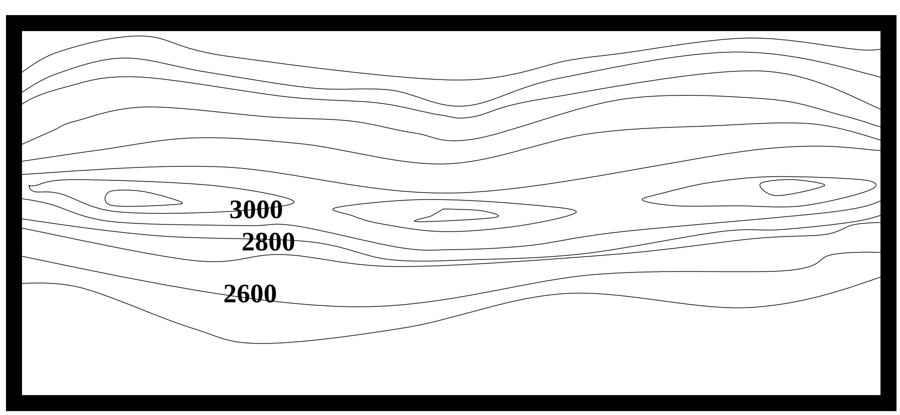


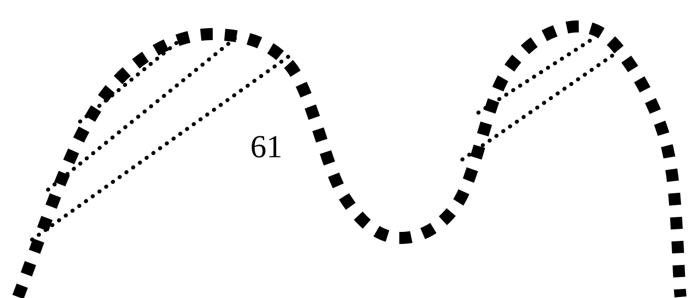
Ridge:

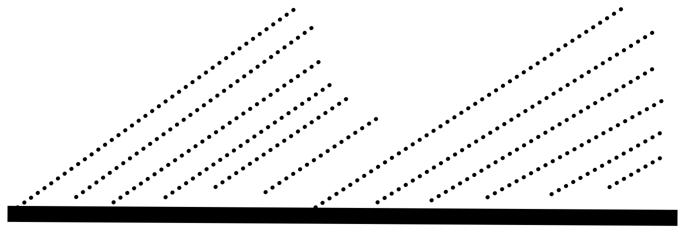
It is a narrow but highland, sloping steeply downward on its sides

Its length is much greater than its width

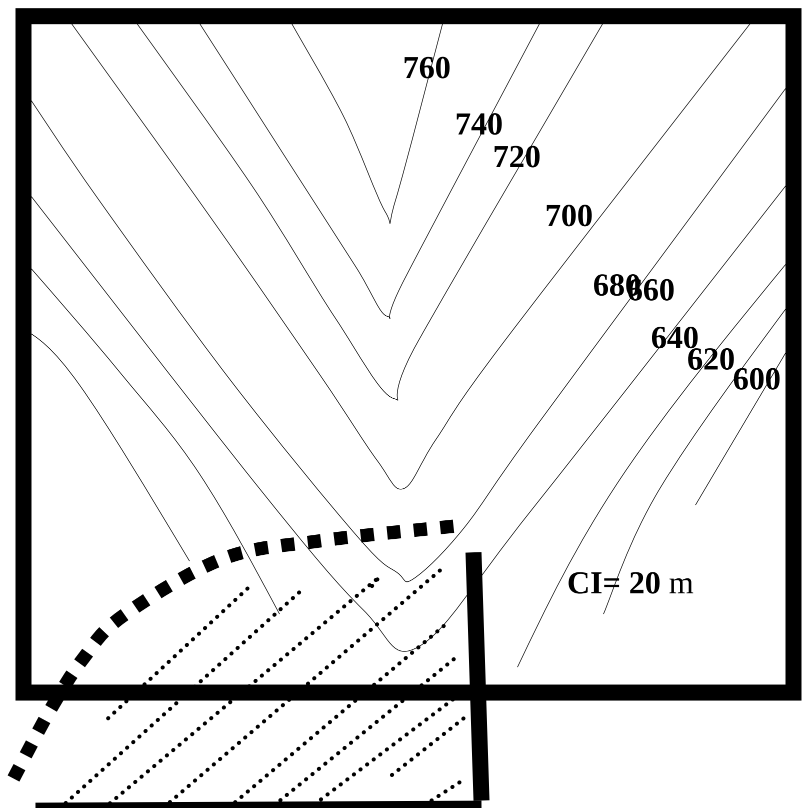
It generally connects two hills and represented by narrow closed contours



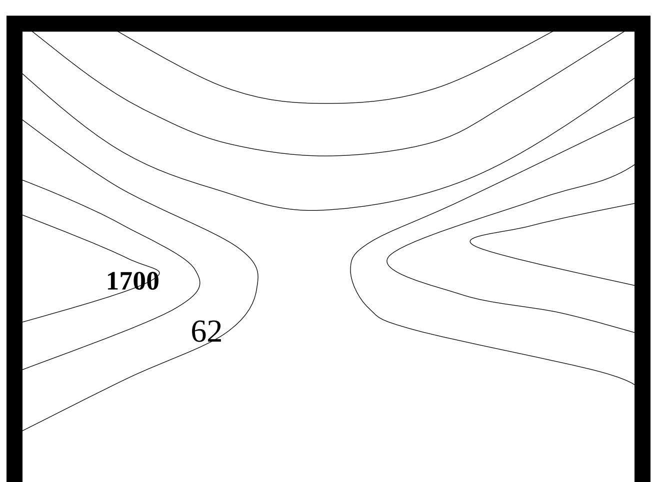


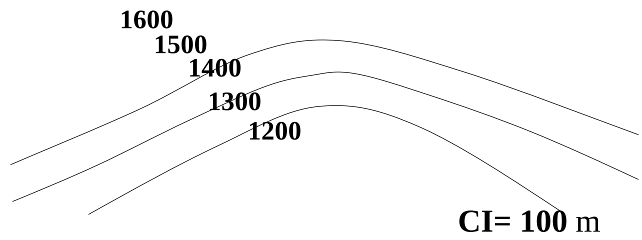


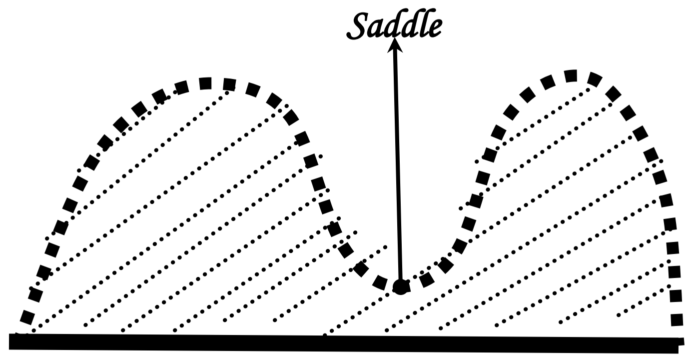
Spur:
It is a ridge projecting from the main body of mountain towards low ground
It is represented by V-shaped contours
The outermost contour shows the minimum height but the innermost contour the maximum height



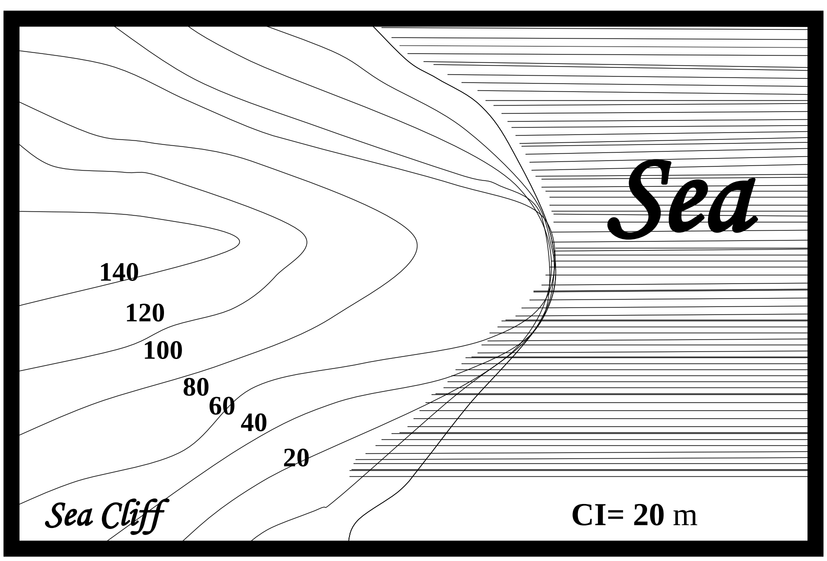
Saddle:
It is the lower part connecting two hills and separating two lowlands
It is used as a pass
It is shown by space between contours representing hills

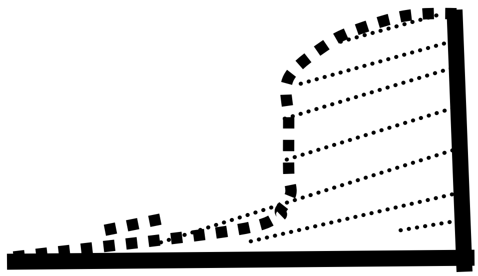




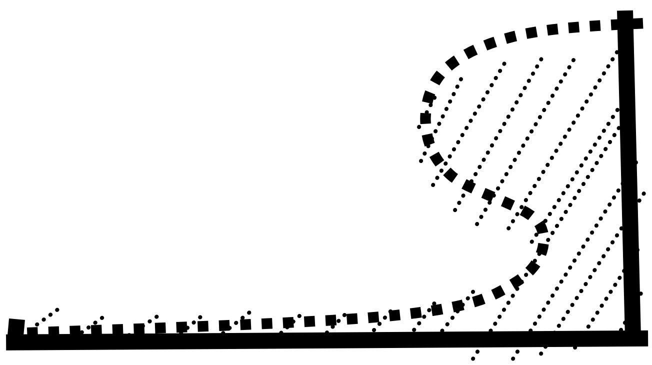


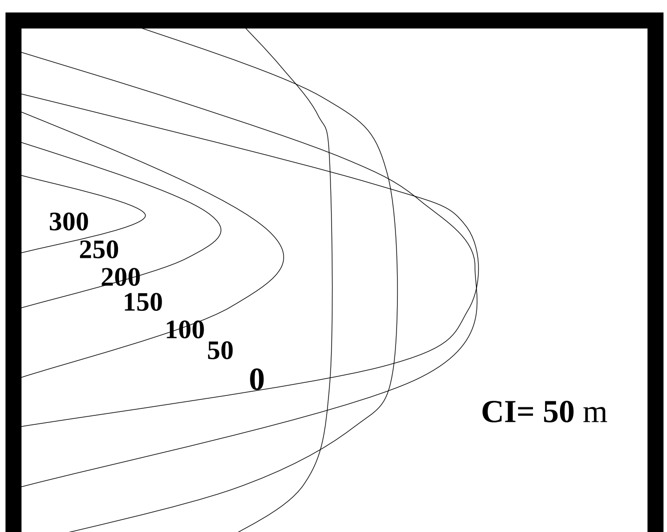
Cliff:
It is a higher and precipitous slope
It is shown by contours, which often coincides





