

# LAND SURVEY-II

## Scale

- Scale is the relationship between distance on the ground and distance on the map
- Map scale is usually given as a fraction or a ratio  $1/10,000$  or  $1:10,000$  and is often accompanied by a visual scale in a bar form
  - One unit on the map is equal to 10,000 on the ground
    - One inch or centimeter on the map is equal to ten thousand inches or centimeters on the ground

# Fractional Scale

- The fractional scale or the representative scale expresses the scale of a map as a fraction or ratio.
  - 1/24,000 or 1:24,000
- This scale, which is read "one to twenty-four thousand", says that one unit of measurement on the map represents 24,000 units of measurement on the Earth.
- At this scale, one centimeter on the map represents an actual distance of 24,000 centimeters on the Earth, and one inch on the map equals 24,000 inches on the map.
  - Units of measurement must be the same in both the numerator and the denominator.

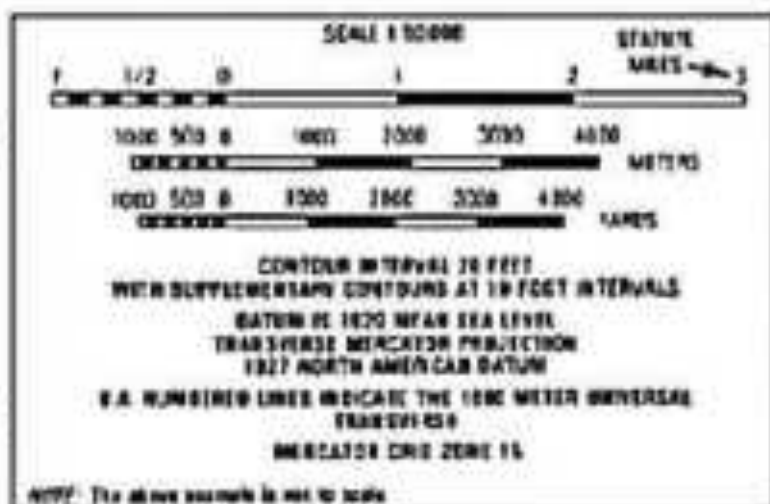
$$\begin{aligned} \frac{\text{Distance on the Map}}{\text{Distance on the Ground}} &= \frac{2 \text{ cm}}{1 \text{ km}} = \frac{2 \text{ cm}}{100,000 \text{ cm}} \\ &= \frac{1}{50,000} \\ &= \mathbf{1/50,000 \text{ Scale}} \end{aligned}$$

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**Linear Scale:** A **linear scale** shows the distance between two or more prominent landmarks. The **linear scale on maps** is a set of lines or dots that represents a landmark. 15-Sep-2017

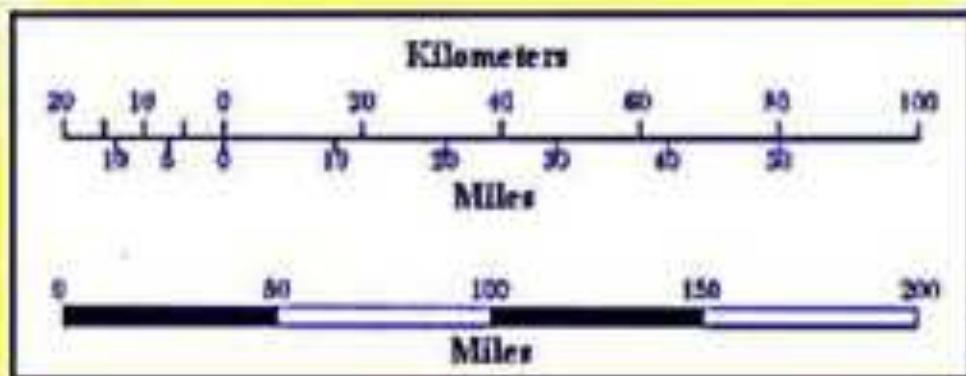
# Graphic Scale

- The graphic scale of a map is a bar graph graduated by distance.
  - Figure one in the lab manual shows the graphic map scale from a U.S. Geological Survey topographic map.
- To use a graphic scale, simply measure a distance on the map (or mark off the distance on the edge of a piece of paper), then compare the measured distance to the bar graph to determine the actual distance represented.
  - On some graphic scales, "zero" is not at the far left, this is to make it easier to read fractions.
- Graphic scales are useful since they remain accurate even if the map is enlarged or reduced.



## Graphic Scales

- Graphic scales are useful since they remain accurate even if the map is enlarged or reduced.



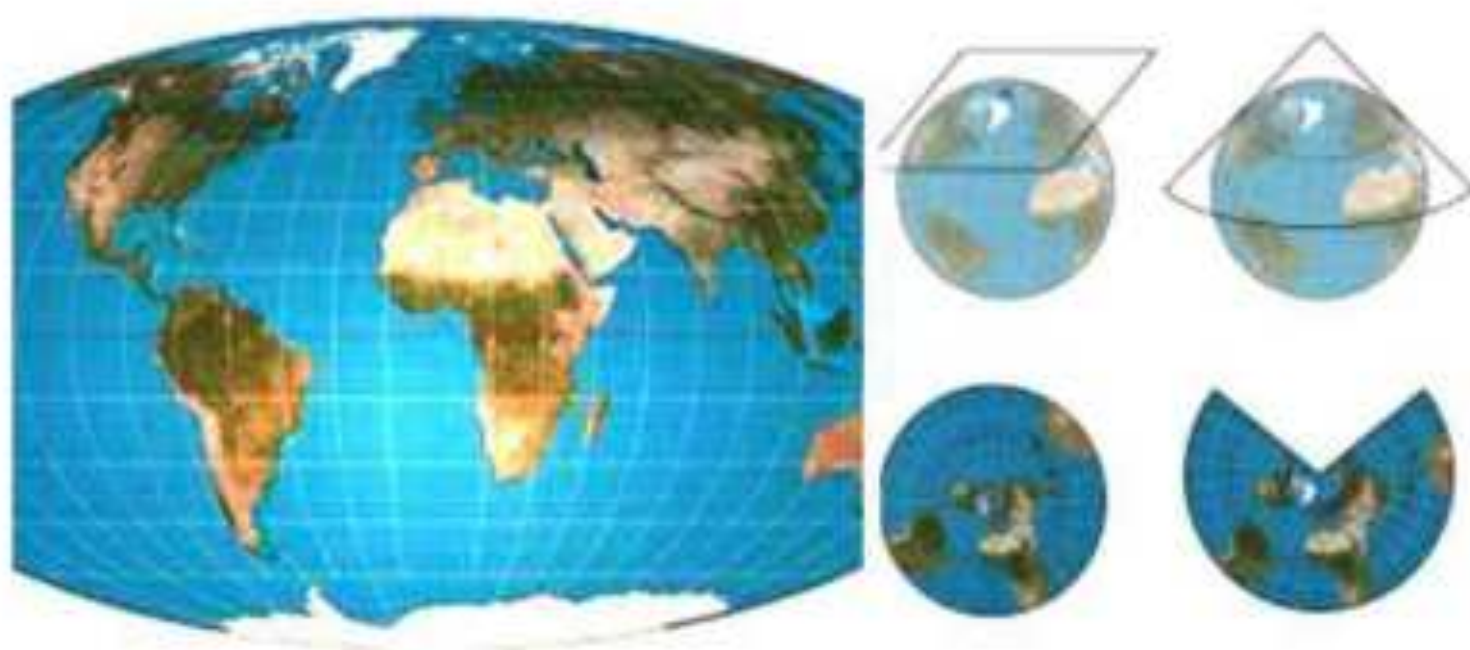
A **map** is a symbolic representation of selected characteristics of a place, usually drawn on a flat surface. **Maps** present information about the world in a simple, visual way. **They** teach about the world by showing sizes and shapes of countries, locations of features, and distances between places.



# What is a Map Scale?

A **map scale** is the relationship between a distance on a map and the corresponding distance on the earth. Map scale may be expressed as an equivalence, usually by different units (e.g., 1 inch = 1 mile or 1:63,360); or graphically, as a bar scale. Large scale maps make each feature look larger, and show a smaller geographic area. Small scale maps make each feature look smaller, and show a larger geographic area.

# Map projection



In cartography, a map projection is a way to flatten a globe's surface into a plane in order to make a map. This requires a systematic transformation of the latitudes and longitudes of locations from the surface of the globe into locations on a plane.

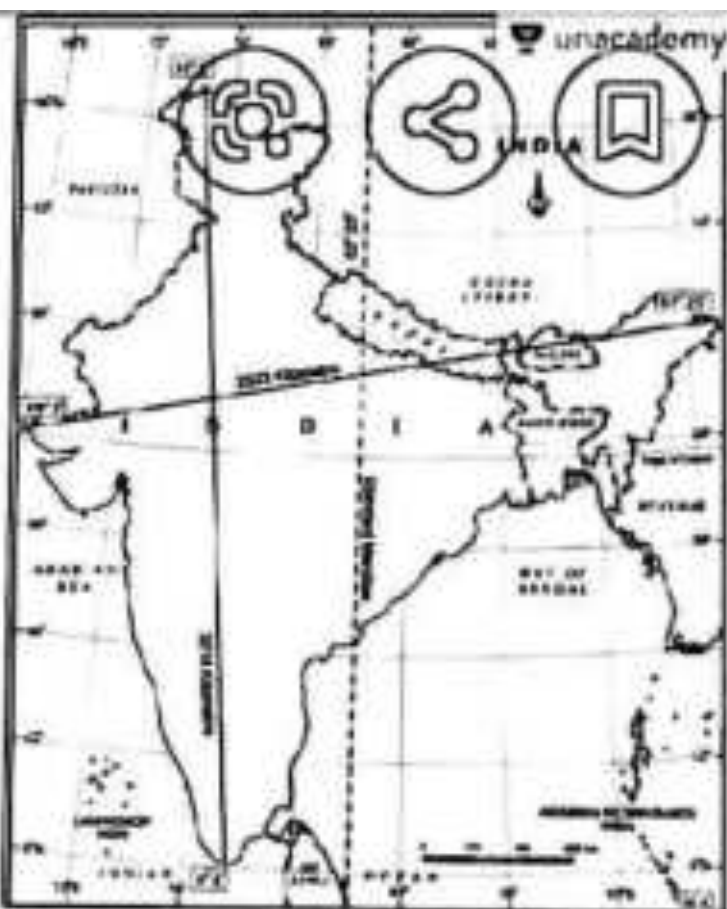


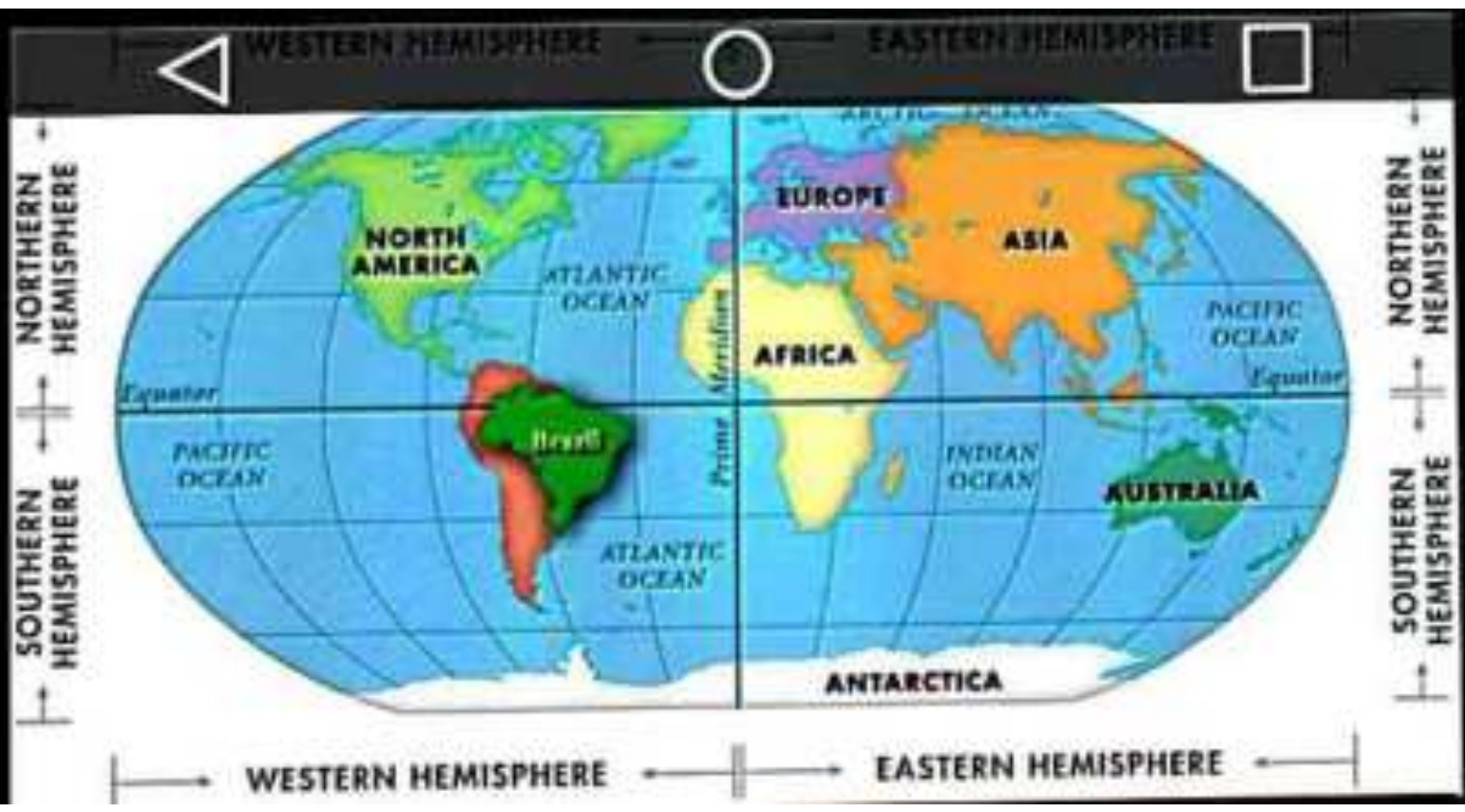


## India: Location

- Located in the Northern Hemisphere in the continent of Asia
- Indian subcontinent is a part of South Asia
- Extends from  $8^{\circ}4'N$  to  $37^{\circ}6'N$  latitude
- Extends from  $68^{\circ}7'E$  to  $97^{\circ}25'E$  Longitude
- The tropic of Cancer at  $23^{\circ}30'N$  cuts the country in almost two equal halves

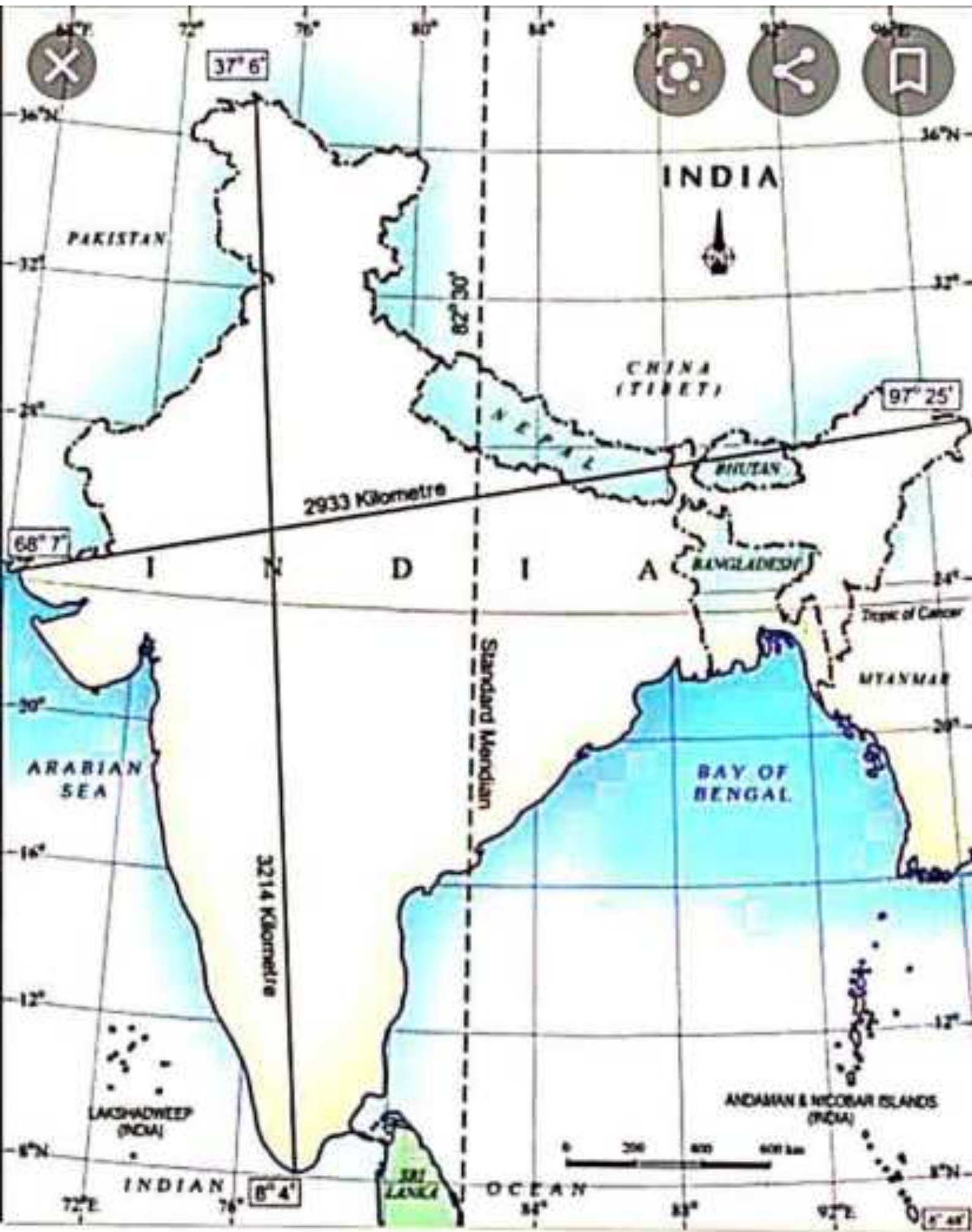
Source: NCERT Text Book





- The mainland of India extends between  $8^{\circ}4'$  and  $37^{\circ}6'$  North Latitude and  $68^{\circ}7'$  and  $97^{\circ}25'$  East longitude.
- Tropic of Cancer  $23^{\circ}30'$  N, divides India into almost two equal halves. So India lies in tropical and sub-tropical zones of Northern hemisphere.
- From (Kashmir to Kanyakumari ) i.e., north to south India covers a distance of about 3214 km
- From (Gujarat to Arunachal Pradesh) i.e., East to West India covers 2933 km
- India has a land frontier of 15200 km and a coast line of about 7516.6 km

- There is a lot of time difference between the eastern and western extremes of the country because of great longitudinal extent.
- The difference in local time between eastern and western hemispheres is about two hours.
- To avoid confusion from this vast time difference,  $82^{\circ}5'$  E longitude located in Mirzapur is taken as standard reference point.
- This reference point is called standard time of India or Indian Standard Time (IST)



## MAJOR PHYSIOGRAPHIC DIVISIONS

The physical features of India can be grouped under the following physiographic divisions:

- i. The Himalayan Mountains
- ii. The Northern Plains
- iii. The Peninsular Plateau
- iv. The Indian Desert
- v. The Coastal Plains
- vi. The Islands

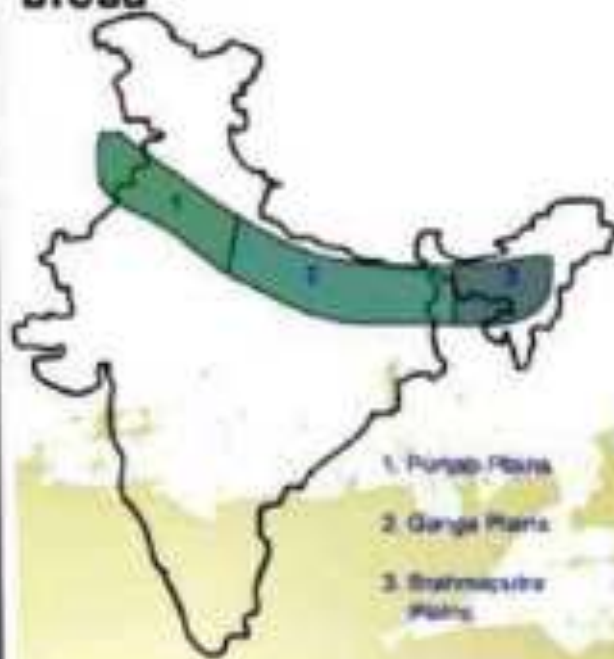


# THE HIMALAYAN MOUNTAINS

- These mountain ranges run in a **west-east** direction from the **Indus** to the **Brahmaputra**.
- They cover a distance of **2,400Km**.
- Their **width** varies from **400Km** in Kashmir to **150Km** in Arunachal Pradesh.
- The altitudinal variations are greater in the eastern half than those in the western half.

## The Northern Plain

The northern plain of India is formed by three river systems, viz. the Indus, the Ganga and the Brahmaputra; along with their tributaries. This plain is composed of alluvial soil which has been deposited over millions of years. The total area of the northern plain is about 7 lakh square kilometer. It is about 2400 km long and about 240 to 320 km broad





**The northern plain is divided into three sections, viz. the Punjab Plain, the Ganga Plain and the Brahmaputra Plain.**

**Punjab Plains:** The Punjab plains form the western part of the northern plain. This is formed by the Indus and its tributaries; like Jhelum, Chenab, Ravi, Beas and Sutlej. A major portion of this plains is in Pakistan. Doabs abound in this plain.

**Ganga Plains:** This plain extends between Ghaggar and Tista rivers. The northern states, Haryana, Delhi, UP, Bihar, part of Jharkhand and West Bengal lie in the Ganga plains.

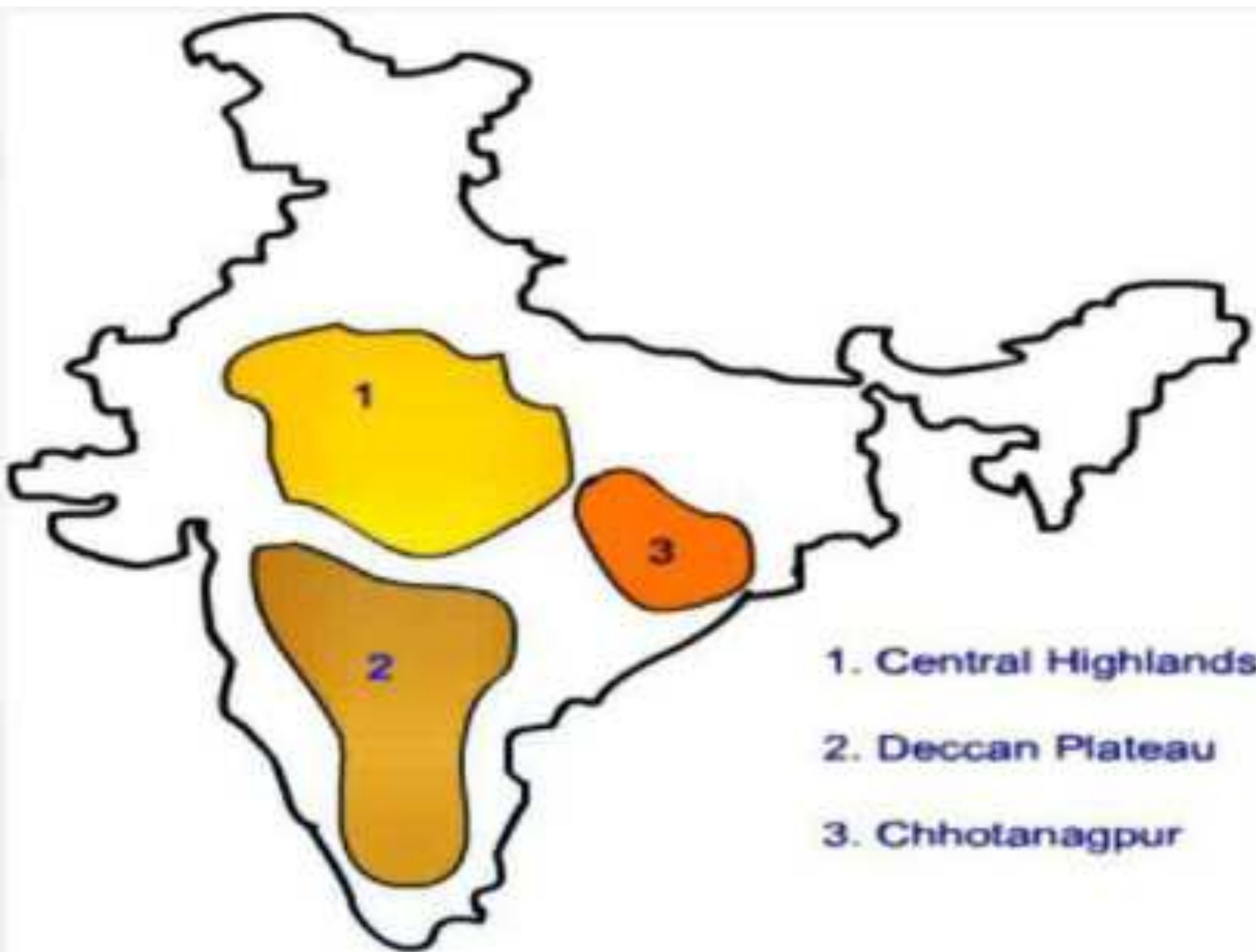
**Brahmaputra Plains:** This plain forms the eastern part of the northern plain and lies in Assam.



## The Peninsular Plateau

The peninsular plateau is a tableland. It is composed of the oldest rocks because it was formed from the drifted part of the Gondwana land. Broad and shallow valleys and rounded hills are the characteristic features of this plateau.





1. Central Highlands
2. Deccan Plateau
3. Chhotanagpur

## The Western and the Eastern Ghats:-

They make the western and eastern edges of the Deccan Plateau. The average elevation of Western Ghats is 900 – 1600 metres; compared to 600 metres in case of Eastern Ghats. The Eastern Ghats stretch from Mahanadi Valley to the Nilgiris in the south. The Western Ghats cause oceanographic rains as they face the rain-laden winds from west.



**The plateau can be broadly divided into two regions, viz. the Central Highlands and the Deccan Plateau.**

**The Central Highlands:** The Central Highlands lies to the north of the Narmada river. It covers the major portion of the Malwa plateau. The rivers in this region flow from southwest to northeast; which indicates the slope of this region. It is wider in the west and narrower in the east. Bundelkhand and Baghelkhand mark the eastward extension of this plateau. The plateau further extends eastwards into the Chhotanagpur plateau.

**The Deccan Plateau:-** The Deccan Plateau lies to the south of the Narmada river. It is triangular in shape. The Satpura range makes its northern part. The Mahadev, Kaimur Hills and Maikal range make its eastern part. The slope of the Deccan Plateau is from west to east. It extends into the north east which encompasses Meghalaya, Karbi-Anglong Plateau and North Cachar Hills. Garo, Khasi and Jaintia hills are the prominent ranges; starting from west to east.

## The Indian Desert:-

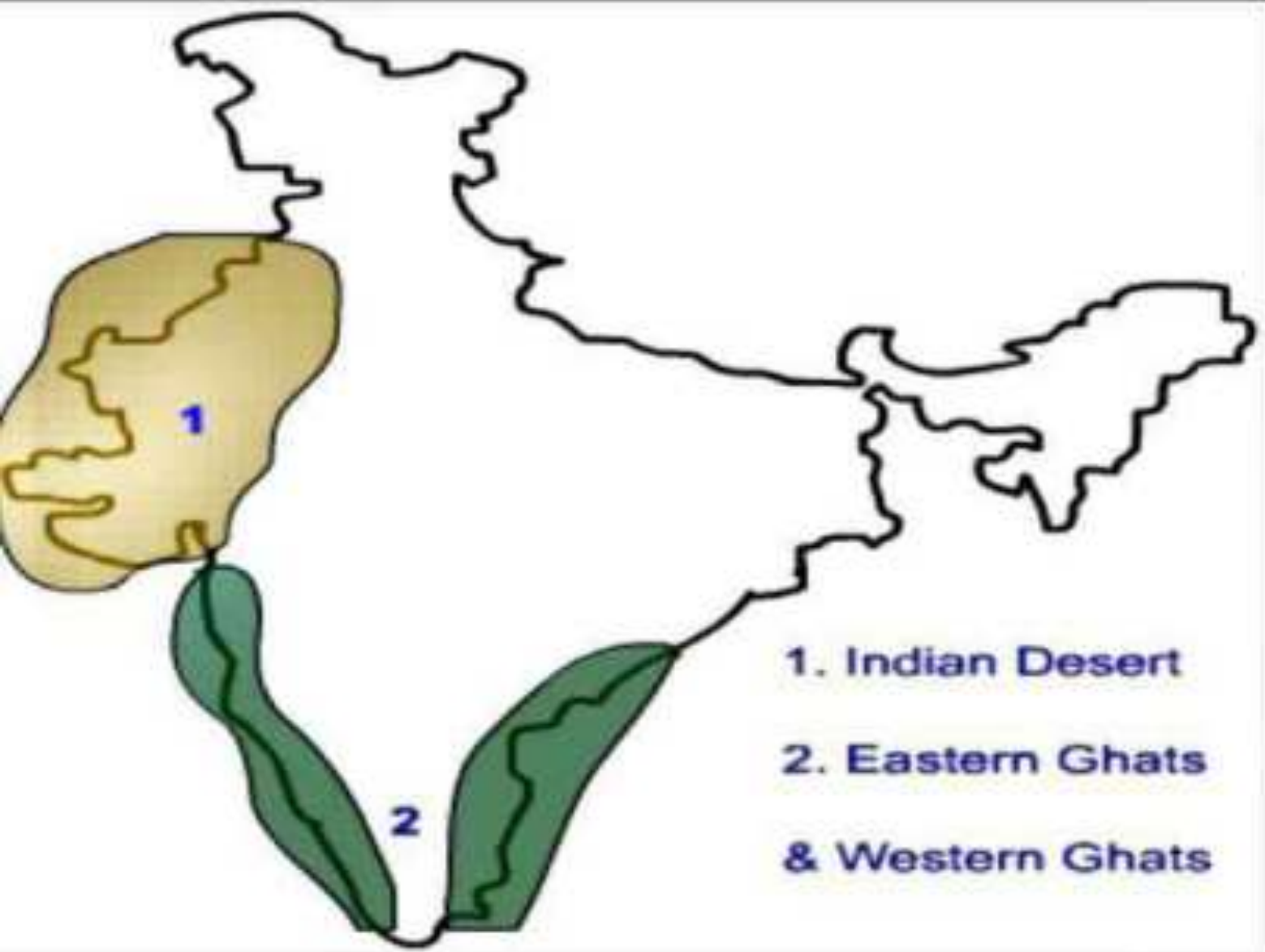
The Indian desert lies towards the western margins of the Aravali Hills. This region gets scanty rainfall which is less than 150 mm in a year. Hence they climate is arid and vegetation is scanty. Luni is the only large river but some streams appear during rainy season. Crescent-shaped dunes (barchans) abound in this area.



# THE INDIAN DESERT

- The Great Indian Desert (also known as the Thar Desert), is a large, arid region in the northwestern part of the Indian subcontinent.
- With an area of more than 200,000 sq.km.
- It is the world's 9th largest subtropical desert.





- 1. Indian Desert
- 2. Eastern Ghats & Western Ghats



## The Coastal Plains

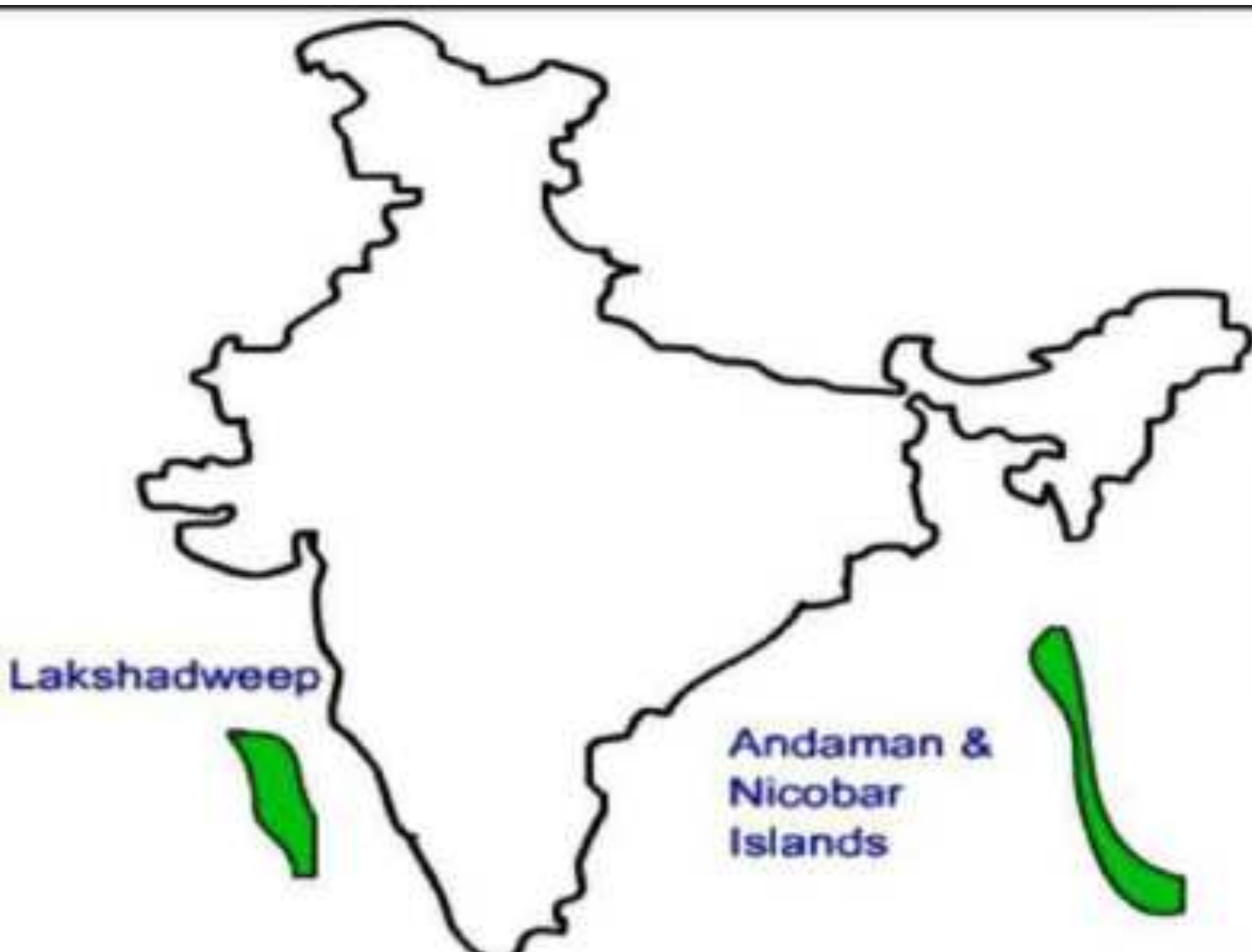
The Peninsular plateau is flanked by stretch of narrow coastal strips. They run along the Arabian Sea on the west and along the Bay of Bengal on the east. The western coast lies between the Western Ghats and the Arabian Sea. It is divided into three sections. The Konkan; which comprises of Mumbai and Goa makes the northern part. The Kannada Plain makes the central part and the Malabar coast makes the Malabara coast.

The western coastal plain is wider and level and it runs along the Bay of Bengal. It is divided into two parts. The northern part is called Northern Circar. The southern part is called the Coromandel Coast. Extensive deltas are formed by large rivers like Mahanadi, Godavari and Kavery. Chilika lake is an important feature along the eastern coast

## THE ISLANDS

An island is any piece of sub-continental land that surrounded by water.





Lakshadweep

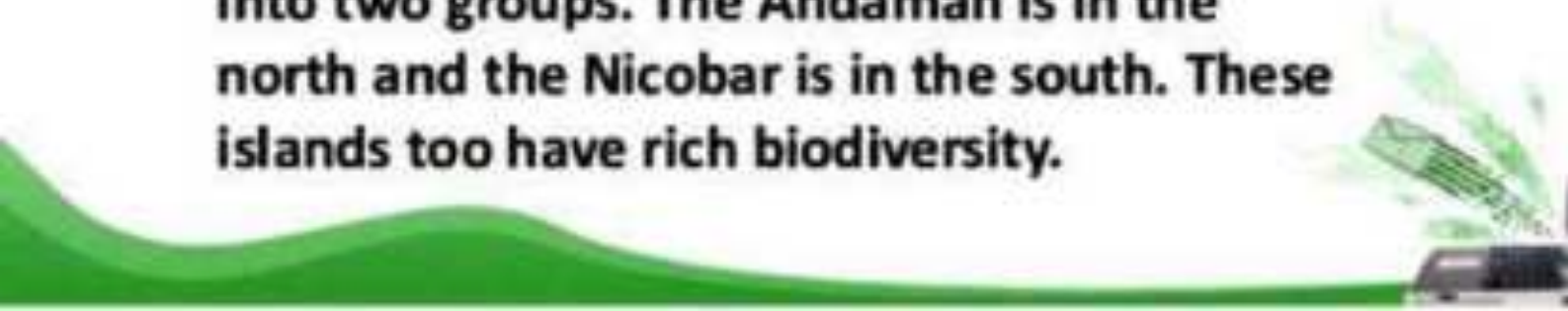
Andaman &  
Nicobar  
Islands

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## The Islands

**The Lakshadweep Islands** are in the Arabian Sea. Its area is 32 sq km. The administrative headquarters of Lakshadweep is at Kavaratti island. This group of islands is rich in terms of biodiversity.

**The Andaman and Nicobar Islands** are bigger in size and has more number of islands. This group of islands can be divided into two groups. The Andaman is in the north and the Nicobar is in the south. These islands too have rich biodiversity.



## INTRODUCTION



India has 15,106.7 Km of land border and a coastline of 7,516.6 Km including island territories. The length of our land borders with neighbouring countries is as under:

Name of the country	Length of the border (in Km)
Bangladesh	4,096.7
China	3,488
Pakistan	3,323
Nepal	1,751
Myanmar	1,643
Bhutan	699
Afghanistan	106
<b>Total</b>	<b>15,106.7</b>

**Southern neighbours** - across the sea consist of the **two island** countries, namely **Sri Lanka** and **Maldives**.

Sri Lanka is separated from India by a narrow channel of sea called **Palk Strait** and the **Gulf of Mannar**.

Myanmar is our **immediate neighbour** across the **Purvanchal Hills**









# MAP OF NORTH-EAST INDIA MAJOR MOUNTAIN RANGES



SIKKIM



## MOUNTAINS RANGES

- ▲ GARO-KHASI-JAINTIA
- ▲ MAHABHART RANGE
- ▲ PURVANCHAL RANGE
- ▲ ARUNACHAL HIMALAYA

## NORTH EAST INDIA NAME\_1

- Arunachal Pradesh
- Assam
- Manipur
- Meghalaya
- Mizoram
- Nagaland
- Sikkim
- Tripura



North East India Info



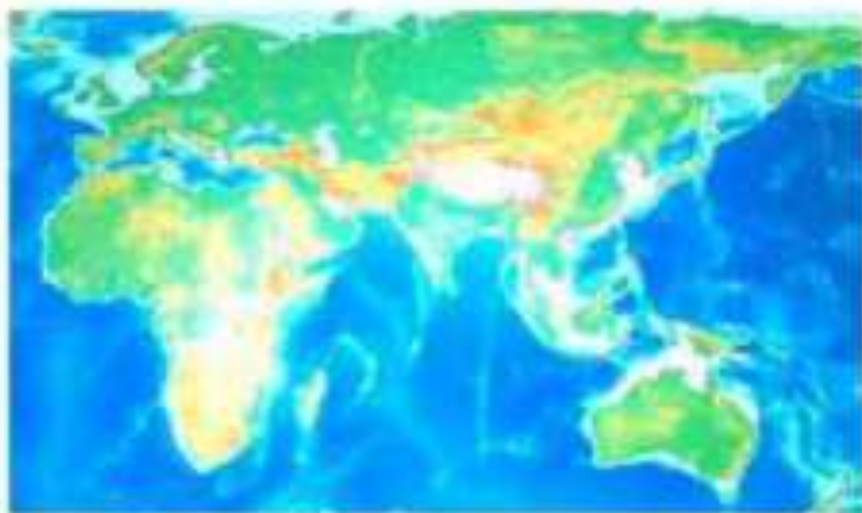
[WWW.NORTHEASTINDIAINFO.COM](http://WWW.NORTHEASTINDIAINFO.COM)

0 80 160 320 Kilometers

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PARITHA PROTIM SAikia  
GIS SPECIALIST  
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North-eastern **tri-junction**, where India, China and Myanmar.

India's location in South Asia is such that it practically **commands the whole of Indian Ocean.**





## Important International Boundary Lines

**Radcliffe Line - India and Pakistan** - drawn by Sir Cyril Radcliffe in 1947.

**Durand Line - India and Afghanistan** - by Sir Mortimer Durand in 1896. Presently it is between **Pakistan and Afghanistan**.

**McMahon Line - India and China** - China does not approve. It was demarcated by **Sir Henry McMahon**.

**24th Parallel** - The line which **Pakistan claims** should be the Demarcation line between India and Pakistan, **not accepted by India**.



'**Open Series Map**' have been introduced as per the National **Map** Policy of 2005 by Survey of India. ... The **map series** is based on Transverse Mercator projection on WGS-1984 datum. A numbering system based on International **Map** of the World (IMW) is used.

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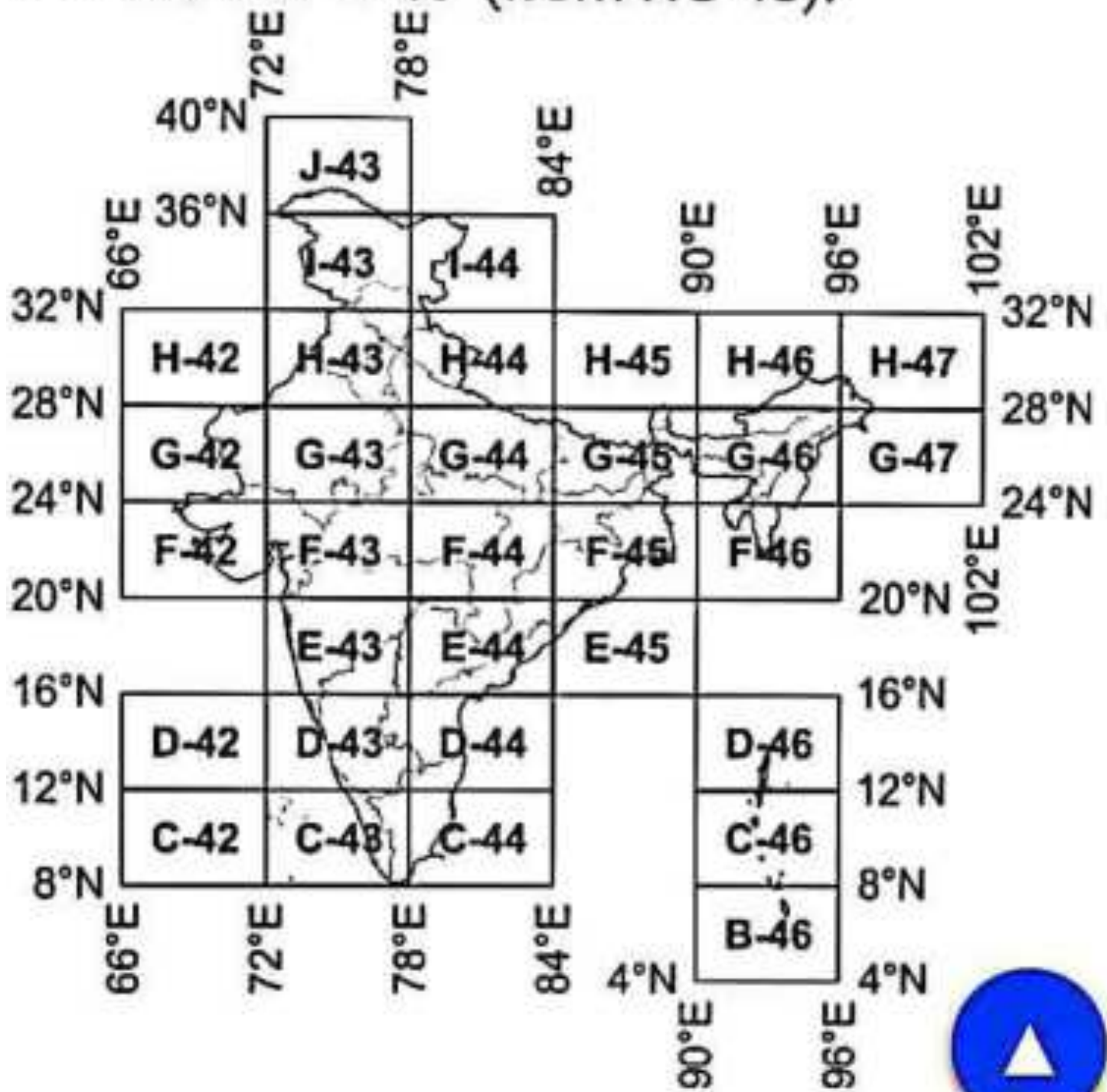
'Open Series Map' have been introduced as per the National Map Policy of 2005 by Survey of India. For the same a new map numbering system has been adopted instead of the previous India and Adjacent Countries (IAC).

The map series is based on Transverse Mercator projection on WGS-1984 datum. A numbering system based on International Map of the World (IMW) is used.

Map numbering is of the form 'A-12A-1':

1. The IMW numbering system with minor modification is used upto  $1^{\circ} \times 1^{\circ} / 1:250,000$  scale.
  - a. Since the IMW map number for India will always start with 'N' (India being in the northern hemisphere), the first letter is omitted.

b. The next alphabet and number of the IMW map number denotes the  $6^\circ \times 4^\circ$  region of the IMW series. So sheet with Kalyanpur ( $77.65489^\circ\text{E}$   $24.11981^\circ\text{N}$ ) would be in 'G-43' (from NG-43):



c. Each  $6^\circ \times 4^\circ$  rectangle is further subdivided into 24 squares of  $1^\circ \times 1^\circ$ . Each square is indicated serially by an alphabet increasing first towards east and then towards south, starting with 'A'. So sheet for Kalyanpur ( $77.65489^\circ\text{E}$   $24.11981^\circ\text{N}$ ) falls within 'G-43X':

28°N	A	B	C	D	E	F	
27°N	G	H	I	J	K	L	
26°N	M	N	O	P	Q	R	
25°N	S	T	U	V	W	X	
24°N							
	72°E	73°E	74°E	75°E	76°E	77°E	78°E

2. Each  $1^\circ \times 1^\circ$  square is further divided into 16 squares of  $15' \times 15'$  (15 minutes  $\times$  15 minutes). Each square is indicated serially by a number increasing first towards south and then towards east, starting with '1' (similar to the system adopted in India and Adjacent Countries). So for the map sheet for Kalyanpur ( $77^\circ 39.293'E$   $24^\circ 7.187'N$ ) would be 'G-43X-12':

25°N	1	5	9	13	
45'	2	6	10	14	
30'	3	7	11	15	
15'	4	8	<b>12</b>	16	
24°N	77°E	15'	30'	45'	78°E



## **DEFENCE SERIES MAPS (DSM) -**

These are prepared on 1:250,000; 1:50,000 and 1:25,000 scales for the use of defence forces of India for supporting national security requirements. Technically maps of this series are based on WGS-84 Datum and LCC Projection. They contain full features of map with grid, contours and other classified information without any dilution of accuracy; therefore, they are kept under restricted category. Survey of India is only authorized for preparation and printing of DSM. For sale and distribution the responsibilities are assigned to ADGMS (GSGS), Ministry of Defence, DGIS Enclave, Rao Tula Ram Marg, Delhi Cantt.

### **What is a topographical map?**

- A topographical map is a large scale map which combine natural features and man made features on a single sheet with the help of colors and conventional symbols. The man made features are referred to artificial features which are made by human, like roads, railways, embankment, settlement, reservoir etc. Natural features include, hills, mountains, valleys, ridges, Plains etc.

### **Who produced topographical map in India?**

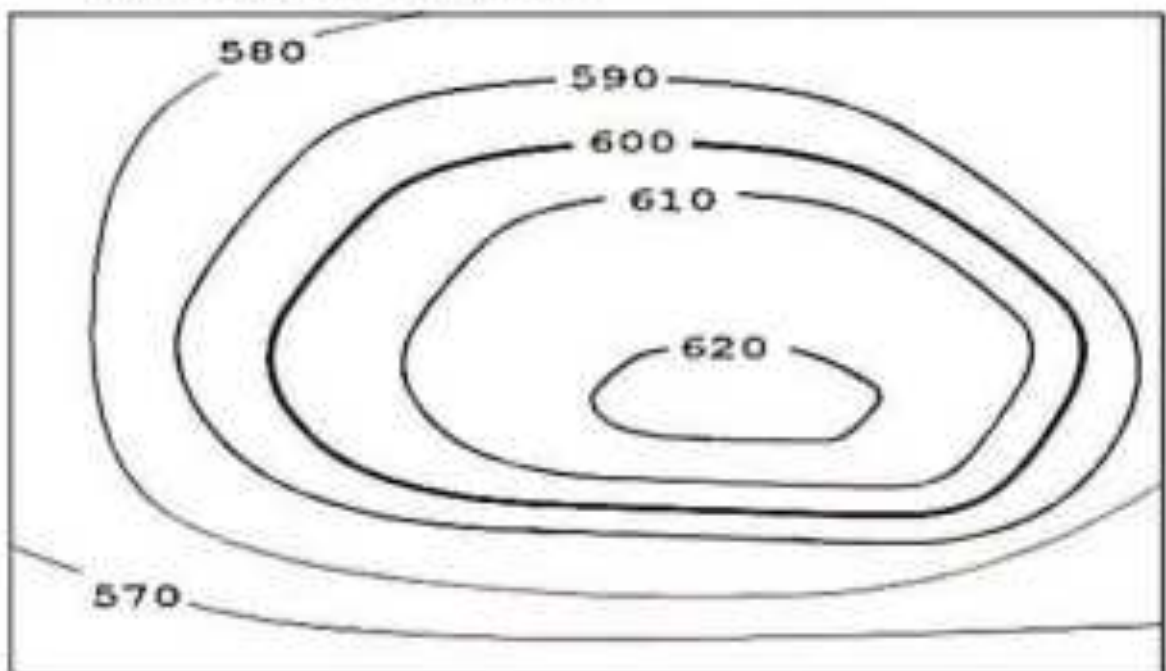
- Topographical maps in India, are produced by survey of India. Survey of India is the national survey and mapping organization which involved in surveying, mapping and map reproduction.

**Contour line**, a **line on a map** representing an imaginary **line** on the land surface, all points of which are at the same elevation above a datum plane, usually mean sea level. ... Numbers on the **lines** give the height in feet. (Sea level is zero.) **Lines** drawn closely together indicate that a slope is steep.

## Characteristics of Contour

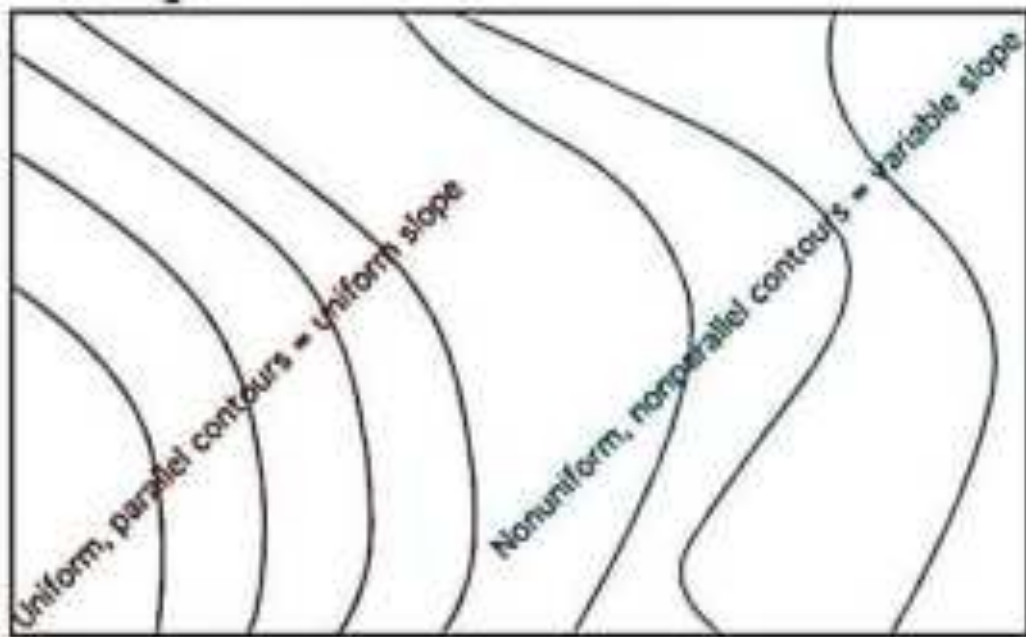
The principal characteristics of contour lines which help in plotting or reading a contour map are as follows:

1. The variation of vertical distance between any two contour lines is assumed to be uniform. Contours are continuous.



(Fig: Contours are continuous)

The horizontal distance between any two contour lines indicates the amount of slope and varies inversely on the amount of slope. Thus, contours are spaced equally for uniform slope ; closely for steep slope contours; widely for moderate slope

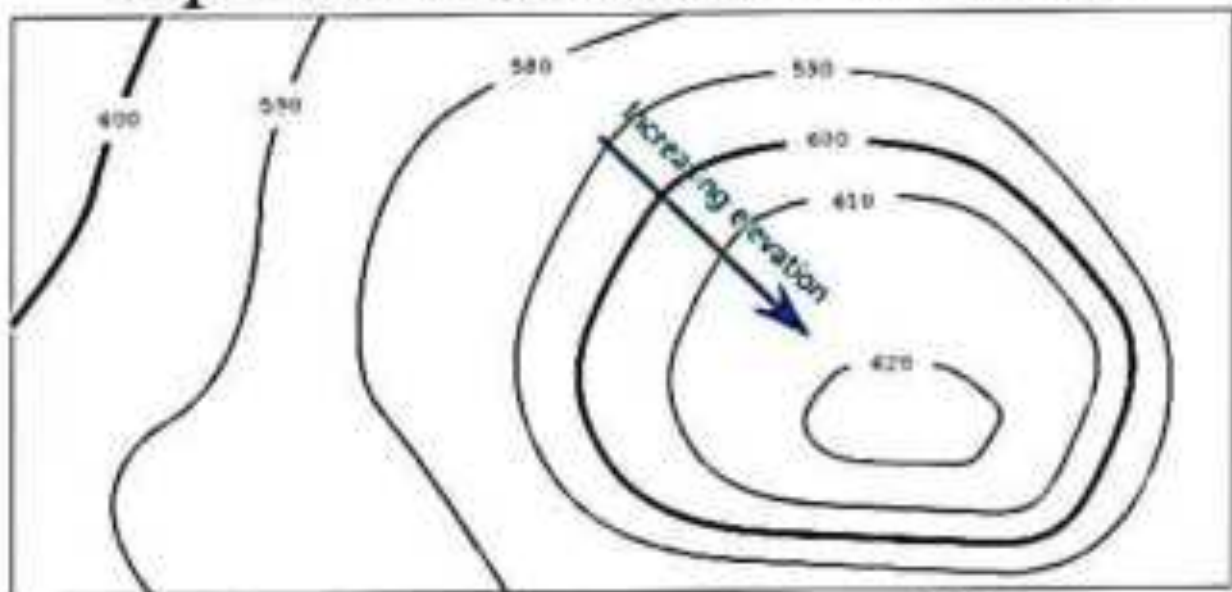


**(Fig: Slope )**

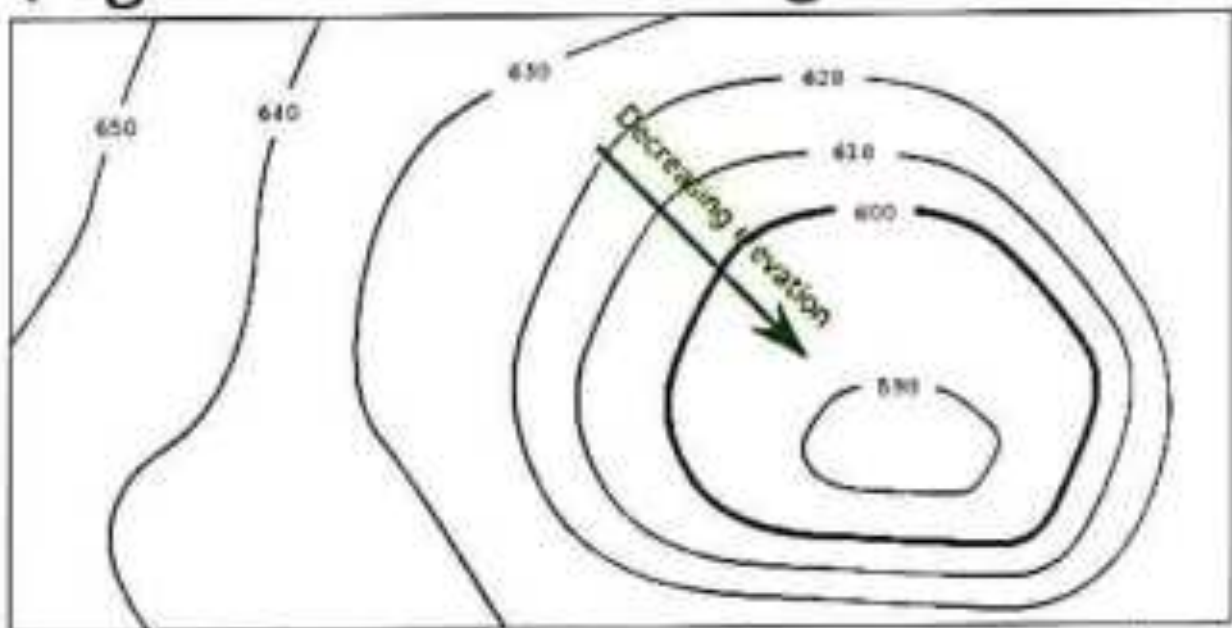
3. The steepest slope of terrain at any point on a contour is represented along the normal of the contour at that point . They are perpendicular to ridge and valley lines where they cross such lines.

4. Contours do not pass through permanent structures such as buildings
5. Contours of different elevations cannot cross each other (caves and overhanging cliffs are the exceptions).
6. Contours of different elevations cannot unite to form one contour (vertical cliff is an exception).
7. Contour lines cannot begin or end on the plan.
8. A contour line must close itself but need not be necessarily within the limits of the map.

A closed contour line on a map represents either depression or hill. A set of ring contours with higher values inside, depicts a hill whereas the lower value inside, depicts a depression (without an outlet).



**(Fig: Contours showing Hill)**



**(Fig: Contours showing Depression)**

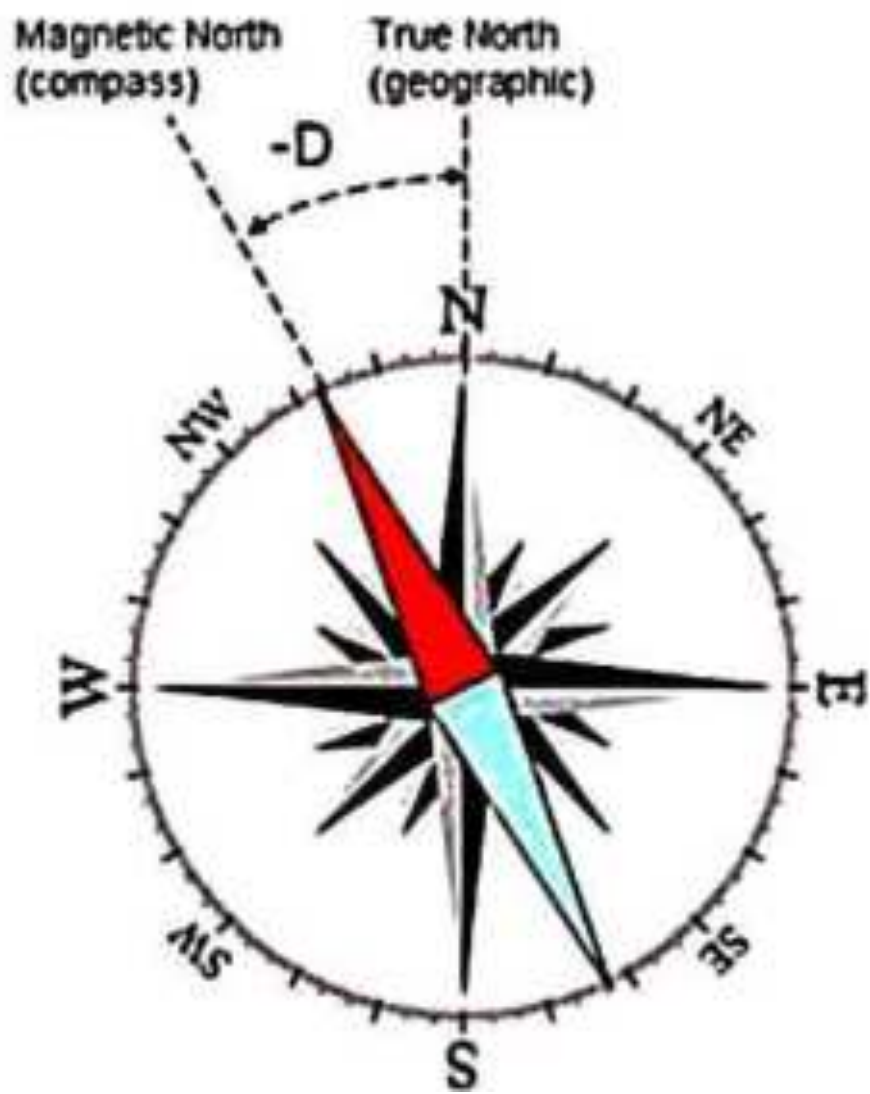
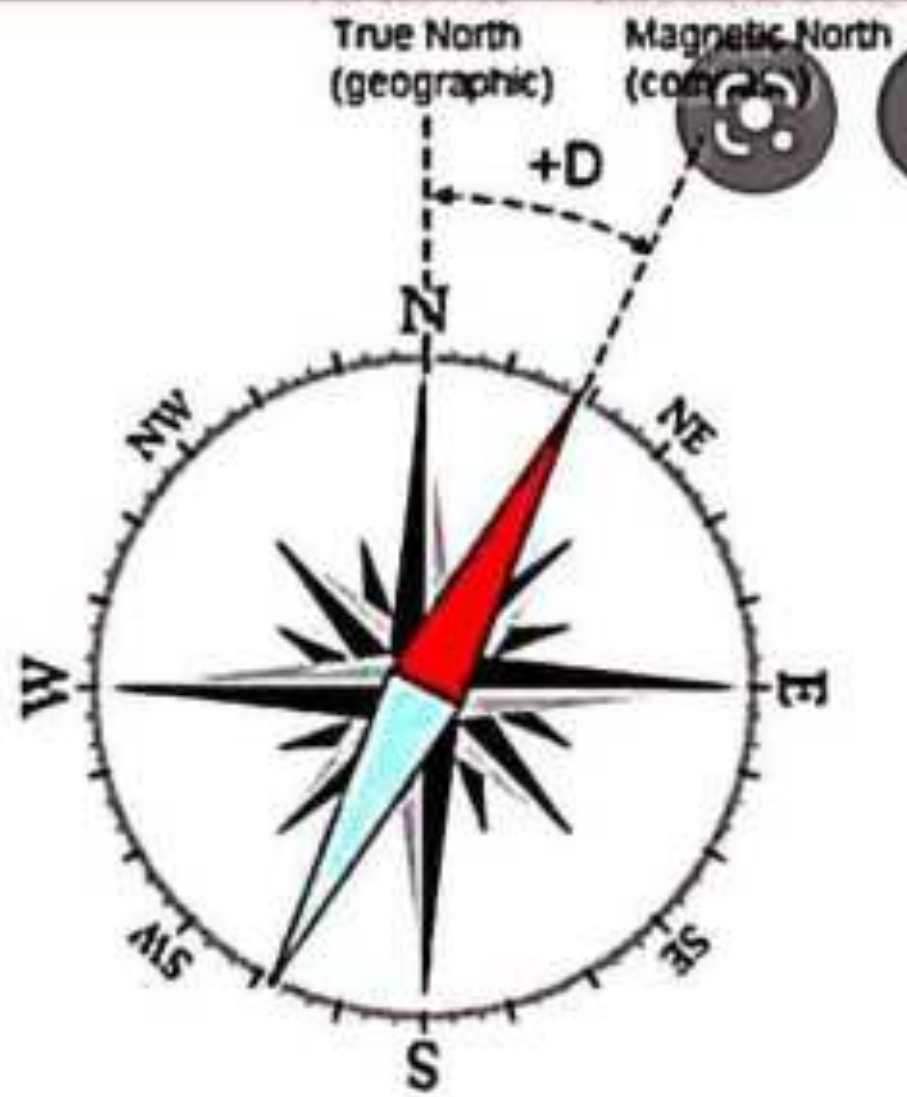
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## **What is Magnetic Declination?**

Magnetic declination can be defined as the angle on the horizontal plane between magnetic and true north. This isn't consistent and keeps on changing relying upon the situation upon the world's surface and time. The Greek letter  $\delta$  is recognized as the magnetic declination symbol and is otherwise called magnetic variation.



The declination will be positive when the magnetic north is east of true north, and the declination will be negative when the magnetic north is west of true north. Different terms utilized are isogonic lines (when the lines along the declination are consistent) and agonic lines (when the lines along the declination are zero)



- **Magnetic declination** (MD) is the angle between **true north** (TN) and **magnetic north** (MN).
- This angle is calculated when the map is drawn.
- The position of **magnetic north** changes, so the angle between **true north** and **magnetic north** (the **magnetic declination**) will also change.



Mean magnetic declination (MD)  $20^{\circ} 10'$  west of true north (January 1998).  
 Mean annual change (AC)  $2'$  westwards.

Calculate the MD for the current year.