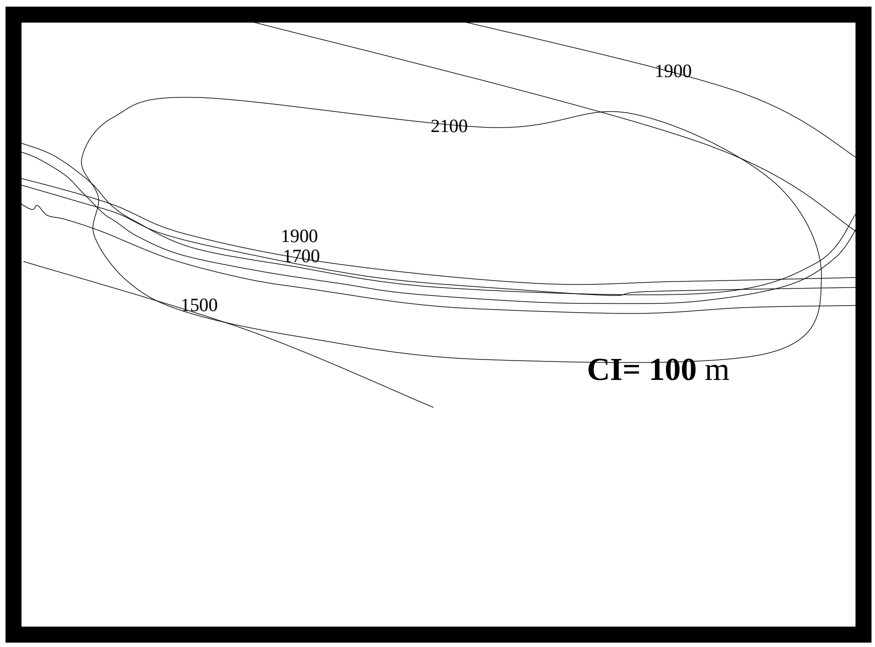
Over-hanging Cliff:
It is a cliff in which the upper part overhangs its lower part
The contour representing the upper overhanging part crosses those representing lower part

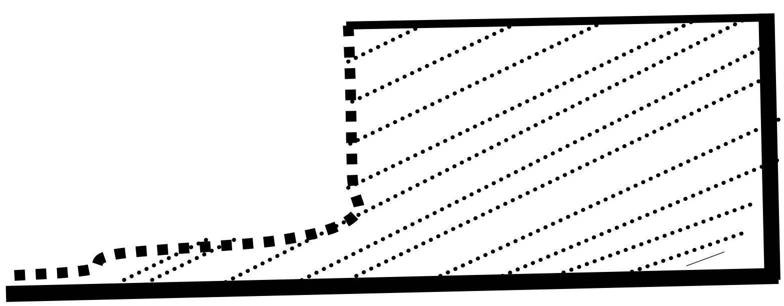




Escarpment:

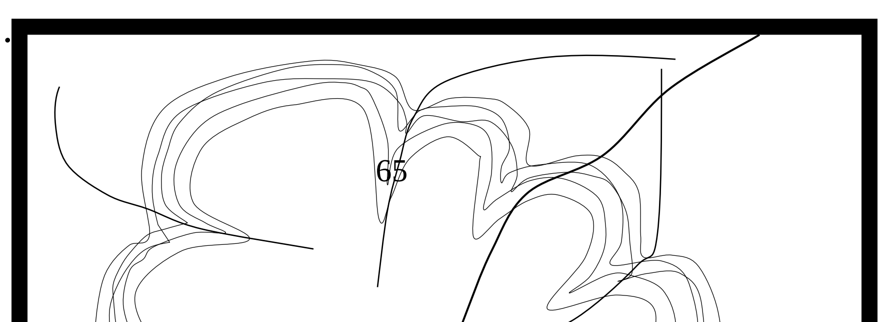
- It is high but steep face of hills or plateau of considerable length
- The upper part of which is represented by widely spaced long contours and its faces are represented by closely spaced contours

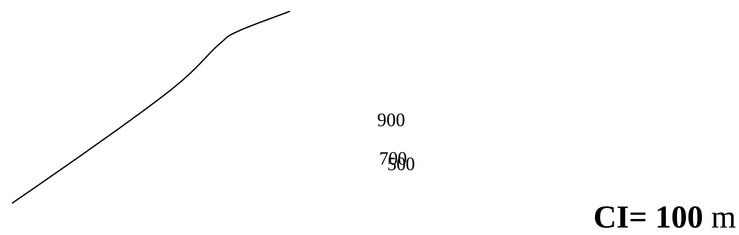


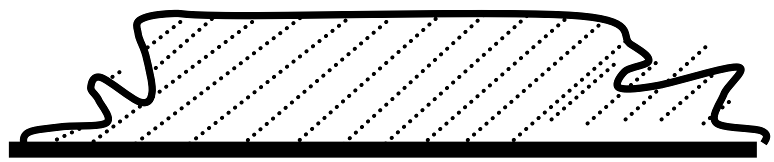


Dissected Plateau:

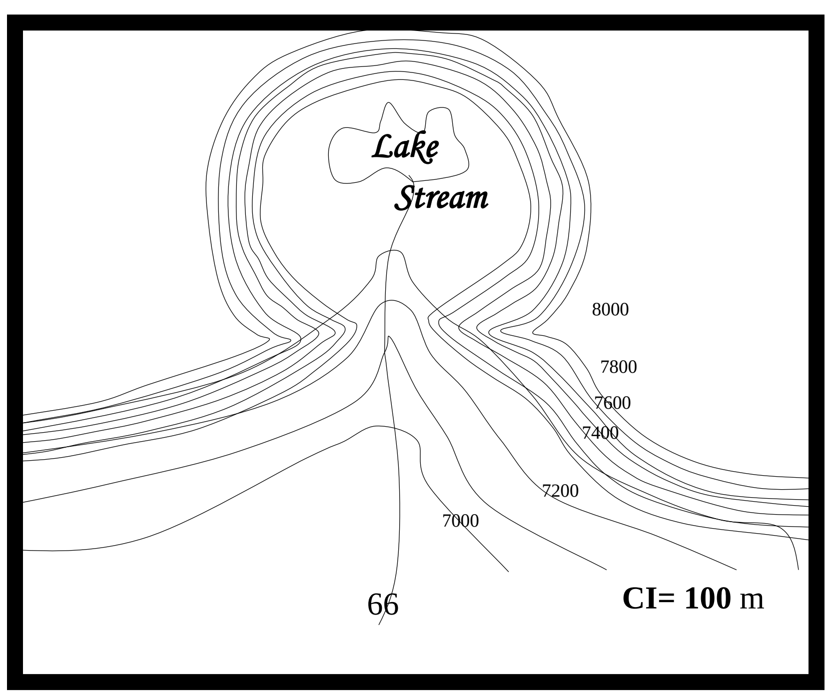
- This is when a plateau is cut by deep valley and gorge







Cirque:
It is large hollow shape formed as a result of glacial erosion on the side of the mountain and it appears like an arm chair
It has generally a lake, which is drained by stream through a gap
The slope forming its back and sides rises steeply but the slope forming the side through which the stream flows fall steeply
The contour representing the back and sides except the one through which the stream flows are closely spaced
Its bottom is nearly level and represented by widely spaced contours

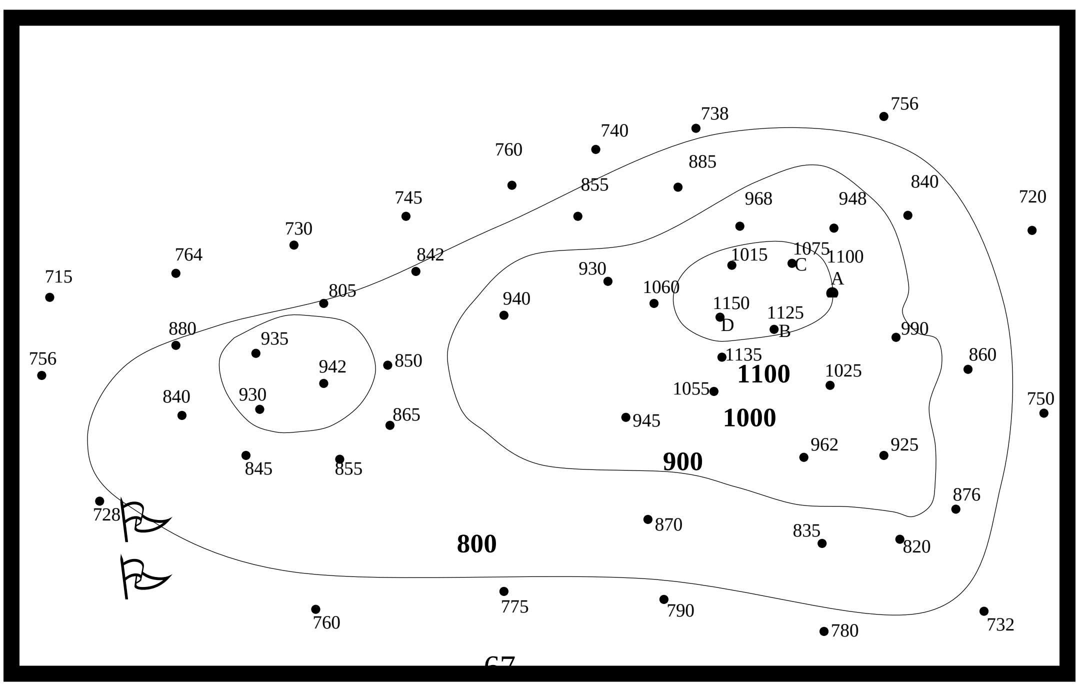


Contour Drawing

- Contours are drawn on a map on which heights of various points are marked by spot height, benchmark and triangulation points

Steps

- To draw contours, have a close look at the heights shown and locate the areas of maximum and minimum height
- Determine the contour interval if it is not given
- For determining contour interval, find out the difference in height of highest point and that of the lowest point
- Keeping in view this difference and space available, fix the contour interval – the contour interval should be a convenient round number
- If the heights are given in feet, the convenient contour interval will be 50feet, 100 ft, 250 ft etc… --if the heights are given in meters, the convenient contour interval will be 10m, 20m, 50m, 100m etc…
- Consider the following figure showing spot heights at different points for drawing contours (all measurements are in meter)



Maximum and minimum heights are 1150m and 715m respectively

The difference between the highest and the lowest points is 1150-715 ➔➔435 m

Since the map is small, so we can fix 100 m as a contour interval – so for the above figure, contours of 800m , 900m, 100m and 1100 m can be drawn

As there are very few points showing heights @ exact 800 m, 900m, 1000m and 1100, so we require interpolating contours

In the figure, 1100m contour will pass through A as its height is 1100m – now, see the adjacent points around A and find the points having just above and below heights than A – say B (1125m) and C (1075m)

Draw a pencil line joining B and C – Measure the distance between B and C – say 0.5 cm

Calculate the height difference between B and C i.e. 1125 – 1075 ➔➔50m

Calculate the height difference between C and 1100 contour – it is 1100-1075 ➔➔25m

Now, for 50m height difference, the length is 0.5cm, therefore, for 25 m height difference the length will be (0.5 x 25)/50 ➔➔0.25 cm

Draw a pencil point at distance 0.25 cm from C – this the point where contour line of 1100m will pass – Repeat the process with the other points and find the points for 1100m contour – Join those points to get 1100m contour

Similarly, contours for 1000m, 900m and 800m can be drawn

Drawbacks:

In this method, we assume that a slope is uniformly steep – But every slope cannot be uniform – Thus it is not the accurate method

It is cumbersome and time-consuming – and hence suitable for small area contouring only

More accurate method like Use of Aerial photograph and Stereo plotter are now used for contouring than manual

Exercise or assignment

Slopes and Gradients

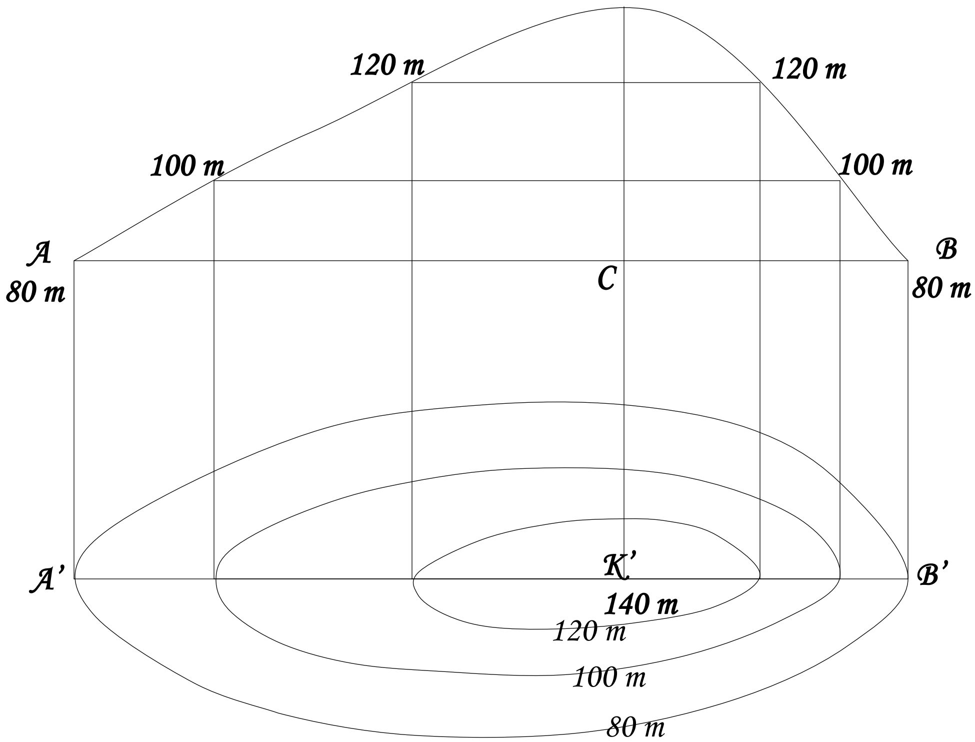
The steepness of slope, the variation in the steepness of a slope from place to place and the average slope has great significance to studying landuses for various purposes

Types of slopes

- Uniform Slope
- Concave Slope
- Convex Slope
- Terraced Slope
- Undulating Slope

Gradient:

Vertical Interval (VI) and Horizontal Equivalence (HE) lend themselves to express the steepness of slopes in terms of gradient



Slope **AK** is represented on the contour map by line **A'K'**

Vertical Interval (VI) = difference in height between the points A'K' i.e. ➔➔➔140 m – 80 m = 60 m

If the distance A'K' on the map is 4.7 cm and the scale of the map is 1cm to 2.5 km ➔➔➔then, distance A'K' on the ground = 4.7 x 2.5 km = 11750 m

Gradient of Slope A'K' = 60/11750 = 1/196

It means that there is a rise of one unit of length in horizontal distance for every 196 units – It is also written as 1 in 196

Gradient of a slope is defined as – the proportion between its Vertical Interval and Horizontal Equivalence expressed as a fraction of the denominator of which is unity (1)

Gradient of slope will become steep or gentle according as the horizontal equivalent decreases or increases in length

Thus, slope BK is steeper than slope AK in the figure, because Horizontal Equivalence BC is shorter than the Horizontal Equivalence AC

Therefore, gradient enables us to find the degree of steepness of a slope

The smaller the value in denominator, the higher will be the gradient and hence steepness of the slope and vice versa

Gradient is used to find out whether the slope is suitable for climbing motor vehicles, railways, animal drawn vehicles etc… Eg. Gradient of 1/25 is steep for railway but gentle for motor vehicle

Expression of Gradient

In addition to expressing gradient as fraction, it is also expressed in two other ways

As a Percentage

In this case, gradient is expressed as 1%, 2%, 3% and so on…

The gradient of slope of 1% is 1/100, 2% = 2/100 = 1/50, and so on…

As a Degree of Angle

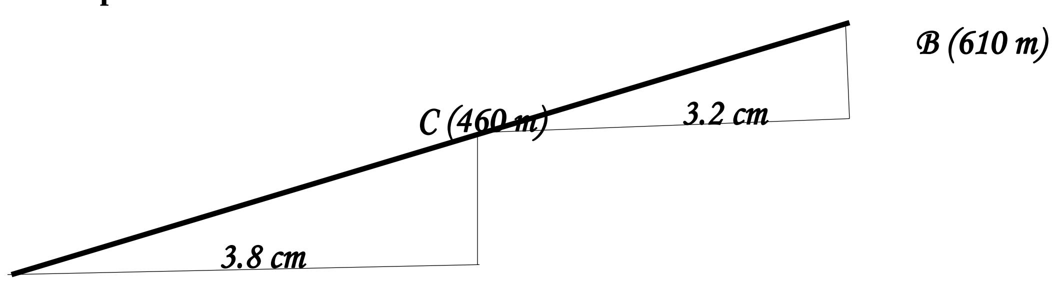
The angle of the slope for a gradient of 1/57.14 is 1^0, for the gradient of 1/28.65 = 2^0, for the gradient of 1/19.08 = 3^0 and so on…

The slope of 1^0 is considered as equal to gradient 1/60 (approximately)

Conversion from slope to Gradient or vice versa – Is possible by remembering

- Gradient of 1 in 100 (1/100) = a slope of 1%
- Gradient of 1 in 60 (1/60) = a slope of 1^0
- For instance, 1/196 Gradient is 0.51% or 0.30^0

Comparison of Slopes



Suppose it is required to compare the steepness of the slope AC with that of the steepness of slope CB – the height of points A, B and C are 380m, 460m and 610m respectively – Say the scale of the map is 2 cm to 1 km

Measure the distance AC and CB on the map – Let it be 3.80 cm and 3.20 cm

Ground distance between A & C = 3.8 x 0.5= 1.9 km = 1900 m

Ground distance between C & B = 3.2 x 0.5 = 1.6 km = 1600m

Vertical Interval between A & C = 460 – 380 = 80 m

Vertical Interval between C & B = 610 – 460 = 150 m

Therefore, Gradient of Slope AC = VI/HE = 80/1900 =1/23.7

Gradient of Slope CB = 150/1600 = 1/10.7

Thus, Gradient of Slope CB is steeper than the Gradient of Slope AC – hence, slope AC is gentler than the slope CB

Profile

A Profile is simply a cross-sectional view through a particular piece of terrain

Profiles provide a relatively quick and accurate means of determining such useful information as the relative steepness of the slope of the terrain at the given location

It is a line, which shows the rise and fall of the surface of the ground along chosen line on a map

It is drawn to get a clear idea of the nature of relief along a line

Steps for Drawing Profile

Draw a line passing through contours – Let this line be AB

Take a piece of drawing paper and place its edge along AB

Draw a line parallel to AB on paper – Say this is CD, which serves as a baseline and is equal to AB

To make CD equal to AB, drop perpendiculars from the points A and B on the line CD