Step 1: Calculate the difference in the years

$$2020 - 1998 = 22 \text{ years}$$

Step 2: Calculate the total change

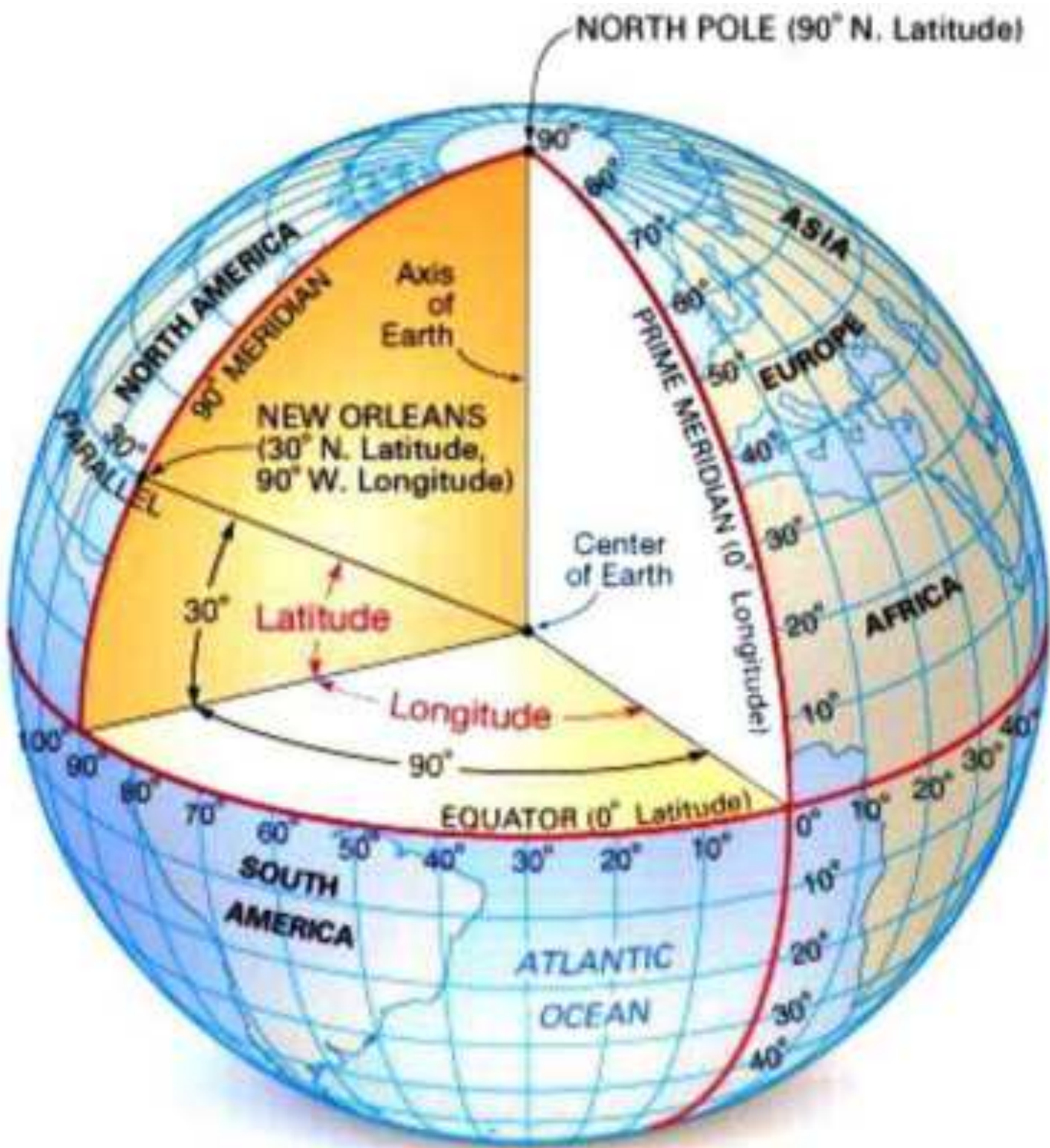
$$22 \times 2'W = 44'W$$

Step 3: Add/subtract to/from the MD

$$20^{\circ} 10' + 44' = 20^{\circ} 54'W \text{ of TN}$$

**Latitude** is the measurement of distance north or south of the Equator. It is measured with 180 imaginary lines that form circles around the Earth east-west, parallel to the Equator. These lines are known as parallels. 06-Nov-2012

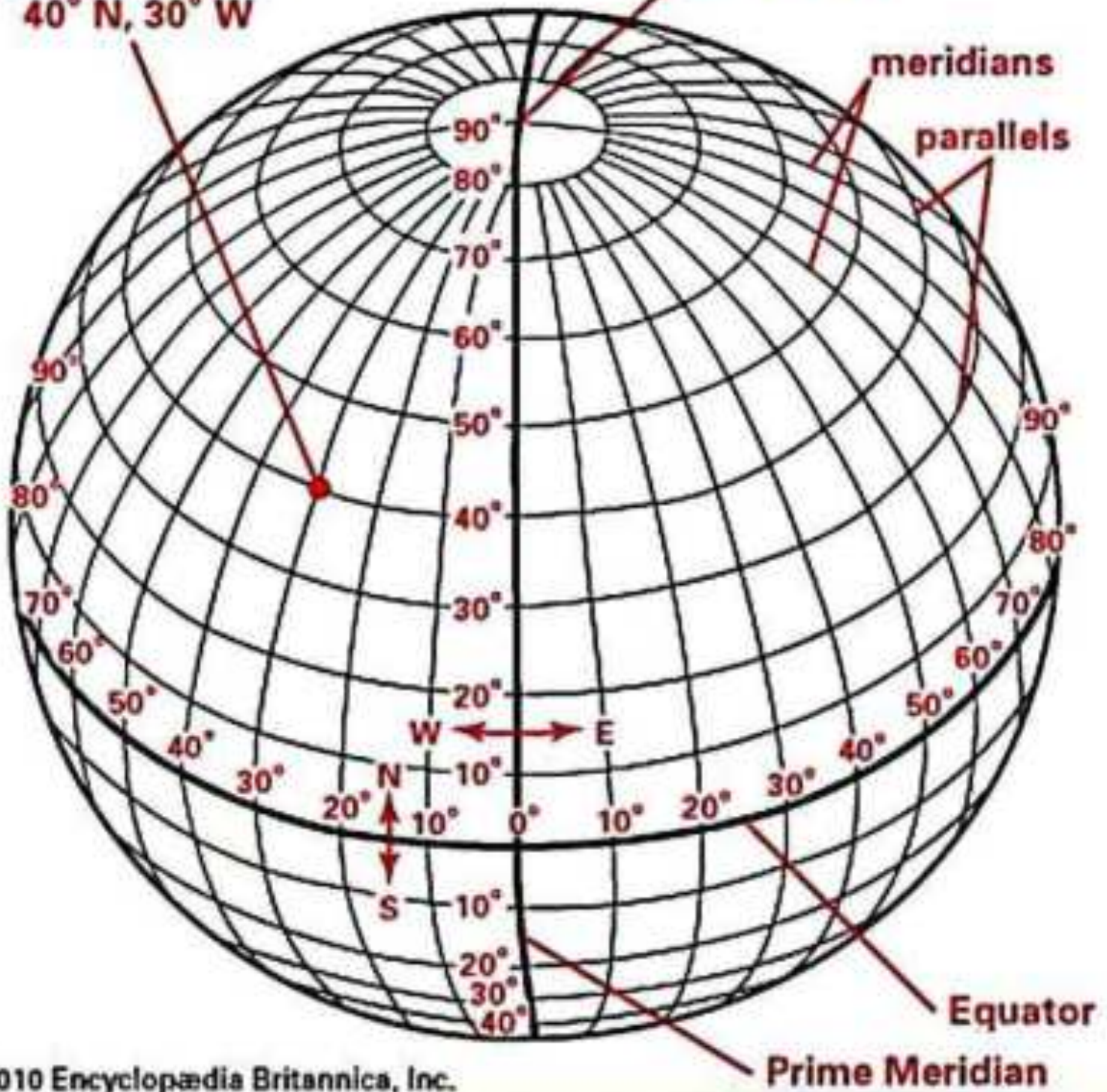
**Longitude** is the measurement east or west of the prime meridian. **Longitude** is measured by imaginary lines that run around the Earth vertically (up and down) and meet at the North and South Poles. These lines are known as meridians. ... The distance around the Earth measures 360 degrees. 06-Nov-2012



point located at  
 $40^{\circ}$  N,  $30^{\circ}$  W

North Pole

meridians  
parallels



Equator

Prime Meridian

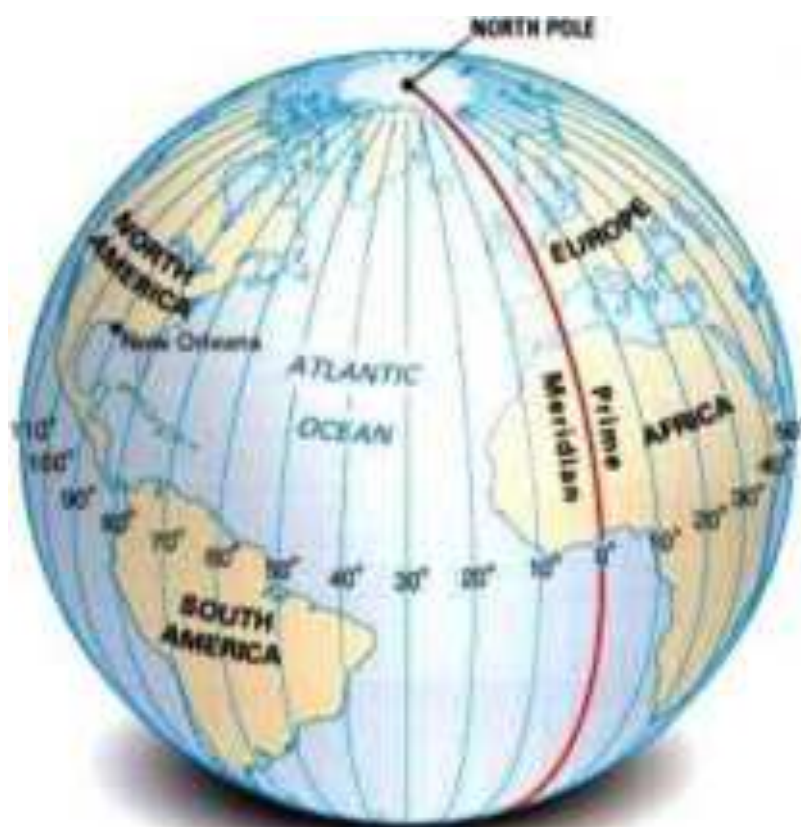




## FACTS ABOUT LINES OF LATITUDE

- Are known as parallels.
- Run in an east-west direction.
- Measure distance north or south from the Equator.
- Are parallel to one another and never meet.
- Cross the prime meridian at right angles.
- Lie in planes that cross the Earth's axis at right angles.
- Get shorter toward the poles, with only the Equator, the longest, a great circle.

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## FACTS ABOUT LINES OF LONGITUDE

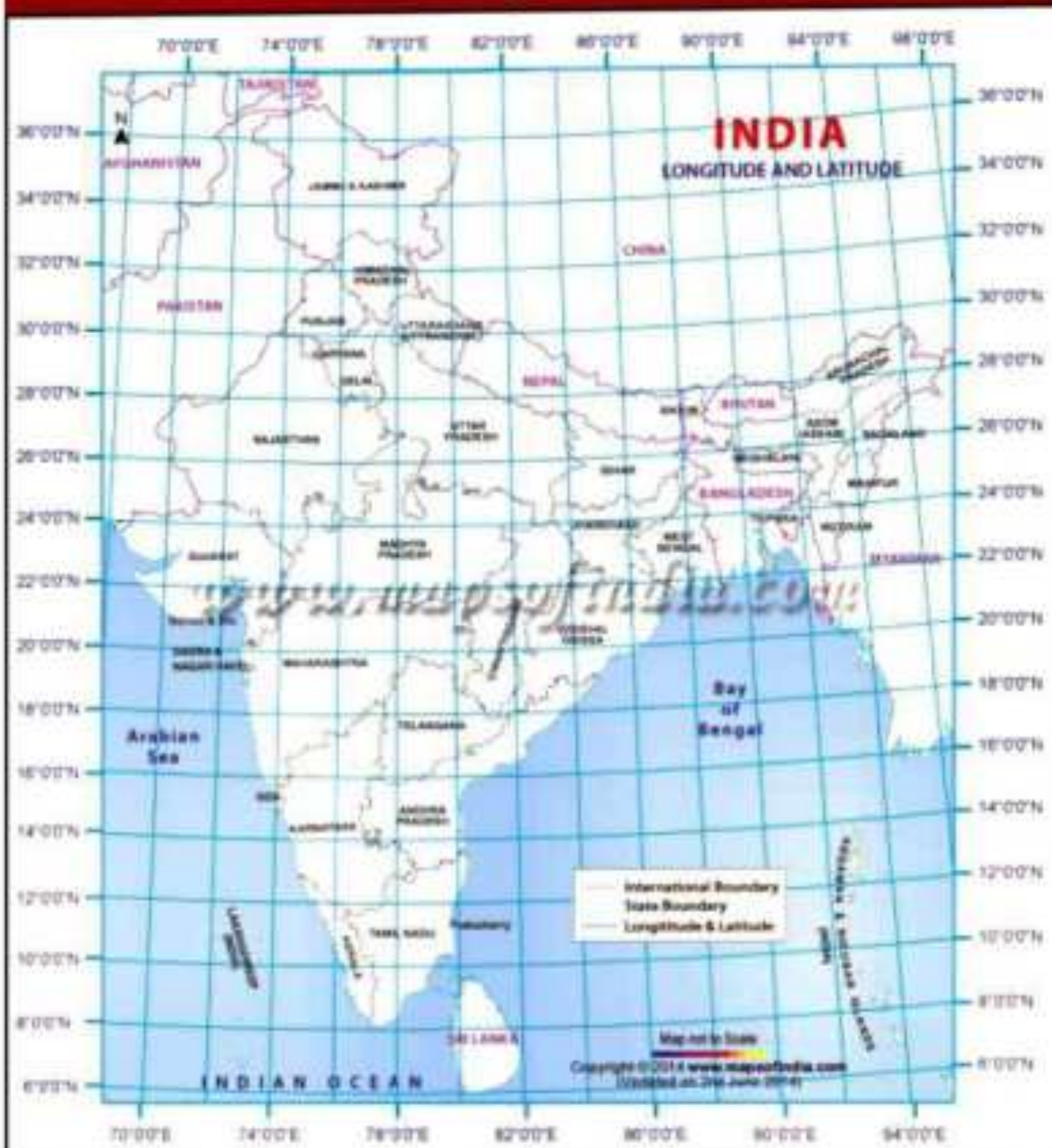
- Are known as meridians.
- Run in a north-south direction.
- Measure distance east or west of the prime meridian.
- Are farthest apart at the Equator and meet at the poles.
- Cross the Equator at right angles.
- Lie in planes that pass through the Earth's axis.
- Are equal in length.
- Are halves of great circles.

# Latitude and Longitude of India

Latitude:  $21.7679^{\circ}$  N

Longitude:  $78.8718^{\circ}$  E

## Latitude and Longitude Map of India



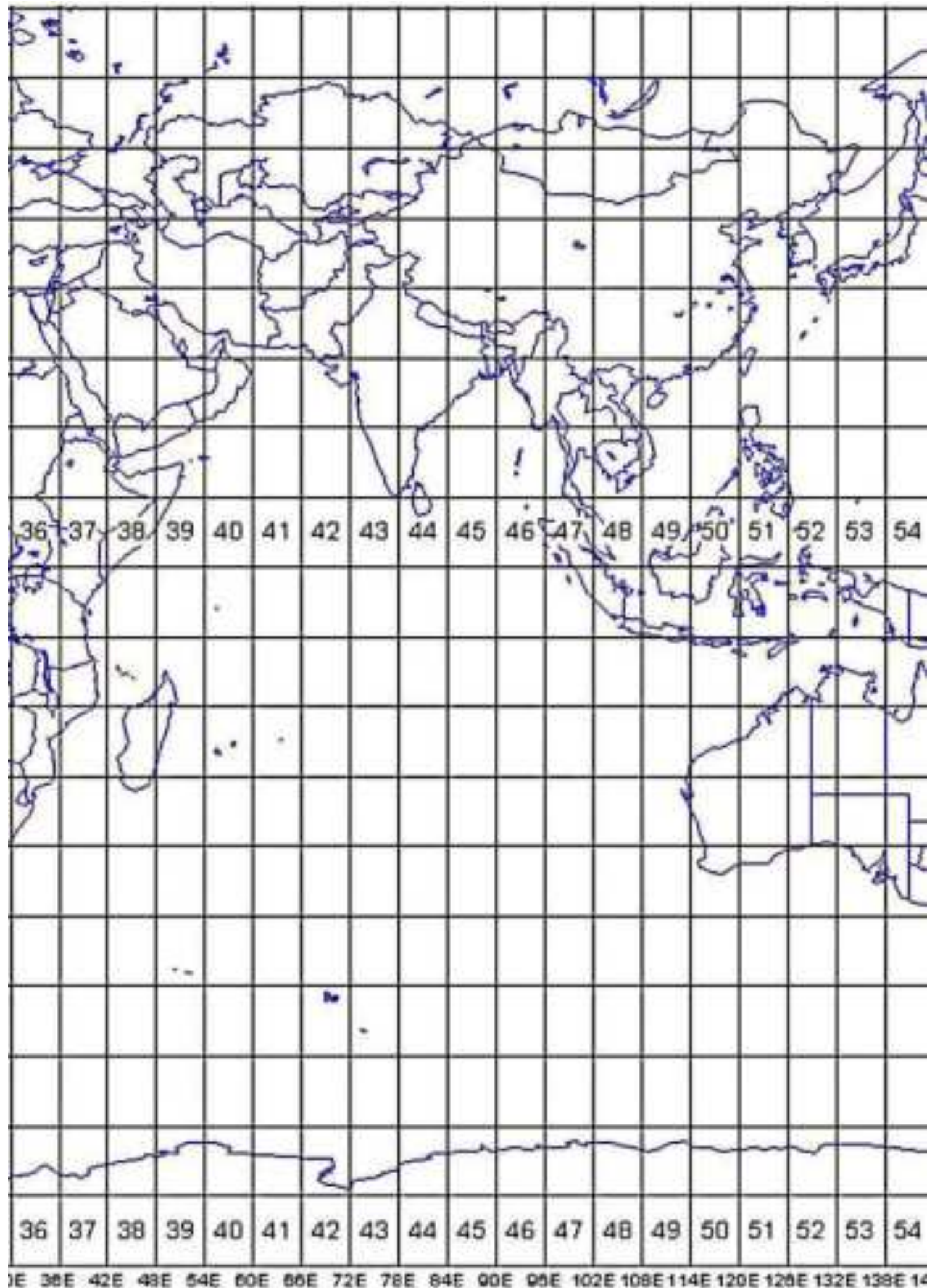
UTM is the acronym for Universal Transverse Mercator, a plane coordinate grid system named for the map projection on which it is based (Transverse Mercator). The UTM system consists of 60 zones, each 6-degrees of longitude in width. The zones are numbered 1-60, beginning at 180-degrees longitude and increasing to the east. The military uses their own implementation of the UTM system, called the Military Grid Reference System (MGRS).

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The **Universal Transverse Mercator (UTM)** is a system for assigning coordinates to locations on the surface of the Earth. Like the traditional method of latitude and longitude, it is a horizontal position representation, which means it ignores altitude and treats the earth as a perfect ellipsoid. However, it differs from global latitude/longitude in that it divides earth into 60 zones and projects each to the plane as a basis for its coordinates.

Specifying a location means specifying the zone and the  $x, y$  coordinate in that plane. The projection from spheroid to a UTM zone is some parameterization of the transverse Mercator projection. The parameters vary by nation or region or mapping system.

The UTM system divides the Earth into 60 zones, each  $6^\circ$  of longitude in width. Zone 1 covers longitude  $180^\circ$  to  $174^\circ$  W; zone numbering increases eastward to zone 60, which covers longitude  $174^\circ$ E to  $180^\circ$ . The polar regions south of  $80^\circ$ S and north of  $84^\circ$ N are excluded.



36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54  
36E 38E 42E 48E 54E 60E 66E 72E 78E 84E 90E 96E 102E 108E 114E 120E 126E 132E 138E 144E

## Option 1 – The Mathematic Approach

If you know the left (or west) most longitude of the dataset in question, then one approach to determining the correct zone number is using good old mathematics. Here is a re-hatch of the technique described in my two-part series above:

- Take your longitude coordinate in decimal degrees and add 180. Most often, people will choose a coordinate in the north-west corner of their data, and assign it this zone number even if the data straddles two zones.
- Then divide by 6.
- Finally round-up to the next highest whole number.

So for example, the UTM zone number for 39° W would be found through these steps:

- $-39 + 180 = 141$
- $141 / 6 = 23.5$
- 5 rounds up to 24

So 39° W is in UTM zone number 24. If the data is above the Equator, then it would be in zone 24 North; and if below the Equator, it would be in zone 24 South.



**Field notes** represent the first step in **preparing** the geological **map** and report. In geologically complex areas the **field** notebook contains more information than the **map**. In all areas, the notebook is as important as the geological **map**.

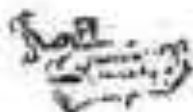
Field notes can be divided into three major conceptual parts:

1. **Numerical values:** Records of all measurements (angles, distances, strikes/dips, etc... made in the field.
2. **Sketches:** Sketches of outcrops, contact relationships, locations, topographic features not clearly shown on map, structural features, fossils, etc...
3. **Explanatory notes:** All descriptions of rocks, contacts and fossils, geographic references, captions for photographs, etc... and all interpretive prose.

### Numerical values

1. Write carefully. Words can be guessed at, numbers can't.
2. Make numbers large. (See above)
3. Never write one number on top of another. Draw a line through, or cross the incorrect one out and write a new number next to it.
4. Do not try to change one number into another.
5. Avoid erasing numbers. Draw a line through the incorrect value and write the correct value either above, below or adjacent to it. Sometimes you have to erase, and when this is the case do so completely.
6. Measurements on sketches should clearly indicate distances or dimensions or directions. If the space on the sketch is too small for numbers, a measurement may be placed to one side, and an arrow drawn to indicate where the measurement should go.
7. When recording measurements in the field (i.e. strike and dip) it is easy to misread geographic coordinates (e.g. make SW into NW). To avoid this:
  - a. Always check that the attitude or measurement is consistent with what is observed on the ground.
  - b. If the note keeper is receiving oral instructions or descriptions from another geologist, the note keeper should repeat back what s/he has written loudly enough to be clearly heard.

### Sketches



1. Put a scale on the sketch. Try to make your sketches to scale. If a sketch is not to scale, it should be labeled as such.
2. Make sketches as large, open and clear as possible. Don't crowd notes.
3. If necessary, use a straightedge for linear features.
4. Try to measure angles/azimuths accurately, and then plot them accurately (in the case of strike/dip, fold axes, etc...)
5. Occasionally you may have to exaggerate details (gasp!) at the cost of scale. This is acceptable as long as the exaggeration/loss of true scale is clearly labeled. Alternatively, you may wish to prepare a second large scale drawing of the 'detail area' next to the true scale original.
6. Determine what you plan to show at what scale before you begin sketching.

7. If necessary, use several sketches to show large portions of the study area.
8. How to decide when to make a sketch: if geologic relationships cannot be easily described, or if the description in words of a feature would take more time and notebook space than would be required for a sketch, then DO IT. 'A picture is worth a thousand words' was never truer than in geological field work. Sketches generally capture geometry and field relationships better than either written descriptions or even high resolution photographs. Moreover, sketching forces you to get to know an outcrop in detail and confront confounding relationships up front. MOREOVER, sketches can also serve as qualitative base maps for recording locations of field measurements, rock samples, fossils, etc..

#### Explanatory Notes

1. Explanatory notes are taken to clarify what is not evident from numbers and sketches.
2. Print. Do not use ordinary handwriting. Be neat and clear! Your writing must be legible.
3. Notes on sketches should be placed in vacant spaces where they do not interfere with other aspects of the sketch or diagram.
4. When writing field notes assume that they will be read by someone not familiar with your study or the field area. Be clear and concise. Put yourself in the place of another geologist who will use the field data.
5. Record your thoughts, ideas, hypotheses, contradictory ideas, plans, etc... in your field notes. At least once a day take the time to summarize your ideas on the geology of the area and the data that you have collected in the field. Reflect on the successes and failures of each day's work. Writing down your thoughts will help you to clarify them.

The **Public Land Survey System (PLSS)** is the surveying method developed and used in the United States to plat, or divide, real property for sale and settling. **Also known as the Rectangular Survey System**, it was created by the Land Ordinance of 1785.

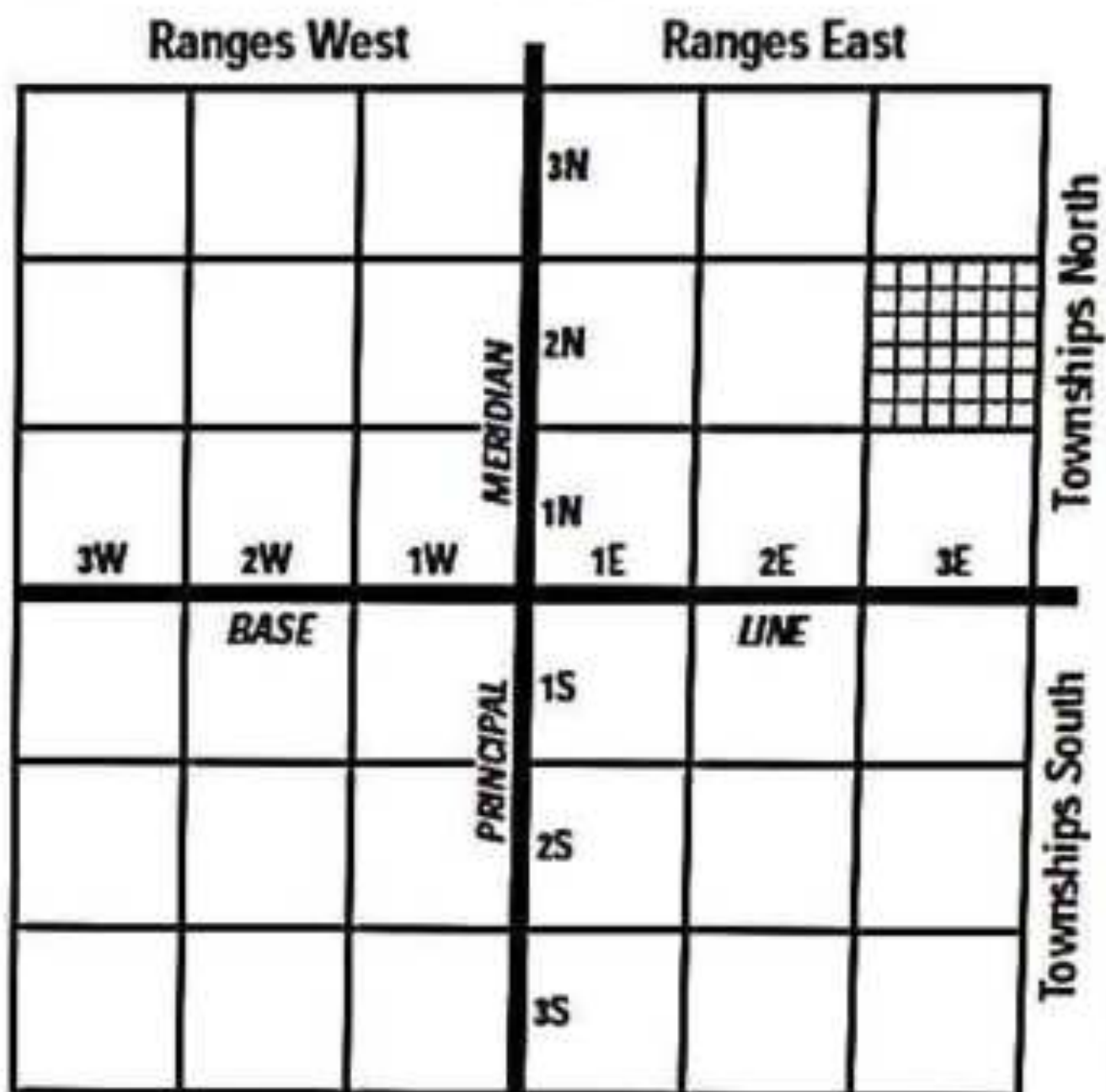
There are two separate and distinct systems of land surveys in the United States:

- System of **metes and bounds** in which each parcel of land is individually described and bounded
- System of **rectangular surveys** under which the land is divided basically into equal-sized townships, sections, and fractions thereof

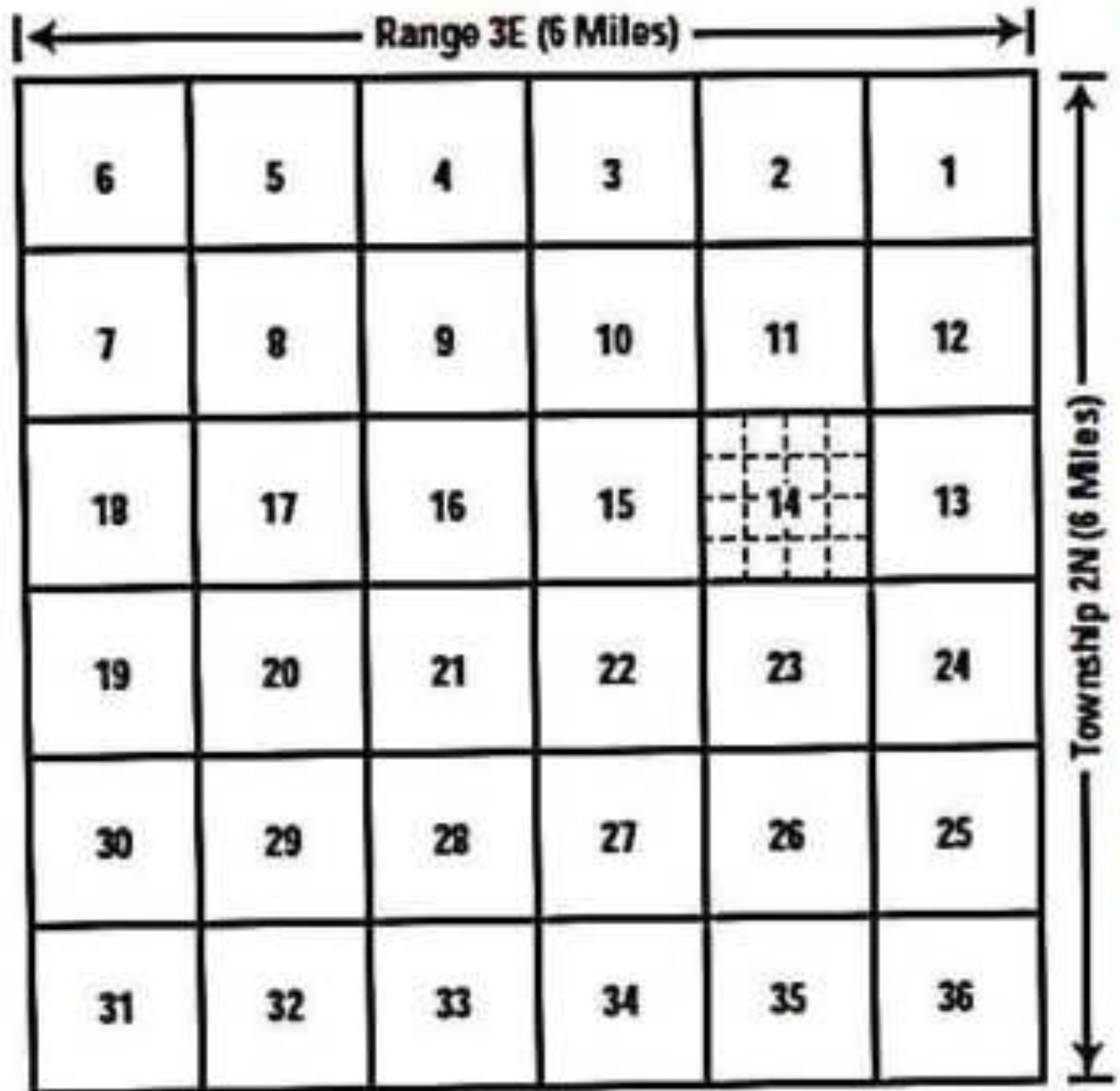
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The **system of rectangular surveys** was inaugurated in 1785 and the laws governing its establishment have, with various modifications, been applied to all of the United States with the exception of the states listed above. Under this system the lands are divided into "townships," 36 miles square, which are related to base lines established by the federal government. The base lines running north and south are known as "**Principal Meridians**", while the east and west base lines are called simply "**Base Lines**". The township numbers east or west of the Principal Meridians are designated as ranges; whereas, the numbers north and south of the Base Line are tiers.

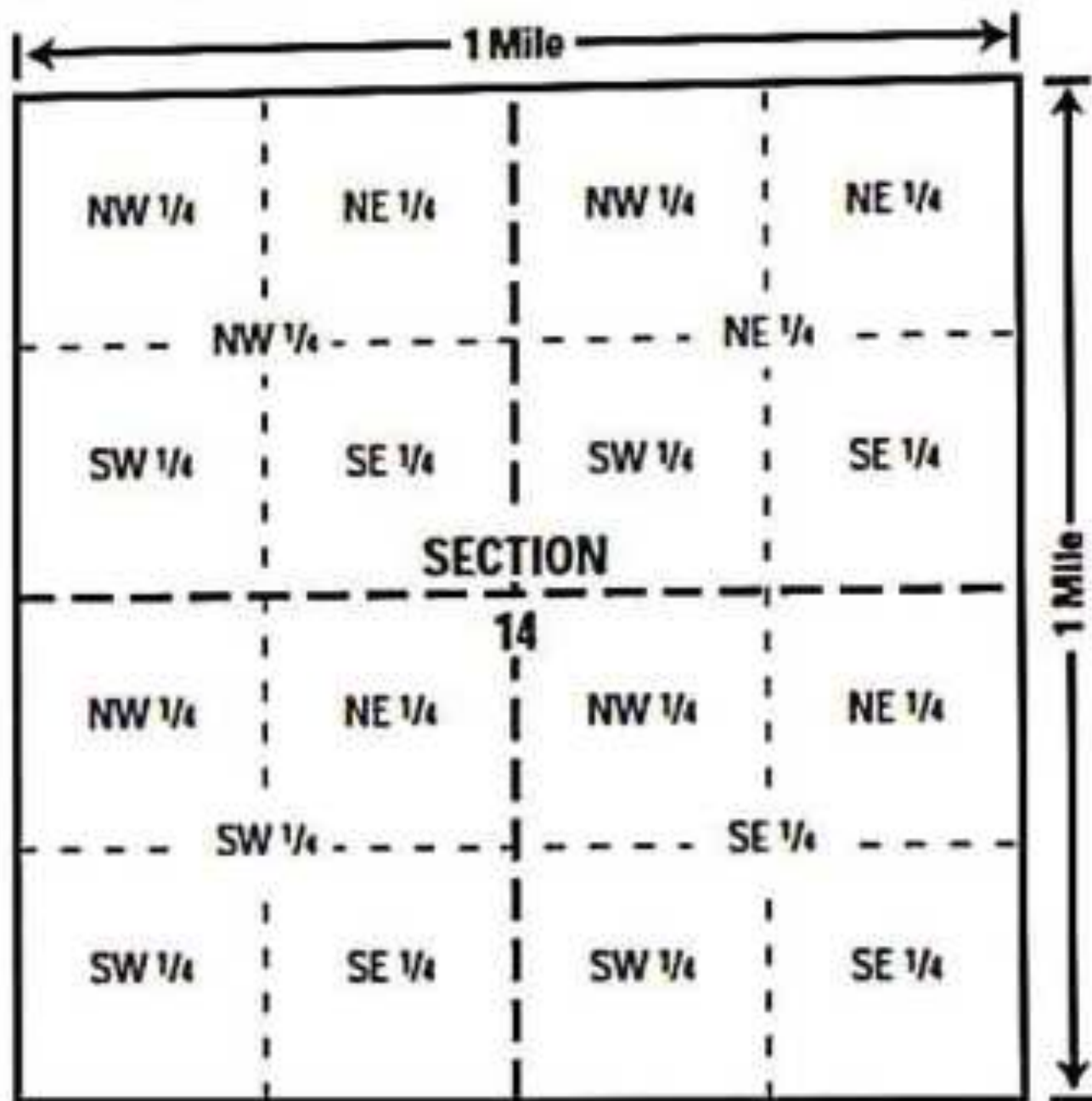
# Township And Range System



# A Township Divided Into Sections



# A Section Subdivided (640 Acres)





**MODULE-5**  
**BASICS OF AERIAL PHOTOGRAPHY, PHOTOGRAMMETRY, DEM AND**  
**ORTHO IMAGE GENERATION**

**What is Photogrammetry?**

The classical definition of Photogrammetry is the process of deriving metric information about an object through measurement made on the photograph of the object. **Photogrammetry is the science of making measurements from photographs. Photogrammetry means the measuring of features on a photograph.**

This is concerned about metric or measurement aspect of the process. In addition to this photo interpretation aspect is also involved while the technology is used for mapping where feature collection is required.

The fundamental task of metric information is derived through establishing the geometric relationship between the image and the object as it existed at the time of the imaging. Once this is established other information of the object are derived.

**Photogrammetry describes from three words:**

‘photo’ – light

‘gram’ – drawing

‘metry’ – measurement

The output of photogrammetry is typically a map, drawing, measurement, or a 3D model of some real-world object or scene. Many of the maps we use today are created with photogrammetry and photographs taken from aircraft.



## **Fundamental principle of Photogrammetry:**

The fundamental principle used by photogrammetry is triangulation. By taking photographs from at least two different locations, so-called “lines of sight” can be developed from each camera to points on the object. These lines of sight (sometimes called rays owing to their optical nature) are mathematically intersected to produce the 3-dimensional coordinates of the points of interest. Triangulation is also the principle used by theodolites for coordinate measurement. If you are familiar with these instruments, you will find many similarities (and some differences) between photogrammetry and theodolites. Even closer to home, triangulation is also the way your two eyes work together to gauge distance (called depth perception).



## **Branch of Photogrammetry:**

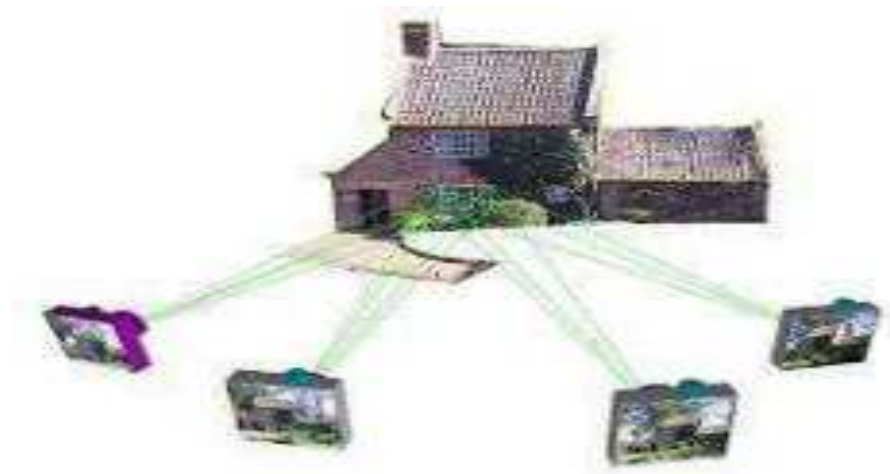
Photogrammetry can be classified based on camera location during photography. On this basis we have Aerial Photogrammetry, Terrestrial Photogrammetry and Space Photogrammetry.

**1. Aerial Photogrammetry:** The camera is mounted in an aircraft and is usually pointed vertically towards the ground. Aerial photographs are taken from the air by special camera mounted in an aircraft flying over the area with the camera axis vertical or nearly so. Multiple overlapping photos of the ground are taken as the aircraft flies along a flight path. These photos are processed in a stereo-plotter (an instrument that lets an operator see two photos at once in a stereo view). These photos are also used in automated processing for Digital Elevation Model (DEM) creation.



Aerial Photogrammetry

**2. Terrestrial Photogrammetry:** is that branch of photogrammetry where photographs are taken from a fixed, and usually known, position on or near the ground and with the camera axis horizontal or nearly so. The position and orientation of the camera are often measured directly at the time of exposure. The instrument used for exposing such photograph is called photo theodolite.



Terrestrial Photogrammetry

**3. Space Photogrammetry:** The space photogrammetry embraces all aspects of extraterrestrial photography and subsequent measurement wherein the camera may be fixed on earth, contained in an artificial satellite, or positioned on the moon or a planet.

The term photo interpretation is applied to that branch of photogrammetry wherein aerial or terrestrial photographs are used to evaluate, analyze, classify, and interpret images of objects which can be seen on the photographs. Consequently, photogrammetry must be considered as a combination of measurement and interpretation.

### **Types of Photogrammetry:**

There are two types of photogrammetry as follows:

1. Interpretative Photogrammetry.
2. Metric Photogrammetry.
  1. Planimetric mapping.
  2. Topographical mapping.

#### **Interpretative Photogrammetry**

Interpretative photogrammetry involves recognizing and identifying objects and judging their significance through careful and systematic analysis from photographic images.

- These images created from satellite imagery which senses energy in wavelengths
- Forms basis for remote sensing (art or science of gathering information about an object or image without actually coming into physical contact).
- Photo interpretation involves in the study of photographic images, while remote sensing involves not only the analysis of photography but also the use of data collected from remote sensing instruments.

#### **Metric Photogrammetry**

It consists of making precise measurements on photographs and other information to determine relative locations of points.

- Common application of Metric Photogrammetry consists of planimetric mapping and topographical mapping.
- Applications used to determine distances, elevations, areas, volumes, and cross-sections to compile topographical maps from photographic measurements
- The photographs used for this purpose are mostly aerial photographs, but terrestrial photographs also used sometimes.

### **Classification of Aerial Photographs:**

Aerial photographs which are normally used for mapping and photo interpretation can be classified in to two main categories viz. vertical and tilted.

#### **(a) Vertical Photograph:**

An aerial photograph taken with the optical axis of the camera held in a vertical or nearly vertical position is classified as vertical photograph. When the geometry of a vertical

photograph is considered, the photograph is assumed to be taken with the optical axis truly vertical.

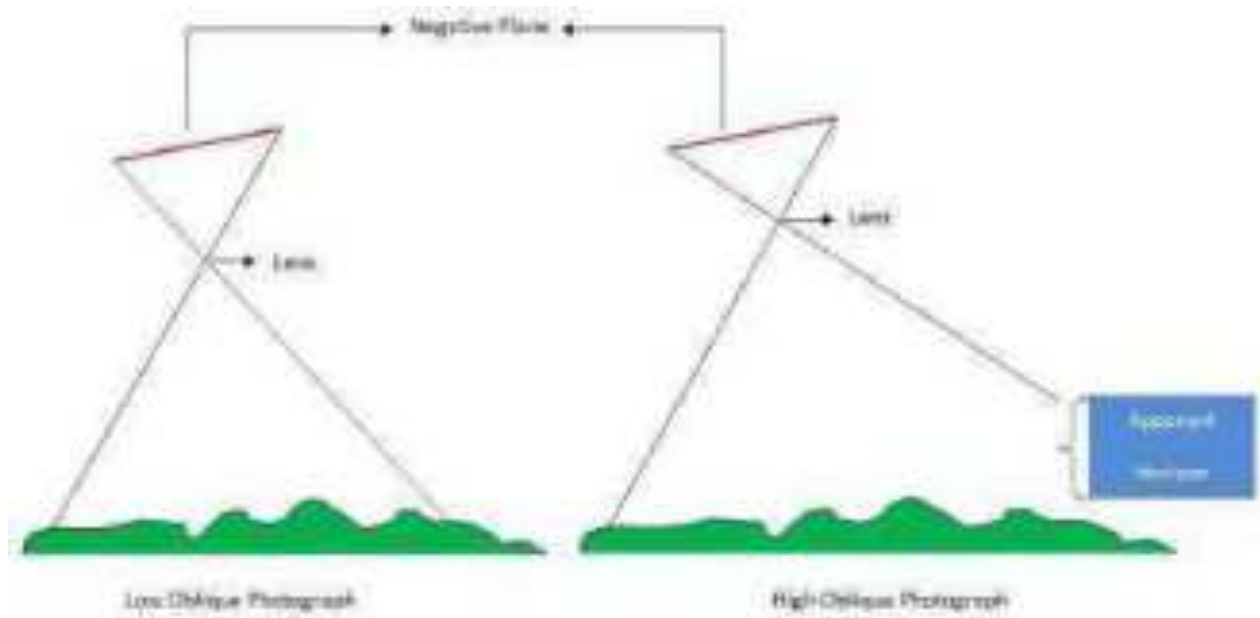
**(b) Tilted Photograph:**

In practice, the camera axis is nearly held vertical. But due to unavoidable aircraft tilts the camera axis is unintentionally tilted from the vertical. Then the resulting photograph is called tilted photograph.

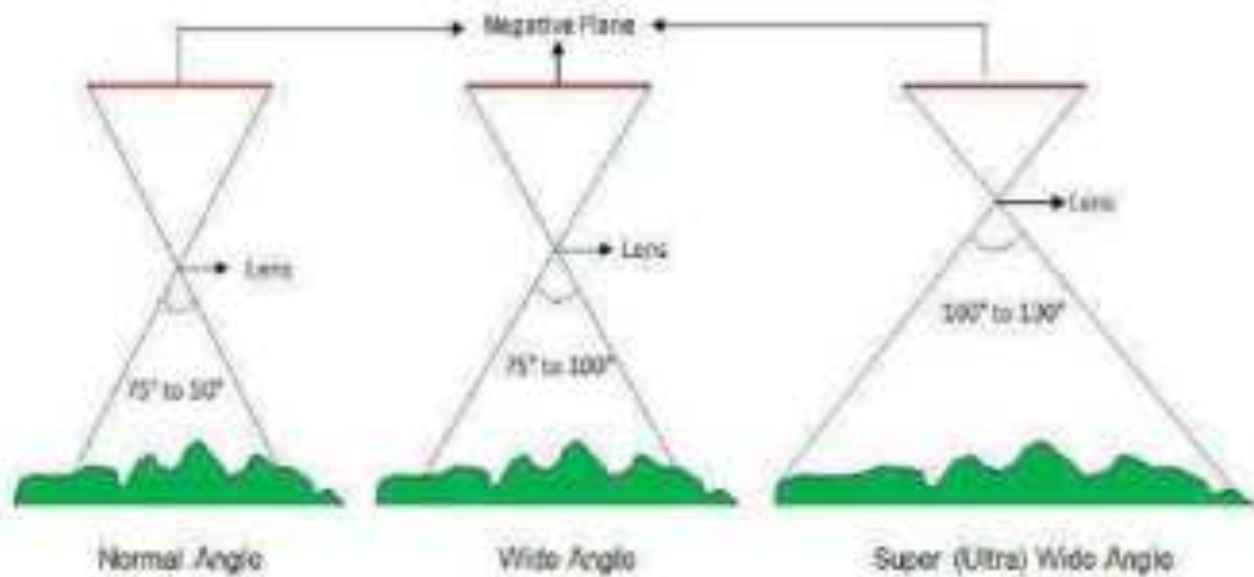
If tilt of the camera axis from the plumb line is less than 3 degree the photograph is called vertical. For tilt more than 3 degree, it is called tilted photograph. Tilted photograph may again be classified in two categorizes viz. low oblique and high oblique.

**Oblique photograph:** An oblique photograph in which the apparent horizon appears is termed as high oblique photograph. Apparent horizon: it is the line in which the earth appears to meet the sky as visible from a point.

**Low oblique photograph:** is one on which the apparent horizon does not appear. A pair of low oblique taken in sequence along a flight direction in such a manner that both photographs cover basically the same area is called *convergent photographs*.



Photographs may also be classified with respect to angular field of view of aerial camera as *normal angle*, *wide angle* and *super (ultra) wide angle photograph*.

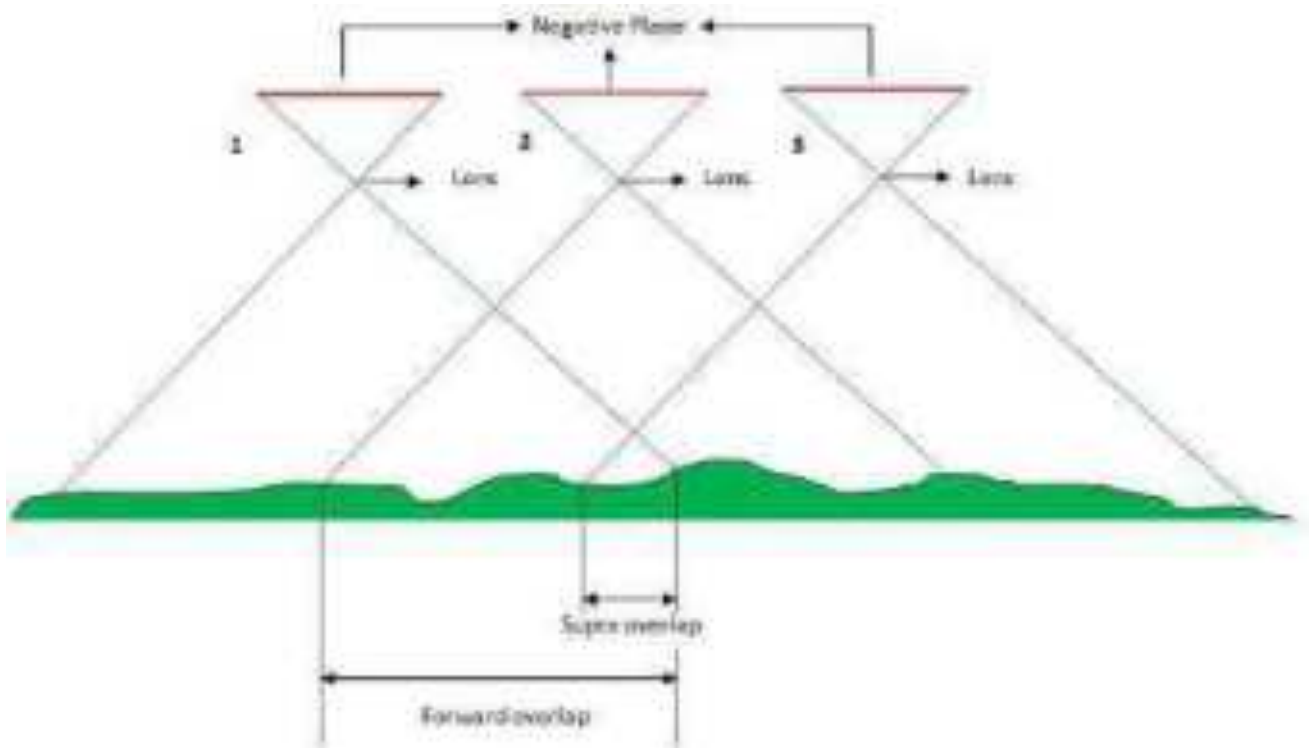


When an area is covered by vertical photography, the photographs are usually taken by a series of parallel passes called flight strip/run. Photographs are normally exposed in such a way that the area covered by each successive photograph along a flight strip duplicates or overlaps part of the coverage of previous photograph.

This lapping along the flight strip is called **end lap** and the area of coverage common between two adjacent pair of photographs called in a flight strip is called **stereoscopic overlap (end lap)**. The amount of end lap is normally from 55% to 65%.

The pair of photograph is called **stereo pair**. The positions of camera at each exposure e.g. 1, 2, 3...are called the **exposure stations** and the altitude of camera at the instant of exposure is called **flying height**.

Adjacent flight strips are photographed so that there is also a common coverage which is called lateral overlap or side lap and is normally held from 25% to 30%. The photographs of two or more side lapping strips used to cover an area is called block of photographs.



**Requirements of Photogrammetry Technology:**

i) Overlapping image for stereo view required for 3D viewing and measurement.



Stereo Pair Photograph

ii) Ground Control Points (XYZ) for establishing positional relationship between photo and ground.



### **Advantages of Photogrammetry:**

1. Cover areas quickly.
2. Low costs.
3. Easy to obtain/access information from air.
4. Illustrates great detail.

### **Applications of Photogrammetry:**

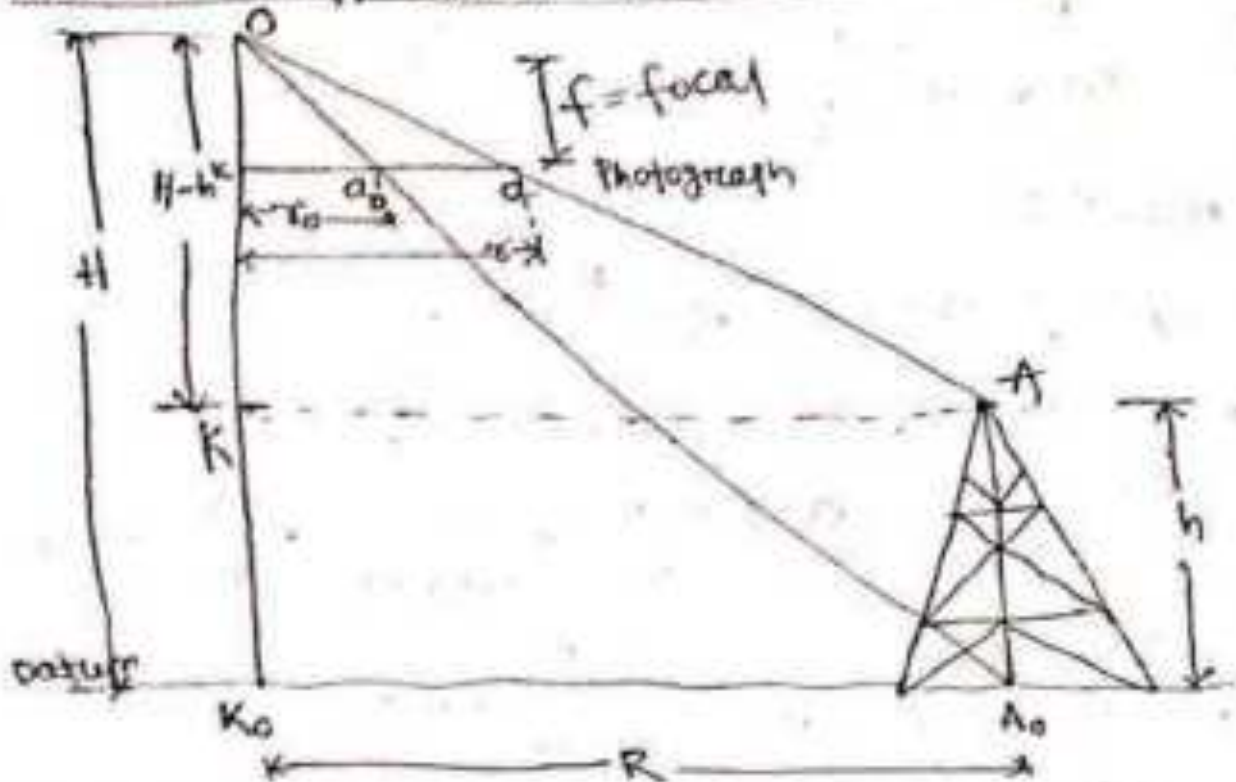
1. To prepare planimetric topographical maps (Surveying/mapping).
2. To determine the space position of ground objects.
3. For acquisition of military intelligence (Military/artificial intelligence).
4. To classify soil (Forestry/agriculture).
5. For the interpretation of geology (Geology/archaeology).
6. Assessment of crop damage due to floods or other natural calamities.
7. To prepare a composite picture of ground.
8. To relocate existing property boundaries.



# Relief displacement :-

Relief displacement is a shift or displaced position of any point on the photograph caused by the elevation.

# Derivation of Relief displacement :-



From the above figure

Let  $r$  = radial distance  $a$  from  $K$

$r_0$  = radial distance  $a_0$  from  $K$

$R$  = radial distance  $a_0$  from  $K_0$

Then from similar triangle  $OKa$  &  $OKA$

$$\boxed{\frac{f}{H-h} = \frac{r}{R}} \dots \dots \dots \textcircled{1}$$

Also from similar triangle  $OK_0A_0$  &  $OKa_0$

$$\boxed{\frac{f}{H} = \frac{r_0}{R}} \dots \dots \dots \textcircled{2}$$

$$\boxed{r_0 = \frac{Rf}{H}} \dots \dots \dots \textcircled{2a}$$

Therefore Relief displacement is given by

$$d = r - r_0$$

$$= \frac{Rf}{H-h} - \frac{Rf}{H}$$

$$= \frac{RfH - Rf(H-h)}{(H-h)H} = \frac{RfH - RfH + Rfh}{(H-h)H}$$

$$\boxed{d = \frac{Rfh}{(H-h)H}} \dots \dots \textcircled{3}$$

From eq<sup>n</sup> (1) & (2)

$$R = \frac{\gamma(H-h)}{f} \text{ \& } R = \frac{H\gamma_0}{f} \dots \dots \textcircled{4}$$

By substituting the value of R in eq<sup>n</sup> (3)

$$d = \frac{Rfh}{(H-h)H} = \frac{\gamma(H-h)}{f} \times \frac{fh}{(H-h)H} = \frac{\gamma h}{H} \dots \dots \textcircled{5}$$

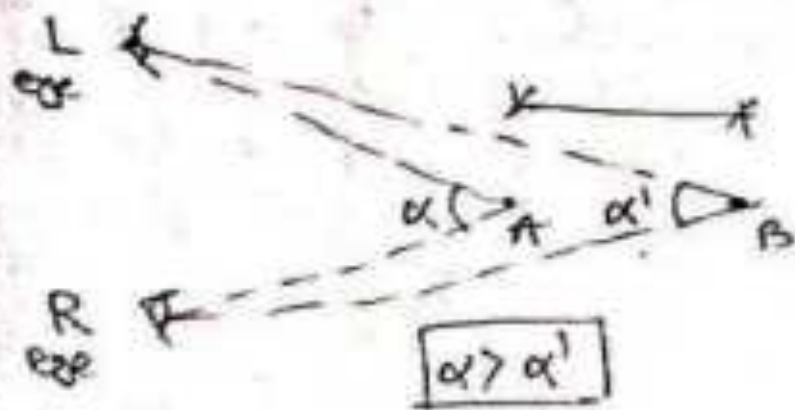
$$d = \frac{H\gamma_0}{f} \times \frac{fh}{(H-h)H} = \frac{\gamma_0 h}{H-h} \dots \dots \textcircled{6}$$

$$\therefore \boxed{d = \frac{\gamma h}{H} = \frac{\gamma_0 h}{H-h}} \dots \dots \textcircled{7}$$

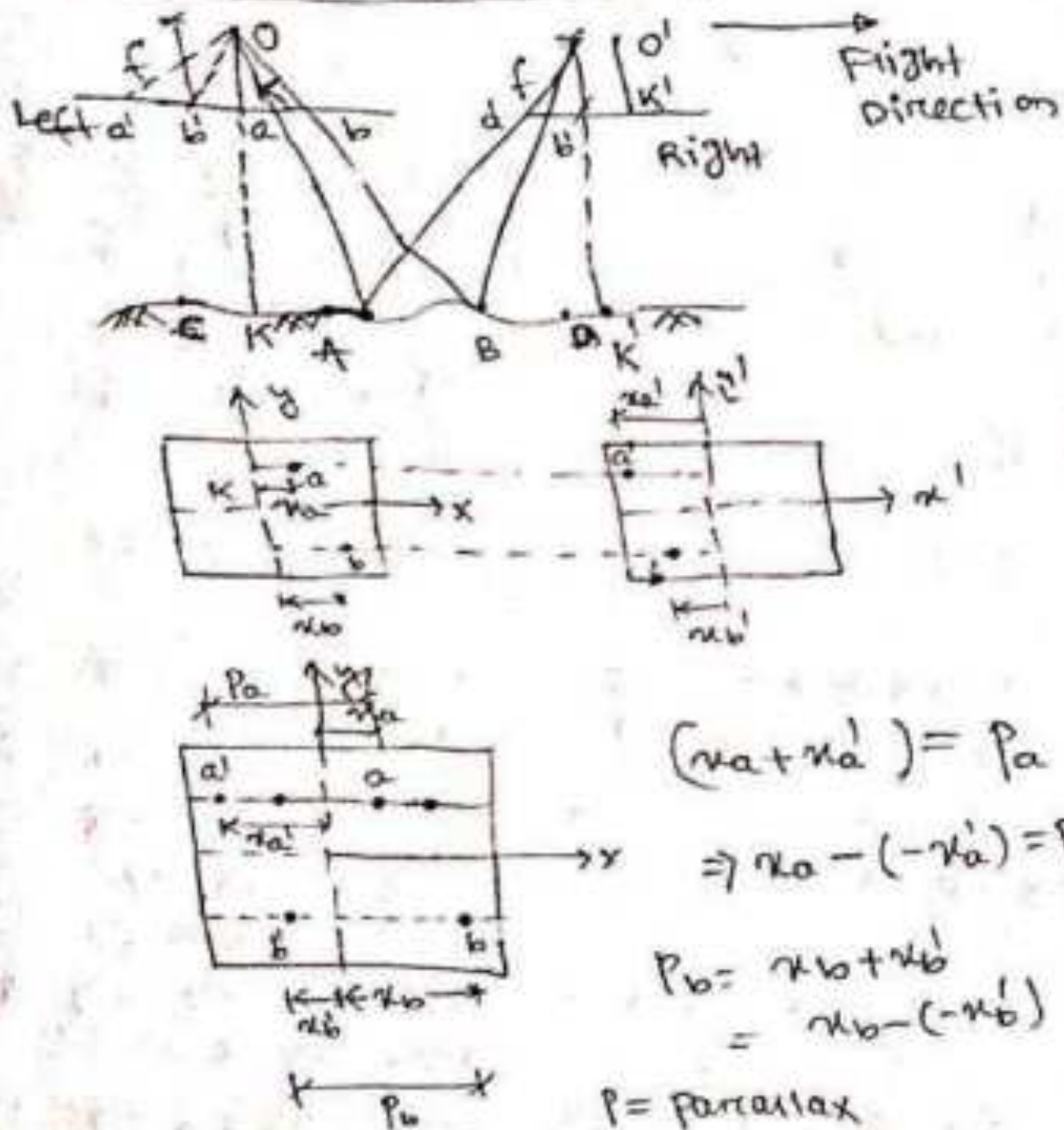
#### # Characteristics of Relief Displacement:-

- (i) The relief displacement increases as the distance from principal point increases.
- (ii) The relief displacement decreases as the flying height increases.
- (iii) For point above datum, relief displacement is positive radially outward.
- (iv) For point below the datum, relief displacement is negative radially inward.
- (v) Relief displacement vertically below point below the exposure station is zero.

# Stereo vision



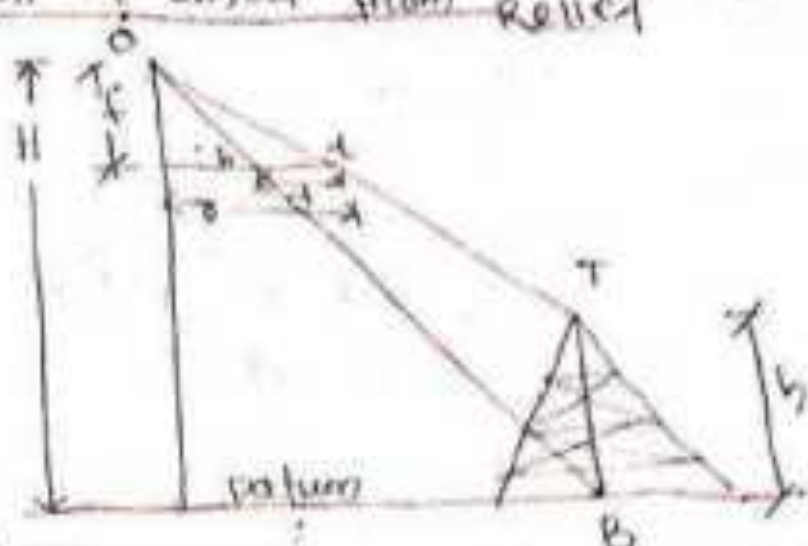
# Parallax in stereoscopy



# Determination of Height of object from Relief Displacement

If the scale of the photograph is known, the height  $H$  can be calculated from the relation

$$S = \frac{f}{H} = \frac{\text{focal length}}{\text{Flying Altitude}}$$



$$\Rightarrow \boxed{H = \frac{f}{S}} \dots \dots \dots (i)$$

Knowing  $H$ , and measuring 'd' and 'r', the height  $h$  is calculated from relief displacement eq<sup>n</sup>

$$d = \frac{rh}{H} \Rightarrow h = \frac{dH}{r} = \frac{d}{r} \times \frac{f}{S}$$

$$\Rightarrow \boxed{h = \frac{df}{rS}} \quad \text{where, } d = \text{Relief displacement}$$

$r = \text{radial distance of photograph}$

$S = \text{scale of photograph}$

Example : A vertical photograph of a flat area having an average elevation of 250m above MSL was taken with a camera of focal length of 20cm. A line AB, 250m long in the area, measured 8.50cm on photograph. The radial distance is 6.96cm on photograph & relief displacement is 0.96cm. Determine the height of tower.

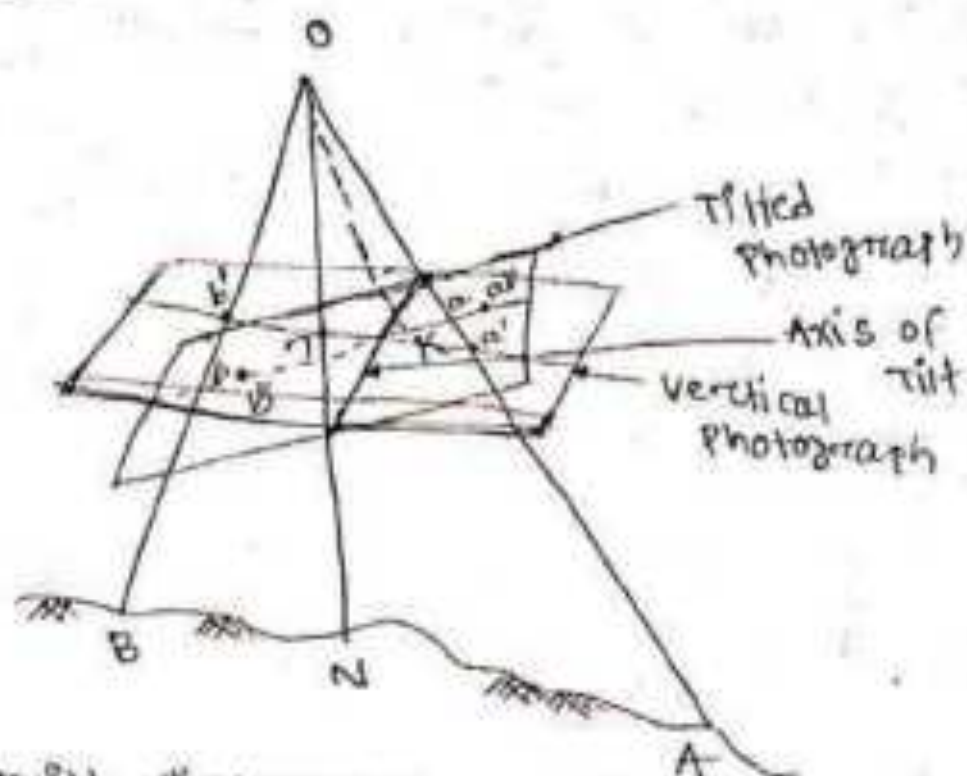
Solution:-  $\text{Scale} = \frac{f}{H} = \frac{20\text{cm}}{H}$

$$\frac{8.50\text{cm}}{250\text{m}} = \frac{20\text{cm}}{H\text{m}} \Rightarrow H = \frac{20 \times 250}{8.50} = 588.2\text{m}$$

$$d = \frac{rh}{H} \Rightarrow h = \frac{dH}{r} = \frac{0.96 \times 588.2}{6.96} = 81.89\text{m}$$

$\therefore$  Height of tower,  $h = 81.89\text{m}$

## # Tilt Distortion:



Tilt distortion or tilt displacement is defined as the difference between the distance of image of a point on the tilted photograph from the isocentre and the distance of the image of the same point on the photograph from the isocentre if there had been no tilt.

$n$  → principal point of vertical photograph

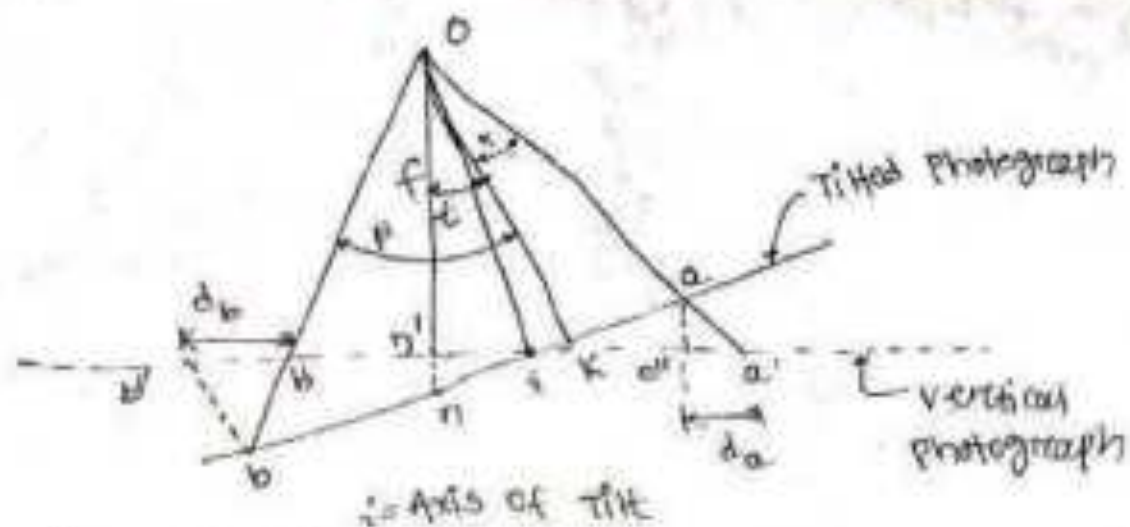
$K$  → principal point of tilted photograph

$a, b$  → images on tilted photograph

$a', b'$  → images on vertical photograph

$A, B$  → the point on the ground

If the vertical photograph is now rotated about the axis of tilt until it is in the plane of the tilted photograph, point  $a'$  would fall at  $a''$  while point  $b'$  will fall at  $b''$ . The tilt displacement of points  $a$  and  $b$  are therefore  $aa''$  and  $bb''$ .



$\alpha$  = Inclination angle between  $oa$  &  $ok$

$\beta$  = inclination of ray  $ok$  to  $ob$

$d_a$  = Tilt displacement of  $a$  with respect to  $a'$

$d_b$  = Tilt displacement of  $b$  with respect to  $b'$

$$z_a = z_k + ka$$

$$= f \tan\left(\frac{t}{2}\right) + f \tan \alpha$$

$$z_{a'} = n'a' - n'i = f \tan(t + \alpha) - f \tan\left(\frac{t}{2}\right)$$

$$\therefore d_a = z_{a'} - z_a$$

$$= f \tan(t + \alpha) - f \tan\left(\frac{t}{2}\right) - f \tan\left(\frac{t}{2}\right) + f \tan \alpha$$

$$\boxed{d_a = f \left[ \tan(t + \alpha) - \tan \alpha - 2 \tan\left(\frac{t}{2}\right) \right]}$$

Similarly,  $z_b = kb - ki = f \tan \beta - f \tan\left(\frac{t}{2}\right)$

$$z_{b'} = b'n' + n'i = f \tan(\beta - t) + f \tan\left(\frac{t}{2}\right)$$

$$\therefore d_b = z_{b'} - z_b$$

$$= f \tan \beta - f \tan\left(\frac{t}{2}\right) - f \tan(\beta - t) + f \tan\left(\frac{t}{2}\right)$$

$$\boxed{d_b = f \left[ \tan \beta - \tan(\beta - t) - 2 \tan\left(\frac{t}{2}\right) \right]}$$

In the above expression

$$\tan \alpha = \frac{ka}{f} \quad \text{and} \quad \tan \beta = \frac{kb}{f}$$

where  $f$  = focal length

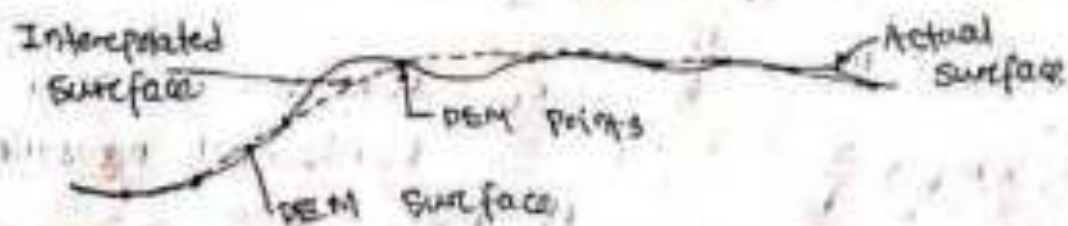
# DEM Model generation :- Digital Elevation Model

Model: It is the thing in which represents something.

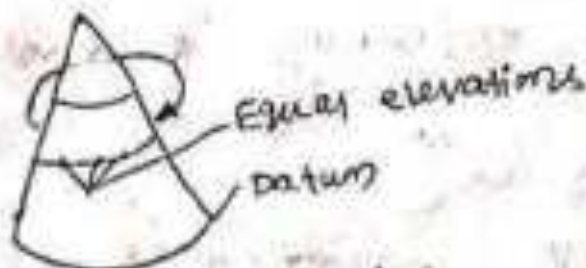
It can be as follows

- conceptual idea
- Mathematical
- Physical

- DEM represents the Earth's surface elevation as an points.
- It is used as raw data (input)
- DEM's generation
  - semi-automated (from contours), and
  - Automated (from stereo images).
- DEM is a grid representation.

# DTM - contour representation :-

- contours are lines of equal elevation on a surface.
- can easily recognize ridge, valley, relative slopes



DTM - Digital terrain Modelling

- It is simply a statical representation of continuous surface of the ground by a large number of selected points with known X, Y, Z co-ordinates in a field.