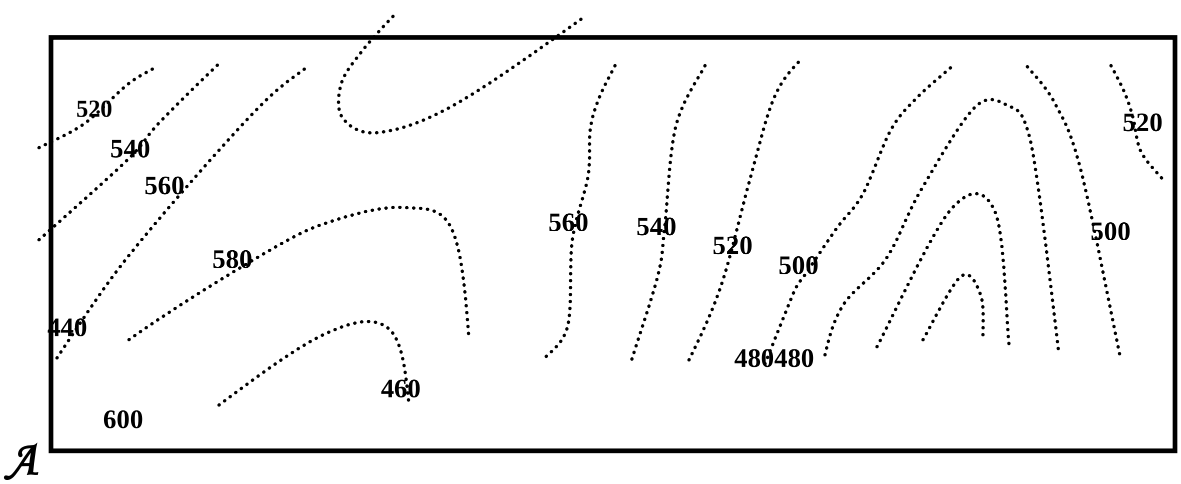
Find the maximum and minimum contour heights – Say it is 600 m and 460 m respectively – It means profile lies between 620 m and 420 m

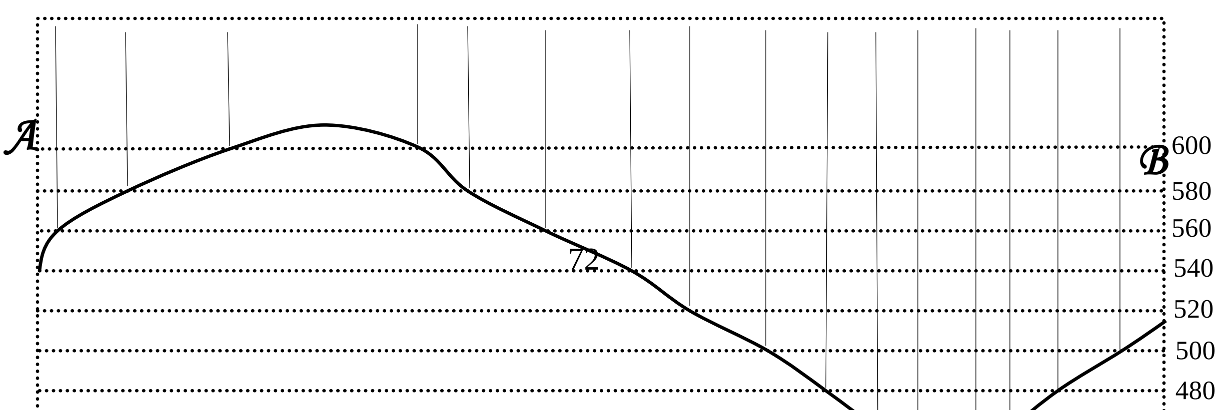
To get a clear picture of the rise and fall of the ground – the vertical scale should be exaggerated and be about 5 to 10 times as large as the horizontal scale – Thus, when horizontal scale is 1:50,000 ➔➔➔the vertical scale should be 5/50,000 = 1:10,000 (exaggeration is 5 times) or vertical scale should be 10/50,000 = 1:5,000 (exaggeration is 10 times)

- Suppose we are taking vertical scale exaggeration as 10 times then, horizontal line representing 440m and 620m will be (620-440)/50 = 3.6 cm apart
- If the contour interval is 20m, then 460, 480, 500, 520, 540, 560, 580, 600, 620 there will be 9 contour between 440 and 620 – spacing between two lines will be 3.6/9 =0.4 cm
- Draw lines parallel to CD at 0.4 cm distance and label these lines with height 440, 460, 480, 500, 520, 540, 560, 580, 600 and 620 m
- Drop perpendicular form the point of intersection of line AB and the contours on the lines representing the corresponding heights
  The points at which perpendicular lines meet with the horizontal line are connected to from a smooth line

This smooth line is the required profile

Write at the bottom of the profile, horizontal scale – 1:50,000, vertical scale – 1:5,000 and vertical exaggeration =10 times


520
540
560
580
440
600
460
560
540
520
500
480480
520
500
A


A
B
600
580
560
540
520
500
480

Horizontal Scale = 1:50,000
Vertical Scale = 1:5,000
Vertical Exaggeration= 10 times

Types of profile:

Traverse Profile – It is drawn across a valley, a mountain ridge etc… and it is a t right angle to the direction in which a valley, a mountain range etc run

Longitudinal Profile – It is drawn along a river course, watershed, road etc…A road, a river course etc… often run in zigzag manner

Intervisibility

Sometimes we need to know from a map whether two points are mutually visible or not

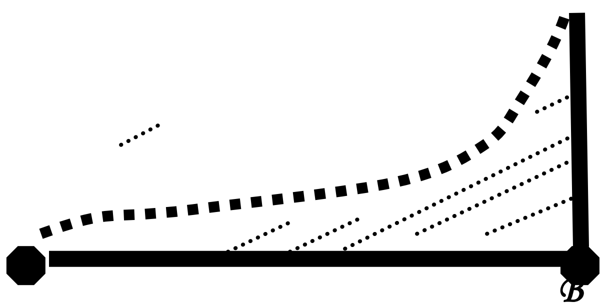
Two points are inter-visible when there is no intervening object to intercept the line of sight

Two points on the ground will be mutually visible ➔➔➔

When the ground is perfectly flat

A *B*

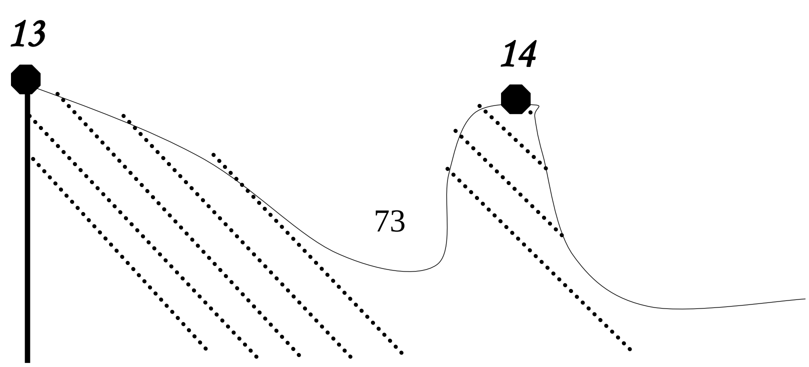
When one point is located at the bottom and the other at the top of a concave slope

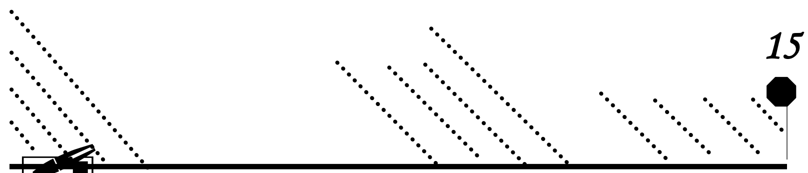


When the intervening ground is not much higher than the target point to be seen

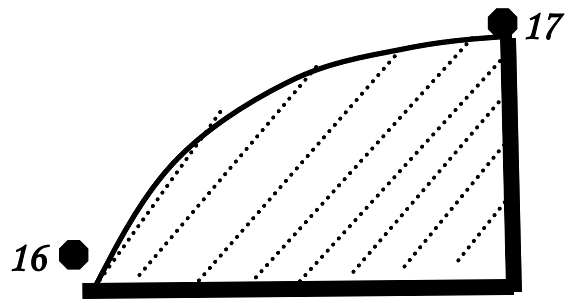
An object will not be visible➔➔➔

When hill, tree or building intervene the object to be seen





When two points are lying on concave slope



Determination of Intervisibility between two Points

By drawing profile:

After having drawn the profile, connect the two points with a straight line

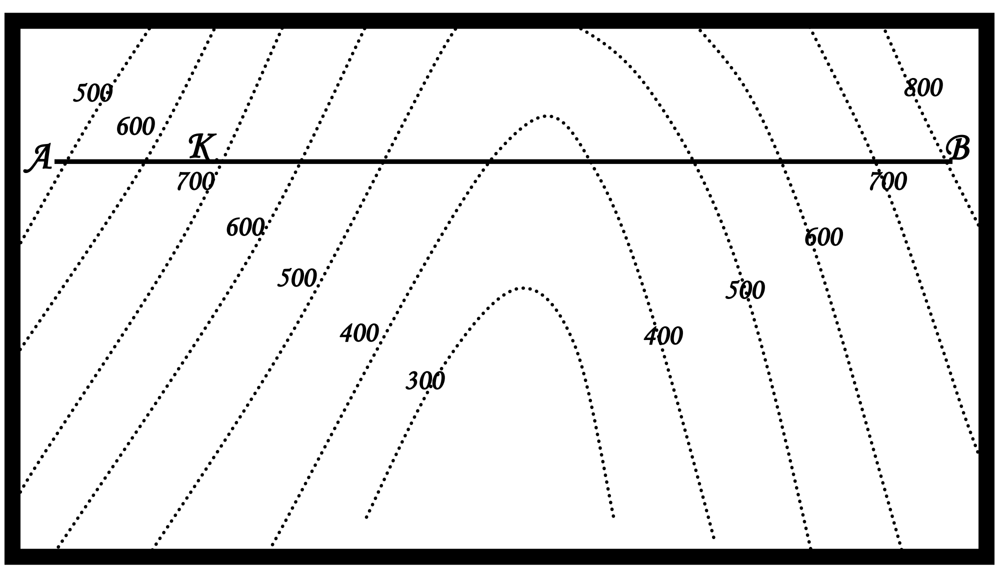
This straight line represents the **Line of Sight**

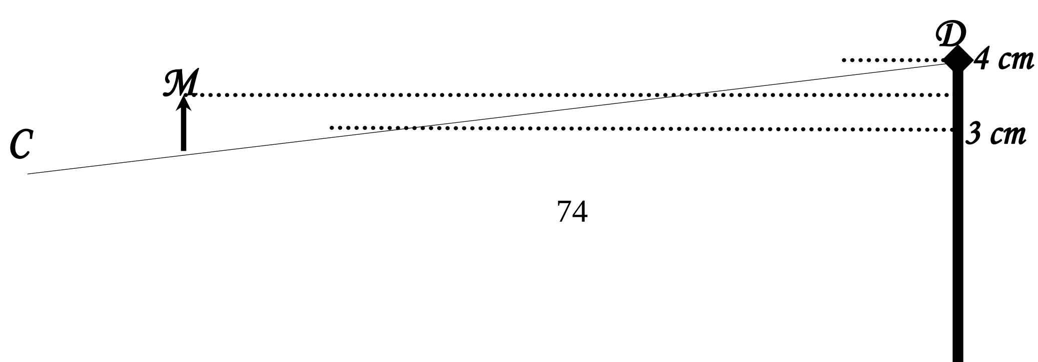
If the profile rise crosses the line of sight, the two points are not mutually visible