- DTM's can be used to calculate of three main terrain variables:-
  - height (altitude above datum)
  - aspect (direction area of terrain facing)
  - slope (gradient of terrain)

### # Accuracy of DEM :-

(a) Accuracy in XY-plane

$$\sigma_{xy} = \sigma_i \times m_b$$

$\sigma_{xy}$  = Planimetric Accuracy

$$\sigma_{xy} = \left(\frac{P_x}{K}\right) \times m_b$$

$\sigma_i$  = image measurement accuracy

$m_b$  = scale factor

$$GSD = P_x \times m_b$$

$P_x$  = image pixel size

$K$  = constant factor

$$\sigma_{xy} = \frac{GSD}{K}$$

GSD = Ground sampling distance

(b) Accuracy in z-direction

$$\sigma_z = \sigma_{px} \times m_b \times \frac{H}{B}$$

$\sigma_{px}$  = Parallax error in horizontal measurement

$$\sigma_z = \sigma_i \times m_b \times \frac{f}{b}$$

$H$  = flying height

$B$  = flying base

$$\sigma_z = \frac{GSD}{K} \times \frac{f}{b}$$

$f$  = focal length of camera

$b$  = image base

### # Applications :-

For civil engineering purposes

- Roads

- canals

- Tunnels

- Bridge construction





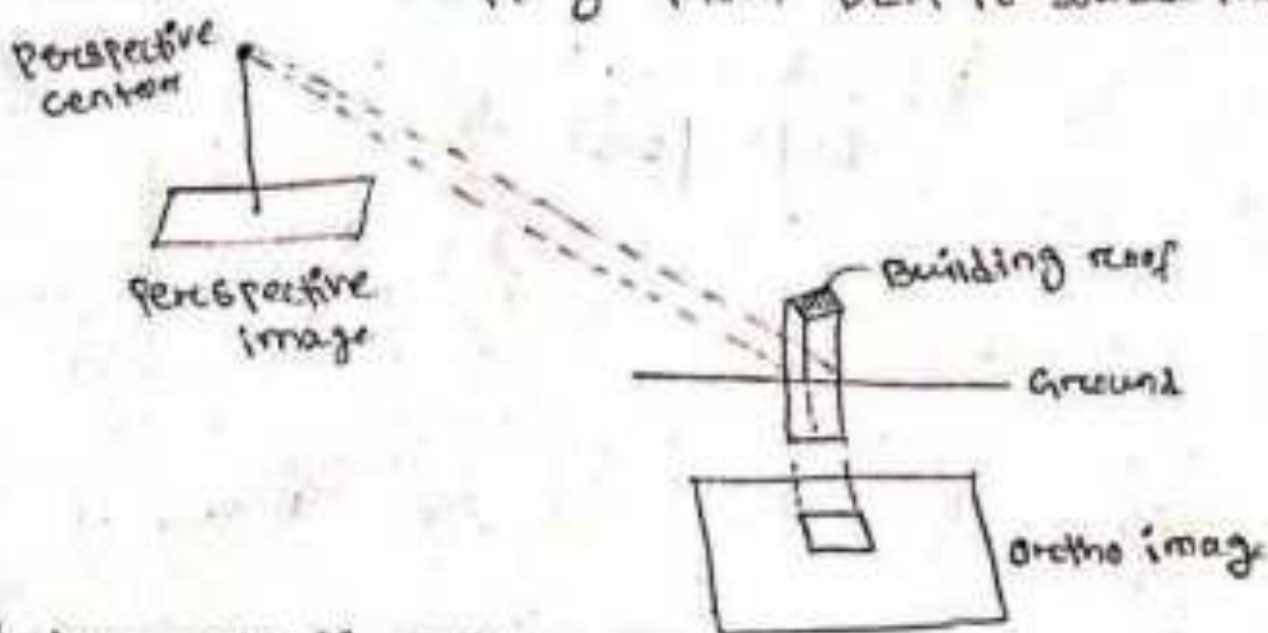
## # Orthomaps or Orthophoto:

### Concept:

- It is the projection of object's surface in orthogonal projection.
- Orthophoto are maps
  - planimetric maps
  - created from DEM by eliminating tilt & relief effects
- Orthophoto can be used as map with texture information to:
  - Measure distances, areas
  - determining the locations of features
- Types: Forward & Backward Projection

Forward  $\rightarrow$  Mapping from source image to DEM

Backward  $\rightarrow$  Mapping from DEM to source image



## # Accuracy of orthophoto:

$$v(x, y) = dz \frac{\sqrt{(x-x_0)^2 + (y-y_0)^2}}{z - z_0}$$

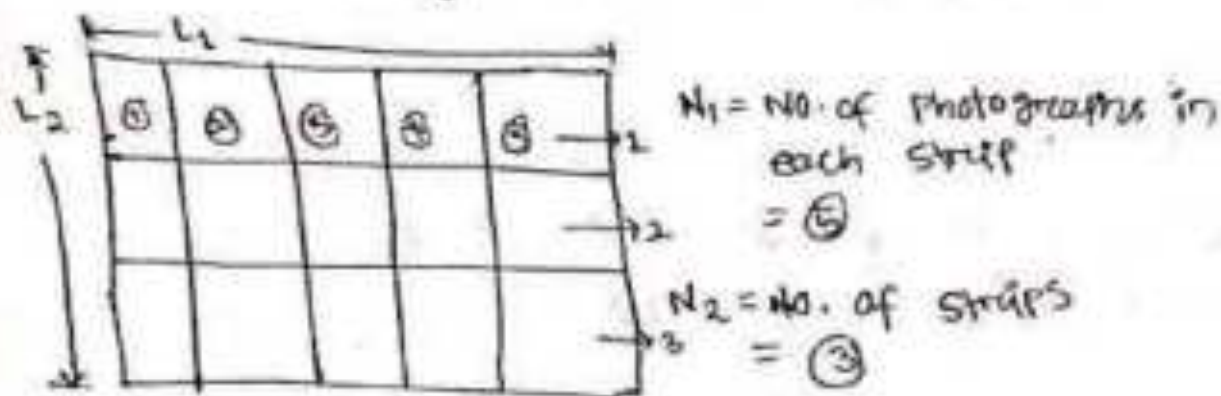
where  $v(x, y)$  = Error in orthophoto

$dz$  = Error of Height

$(x_0, y_0, z_0)$  — Location of the perspective center

$(x, y, z)$  — object co-ordinate

If, however instead of the total area  $A$ , the rectangular dimensions (i.e. length and width) of the ground area given the number of the photographs required to complete the survey are computed by calculating the number of strips & number of photographs required in each strip and multiplying the two.



$N = \text{No. of photographs required to cover the total area}$

$L_1 = \text{Length parallel to flight line}$

$L_2 = \text{Width ~~parallel~~ normal to the line of flight.}$

Now Net length covered by each ~~strip~~ photograph  
 $= L = (1 - p_l) S L$

$\therefore$  No. of photographs in each strip is given by

$$N_1 = \frac{L_1}{L} + 1 = \frac{L_1}{(1 - p_l) S L} + 1$$

Similarly net width covered by each photograph  
 $= W = (1 - p_w) S W$

$$\therefore N_2 = \frac{L_2}{W} + 1 = \frac{L_2}{(1 - p_w) S W} + 1$$

$\therefore$  Thus the no. of photograph required

$$N = N_1 \times N_2$$

Example The scale of an aerial photograph is  $1\text{ cm} = 100\text{ m}$ . The photograph size is  $20\text{ cm} \times 20\text{ cm}$ . Determine the no. of photographs required to cover an area of  $8\text{ km} \times 12.5\text{ km}$ , if the longitudinal lap is  $60\%$  and the side lap is  $30\%$ .

Solution  $N_1 = \frac{L_1}{(1-L)SL} + 1 = \frac{12500}{(1-0.6) \times 200 \times 20} + 1 = 17$

$N_2 = \frac{L_2}{(1-P)SW} + 1 = \frac{8000}{(1-0.3) \times 200 \times 20} + 1 = 7$

$\therefore$  No. of photographs required =  $N = N_1 \times N_2$

$\therefore N = 17 \times 7 = \textcircled{119}$  Arbs.

#### # Ground Control for photogrammetry:-

The ground control survey consists in locating the ground positions of points which can be identified on aerial photographs. The ground control is essential for establishing the position and orientation of each photograph with respect to ground.

The ground survey for establishing the control can be divided into two parts:

(a) Basic Control

(b) Photo Control

The basic control consist of establishing the basic network of triangulation stations, azimuth marks and bench marks.

photo control consists of establishing the horizontal points or elevations of the images of some identification points on it with respect to the basic control.

The photo control can be established by two methods

(i) Post-marking methods

(ii) Pre-marking methods

In the post marking method, the photo control points are selected after the aerial photography. The distinct advantage of this method is in positive identification & favour of location points.

In the pre-marking method, the photo control points are selected ~~after the aerial~~ on ground first and then included in the photograph. The marked points on the ground can be identified on the subsequent photograph. The selected control points should be sharp and clear in plan.

# Selection of flying altitude :-

The selection of height above ground depends upon the accuracy of the process to be used and the contour interval desired. Several inter-related factors which affect the selection of flying height, such as desired scale, sit of photograph. Since the vertical accuracy in a topographic map is the limiting factor in the photogrammetric process, the flying height is often related to the contour interval of the map.

$$\text{Flying height} = \text{contour interval} \times \text{C-factor}$$

C-factor for various processes vary from 500 to 1500.

# No. of photographs necessary to cover a given Area :-

In preliminary estimate

$$\text{No. of photographs (N)} = \frac{A}{a}$$

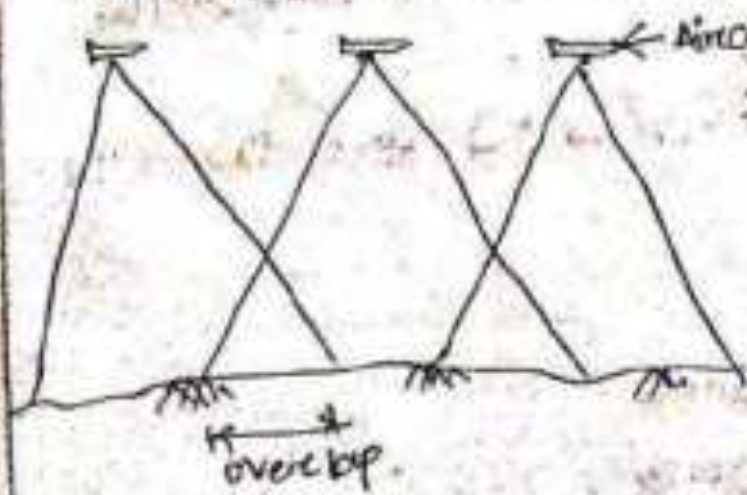
A = Total area of ground

a = Photograph area

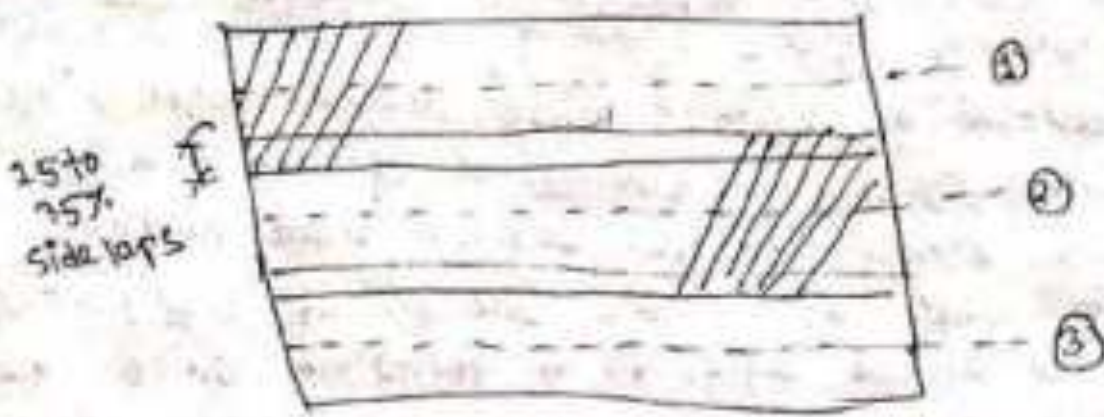


# Overlap & side lap in flight lines

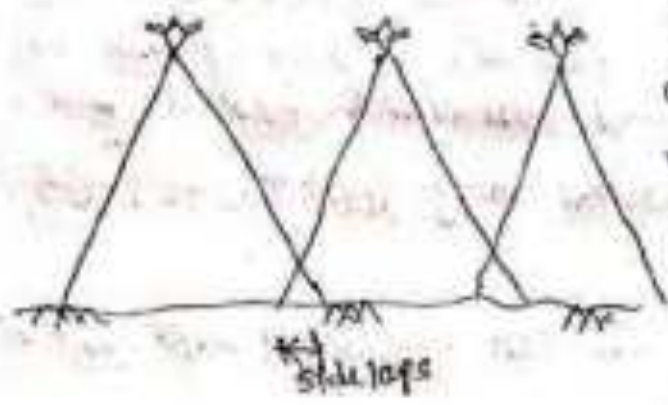
(Overlap): The overlap of photographs in the direction of flight line is called longitudinal overlap.



\* overlap by 55 to 65%



----- Flight lines  
# side lap or lateral Lap



\* The overlap between two adjacent flight lines is known as side lap.  
 \* The side lap amount is about 15 to 35%.

No. of photographs required (N)

since each photograph has a longitudinal lap of  $P_L$ , the actual ground covered by each photograph is given by

$$L = (1 - P_L) S l$$

$L$  = Length of ground

$l$  = Length of photograph

$P_L$  = % of overlap between successive photographs

$S$  = scale of the photograph

similarly actual width ( $w$ ), covered by each photograph

$$w = (1 - P_w) S w$$

$P_w$  = % of side lap

$w$  = Net ground distance

$w$  = width of photograph

Hence the ground area (a) covered on photograph

$$a = L \cdot W \\ = (1 - P_l) S_l \times (1 - P_w) S_w$$

$$a = L W S^2 (1 - P_l) (1 - P_w)$$

∴ No. of photographs (N) required

$$N = \frac{A}{a}$$

### Example-1

The scale of an aerial photograph is  $1\text{cm} = 100\text{m}$ . The size of photograph is  $20\text{cm} \times 20\text{cm}$ . Determine the no. of photographs required to cover an area of  $100\text{km}^2$ , if the longitudinal lap is 60% and side lap is 30%.

Solution:  $l = 20\text{cm}$ ,  $w = 20\text{cm}$ ,  $P_l = 0.6$  &  $P_w = 0.3$ ,  $A = 100\text{km}^2$

$$S = \frac{100\text{m}}{100\text{cm}}$$

$$1\text{cm} = 100\text{m}$$

$$\text{so } 20\text{cm} = (100 \times 20)$$

$$\therefore L = (1 - P_l) S \cdot l$$

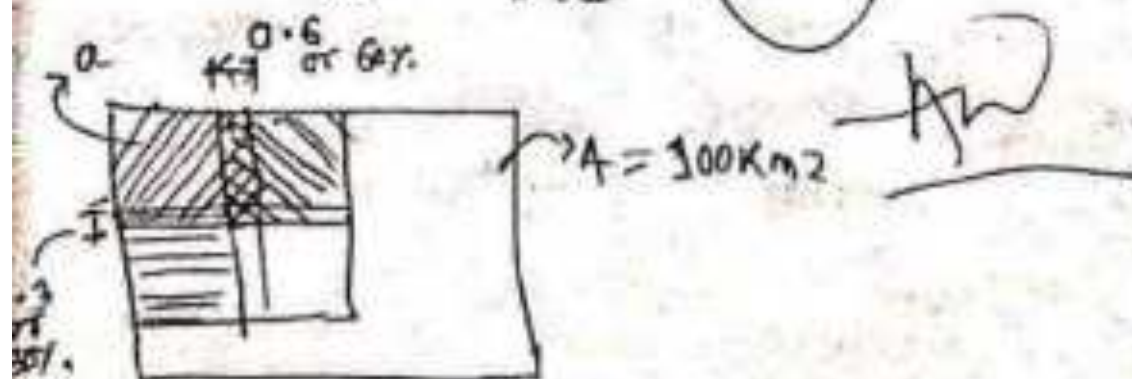
$$= (1 - 0.6) \times 100 \times 20 = 800\text{m} = 0.8\text{km}$$

$$\therefore W = (1 - P_w) S \cdot w$$

$$= (1 - 0.3) \times 100 \times 20 = 1400\text{m} = 1.4\text{km}$$

$$\therefore a = L \times W = 0.8 \times 1.4 = 1.12\text{km}^2$$

$$\therefore N = \frac{A}{a} = \frac{100}{1.12} = 90 \text{ nos.}$$



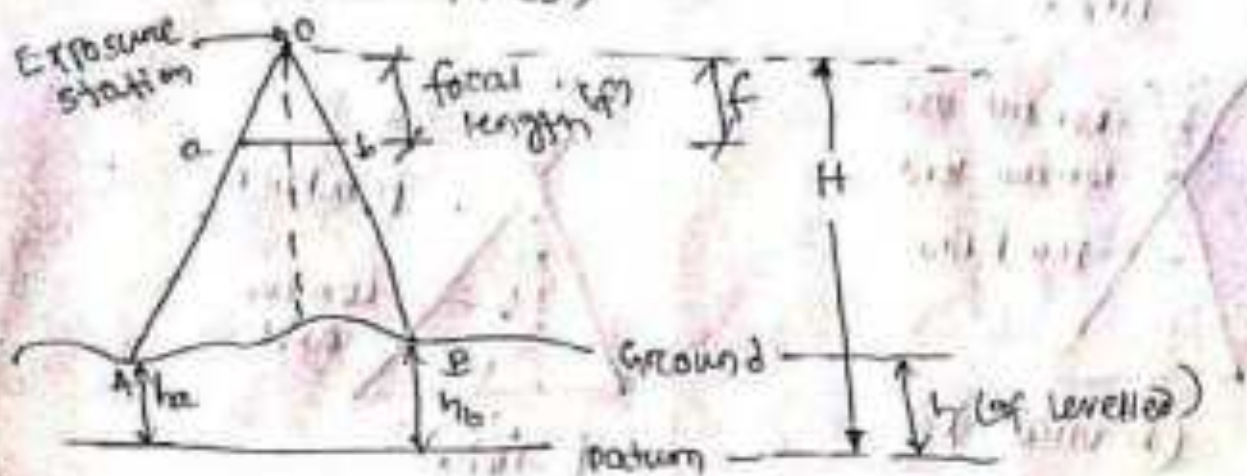
# Photogrammetry

Film: It is the sensor or plane where images form in photogrammetry.

- B&W
  - Coloured
- } according to colour of photograph

Focal Length ( $f$ ): The distance between the front of camera lens to the plane of photograph is known as focal length of camera.

Scale of photograph ( $S$ )



$$\text{scale} = \frac{\text{Photo distance}}{\text{Ground distance}} = \frac{ab}{AB}$$

$$\Rightarrow \left| \frac{ab}{AB} = \frac{f}{H - h_{avg}} \right|$$

$$h_{avg} = \frac{h_a + h_b}{2}$$

$h_{avg}$  is taken when ground having different elevation at A & B.

\* If the ground level then Scale

$$\boxed{\text{Scale of photograph} = \frac{f}{H - h}}$$

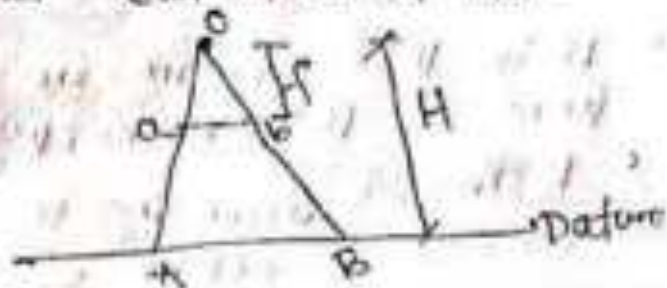
- \* Scale depends on ground elevation
- \* Scale will increase with elevation

$H$  = flying height  
 $h$  = height of ground (elevation of ground)



Datum scale: Scale at datum line at MSL

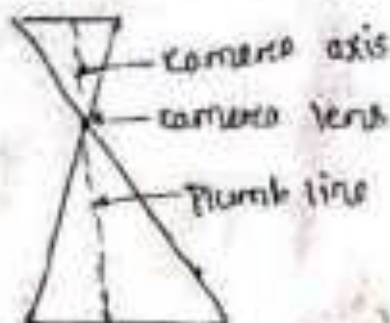
$$S_d = \frac{f}{H}$$



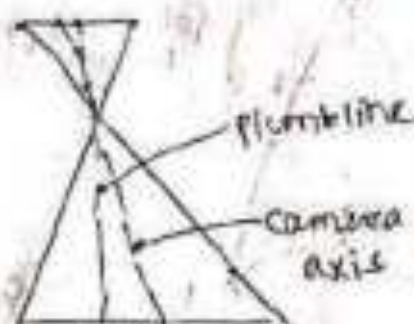
Vertical Photograph: optical axis of camera is vertical

Tilted Photograph: optical axis is tilted by a small angle (Not perpendicular)

$\theta$ : angle formed between optical axis & plumb line.



(Vertical)



(Tilted)

### Classification of Aerial Photography

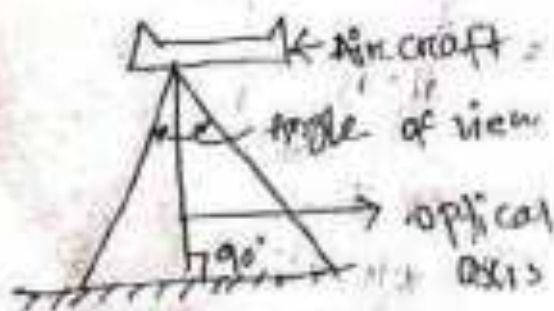
(1) Vertical Photograph ( $90^\circ$ )

(2) Tilted photograph ( $90^\circ \pm 3^\circ$ )

(3) Oblique photographs ( $90^\circ \pm 15^\circ$ )

(a) Low oblique  $\rightarrow$

(b) High oblique  $\rightarrow$  greater than  $15^\circ$

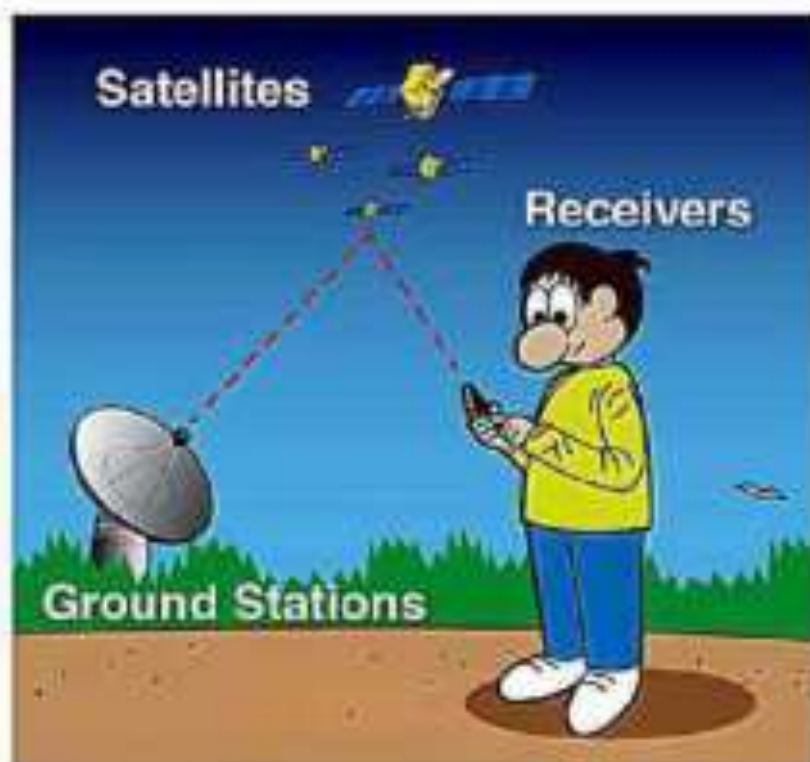


(1)



(2)

# What is GPS?



*The Global Positioning System (GPS) is made up of satellites, ground stations, and receivers.*

GPS is a system. It's made up of three parts: satellites, ground stations, and receivers.

Satellites act like the stars in constellations—we know where they are supposed to be at any given time.

The ground stations use radar to make sure they are actually where we think they are.

A receiver, like you might find in your phone or in your parents car, is constantly listening for a signal from these satellites. The receiver

## The Global Positioning System

This system consists of three **segments**: the space **segment**, the control **segment**, and the user **segment**. The U.S. Space Force develops, maintains, and operates the space and control **segments**.



Space Segment



GPS Signal

Downlink

Uplink

ELECTRONIC BLUE



Control Segment




User Segment

## 1. Space Segment

Each satellite broadcasts a navigation message with exact position, clock, status, and orbit details of itself (called Ephemeris) and general position and health information of all the other satellites (called Almanac). The nominal space segment consists of 24 satellites:

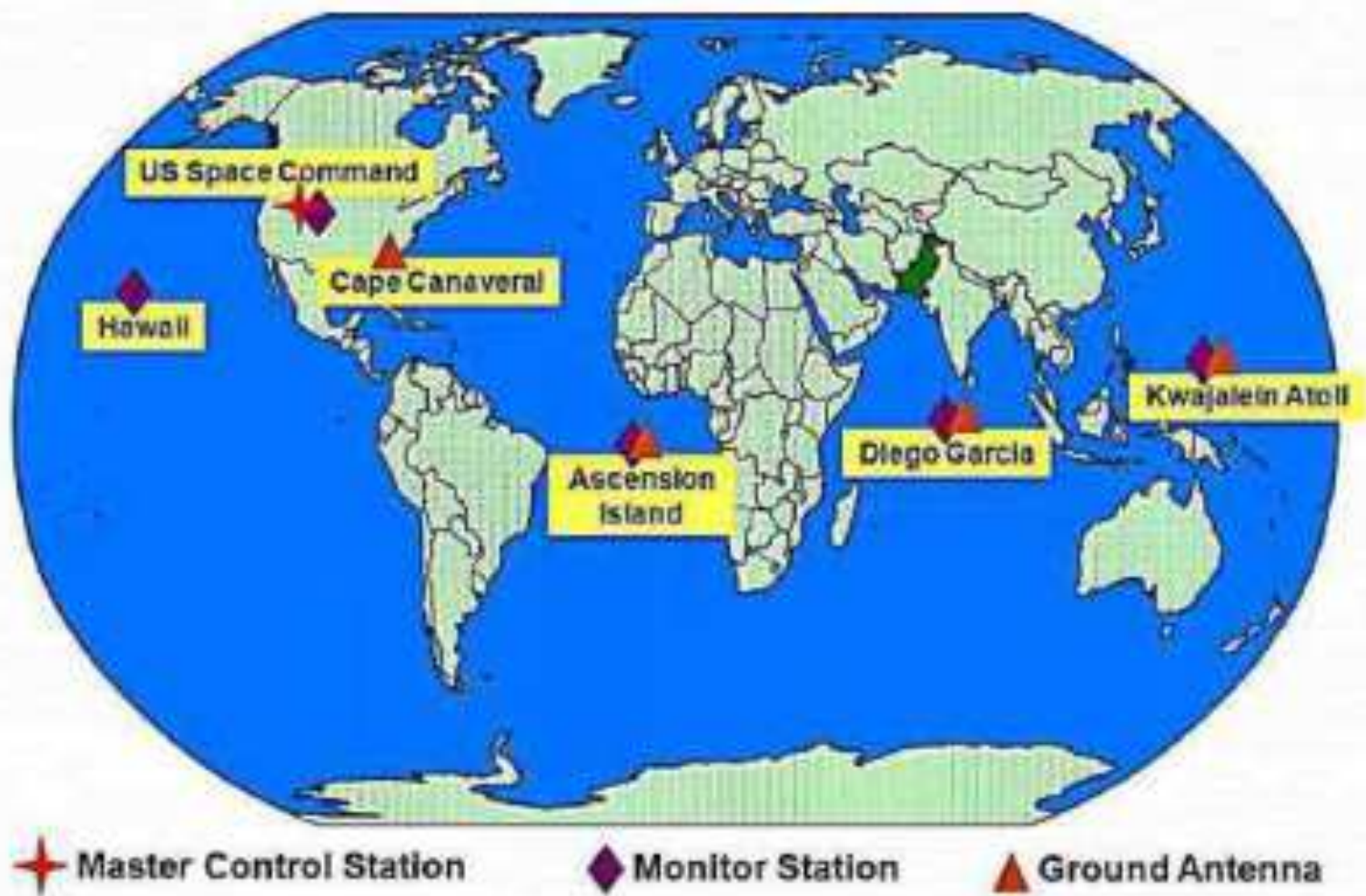
- Six (6) fixed orbital planes
- Altitude 20.200 km (10.981 NM)
- Orbit period is almost 12 hours
- Orbital planes are equally spaced 60 degrees apart
- Inclined 55 degrees with respect to the equatorial plane
- 4 satellites in each orbit
- 3 satellites are active spares that can replace failed satellites
- Satellites repeat the same track/configuration over any point on earth every 24 hrs  
(4 minutes earlier each day due to the earth's rotation around the sun)



## Control Segment

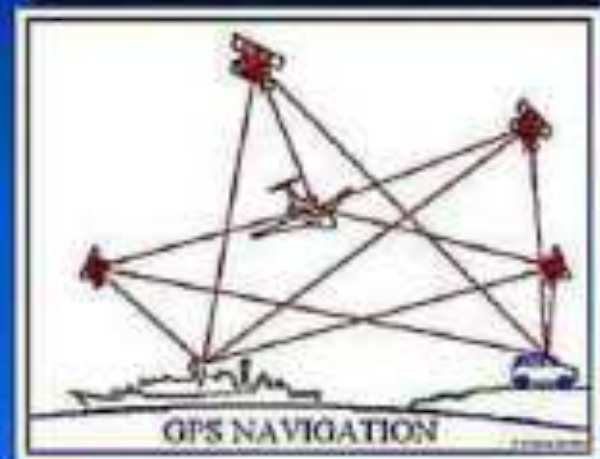
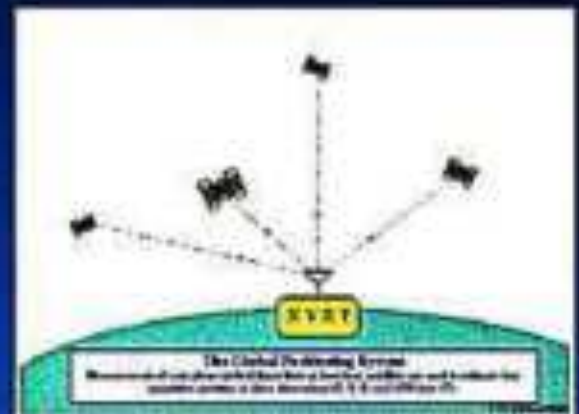
- 5 Monitor stations
  - Track GPS signals and send them to master control station
- 1 Master Control Station located at Falcon AFB (air force base) Colorado
  - Correct orbit and clock errors
  - Create new navigation messages
- Ground Antenna (upload station)
  - 4 ground antennas

## Control Segment



## User Segment

- Consists of GPS receivers and user community.
- GPS receivers convert Radio Signals into Position, Velocity, and Time estimates.
- 3 satellites are required to compute Position (X, Y, Z).
- 4<sup>th</sup> satellite is used to recalibrate receiver clock (Time).
- Navigation in three dimensions is the primary function of GPS.





The **working/operation** of the Global positioning system is based on the 'trilateration' mathematical **principle**. The position is determined from the distance measurements to satellites. From the figure, the four satellites are used to determine the position of the receiver on the earth.

---

# **L1, L2, and L5 GPS Signals: What Do They Mean?**

Have you ever been confused by how many different types of GPS signals there are? If so, here is your quick-and-easy summary explaining L1, L2, and L5 signals and how they are used.

# L1

The L1 signal is the oldest GPS signal. It has two parts: the Coarse/Acquisition Code (C/A) and the Precision Code (P-code). The P-code is reserved for military use, while the C/A is open to the public. The L1 signal uses the frequency 1575.42 MHz. (source) Since the L1 is the oldest and most established signal, even the cheapest GPS units are capable of receiving it. However, because its frequency is relatively slow it is not very effective at traveling through obstacles.

# L2

The L2 frequency was implemented after the L1. It also has a military code and a civilian use code. The L2 uses the frequency 1227.60 MHz, which is faster than the L1. This allows the signal to better travel through obstacles such as cloud cover, trees, and buildings. (more on obstacles here) However, since L2 is newer, it's infrastructure is not yet complete. Because of this, it cannot be used on its own: it must be used along with L1 frequencies. (source)

# L3

L5 is the third GPS signal, operating at 1176 MHz. It is the most advanced GNSS signal yet, but it is still in its infancy, with deployment scheduled for 2021.

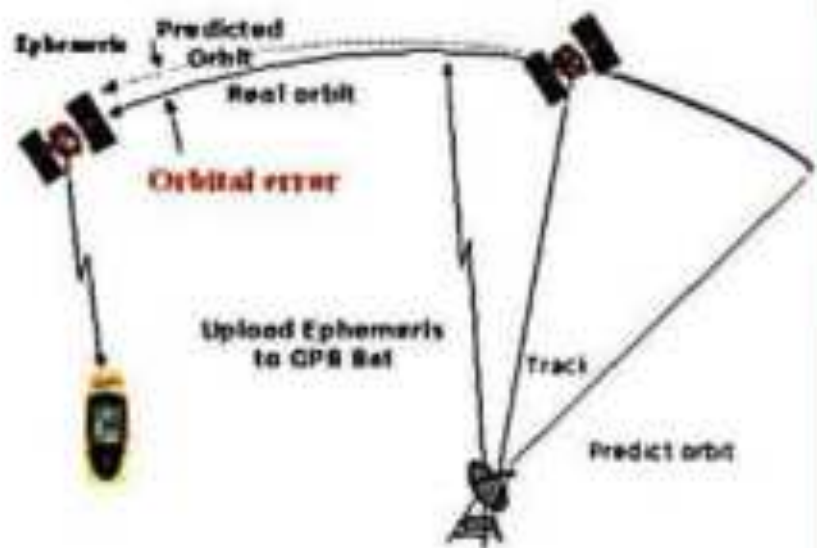
(source) It will be used for safety-of-life transportation and other demanding applications such as aviation. It will eventually become another signal available for civilian users. (source)

Since it is so new, it's not yet useful for surveyors, but it is something to keep in mind when designing the GPS receivers of the future.

# Satellites Errors

## 1. Ephemeris or Orbital Error

- Satellite positions are a function of time
- Forces acting on the GPS satellites are not perfect
- Errors in the estimated satellite positions known as ephemeris errors.



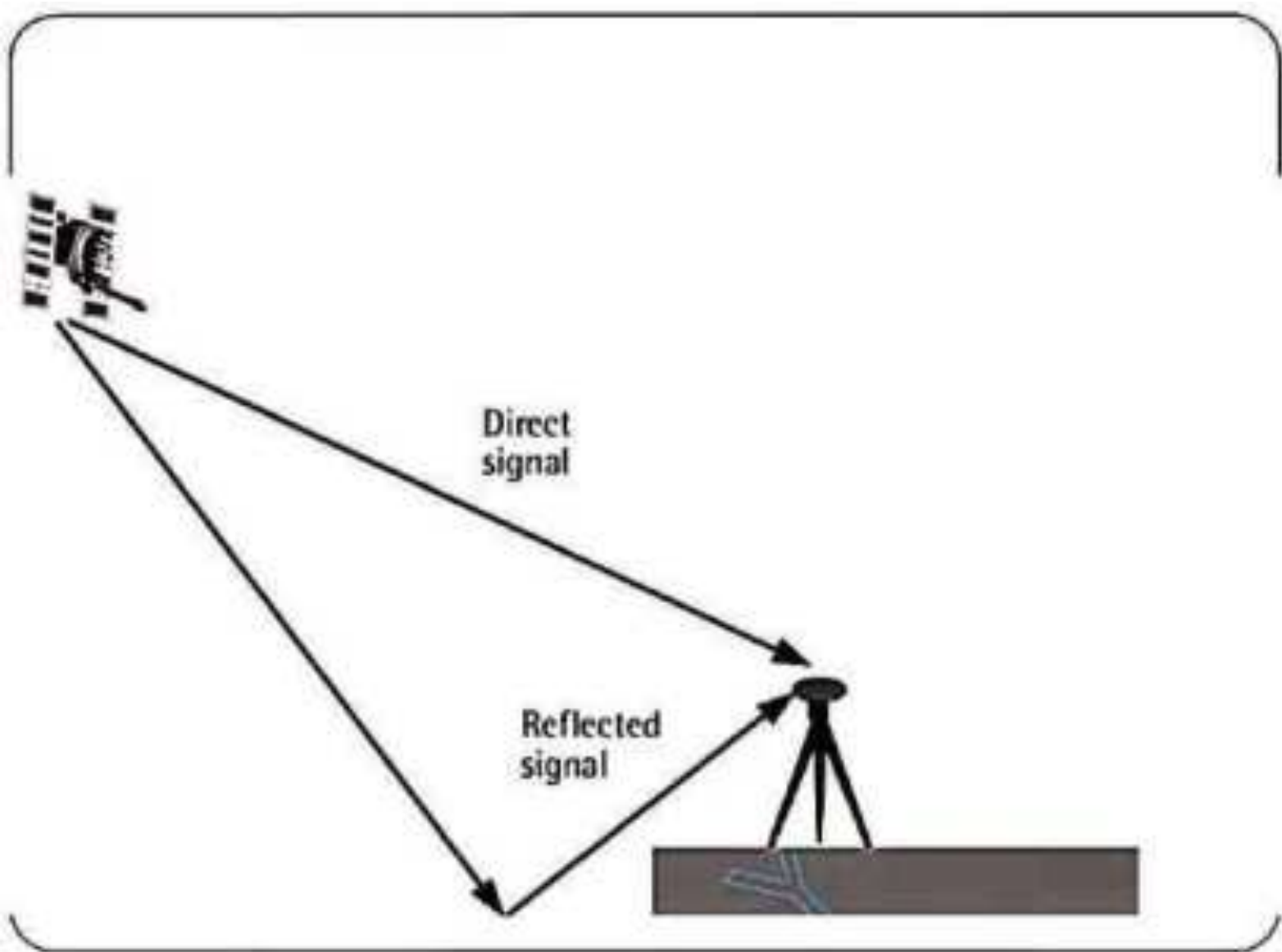
## Multipath Error

- A signal that bounces off a smooth object and hits the receiver antenna.
- Increases the length of time for a signal to reach the receiver.
- A big position error results.
  - Gravel roads
  - Open water
  - Snow fields
  - Rock walls
  - Buildings



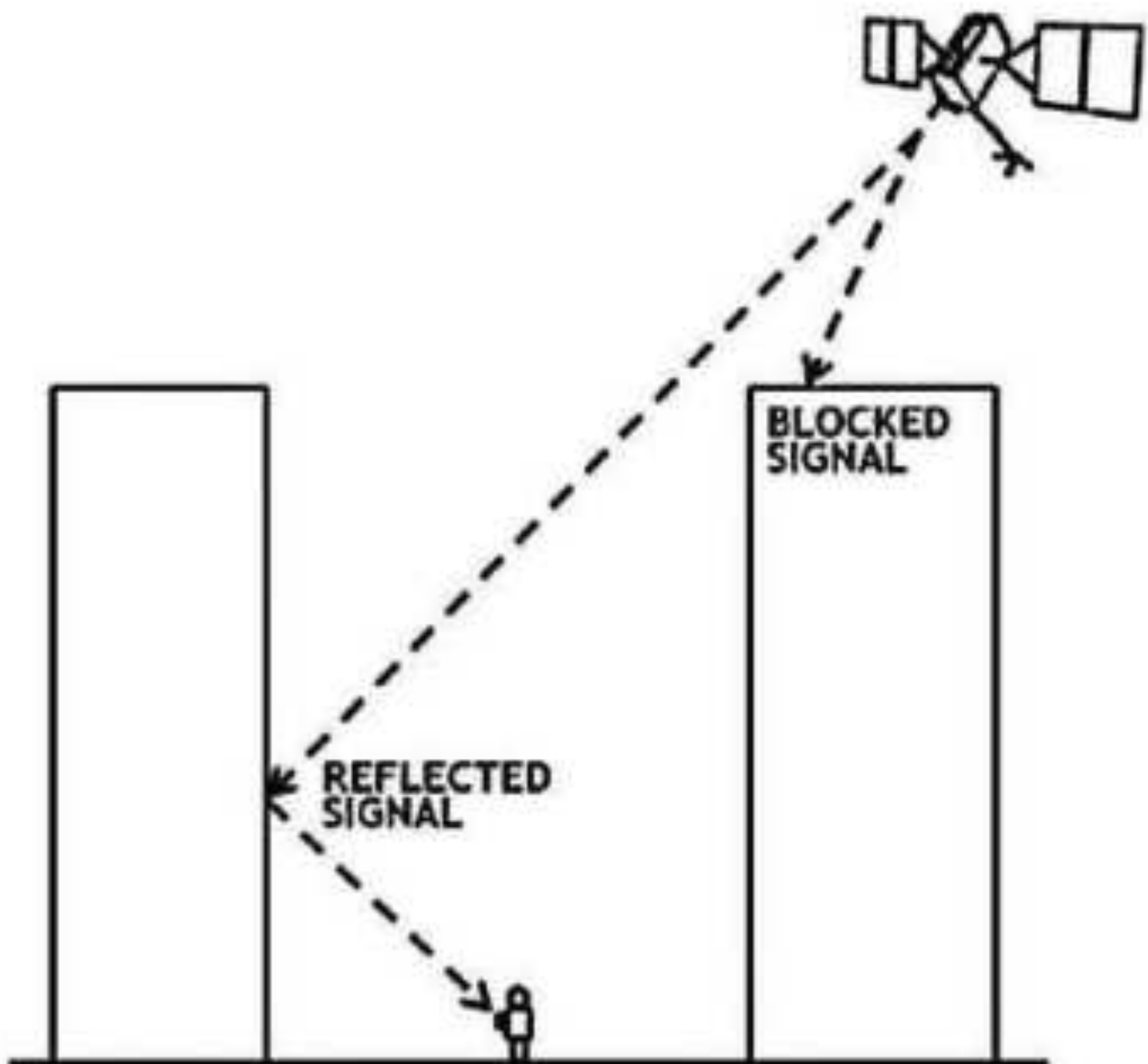
- Technically speaking, multipath error occurs when the GPS signal arrives at the receiver antenna through different paths. These paths can be the direct line of sight signal and reflected signals from objects surrounding the receiver antenna.
- Multipath distorts the original signal through interference with the reflected signals at the GPS antenna.
- ***Multipath-mitigation techniques***, multipath error is reduced to several meters, even in a highly reflective environment





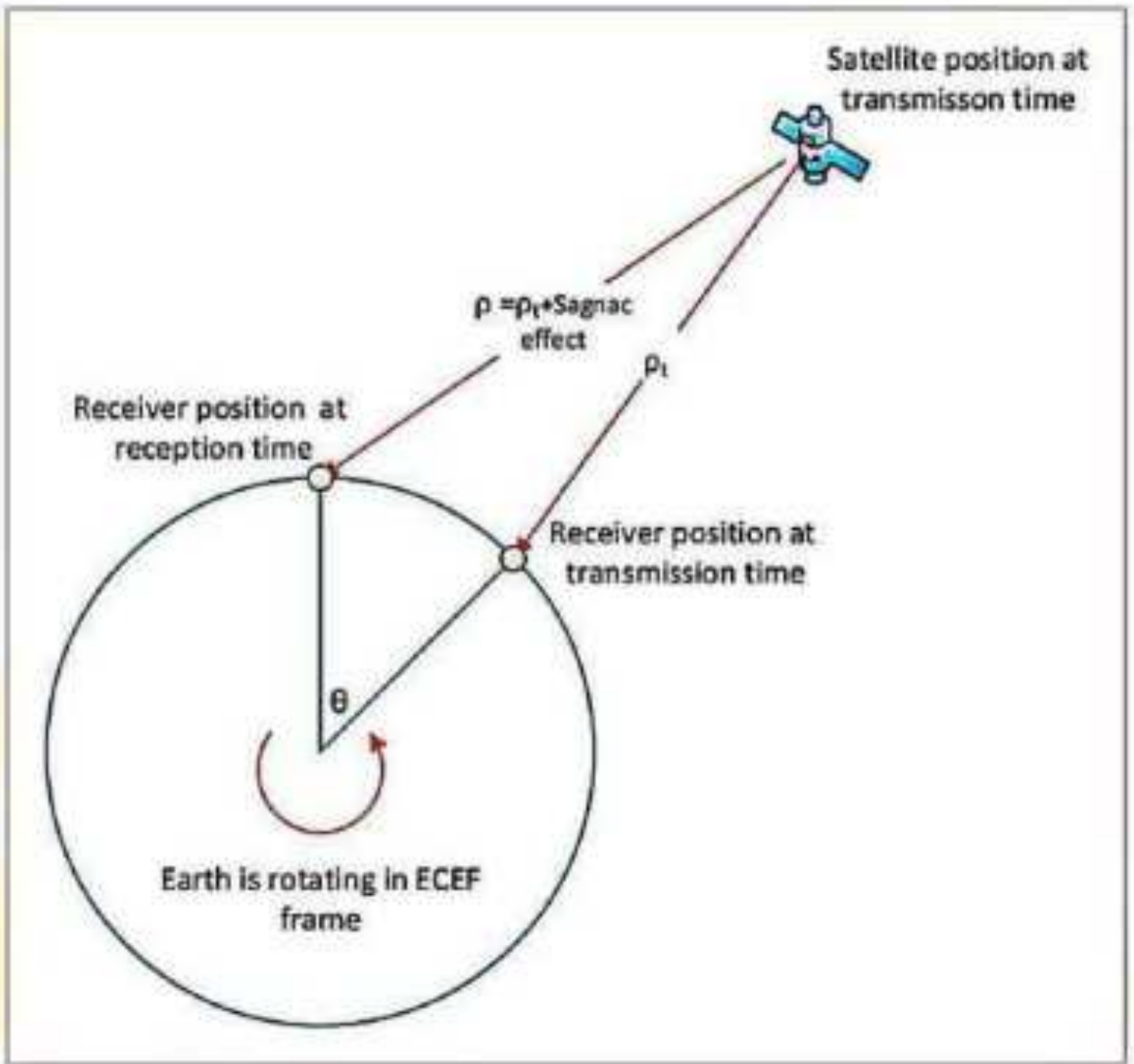
Many things can degrade GPS positioning accuracy. Common causes include:

- Satellite signal blockage due to buildings, bridges, trees, etc.
- Indoor or underground use
- Signals reflected off buildings or walls ("multipath")



### 2.2.1. Sagnac effect

The Sagnac effect is a relativistic error caused by the Earth's rotation during signal propagation time between the satellite and the receiver [11]. Ephemeris



**Figure 2.**

The Sagnac effect.

## **Ionosphere**

The ionosphere is the layer of the atmosphere ranging in altitude from 50 to 500 km.

It consists largely of ionized particles which can exert a perturbing effect on GPS signals.

While much of the error induced by the ionosphere can be removed through mathematical modeling, it is still one of the most significant error sources.

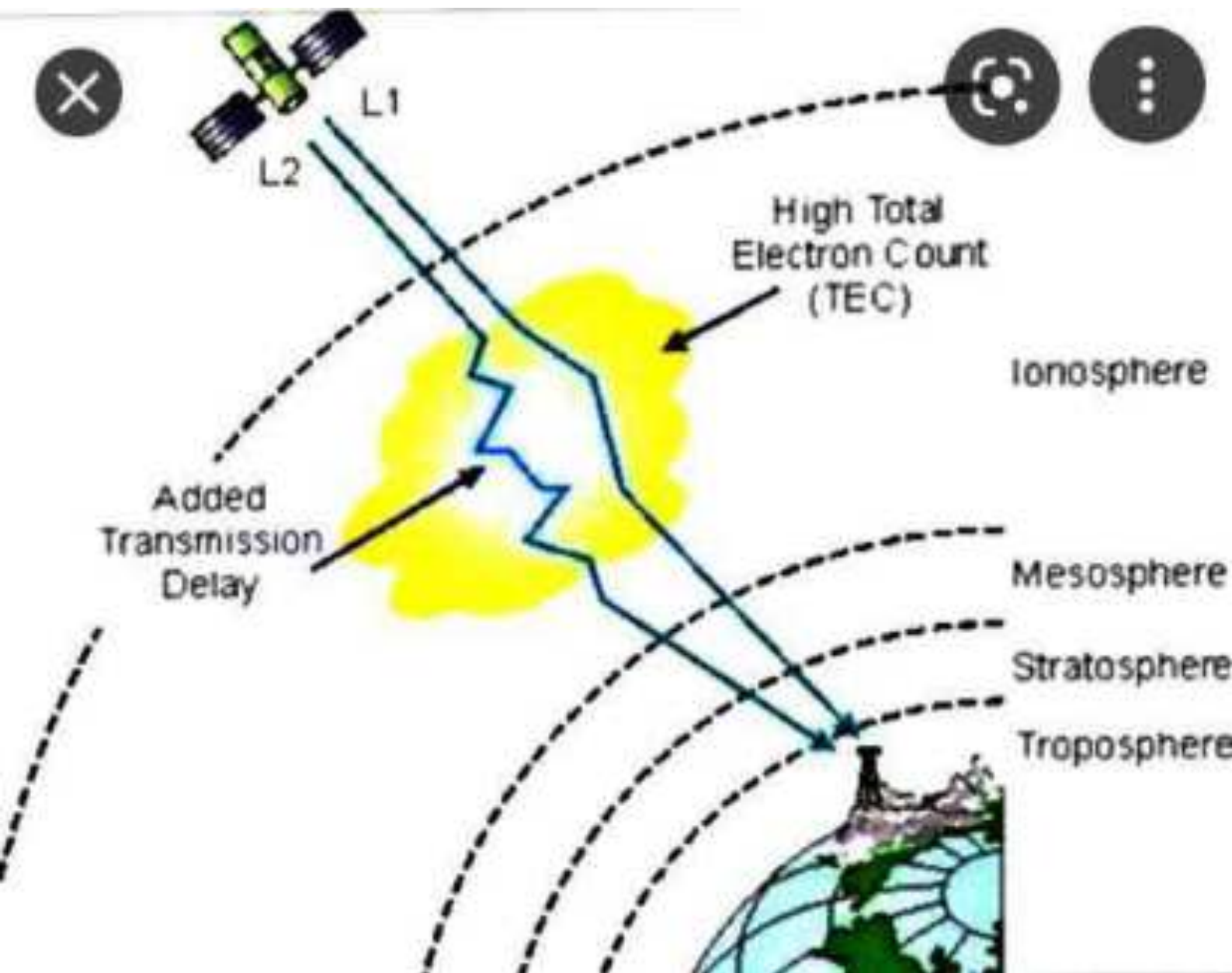
## **Troposphere**

The troposphere is the lower part of the earth's atmosphere that encompasses our weather.



It's full of water vapor and varies in temperature and pressure.

But as messy as it is, it causes relatively little error.



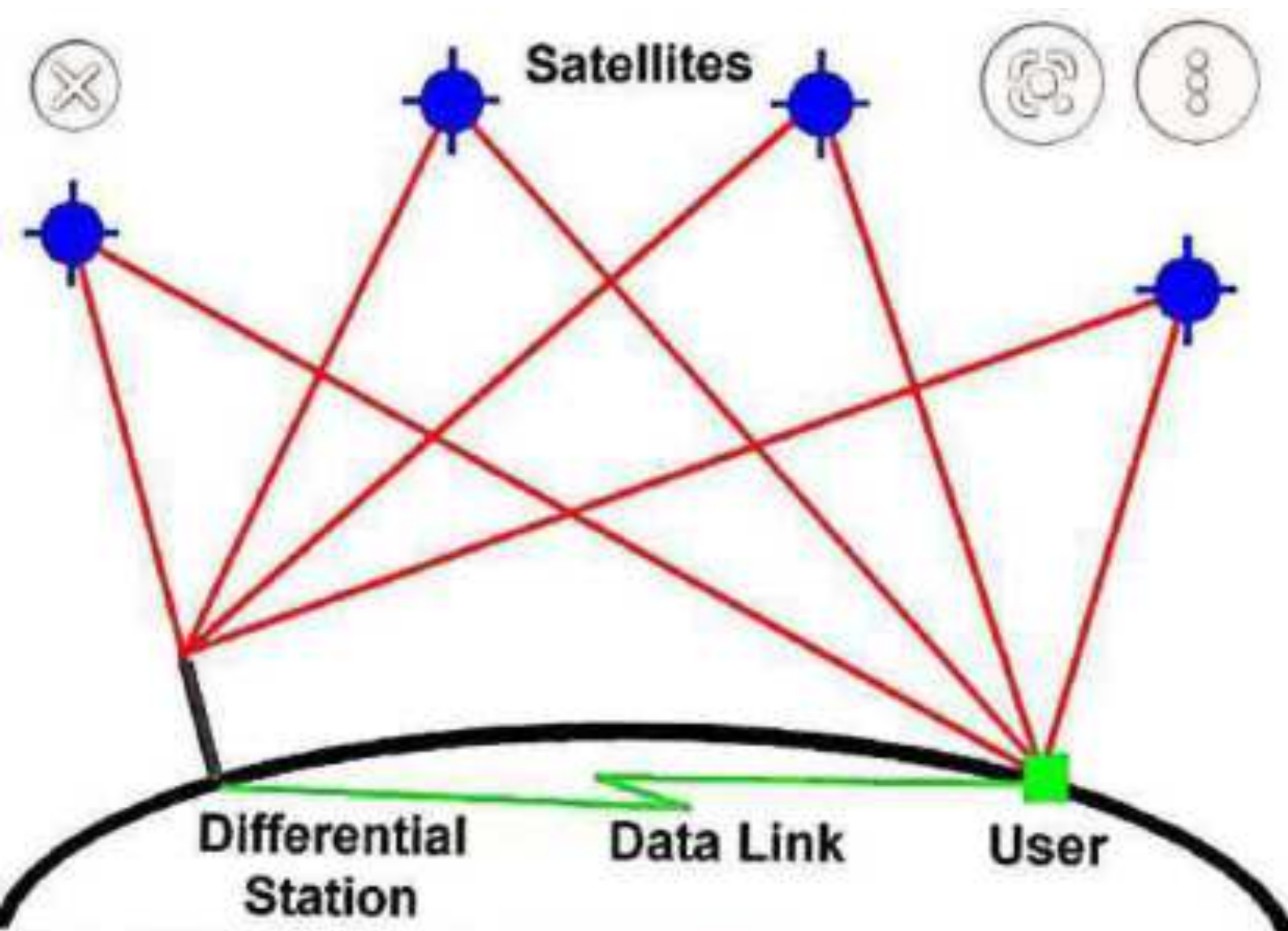
The **GPS** and **DGPS** are the satellite-based navigation systems. The basic **difference between GPS and DGPS** lies on their accuracy, **DGPS** is more accurate than **GPS**. **GPS** provides the accuracy about 10 meters, but **DGPS** can provide accuracy around 1 meter, even beyond that 10 cm. ...

## DGPS in Detail

- ✓ DGPS is a method of improving the accuracy of your receiver by adding a local reference station to augment the information available from the satellites. It also improves the integrity of the whole GPS system by identifying certain errors.
- ✓ Differential GPS uses one unit at a known location and a rover.
- ✓ The stationary unit compares its calculated GPS location with the actual location and computes the error.
- ✓ The rover data is adjusted for the error.







## **Total Stations**

A total station is an optical instrument used in modern surveying. It is a combination of an electronic theodolite (transit), an electronic distance measuring device (EDM) and software running on an external computer, such as a laptop or data collector.

**Electronic distance measurement (EDM)** is a method of determining the **length** between two points **using** electromagnetic waves. EDM is commonly carried out **with** digital instruments called theodolites.

Following are different types of total station errors:

### **1. Horizontal Collimation or Line of Sight Error**

Horizontal collimation or line of sight error is when the line of sight is not perpendicular to the tilting axis of the instrument. This is an axial error.

Line of sight error effects the horizontal angle readings and increases with steep sightings. The error can be overcome or eliminated by observing on two faces.

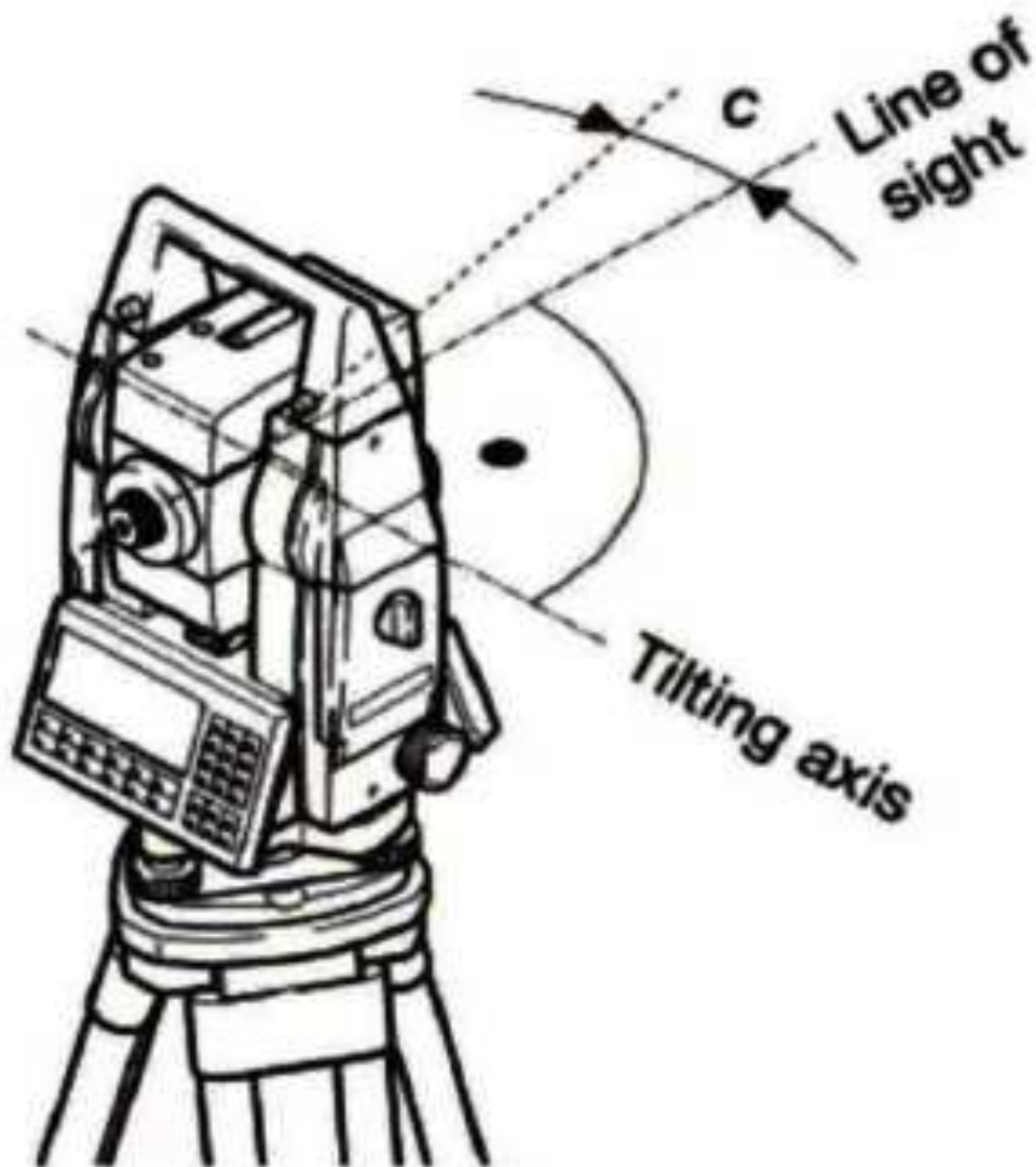


Image Source: Lecture Series by Trinity  
College Dublin

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## 2. Tilting Axis Error or Tilt Error

Tilting axis or tilt error is the error when the axis to the total station is not perpendicular to the vertical axis or plumb line. The error effect on horizontal readings when the instrument is tilted (steep sightings) but have no effect on sightings taken when the instrument is horizontal.

Like horizontal collimation error the tilting error can be eliminated by two face measurement. Another method is to apply the measured tilting error at the time of calibration process for all readings.

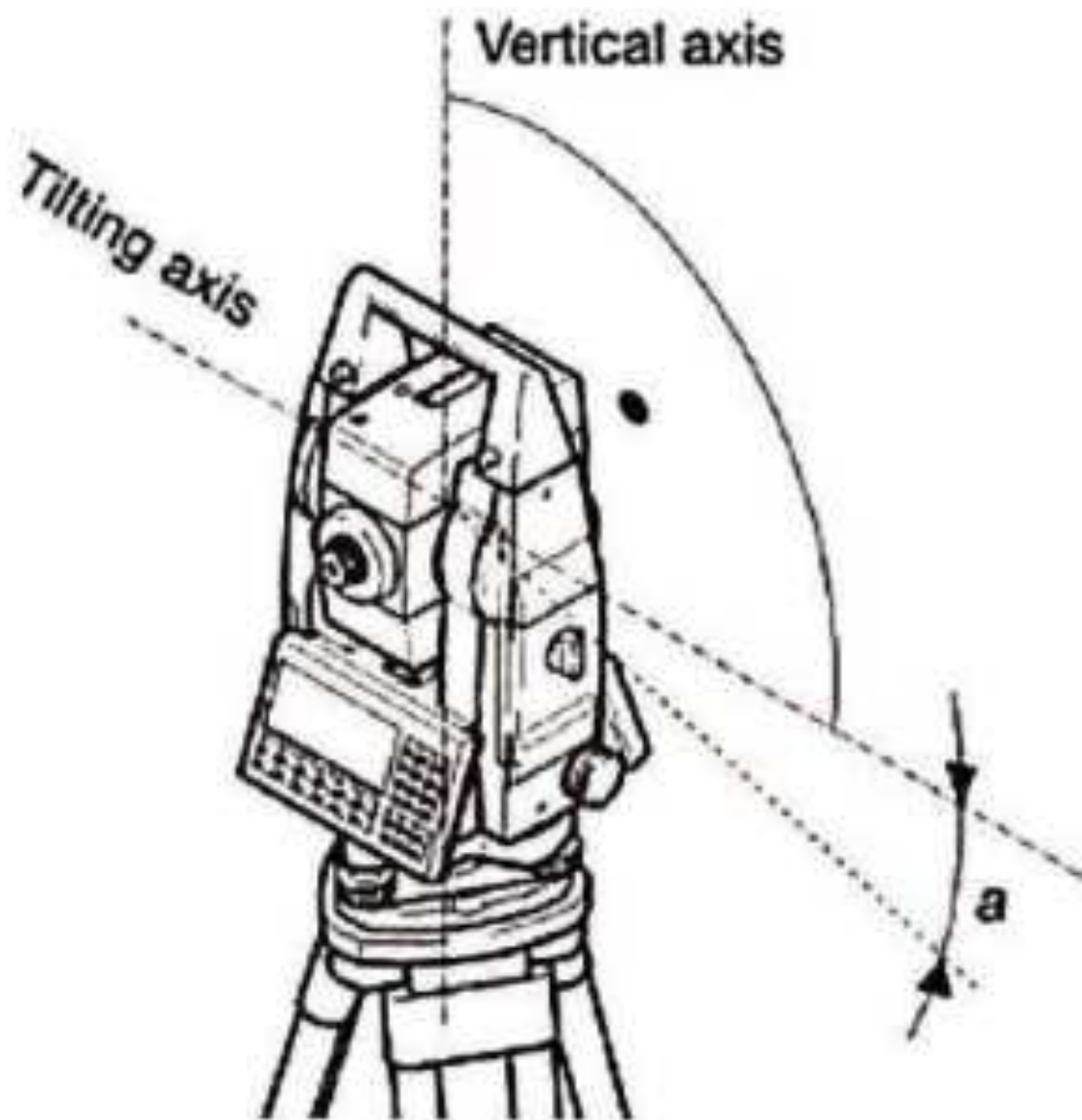


Image Source: Lecture Series by Trinity  
College Dublin

### **3. Vertical Collimation Error or Vertical Index Error**

If the horizontal base line of angle from  $0^\circ$  to  $180^\circ$  in the vertical circle does not coincide with the vertical axis of instrument. This zero point error is present in all vertical circle readings and like the horizontal collimation error, it is eliminated by taking FL and FR readings or by determining  $i$ .



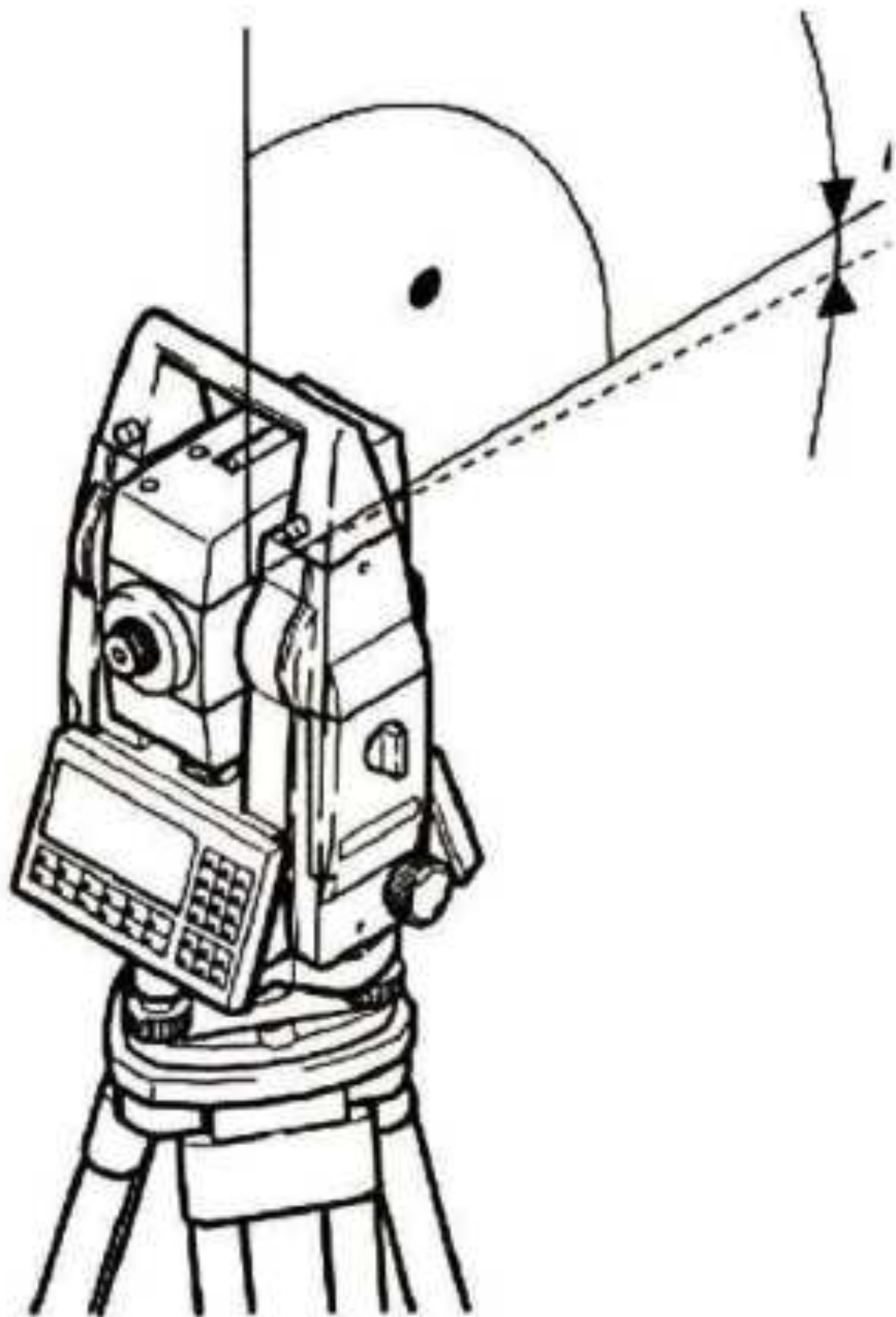


Image Source: Lecture Series by Trinity  
College Dublin

#### **4. Compensator Index Error**

This error is caused by not leveling the total station correctly and carefully. This error can't be eliminated by taking two face (face left and face right) readings unlike the horizontal collimation error.

## **Recording Errors**

The two most common errors are reading an angle incorrectly and/or entering incorrect information into the field book. Another common (and potentially disastrous) error is an incorrect instrument or rod height.

A **Geographic Information System (GIS)** is a system wherein data related to earth, associated phenomena, and events is mapped and analyzed. It is a powerful system that incorporates spatial data, manages it, analyzes it, answers geographic queries and provides great visualization capability. There are five basic **GIS components** that make it effective.

- **Hardware:**



Hardware consists of the technical equipment needed to run a GIS efficiently. It includes computer/s (standalone / networked) with good configuration – good processing capability to run the GIS software, enough hard disk space to store large spatial data, and

input and output devices such as scanners, printers, etc.

- **Software:**

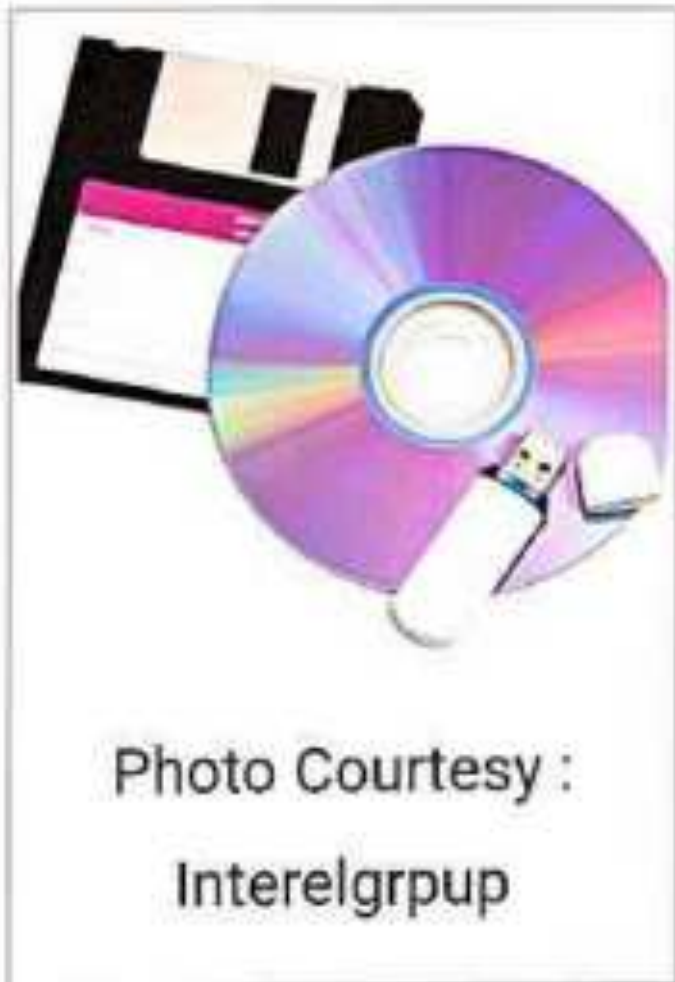


Photo Courtesy :  
Interelgrup

GIS software helps to store, analyze, and display geographic information in the form of maps and reports. It provides the a Graphical User Interface (GUI) for easy display and access to tools for input, visualizing, processing, editing, analyzing and

querying geographic data. Data is accessed and managed through Data Base Management System (DBMS).

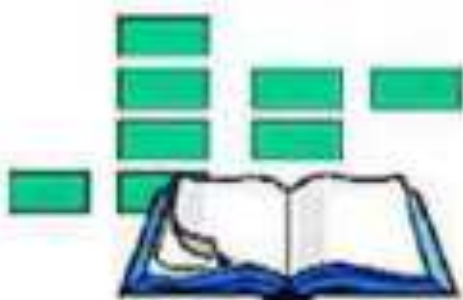
## • Data:



The most important GIS component is the data – how it is managed and accessed. Data is stored as geographic data (spatial data) and related tabular

data (non-spatial data). Data comes in various formats, and GIS integrates such spatial data and non-spatial data by using DBMS. It is the key functionality of GIS that helps in organizing, managing and accessing data.

## • Methods:



To make a GIS system work properly requires not only the necessary investments in hardware, software and data, but also requires knowledge

to utilize the GIS technology. The methods are the procedure followed to answer the question need to be resolved. Method in GIS includes how the data will be accessed, stored, managed, processed, analyzed, and finally presented as output for particular application.

## • People:



People in GIS are technical persons (GIS managers, database administrators, specialists, analysts, and programmers) who design and maintain the GIS work

and those who use it. They are the ones who make GIS work.

---

**Spatial data**, also known as **geospatial data**, is information about a physical object that can be represented by numerical values in a geographic coordinate system. ... Geographic Information Systems (**GIS**) or other specialized software applications can be used to access, visualize, manipulate and analyze **geospatial data**.



---

A. **attribute**. [data models] Nonspatial information about a geographic feature in a **GIS**, usually stored in a table and linked to the feature by a unique identifier. For example, **attributes** of a river might include its name, length, and sediment load at a gauging station.

## 5. Integrated Analysis of Spatial and Attribute Data

- ▶ The power of GIS lies in its ability to analyze spatial and attribute data together
- ▶ Retrieval, classification, and measurements
- ▶ Overlay



# Three Views of a GIS

- **The Database View:** A GIS is a unique kind of database of the world—a geographic database (geodatabase). It is an "Information System for Geography." Fundamentally, a GIS is based on a structured database that describes the world in geographic terms.
- **The Map View:** A GIS is a set of intelligent maps and other views that show features and feature relationships on the earth's surface. Maps of the underlying geographic information can be constructed and used as "windows into the database" to support queries, analysis, and editing of the information.
- **The Model View:** A GIS is a set of information transformation tools that derive new geographic datasets from existing datasets. These geoprocessing functions take information from existing datasets, apply analytic functions, and write results into new derived datasets.