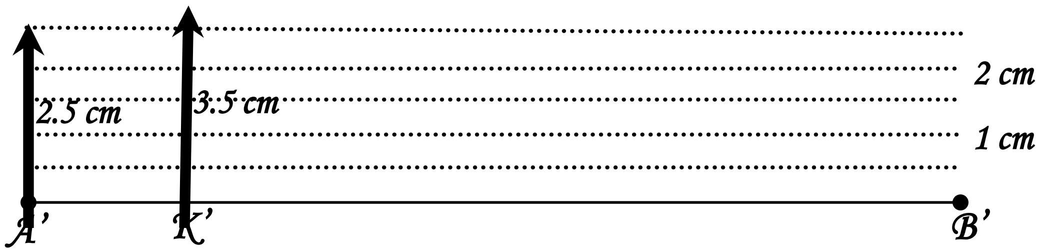
For example – points A and B are not mutually visible in case of the profile drawn previously

By comparing heights:

The above method is shortened by drawing perpendicular line only from the two given points and a third point which may be expected to intervene



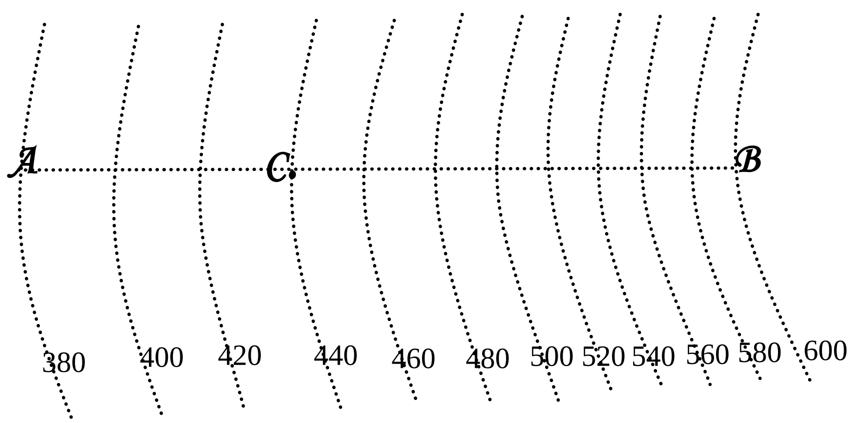




Suppose K is intervening point between A and B – Draw a line A'B' parallel and equal to line AB (Line of Sight of Contour Map)
Mark point K' on line A'B' so that A'K' =AK and K'B' =KB
Select a suitable vertical scale and draw perpendiculars from the A', K' and B' based on vertical scale – The length of the perpendicular can be calculated as …Suppose height of 1000m is represented by 5 cm… then height of 500m is represented by 2.5 cm, 7000m by 3.5 cm and 800m by 4cm
Draw perpendicular CA' = 2.5cm, MK'=3.5cm and DB' = 4cm
Since perpendicular MK' crosses the line CD, point B is not visible from the point A
Had line MK' not crossed the line CD, the point B would have been visible from point A

By comparing Gradients

Suppose it is required to find whether or not the point B is visible from point A when ground at the point C is expected to intervene



Height of A = 380m, B = 600m and C = 460 m
Map distance AC = 3.8cm, BC = 3.2 cm
Ground distance AC = 3.8cm x 0.5 = 1900m
Ground distance CB = 3.2 x 0.5 = 1600m
Gradient of slope AC = 460 – 380/1900 = 1/23.7
Gradient of slope CB = 600 – 460/1600 = 1/10.7
The gradient of slope CB is greater than the gradient of slope AC – it means slope AC is gentler than slope CB – Therefore slope ACB is concave slope and points A and B are mutually visible

Had the slope CB been gentler than the slope AC, the slope ACB would have been convex slope and the two points A and B would have not been mutually visible

Map Making (Projection)

- During the process of map-making, the map should follow the characteristics of globe – the earth's shape, as aforementioned, is basically spherical
- It is not possible to retain all the globe characteristics on a flat map ➷➷
- Attempts to represent spherical earth on a flat piece of paper result in distortion
- So whatever is possible, try to retain some characteristics, depending upon your requirement ➔ accordingly projection is selected
- **Map Projection** is a systematic rendering on a flat sheet paper of a Graticule, by adding a representation of geographic features found on the earth
- Three physical surfaces are commonly used for the construction of map projection **, Projection Surfaces** ➔Plane, Two developable surfaces (Cone and Cylinder)
- Projection onto Planar (Flat) Surface is called **Azimuthally Projection**
-

Globe Characteristics

- On a globe, features from the earth surface (their shape, the area they occupy and the distance and direction between them are correctly shown

- An ideal map projection retains all of these characteristics and translates them to the map
- The characteristics of an ideal map projection should be:
  - **Co formality**:
    - The retention of correct shape of the earth feature on the map is called Co formality – i.e. map features can be recognized by their distinctive shapes
    - Co formality also allows the accurate recording of direction
    - The requirement for a conformal map are that the lines of latitude and longitudes must cross one another at right angles and the scale must be the same in all the directions at any given point
    - It is true only for the small area
    - Example, Mercator Projection, Lambert conformal Conic, Traverse Mercator
    - Mercator Projection is designed in such a way that the North-South scale changes at the same rate as the East-West scale – this means scale of Mercator is same in all the directions t the given point on the map
  - **Equivalence (Equal Area):**
    - When a map is produced on equal area projection, a unit area drawn on it always represent the number of square kilometers (Sq km or km^2) on the earth's surface
    - To retain equivalence, any scale changes that occur in one direction must be compensated by suitable changes of scale in opposite direction depending upon the position on earth
    - Example, Albert Equal Area Projection and Sinusoidal Projection
    - In the Sinusoidal Projection, the scale is true along the central meridian and each parallel, which gives the projection its equal area characteristics
  - **Distance (Equidistant):**
    - Correct distance relationship requires that the length of a straight line between two points on the map represents the correct great circle distance between the same points on the earth

- Example, Azimuthal Equidistant Projection – All the points on Azimuthal Equidistant Projection are plotted at their distance from the center of the projection and are in their true globe direction or azimuth from the center
- Distance relationship other than those measured from the center of the projection is increasingly distorted away from the central point

Direction:

- When a projection retains correct direction, a straight-line drawn between two points on the map shows the correct Azimuth of the line
- An azimuth is an Angle formed @ the starting point of a straight line in relation to Meridian – Example, Gnomonic Projection
- Here spacing of the Graticule increases rapidly away from the center of the projection resulting in and increasingly exaggerated scale

Projection Selection:

- The characteristics of a map are determined by the projection on which it is plotted
- The relation of shape, equivalence, direction, and distance with some compromise in these are used for the preparation of a map
- The selection of a projection system is based on area, shape and purpose of the map

Purpose of the Map

- Mercator and Gnomic projections are used for Navigational Purposes
- Azimuthal Equidistant Projection is used for distance measurement purpose
- Lamberts Conformal Conic Projection is used for mid-latitude air chart – route selection and distance determination
- Conformal projection such as Traverse Mercator is used for Topographical Mapping – short distance, directions and area calculation can be done on these maps

Projections depending upon the Area to be Mapped

- ☞ Small area – less distortion
- ☞ Large area – more distortion
- ☞ Latitude of the area of interest ➔areas near equator – cylindrical projection, as in a normal orientation its tangent is at the equator
- ☞ Pole-centered – Azimuthal Projection is suitable for poles

✍ **Projections based on the Shape of the Area of interest**

- ❄ Area to be mapped is long in North-South direction and short in East-West direction ➔traverse Mercator Projection or Sinusoidal, Example, Chile
- ❄ Area more in East-West direction and less in North-South direction ➔Conic Projection, Example, Lamberts conformal and Alberts Equal Area projections are suitable for the mapping of USA
- ❄ When compass direction between locations are important ➔ Conformal, Example, Mercator
- ❄ For radio or Seismic work – as waves involved in such studies, travels in great circle direction and is plotted as straight line ➔Gnomonic Projection

Locational System (Coordinate System)

- ☪ There are two basic systems for designating locations on the map
- ☪ One system involves the use of **Latitude and Longitude Graticule** and the other involves the use of state plane rectangular grid system
- ☪ Either of the two Locational systems can be used
- ☪ The mapping area should be given correct coordinate system, which is further subdivided into small Graticule, Example, on 1:50, 000 scale map, the outer boundaries of both latitude and longitude vary by 15 minutes – This can be further subdivided into 5 minutes Graticule
- ☪ This method of defining location is being used internationally and hence one should follow the same technique during the preparation of map

Plotting

- Once the format and scale of the map is decided, the next step is plotting the map ➔this is the process of transferring the surveyed data to the map
- In the preparation of the topographical maps, the first plotting task is to define accurately the position of the control points on the map
- This is best accomplished by preparing a rectangular grid and plotting each traverse point by means of its computed coordinates
- The plotting of other details including contour can be done with the use of circular protractor
- A measuring scale can also be used to locate the points

- One should check the correct relationship between the features after the process of plotting

Enlargement and Reduction of Maps

- Sometimes you might like to use a map that you find in a book as an aid for some demonstration purpose, in teaching or for a wall display dealing with the certain developments some where in the world
- The problem you face is that the original map in the book, magazine or atlas is drawn in such a small scale that it doesn't lend itself very well directly for wall poster display or teaching aid
- What is needed in this case is a change of scale, an enlargement of scale – The opposite also might be the case
- You might like to use large-scale map as an illustration in your notebook but you cannot possible fit that map on the page of your notebook
- What you now have to do is reduce the scale
- These changes of scale can be done accurately with the help of specially designed machine called Pantograph
- But as they are not available everywhere, simpler and less accurately can be used
- The various steps are:
    - Find the size of the original map through measurement and your mind that about how big you want your new map to be
    - This will give you the scale of new map that you want to construct
    - The number of times you can increase the original scale is of course decided by the size of the paper that is at your disposal – suppose you are enlarging two times
    - Draw a frame of your new map in such a way that the sides are double to the sides of original map
    - Cover the original map with a grid of 0.5 x 0.5 cm squares (Grid), draw with a soft pencil so that it can be removed later
    - Cover your map under construction with a 1 cm x 1 cm squares
    - Using grid as guide, trace the major features that you want to show on your enlargement map carefully with the pencil