## Three Views of a GIS

- **The Map View:** A GIS is a set of maps and views that show features and relationships on the earth's surface.
- Maps of the underlying geographic information can be constructed and used as "windows into the database" to support queries, analysis, and editing of the information. This is called geovisualization.



## Three Views of a GIS

- **The Database View: A GIS is a unique kind of database of the world—a geographic database (geodatabase). It is an "Information System for Geography."**
- **All information in a GIS is linked to a spatial reference. Other databases may contain locational information (such as street addresses, or zip codes), but a GIS database uses georeferences as the primary means of storing and accessing information.**

### Addresses

3350 45th Ave NE

3383 30th Ave NE

2459 Country Rd. 9 NE

3383 30th Ave NE


2459 Country Rd. 9 NE



## Three Views of a GIS

- **The Model View:** A GIS is a set of information transformation tools (i.e. geoprocessing) that derive new data from existing data.





## Spatial data

The data or information that identifies the geographic location of features and boundaries.

On earth, such as natural and constructed features like Ocean, lake, pond etc.

Spatial data is usually stored as coordinate and topology, and is data that can be mapped.

IN GIS THERE ARE TWO TYPES OF SPATIAL  
DATA TYPES

RASTER  
DATA

VECTOR  
DATA

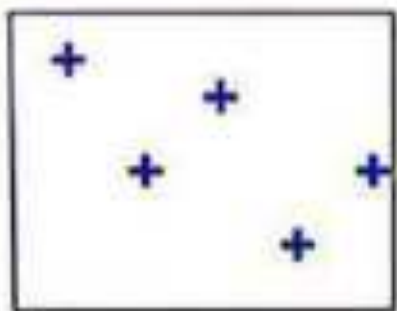
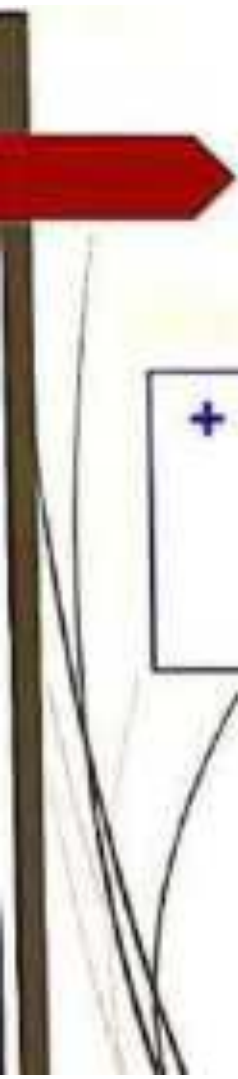


## **Vector Data**

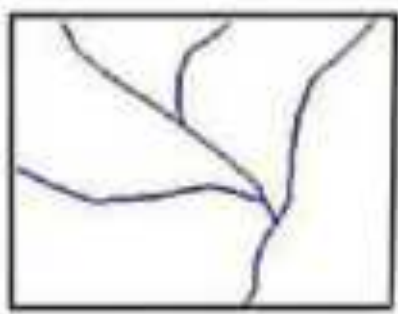
Vector data provide a way to represent real world features within the GIS environment. A vector feature has its shape represented using geometry. The geometry is made up of one or more interconnected vertices. A vertex describe a position in space using an x, y and optionally z axis. In the vector data model, features on the earth are represented as:

## Vector Data

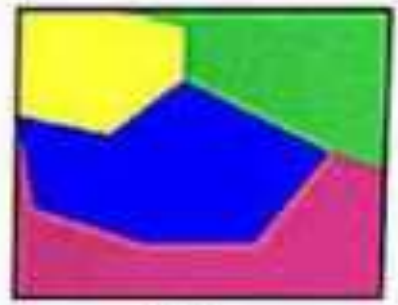
This system of recording features is based on the interaction between arcs and nodes, represented by points, lines and polygons. A **point** is a single node, a **line** is two nodes with an arc between them, and a **polygon** is a closed group of three or more arcs. With these three elements, it is possible to record most all necessary information.



Points



Lines



Polygons

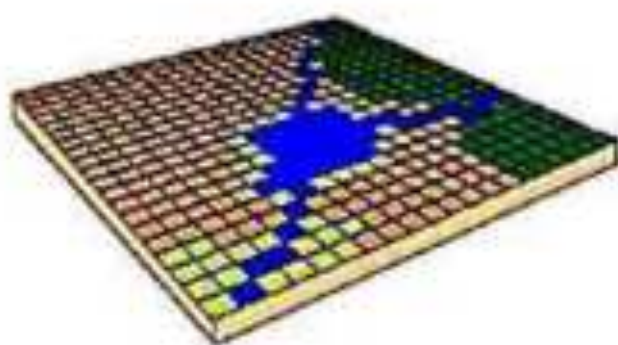
## Vector Data



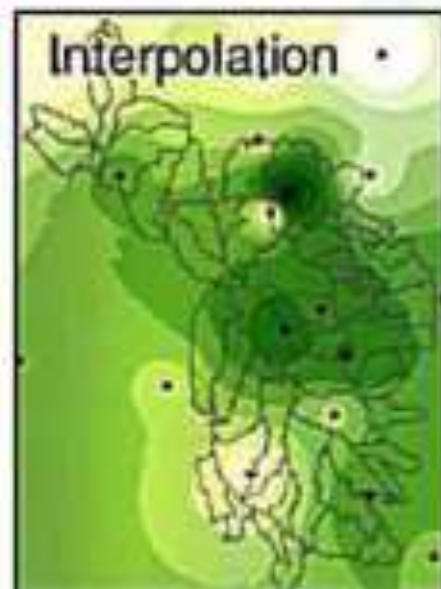
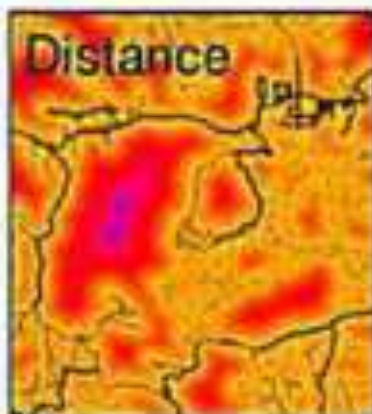
## Raster Data

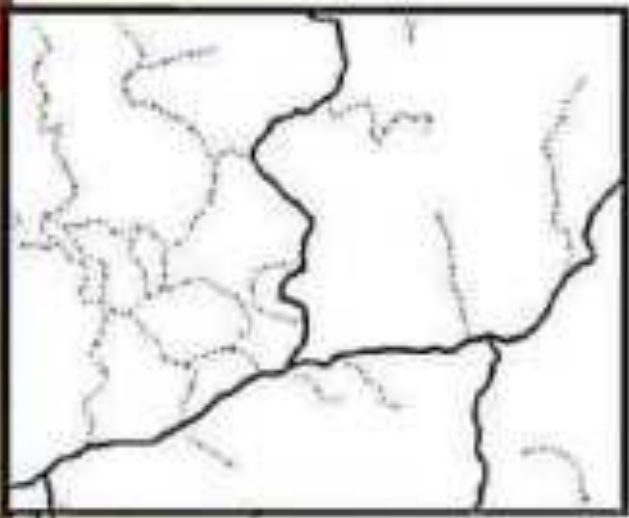
Raster Data – cell –based data such as aerial imagery and digital elevation models. Raster data is characterized by pixel values.

Basically, a raster file is a giant table, where each pixel is assigned a specific value from 0 to 255. The meaning behind these values is specified by the user – they can represent elevations, temperature, hydrology and etc.

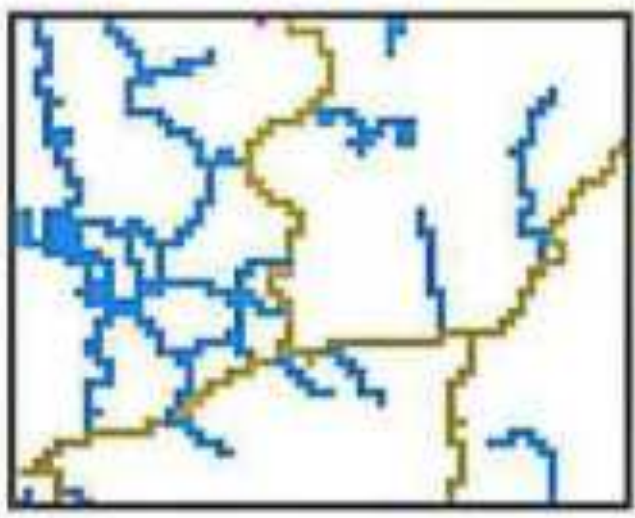


## Raster analysis functions



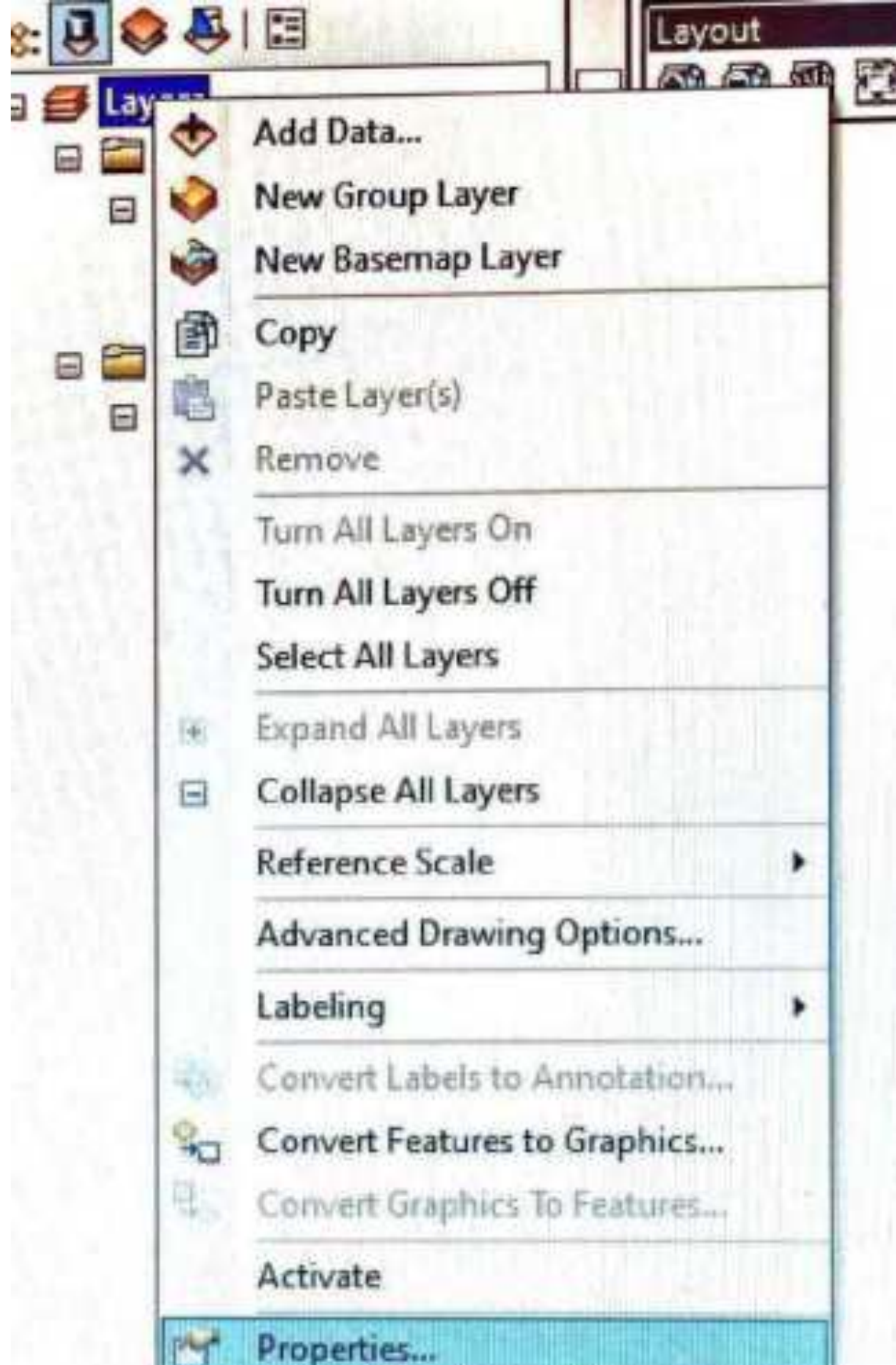


Vector model



Raster model

# GIS data models



Add Data...

New Group Layer

New Basemap Layer

Copy

Paste Layer(s)

Remove

Turn All Layers On

Turn All Layers Off

Select All Layers

Expand All Layers

Collapse All Layers

Reference Scale

Advanced Drawing Options...

Labeling

Convert Labels to Annotation...

Convert Features to Graphics...

Convert Graphics To Features...

Activate

Properties...

### Data Frame Properties

Change the properties of this data frame, such as the coordinate system it uses.



Feature Cache

Annotation Groups

Extent Indicators

Frame

Size and Position

General

Data Frame

Coordinate System

Illumination

Grids

Reference grids are drawn on top of the data frame in *Layout* view only.



New Grid...

Remove Grid

Style...

Properties...

Convert To Graphics

OK

Cancel

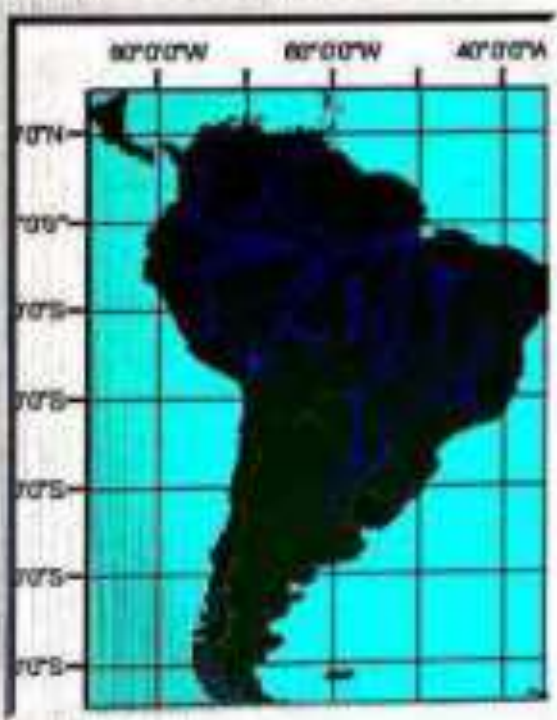
Apply

Custom... | 20

### Data Frame Properties

Feature Cache	Annotation Groups	Extent Indicators	Frame	Size and Position
General	Data Frame	Coordinate System	Illumination	Grids

### Grids and Graticules Wizard



Which do you want to create?

- Graticule: divides map by meridians and parallels
- Measured Grid: divides map into a grid of map units
- Reference Grid: divides map into a grid for indexing

Grid name:

< Back    Next >    Cancel

Data Frame Properties



Feature Cache	Annotation Groups	Extent Indicators	Frame	Size and Position
General	Data Frame	Coordinate System	Illumination	Grids



Which do you want to create?

- Graticule: divides map by meridians and parallels
- Measured Grid: divides map into a grid of map units
- Reference Grid: divides map into a grid for indexing

Grid name:

< Back

Next >

Cancel

stom

### Data Frame Properties

Feature Cache | Annotation Groups | Extent Indicators | Frame | Size and Position

General | Data Frame | Coordinate System | Illumination | Grids

120



Which do you want to create?

- Graticule: divides map by meridians and parallels
- Measured Grid: divides map into a grid of map units
- Reference Grid: divides map into a grid for indexing

Grid name:

< Back | Next > | Cancel

Feature Cache

Annotation Groups

Extent Indicators

Frame

Size and Position

General

Data Frame

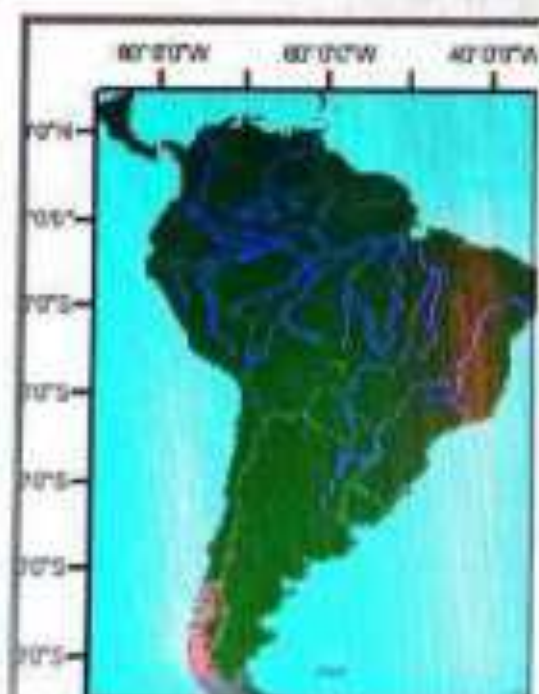
Coordinate System

Illumination

Grids

20

### Create a graticule



#### Appearance

- Labels only
- Tick marks and labels
- Graticule and labels

Style:



#### Intervals

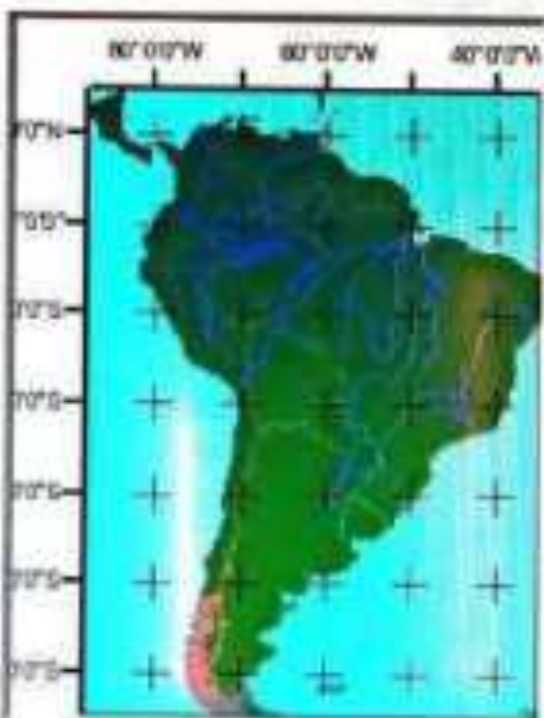
	Deg	Min	Sec	
Place parallels every	<input type="text" value="10"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	latitude
Place meridians every	<input type="text" value="10"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	longitude

< Back

Next >

Cancel

Create a graticule



Appearance

- Labels only
- Tick marks and labels
- Graticule and labels

Style



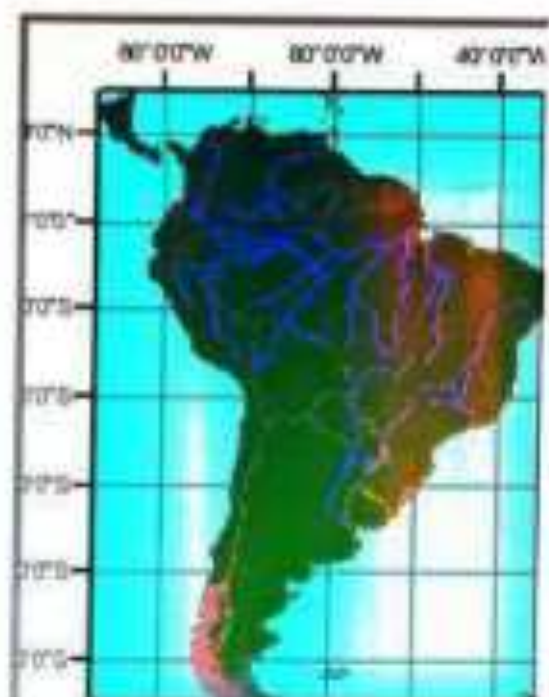
Intervals

	Deg	Mn	Sec	
Place parallels every	<input type="text" value="10"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	latitude
Place meridians every	<input type="text" value="10"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	longitude

< Back

Next >

Cancel



## Appearance

- Labels only
- Tick marks and labels
- Graticule and labels

Style:

## Intervals

	Deg	Min	Sec	
Place parallels every	<input type="text" value="10"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	latitude
Place meridians every	<input type="text" value="10"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	longitude

&lt; Back

Next &gt;

Cancel

Feature Cache  
General

Annotation Groups  
Data Frame

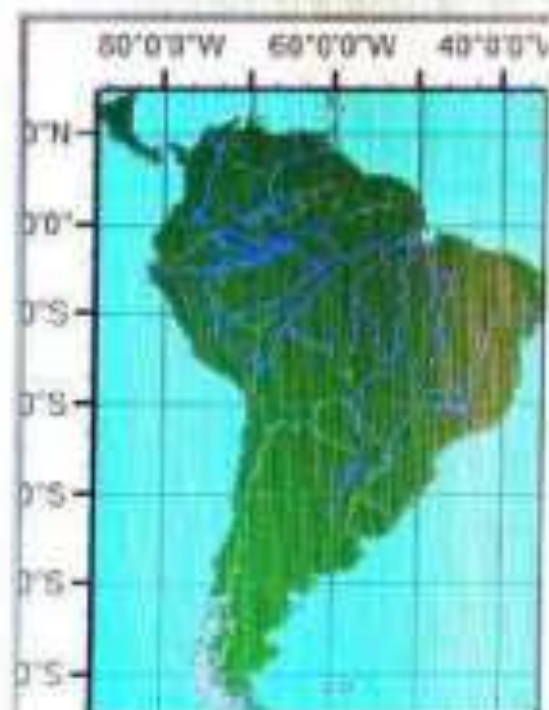
Extent Indicators  
Coordinate System

Frame  
Illumination

Size and Position  
Grids

20

### Axes and labels



#### Axes

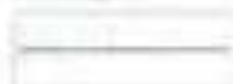
Major division ticks

Line style:



Minor division ticks

Line style:



Number of ticks per major division:

#### Labeling

Text style:

AaBbCc...

< Back

Next >

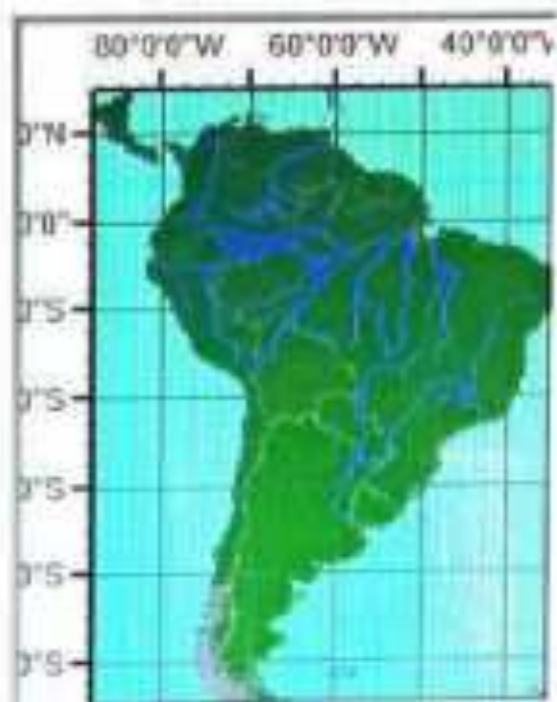
Cancel



Custom Data Frame Properties

Feature Cache	Annotation Groups	Extent Indicators	Frame	Size and Position
General	Data Frame	Coordinate System	Illumination	Grids

Axes and labels



Axes

- Major division ticks
- Minor division ticks

Line style

Line style

Number of ticks per major division

Labeling

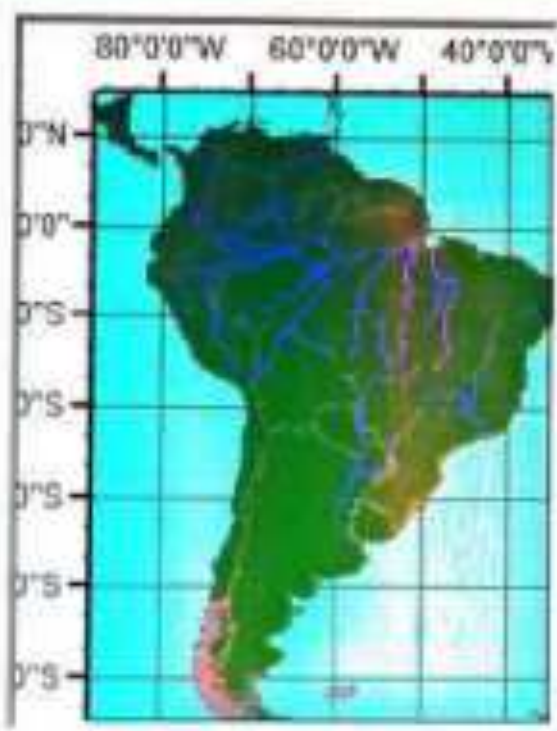
Text style:

Custom... | Data Frame Properties [X]

Feature Cache    Annotation Groups    Extent Indicators    Frame    Size and Position  
General    Data Frame    Coordinate System    Illumination    Grids

20

Create a graticule [X]



Graticule Border

Place a simple border at edge of graticule



Place a calibrated border at edge of graticule



Neatline

Place a border outside the grid



Graticule Properties

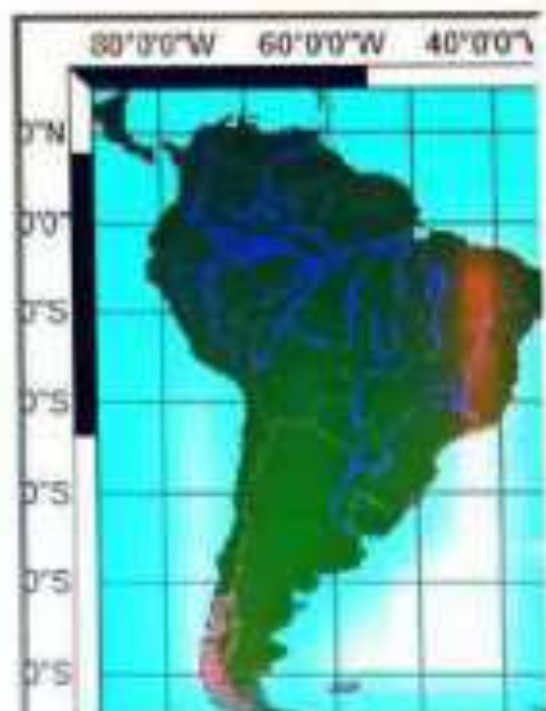
Store as a static graphic that can be edited

Store as a fixed grid that updates with changes to the data frame

< Back    Finish    Cancel

Feature Cache	Annotation Groups	Extent Indicators	Frame	Size and Position
General	Data Frame	Coordinate System	Illumination	Grids

### Create a graticule



#### Graticule Border

- Place a simple border at edge of graticule



- Place a calibrated border at edge of graticule

Properties...

#### Neatline

- Place a border outside the grid



#### Graticule Properties

- Store as a static graphic that can be edited
- Store as a fixed grid that updates with changes to the data frame

< Back

Finish

Cancel

Feature Cache  
General

Annotation Groups  
Data Frame

Extent Indicators  
Coordinate System

Frame  
Illumination

Size and Position  
Grids

Reference grids are drawn on top of the data frame in Layout view only.

Graticule

New Grid...

Remove Grid

Style...

Properties...

Convert To Graphics

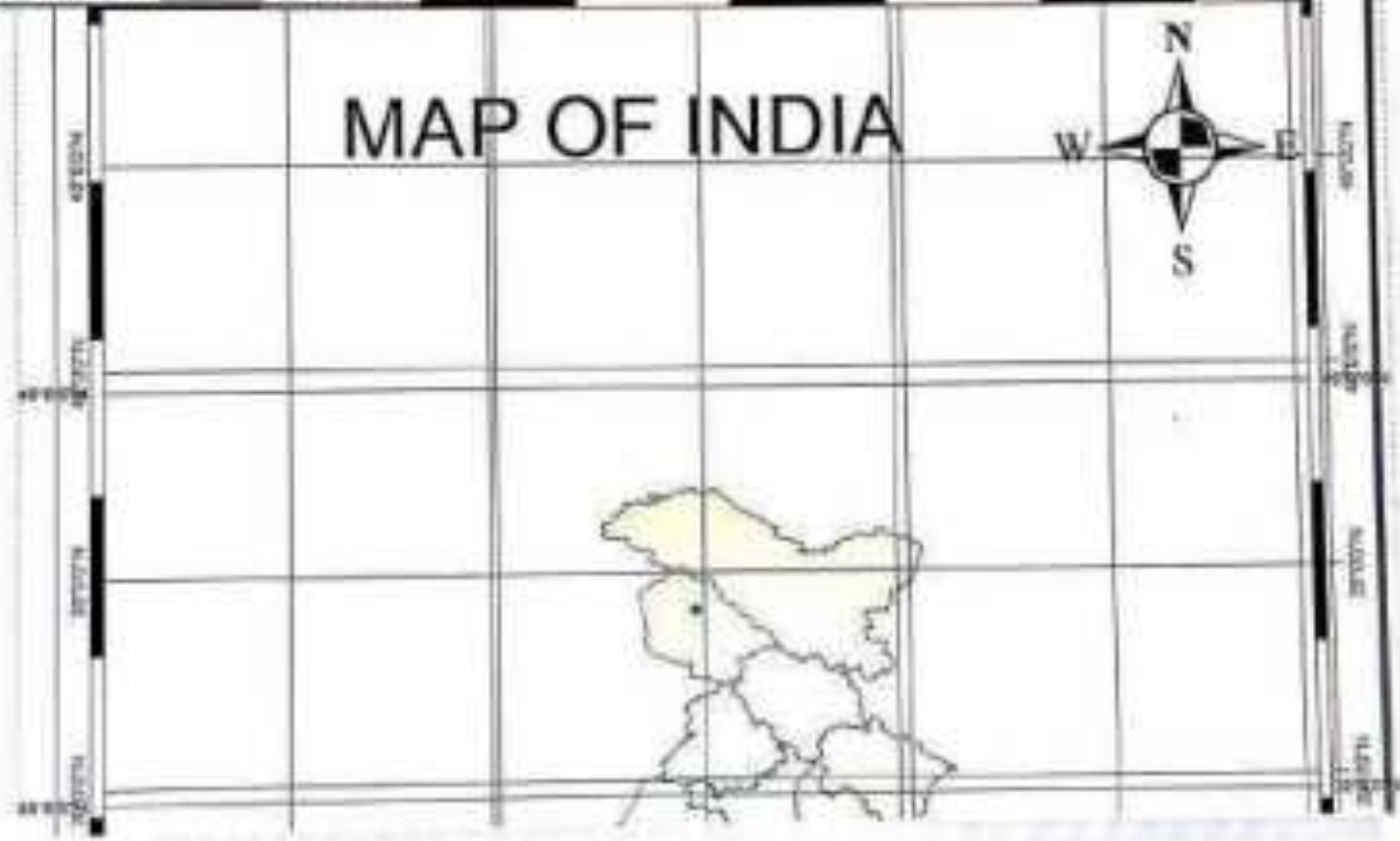
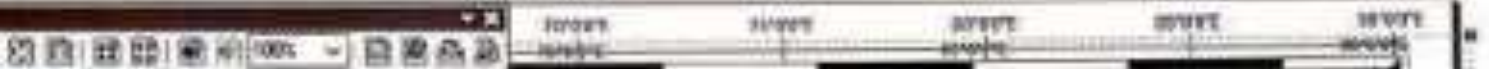
OK

Cancel

Apply



1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20



**Hands On**

# CONVERSION OF TABULAR DATA INTO GIS

**Training Course on  
'Marine GIS for Operational Oceanography'**

**January 18-22, 2016**

**P Sai Bharadwaj**  
[saibharadwaj.p@incois.gov.in](mailto:saibharadwaj.p@incois.gov.in)

**International Training Centre for Operational Oceanography(ITCOcean),**

**INCOIS, Hyderabad, India**



# Overview

- Generation of point shapefile from tabular data (spreadsheet or CSV)
- Joining attribute information to shapefile
- Prepare population map
- Tools needed
  - ArcGIS
  - Microsoft excel or any spreadsheet software

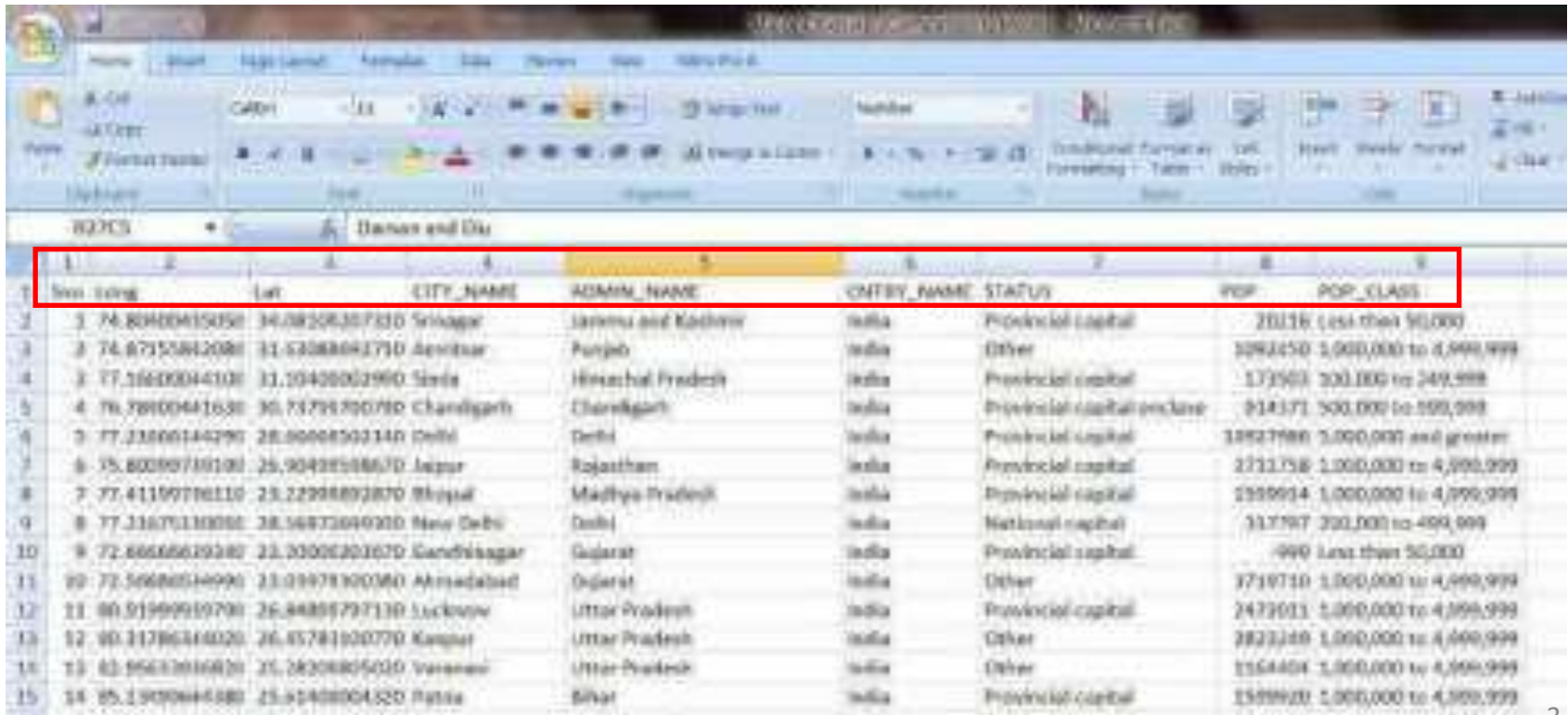
Data Credits:

Global Admin Boundaries - <http://www.gadm.org>

Wikipedia

## Task -1 : Importing spreadsheet data in to ArcGIS

- Open the exercise folder and open the excel file “Major cities.xls”
- It contains the positional information (Longitude, Latitude) and the attribute information (City name, State Name, Population information, etc.)