- Finalize your map using ink, color etc… for the different features that you wanted to show – Give other marginal information of the map
- Check your work carefully – Remove your gridlines from the map

This method of enlargement or reduction of scale can be used for any kind of drawing and the result is relatively accurate if your measurement and tracing are accurately done

✈ Example: Given original scale 1:50,000
✈ Then, increased Twice ➔ 2/50,000 = 1:25,000 will be the scale of the new map
✈ Increased four times ➔ 4/50,000 = 1:12,500 will be the scale of the new map
✈ Decreased twice ➔1/ 2 x 50,000 = 1:100,000 will be the scale of the new map
✈Decreased four times ➔ 1/ 4 x 50,000 = 1:200,000 will be scale of new map And so on
Graphical Geometrical Method

What is a Map Scale

- **Cartography** is concerned with **reducing** the spatial characteristics of an outsized area, a portion or the entire earth – and putting it in a map to make it **observable** ⊷This is possible with the help of Map **Scale**
- A map is a hardcopy **representation** of part of the earth's surface and it is essential that a **scale** ratio be present on the map to convey the reduction factor
- A Map is ➔
  - **Bird's eye view** of the earth's surface ⊷is drawn to **Scale**
  - Abstract/pictorial **representation** of the reality for which the location on the earth is known⊷**Reduced** by a certain ratio
  - The accurate **representation** of 3D (reality) by 2D (Planar/flat paper/surface)
- **Map Scale:** is the **reduction** needed to display/portray a **representation** of the Earth's surface on a map
- The scale of a map is the **ratio** between a distance (or dimension) on a map and the corresponding distance (or Dimension) on the earth, with the distance (or dimension) on the map typically expressed as 1 unit (UNITY) ➔ Thus, a scale of

1:100,000 means 1 inch on the map equals 100,000 inches (approximately 1.6 miles) on the earth

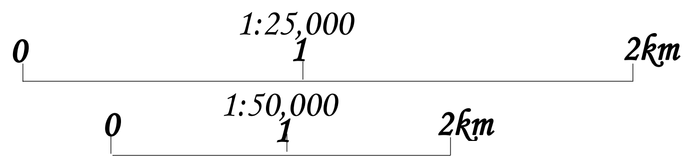
- Large scale maps depict a small area and show more detail, but small scale maps depict a large area and show less detail. ...
- Map scale is the relationship between the actual size of a place and its size as shown on a map
- A busy definition ➔ **Scale** is the ratio between the size of something and a representation of it ⊷the ratio between the distance of any two points on the map and the distance representing the same two points on the ground
- Linear Scale (or simply Scale) = Map distance (**MD**) /Ground Distance (**GD**), ⊷Noting that both the Numerator and the Denominator are of the **same unit** so that scale becomes **unit less**…If different units are given convert them to a same unit
- Example, when 1 cm on a map (Equivalent to 0.00001Km) represents 1km on the ground (i.e. simply, converted to be 100,000cm), then **Linear Scale** = 1cm / 100,000cm ➔1:100,000 (unit less) or 0.00001km / 1km ➔1:100,000 (unit less)…But the first method is simpler
- **Areal** Scale = Square of (Linear Scale) ➔ Used to find Map Area (Ground Area x Areal Scale) or Ground Area (Map Area x Areal Scale)…Unlike Linear scale which is used to find Map Distance (Ground Distance x Linear Scale) or Ground Distance (Map Distance x linear Scale)
- **Scale line:** A line representing graphical scale, used to convert map distances into Ground Distances, Usually lengthened @ a whole number ➔One main unit is to the left of the zero and conveniently divided into smaller units
- Let, Given Scale= 1:100,000 and Ground Distance to be represented/drawn on the map =11km ➔Length of Scale line (calculated just like MD) = 11 cm
- What if the space where a scale line of Kilometers is to appear on the map became limited? Example, @ a scale of 1:250,000, only 19cm space remains @ the map for scale line ➔MD/S = (19 x 0.25) km = 4.75 km can be represented @ the reserved space, i.e. Full/Whole 4 kms ➔Therefore, Total Length of Scale line = 4km/0.25km = 16 cm

Scale Factor

- A constant, which is proportional to scale used to convert MD to GD or vice versa
- It is a size change magnitude, expressed in decimal
- Example, if Scale = 1: 100,000 ➔Scale factor (SF) = $\frac{1}{100,000}$ = 0.00001
  - Scale = $\frac{MD}{GD}$ ➔**GD** = $\frac{MD}{Scale} = \frac{1}{Scale}$ x (MD) = MD x SF
  - Scale = $\frac{MD}{GD}$ ➔**MD** = Scale x (GD) = $\frac{GD}{\frac{1}{Scale}} = \frac{GD}{SF}$

To convert series of MD's into GD's, simply multiply them by SF ➔and to convert series of GD's into MD's. simply divide them by SF

Conversion of Scales



- Both scales represent the same ground distance…2km
- 1:50,000 is half (1/2) smaller than 1:25,000, or 1:25,000 is twice larger than 1:50,000
- The larger the denominator in the fraction representing the scale (50,000 > 25,000), the smaller the scale (1:50,000 < 1:25,000) because 1/50,000 < 1/25,000
- i.e. while a map is reduced, the denominator increases (E.g. if 1:25,00 is reduced by half ➔New Scale = 1:50,000) and/or while a map is enlarged, the denominator decreases (E.g. if 1:50,00 is enlarged twice ➔New Scale = 1:25,000)
- Reduction/Enlargement Percentage =

$$\frac{\text{Scale Denominator of Original Scale}}{\text{Scale denominator of New Scale}} \times 100$$

- Example, If 1:50,000 is enlarged to 1:2,500… ➔ Enlargement Percentage = 50,000 / 40,000 = 125%...... Always, Enlargement Percentage is > 100% Where as Reduction Percentage is < 100%
- Production of smaller-scale maps from a larger scale map is possible ☜To determine the total number of maps to be produced

$$\left[\frac{\text{Larger Scale}}{\text{Smaller Scale}}\right]^2 = \text{Number of maps needed}$$

Types of Scale

- The scale can be represented in either of the three ways:
  - Word statement
  - Representative Fraction (Arithmetic Ratio)
  - Graphical Scale

- **Word statement (verbal Scale)**:

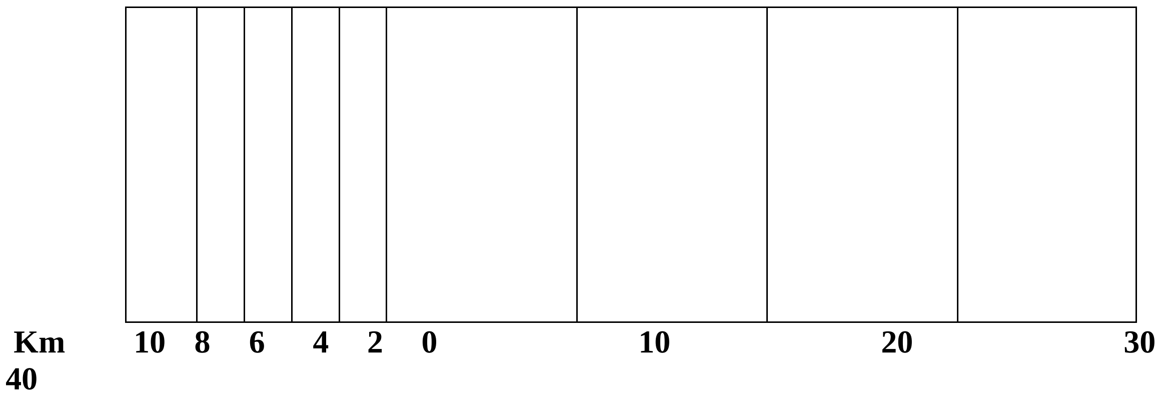
  - Quick idea of size relationship ➔ Expressed in a phrase such as **"Ten centimeters to one kilometer"** which means that 10cm on particular map is equivalent to 1 km on the ground)
  - It is more appropriate to use word statement that indicates the map is at a scale of 10, 100, 1000, etc… (E.g. Ten centimeters to one kilometer — **Map scale**= 10 cm to 1 km)

- **Scale Ratio (Representation Fraction ➔RF)**:
  - expressed as the ratio between two distances :
    - The distance between two points as measured on the map
    - The actual distance between the same two points as measured on the earth's surface
    - This ratio is always presented with the map units listed first
  - E.g. Distance between two points on the map is 10cm and the distance between equivalent points on the earth is 1km (100,000cm). Then the ratio is 10:100,**000** –which is reduced to 1:10,000 for listing on map
  - Scale ratios are not expressed in any specific units of measurements (Are unit less or unit free) – i.e. both sides of the ratio (Numerator and Denominator) must always be specified in the same units
  - E.g. 1: 10,000 means 1cm on map represents 10,000 cm on the ground
  - Frequently the scale ratio is written as a fraction called **representative fraction** (or **Scale Factor**) – E.g. 1: 10,000 can be written as 1/10,000

- **Graphical Scale**:

  - Map scales also are represented in graphic form --- dividing the line in to units, each of which represents, @ map scale, the actual distance between two points on the earth ➴
  - **Graphic scale** is a line drawn on a map and subdivided into units appropriate to the scale of the map
  - These units generally are chosen to be easily usable, rounded numbers, such as tens or hundreds of kilometers, miles, miles, meters or feet
  - Often, part of the scale is subdivided into fractional units to aid in measuring distance more precisely – Deal with Scale line

- Is a usually used scale, because the map may shrink with time and the scale shrinks accordingly



Map Classification based on Scale of the Map

- **Large-scale Map**:
  - When a map of a given size covers a relatively small area of the earth's surface, it is called a Large-scale Map
  - Large-scale map can include a considerable amount of information
  - Maps scaled => 1:50,000 / 1:10,000 / 1:5,000 / 1:25,000 are considered as Large-scale maps
  - Convey more information
- **Small-scale Map:**
  - If the map of the same size covers a large area of the earth's surface, relatively little detail can be included and the map is called Small-scale map
  - Scale => 1:500,000 / 1:1,000,000
  - Convey less information
- **Medium-scale Map:**
  - The scale lies between large and small scale i.e. greater than 1:50,000 but less than 1:500,000 are considered as medium-scale

Convey intermediate information

How to find out scale when it is not given

- We need to **deduce** scale when it is either not given on the map or the scale given on a foreign map shows distances in unknown units to us
- Map without scale is called Drawing or Sketch

Case I – When some ground distance is given:

- E.g. – Distance between A and B on ground is 5 km
- Then measure the distance between A and B on the map (Map distance) – Let us say it is 50 cm
- Hence 50 cm to 5 km = 50 cm to 50,000 cm
- 1cm to 10,000 ➔RF = 1: 10,000

Case II – When nothing is known about the distance on the map but map is provided with Latitude and Longitude:

- The map distance between two latitude or Longitude lines can be compared to the earth distance between them
  - Average length of degree of latitude is 110.5 km near equator and 111.7 km near poles
  - So depending upon the place, we can calculate ground distance between two latitude degrees
  - Measure the same distance between two latitude lines on map
  - Calculate the scale using the formula:

Scale = Map distance/Ground distance

  - If length of Longitude is used then distance between Longitude degrees is Cosine of latitude multiplied by 111.3 km
  - i.e. if longitude is measured at 45^0 latitude, then

Cos (latitude degree) X 111.3 km = Ground distance

- Distance between two longitude degree = Cos 45^0 X 111.3 km = **Ground distance**

  - measure the map distance between the same points and calculate the scale using the formula above

- **Case III – By comparison with other map:**
    - The map distance between points A and B on map X is 50 cm and the scale is 1:50,000
    - The same points A and B are present on another map Y where the map distance between AB is 25 cm, what will be the scale of the other map
    - On map X, 1cm = 0.5 km
    - → 50 cm is 50 x 0.5 = 25 km
    - Now on map Y, AB = 25 cm
    - → 1cm on map Y = 25/25km = 100,000
    - Scale of Y is 1:100,000

Measurements from Maps

- A variety of information about the earth, and about the features distributed on its surface, is obtained by direct measurements from maps

- Two measurements of primary importance:
    - The distance between locations
    - The area of a region

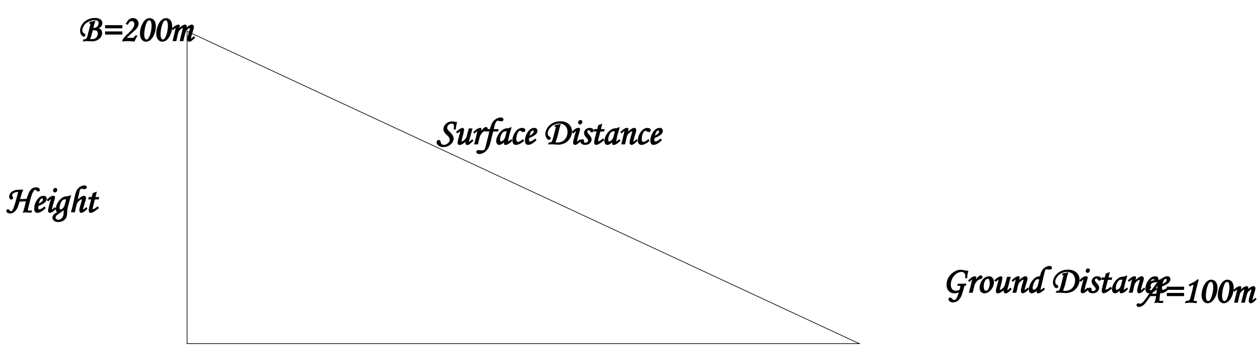
Measurement of distance

- Map distance measurement assume that one of the two conditions is met so that the measurements taken are valid
    - First condition is that the distances are short so that the earth's curvature is not an important factor
    - The second is that the map is on equidistant projection and the measurements are taken along appropriate alignments
        - For E.g. it is not appropriate to directly measure the distance between New York and London. However, to measure the distance between the downtown and suburbs of a city is valid
- Before starting any measurement on map, it is advisable (necessary) to consider the following three points
    - If you are asked to measure a distance between two points A and B, it is the real distance (ground distance) that is wanted not distance on the map
        - Therefore, don't give answer like this, "the distance from A to B is 30 cm"
        - To obtain the real answer it is required to change the distance obtained through measurement on map (map

distance) to real distance (ground distance) with the help of scale of the map

- Distance on map is measured in centimeters but distance on field is given in kilometers
  - Therefore it is meaningless to say that, “the distance from Addis Ababa to Asmara by road is 10740000 cm=1074 km
- All distance obtained through measurements on maps called map distance don’t consider the ups and downs on the field
  - In the real world the routes between locations almost always involve ups and downs
  - The actual surface distance between two objects, therefore is longer than the map distance, except in exceptional case where ground surface is perfectly flat
  - Assuming that there is relatively uniform slope between two points, the calculation of the distance correction for elevation involves simple application of the Pythagorean theorem

- Suppose two points A and B have map distance of 30 cm and elevation is 100m and that of is 200m. The scale of the map is 1:50,000
  - Then map distance=cm
  - Scale 1cm=0.5 km
  - Ground distance= 30 x 0.5= 15 km



- Now **Height difference** between A and B is 200m-100m=100m
- The field or surface distance= $\sqrt{(1500)^2} + \sqrt{(100)^2}$=

- **Opisometer –** is an instrument having route measuring wheel
  - The wheel is allowed to move along the rote whose distance is required
  - The length traversed by the wheel is indicated on the instrument
  - The total length recorded by the instrument is converted into ground distance
  - Accurate measurements along bending lines like roads are possible only on large-scale map

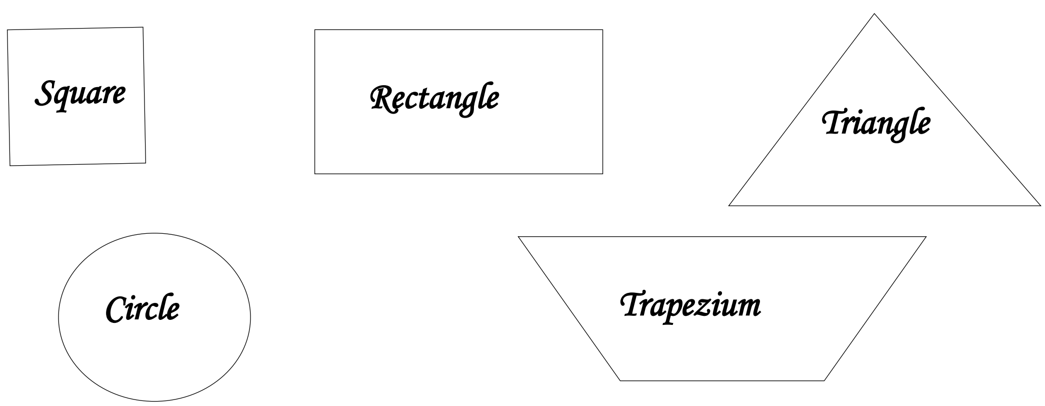
- On small and medium scale maps, roads are shown in such a generalized way that all small bends of roads are eliminated
- In such case accurate road distance measurement is not possible

Measurement of Areas

- The normal scale of a map usually is defined in linear dimensions
- The aerial scale of a map in contrast is defined in aerial units
- The scale of a map is sometimes used to describe the relationship between the area of a feature plotted on a map and area of the same feature on earth's surface
- The ratio between area of a region on a map and the area of the same region on the earth is the square of map's linear scale
- Arial scale=(linear scale)^2
- For Eg. if the scale is 1:50,000
  - Linear scale is 1 cm to 0.5 km
  - Arial scale = (0.5km)^2 =0.25 km^2

Areas of Regular shapes

- Regular shapes include square, rectangles, triangles, trapezoid, etc…
- From geometry, areas of regular shapes can be calculated by knowing the necessary parameters like base, height, length, radius etc…
- These parameters are obtained through measurements on maps
- Using scale of the map, the map area is converted to ground area



- ***Area of Square** = (side)^2*
- ***Area of circle** = πr^2*
- ***Area of Rectangle** = Length x Breadth*
- ***Area of Triangle** = ½ x base x height*
- ***Area of Trapezoid** = ½ (side1 + side2) x height etc…*

Areas of Irregular shapes

- Most areas to be measured from maps are irregular in shapes
- The following methods are used to calculate the area of irregular shapes on maps and then using the scale of the map, it is converted into ground area

Direct Methods of Measurements

Polar Plannimeter:

- Is an instrument that measures areas on a map in terms of square inches or square centimeters
- As usual, these measurements are then arithmetically converted to earth measurements

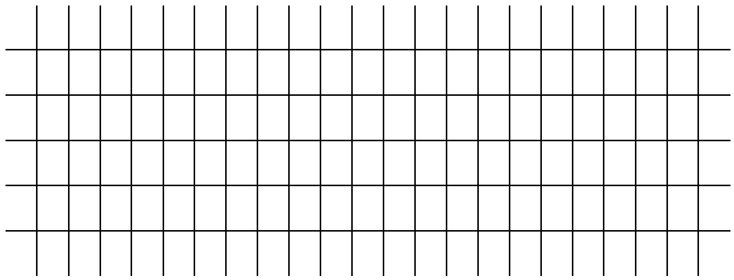
Digital Plannimeter:

- Is an instrument to calculate the area on map with high accuracy
- Steps:
  - The Plannimeter dial is set zero
  - Scale of the map is entered into the Plannimeter
  - Tracing point is marked on the area to be measured
  - Tracing point is placed over the starting point – then carefully moved over the Perimeter of the area in clock-wise direction and returning to the starting point
  - Note the reading on the dial – at least 3 readings should be taken for an area – measure at least thrice
  - A final area is recorded after taking the average of the readings

Indirect Methods of Measurements of Irregular Shapes

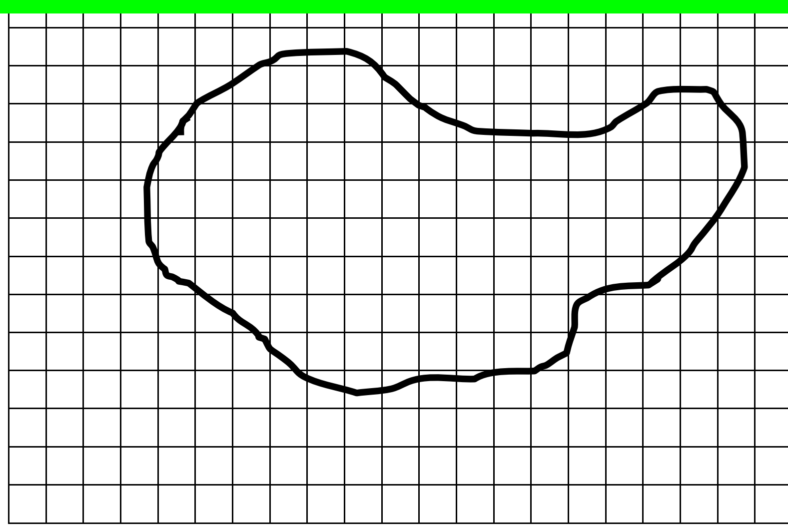
Grid square:

- A grid is an array of horizontal and vertical lines intersecting each other at right angles
- Each square is called grid cell



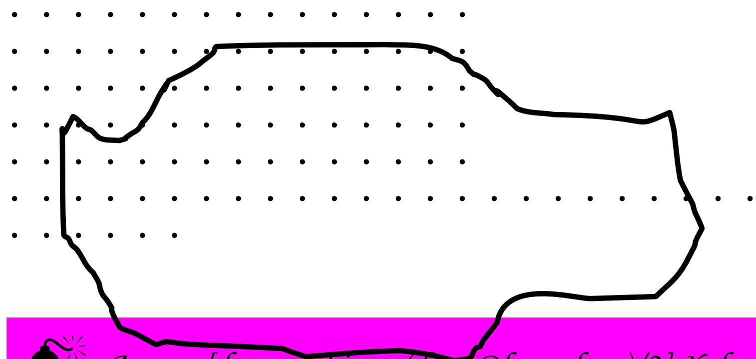
- Steps:
  - A grid of known area (generally each cell =1cm^2) is drawn on tracing or transparent sheet
  - These grids are overlaid on area of interest
  - Count the full square that completely fall within the area
  - Count the half or partial cells

Then, Area = [Full Cells + (half cells)/2 + (Quarter cells)/4] etc … X Cell value



- With the dot-Plannimeter method of aerial measurement which is a variant of the grid square method, a regularly spaced pattern of dots is placed over the map
- This is similar to the grid square method – the only difference is that instead of using grids, dots are used

- Dots of known widths (generally 1 cm^2) are overlaid on the shapes
- Number of dots within the shape and number of dots at the boundaries are counted



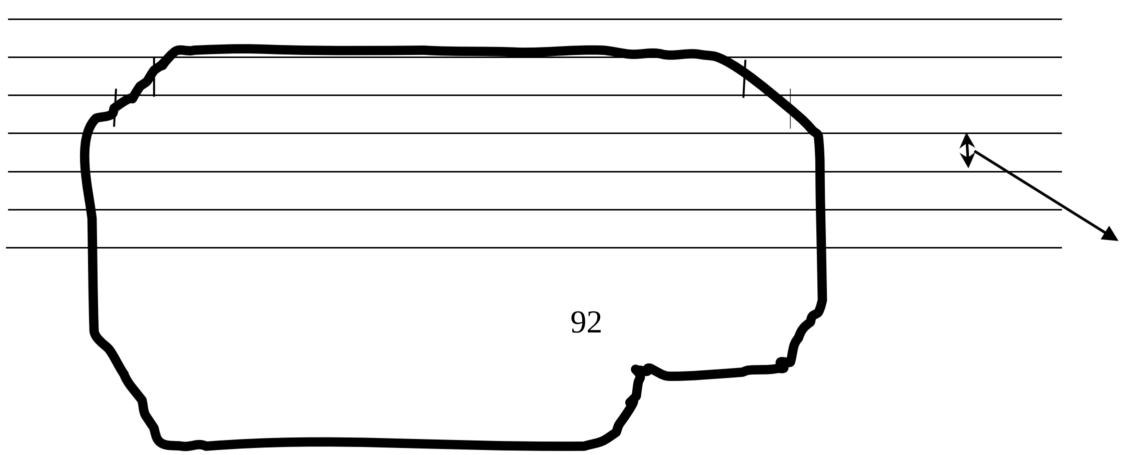
Area = [dots within + (dots @boundary)/2] X dot width

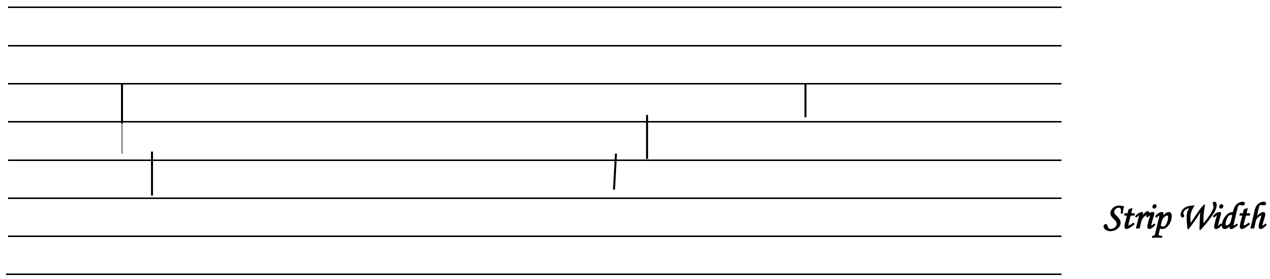
- In contrast to grid square method and strip method, which are exhaustive counting methods, the dot Plannimeter method is simple procedure

Strip method:

- In strip method, a series of parallel lines of known width (generally 1 cm^2) are drawn over the area
- The end of each strip is formed by drawn vertical lines at the edge of area being measured
- Length of each strip is measured
- Sum the individual strip lengths and multiply the total length with strip width to get the area

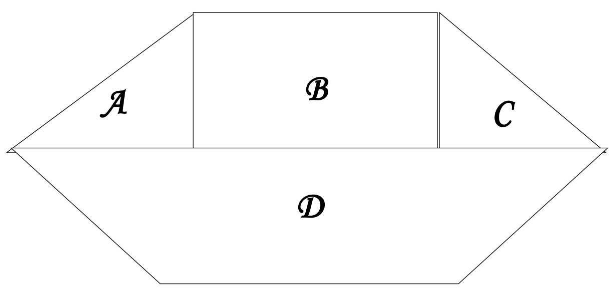
Area = Total strip length (cm) X strip width (cm)





Polygon method:

- It is based on methods of measurement for regular shapes
- Divide the area into number of regular shapes
- Measure the required parameters for each regular shape
- Calculate the area for each shape
- Sum the area to get the area of irregular shape

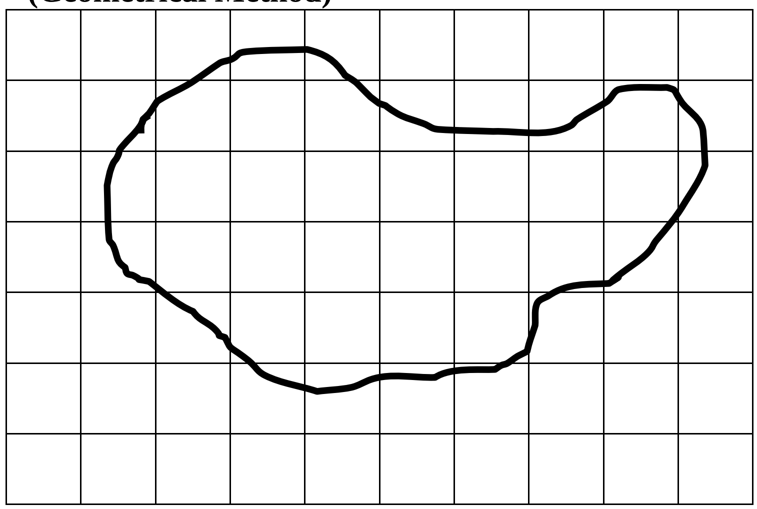


Enlargement a

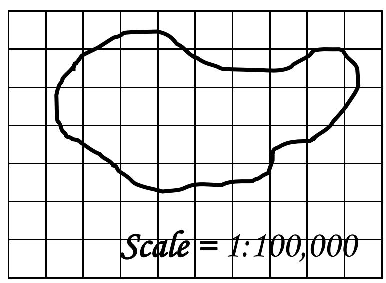
Area = Area A + Area B + Area C + Area D

- Sometimes you might like to use a map that you find in a book as an aid for some demonstration purpose, in teaching or for a wall display dealing with the certain developments some where in the world
- The problem you face is that the original map in the book, magazine or atlas is drawn in such a small scale that it doesn't lend itself very well directly for wall poster display or teaching aid
- What is needed in this case is a change of scale, an enlargement of scale – The opposite also might be the case
- You might like to use large-scale map as an illustration in your notebook but you cannot possible fit that map on the page of your notebook
- What you now have to do is reduce the scale

- These changes of scale can be done accurately with the help of specially designed machine called **Pantograph** or manually using **Graphical (Geometrical Method)**



Scale = *1:50,000*



Scale = *1:100,000*

- Optical instruments such as **Optical Pantograph** and **Cartographic Camera** and/or making use of computers (**Computer-Assisted Methods**) may serve the same purpose

- But as they are not available everywhere, pantographs are simpler and less accurately used

- The various steps are:

    - Find the size/Scale of the original map through measurement and your mind that about how big you want your new map to be

    - This will give you the scale of new map that you want to construct

    - The number of times you can increase the original scale is of course decided by the size of the paper that is at your disposal – suppose you are enlarging two times

- Draw a frame of your new map in such a way that the sides are double to the sides of original map
- Cover the original map with a grid of 0.5 x 0.5 cm squares (Grid), draw with a soft pencil so that it can be removed later
- Cover your map under construction with a 1 cm x 1 cm squares
- Using grid as guide, trace the major features that you want to show on your enlargement map carefully with the pencil
- Finalize your map using ink, color etc… for the different features that you wanted to show – Give other marginal information of the map
- Check your work carefully – Remove your gridlines from the map

- This method of enlargement or reduction of scale can be used for any kind of drawing and the result is relatively accurate if your measurement and tracing are accurately done

✈ Example: Given original scale 1:50,000
✈ Then, increased Twice ➔ 2/50,000 = 1:25,000 will be the scale of the new map
✈ Increased four times ➔ 4/50,000 = 1:12,500 will be the scale of the new map
✈ Decreased twice ➔1/ 2 x 50,000 = 1:100,000 will be the scale of the new map
✈Decreased four times ➔ 1/ 4 x 50,000 = 1:200,000 will be scale of new map And so on