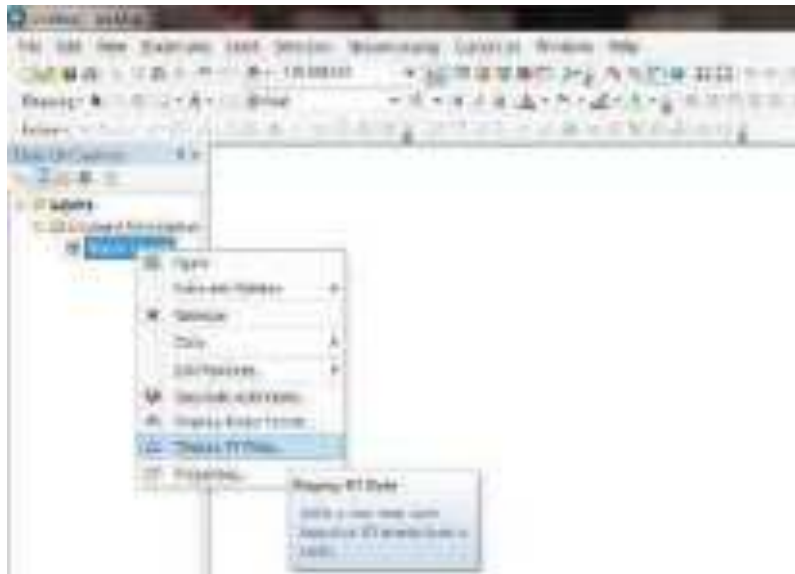
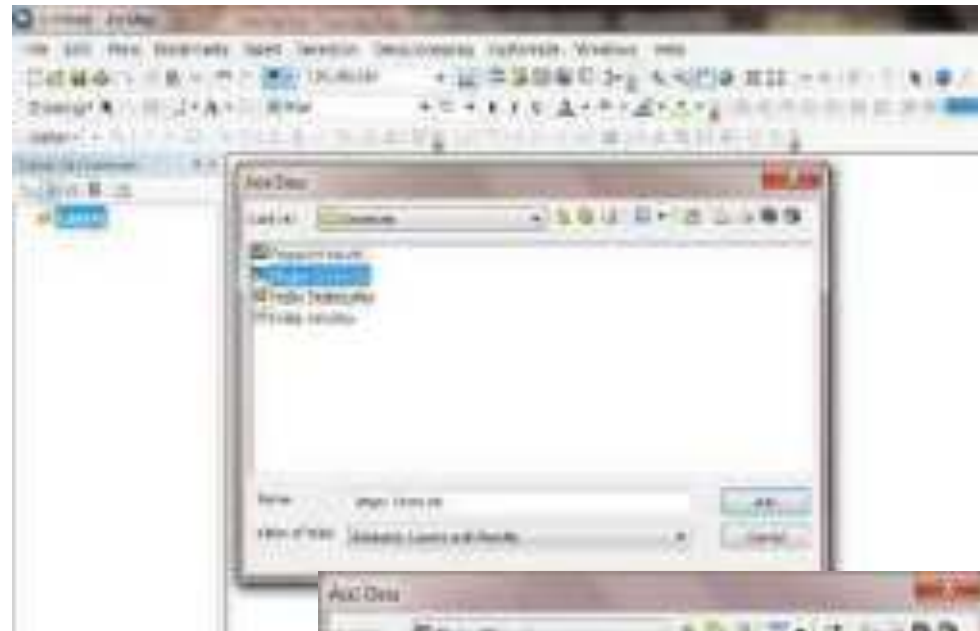


The image shows a screenshot of an Excel spreadsheet with the following data:

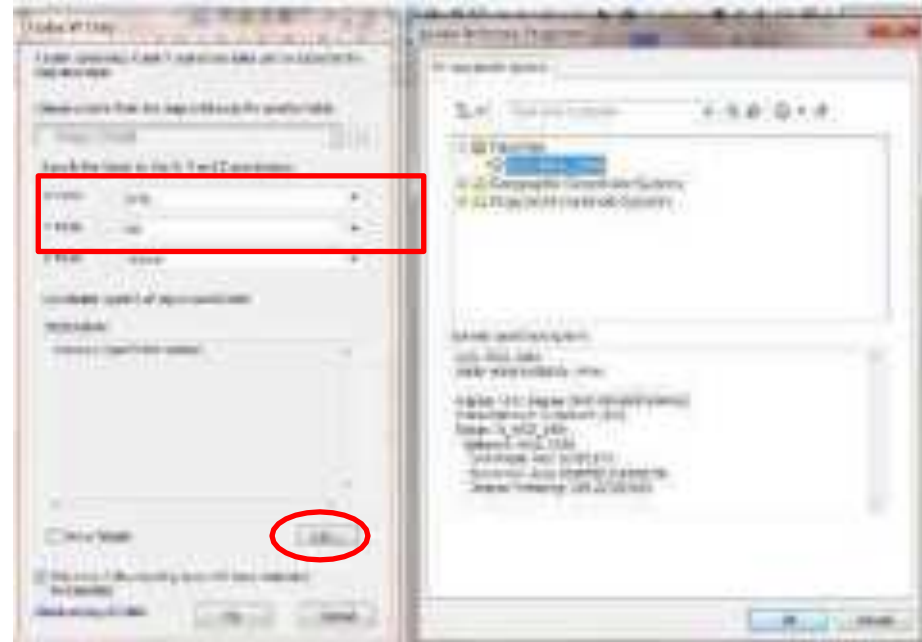
	1	2	3	4	5	6	7	8	
	lon	long	lat	CITY_NAME	ADMIN_NAME	CNTRY_NAME	STATUS	POP	POP_CLASS
2	1	74.80400415050	34.08204307310	Shriagar	Jammu and Kashmir	India	Provincial capital	20116	Less than 50,000
3	2	74.87555812080	31.62888641710	Ajmir	Punjab	India	Other	1084450	1,000,000 to 4,999,999
4	3	77.19000044100	31.20400022960	Simla	Himachal Pradesh	India	Provincial capital	173503	300,000 to 249,999
5	4	76.78000441630	30.73791700780	Chandigarh	Chandigarh	India	Provincial capital enclave	914371	500,000 to 999,999
6	5	77.21860144290	28.30000503140	Delhi	Delhi	India	Provincial capital	1882788	5,000,000 and greater
7	6	75.80000718100	25.90428508670	Jodhpur	Rajasthan	India	Provincial capital	2711758	1,000,000 to 4,999,999
8	7	77.41199718110	23.22998892870	Bhopal	Madhya Pradesh	India	Provincial capital	1906914	1,000,000 to 4,999,999
9	8	77.31670118080	28.56872649300	New Delhi	Delhi	India	National capital	317787	300,000 to 499,999
10	9	72.66000619380	21.30000301670	Gandhinagar	Gujarat	India	Provincial capital	990	Less than 50,000
11	10	72.59000514990	21.03978300360	Ahmedabad	Gujarat	India	Other	3718710	1,000,000 to 4,999,999
12	11	80.91999919790	26.44889797130	Lucknow	Uttar Pradesh	India	Provincial capital	2473011	1,000,000 to 4,999,999
13	12	80.31786314020	26.85781900770	Kanpur	Uttar Pradesh	India	Other	2823248	1,000,000 to 4,999,999
14	13	81.89030816670	25.26308805000	Vareanasi	Uttar Pradesh	India	Other	1164404	1,000,000 to 4,999,999
15	14	85.19000444880	25.91400043200	Ratna	Bihar	India	Provincial capital	1588920	1,000,000 to 4,999,999



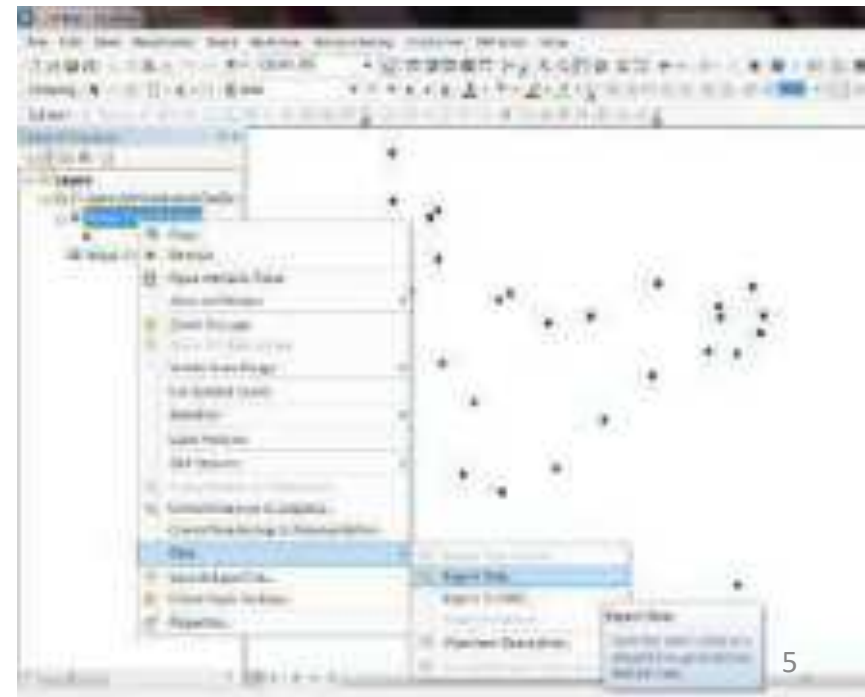
- Now to connect to this folder in ArcMap document and select the “Major cities.xls” file and click add
- Select the sheet “Major Cities\$” and click add
- The sheet is now added to the ArcMap document
- Right click on the ‘Major cities\$’ and select Display XY data



- In the X Field and Y Field select Long and Lat respectively
- Click on **“Edit”** tab below **Description** and choose **GCS\_WGS\_1984** in **Spatial Reference Properties** and click **ok**
- Or search for 4326 (EPSG Code)

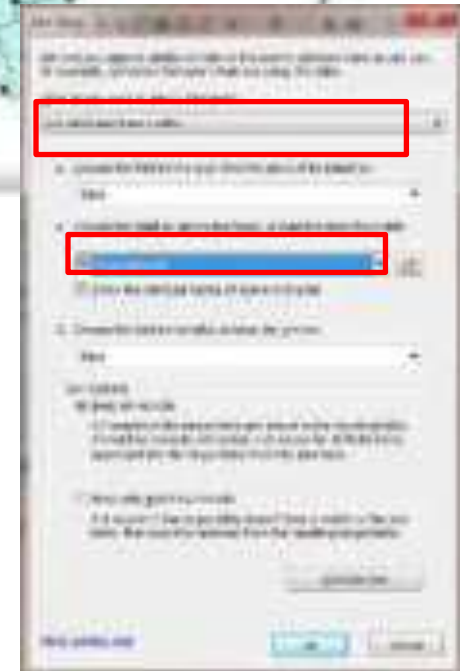
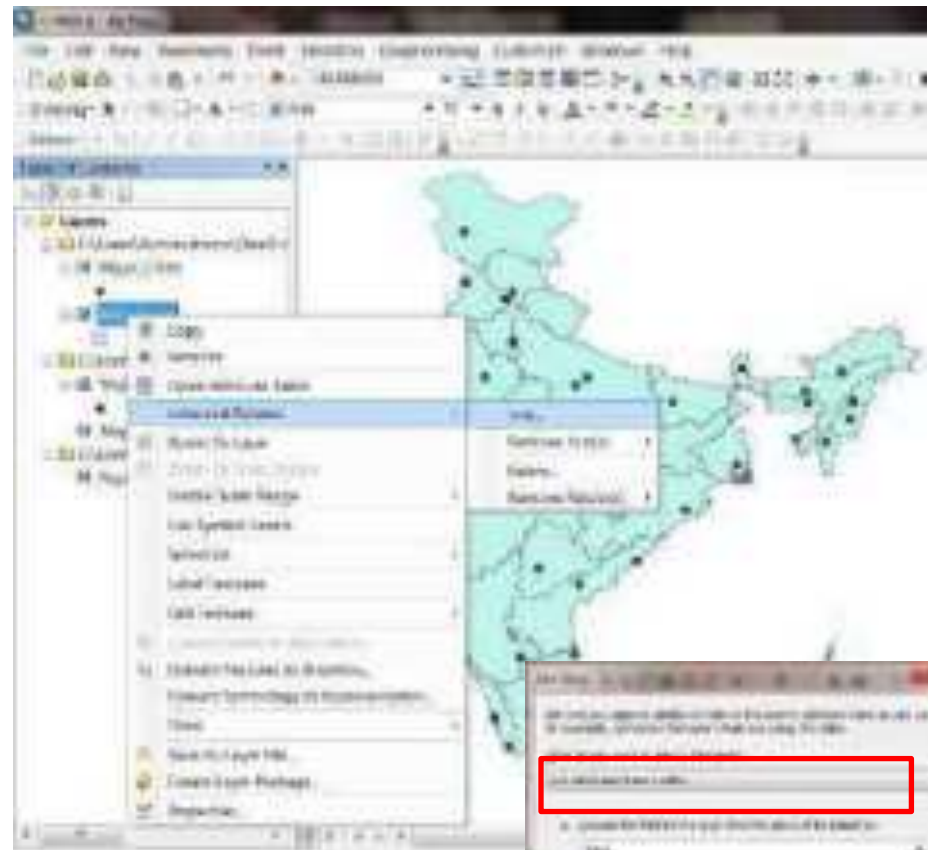


Right click on the point file and **Export Data** as shapefile and add it to the ArcMap document



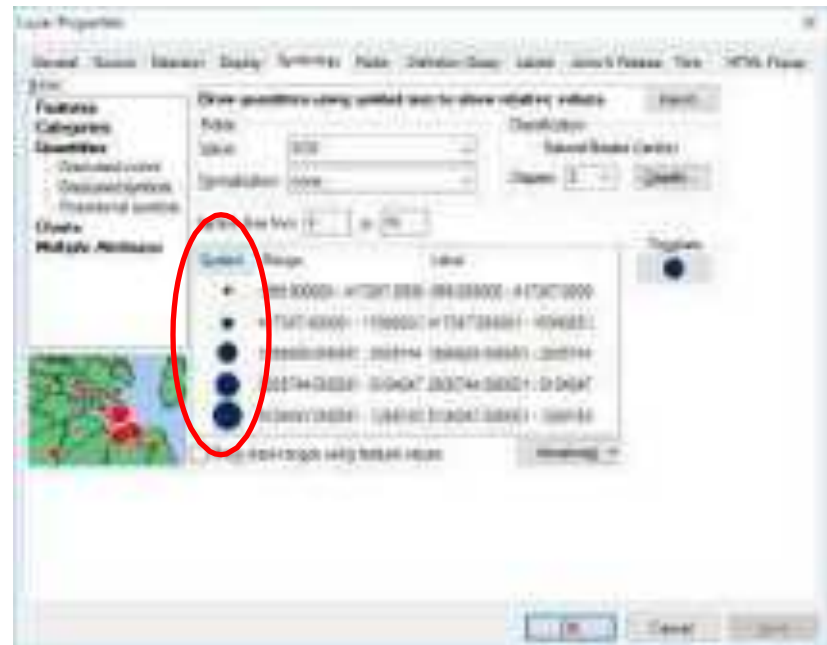
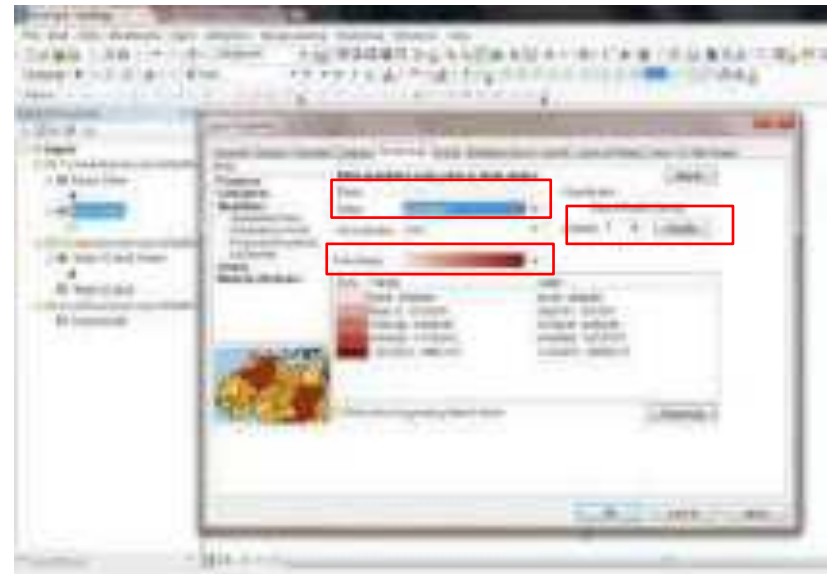
## Task -2 : Joining attribute data to shapefile

- Add the **India States** shapefile to the ArcMap document
- Add **Population\$** sheet from the excel file **Population.xls** which contains the state names, population and area.
- Right click on **India States** and select **Join** in the **Join and Relates** tab
- Choose **Population\$** as the table to join and select the States as the join **Fields** and click ok.
- Open attribute table of the India States it can be observed that the fields of Population excel sheet are added

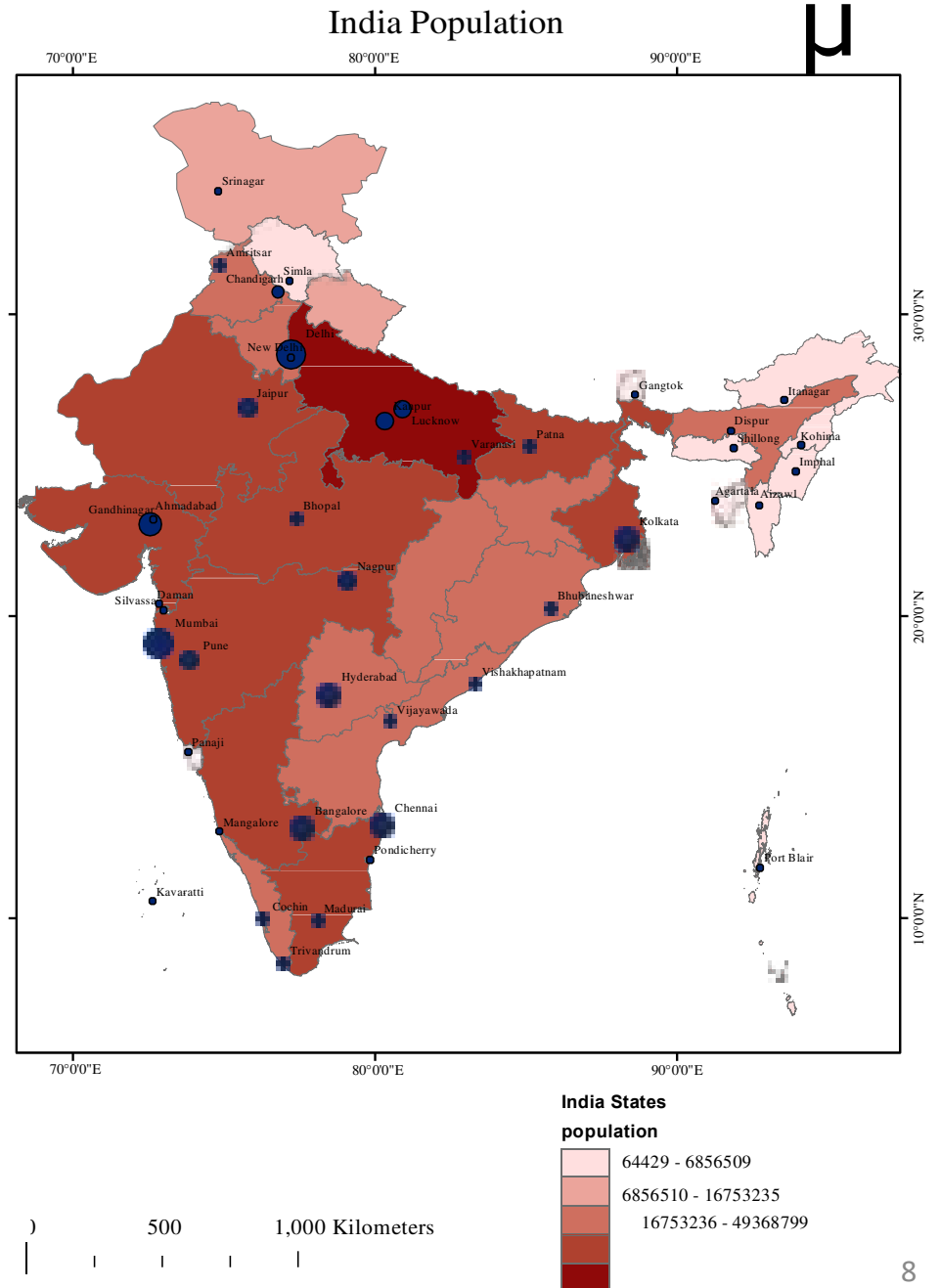


### Task – 3 : Generation of population map

- Goto Layer **Properties** → **Symbology** → **Quantities** → **Graduated colors**
- Select value as population and choose the Color Ramp, set the classes to five and click ok
- Insert Label for the cities and states
- Apply symbology to major cities based on population
- **Properties** → **Symbology** → **Quantities** → **Graduated Symbols**
- Choose the **Value** field as POP and with the left click on the **Symbol** change the change the symbol color and size



Switch to layout view and insert Grid,  
 Label, Scale, Legend and North  
 Arrow and export map



## Other Tutorials

<http://www.esri.com/news/arcuser/0312/importing-data-from-excel-spreadsheets.html>



Legend Wizard

Choose which layers you want to include in your legend

Map Layers:

Sheet 1\$ Events  
india\_states



Legend Items

india\_states  
Sheet 1\$ Events



Set the number of columns in your legend:

1

Preview

Back

Next >

Cancel





5 10 15 20

Legend Wizard

Legend Title

INDIA MAP WITH ITS CAPITALS

Legend Title font properties

Color: 

Size: 14

Font: Arial



Title Justification

You can use this to control the justification of the title with the rest of the legend



Preview

Back Next Cancel



Legend Wizard



You can change the size and shape of the symbol patch used to represent line and polygon features in your legend.

Select one or more legend items whose patches you want to change.

Legend Items:

- roads - lines

Patch

Width: 28.00 (pts.)

Height: 14.00 (pts.)

Line:  v

Area:  v

Preview

< Back

Next >

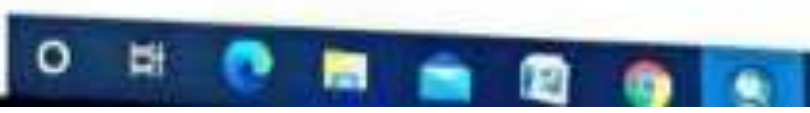

Cancel

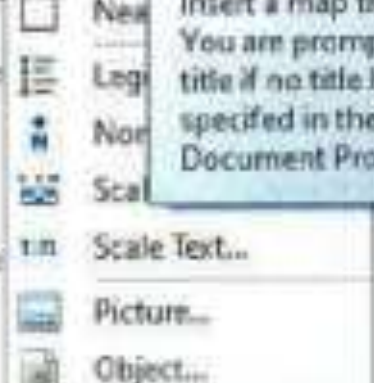
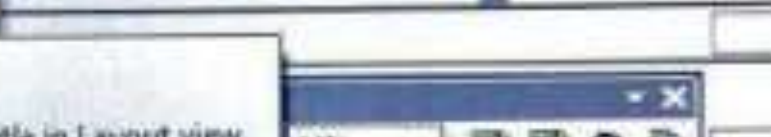
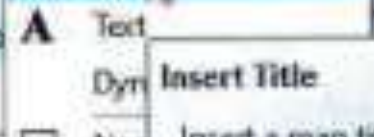
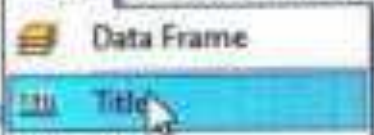
Layout

File Edit View Insert Format Tools Help

INDIA MAP WITH ITS CAPITALS

- State Name
- State's Capital





**Insert Title**  
 Insert a map title in Layout view. You are prompted to enter the title if no title has already been specified in the File > Map Document Properties dialog.



Insert Title

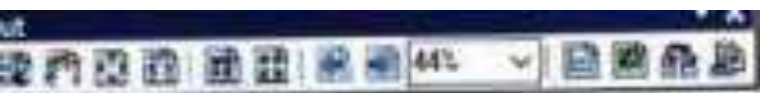
What title would you like to give your map?

OK Cancel

**INDIA MAP WITH ITS CAPITALS**

- India\_states
- State's Capitals





What title would you like to give your map?

MAP OF INDIA

OK Cancel

**INDIA MAP WITH ITS CAPITALS**

- INDIA\_STATES
- INDIA\_CAPITALS



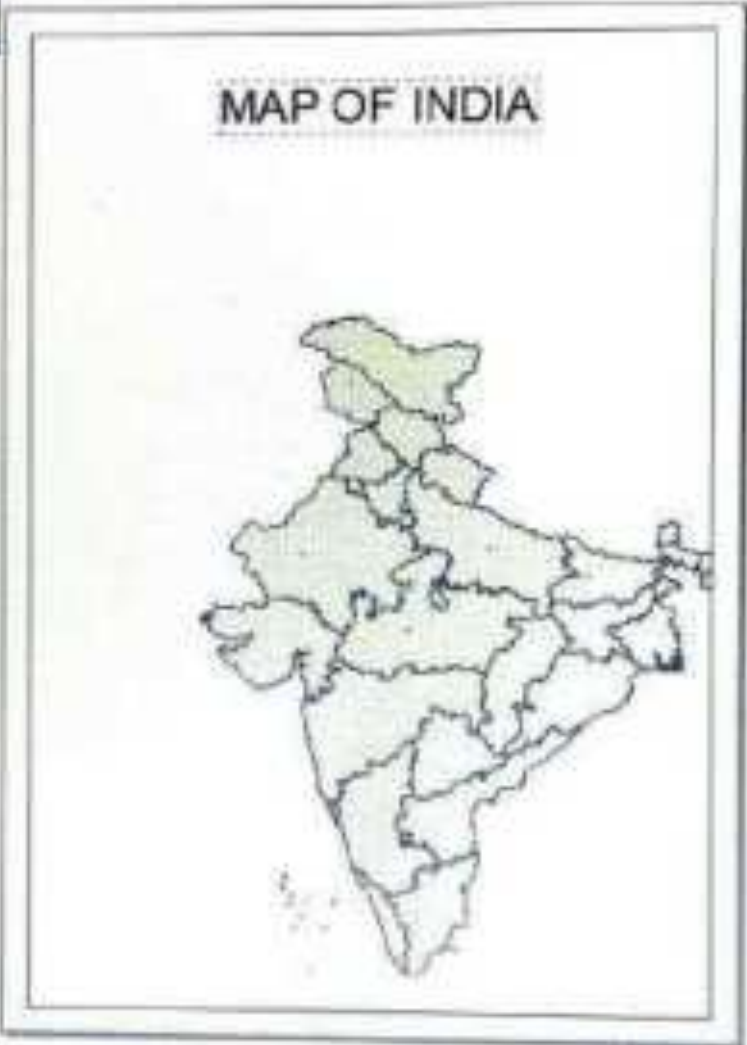
Layout [X]

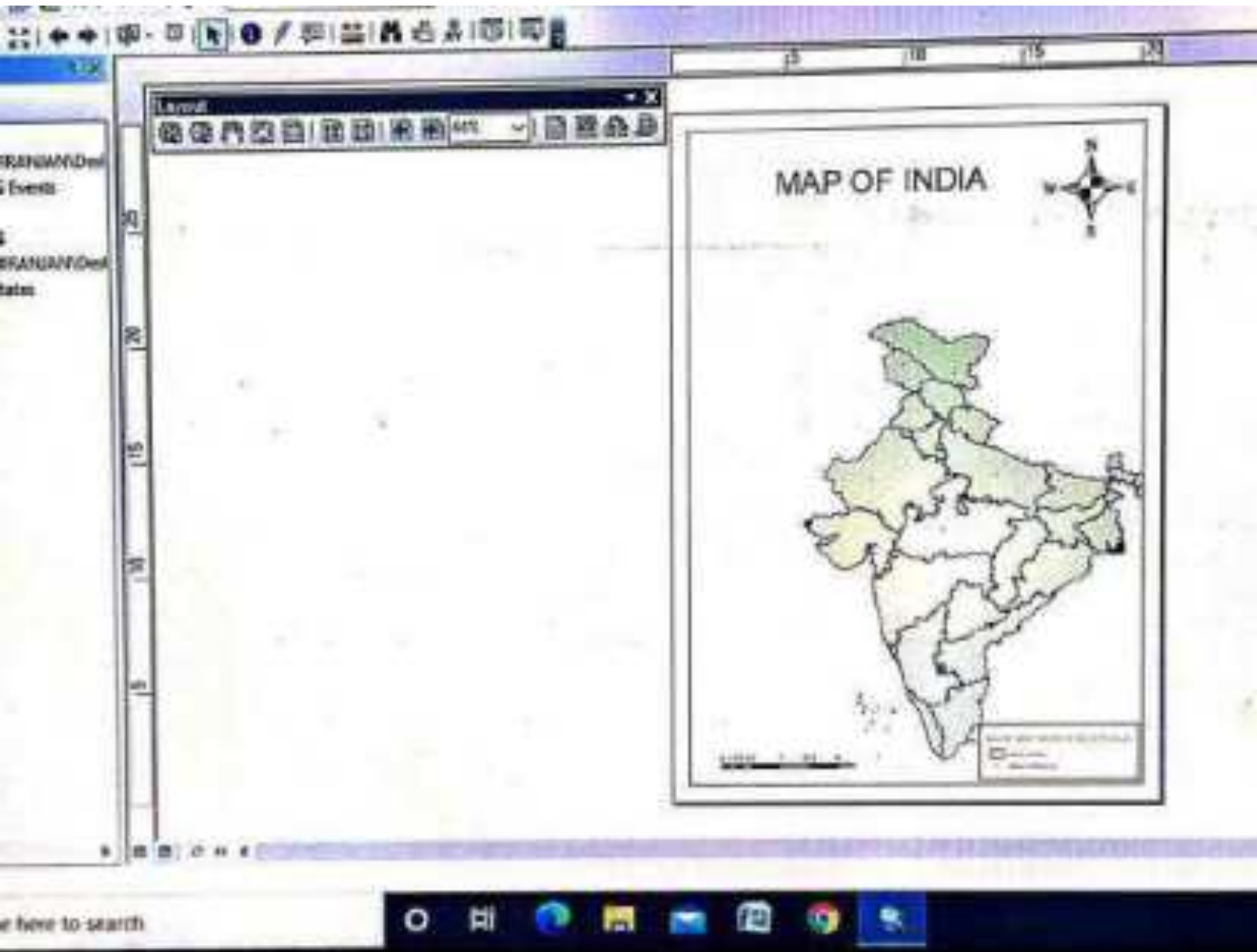
Navigation icons: Home, Back, Forward, Search, Print, Refresh, etc.

44%

**INDIA MAP WITH ITS CAPITALS**

- India\_states
- State's Capitals





# MAP OF INDIA



- Legend
- State
- Union Territory

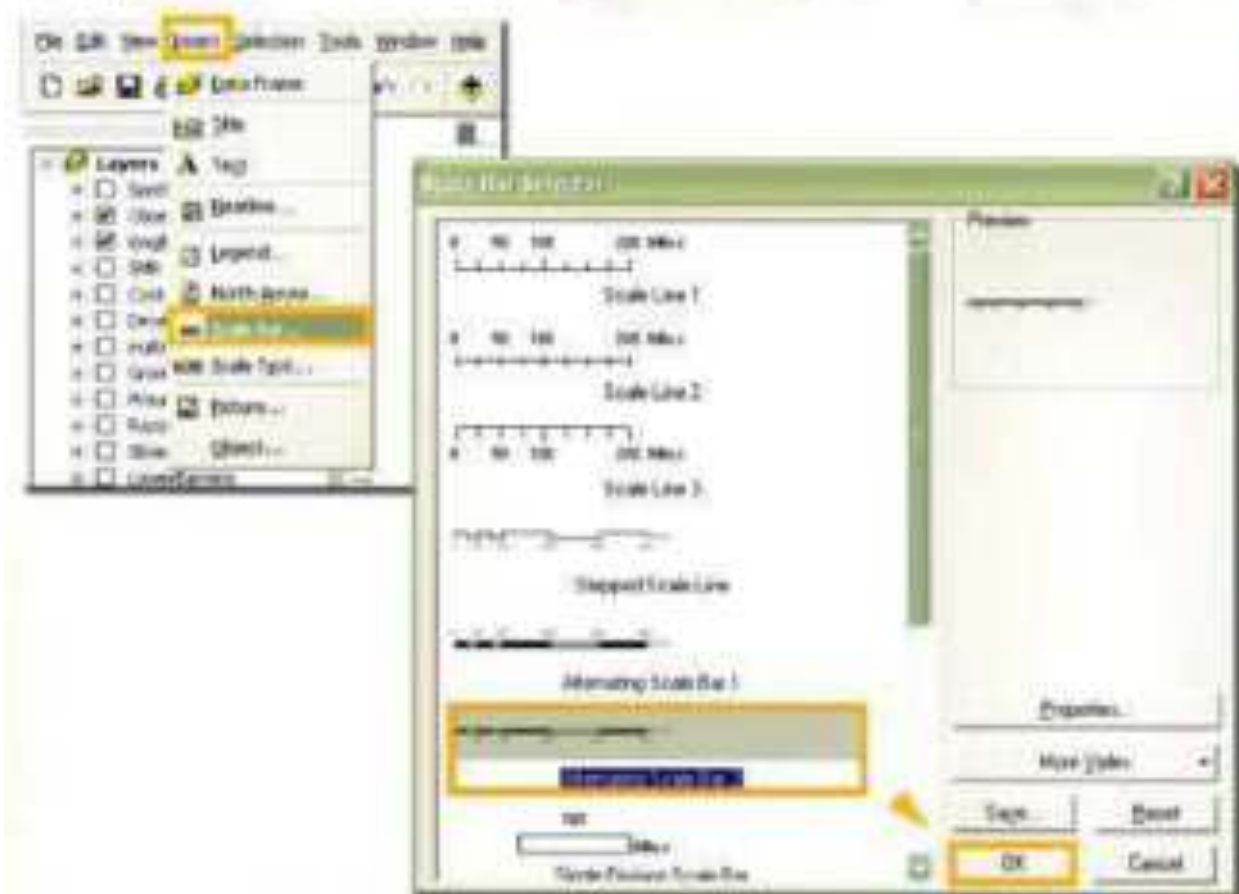
Search here to search



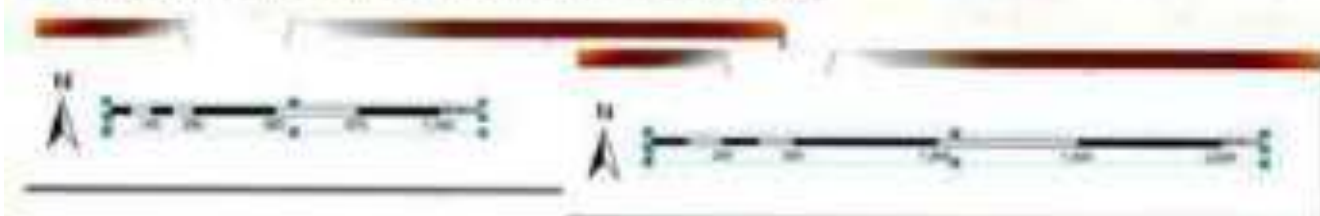


### 3. Adding a scale bar to a map

Next, we need to add a scale bar. Return to the "Insert" menu and select "Scale Bar". A new form will appear. Choose an bar that you like from the list, and click on "OK". It will appear somewhere in the middle of your map.



Drag it to a more sensible position, preferably somewhere over the white page. You will notice that it will likely be split into subdivisions at rather odd positions. Click on the bar, grab the square on the right hand edge and resize it horizontally. The split positions will change. Repeat this until the scale bar features sensible round number units:

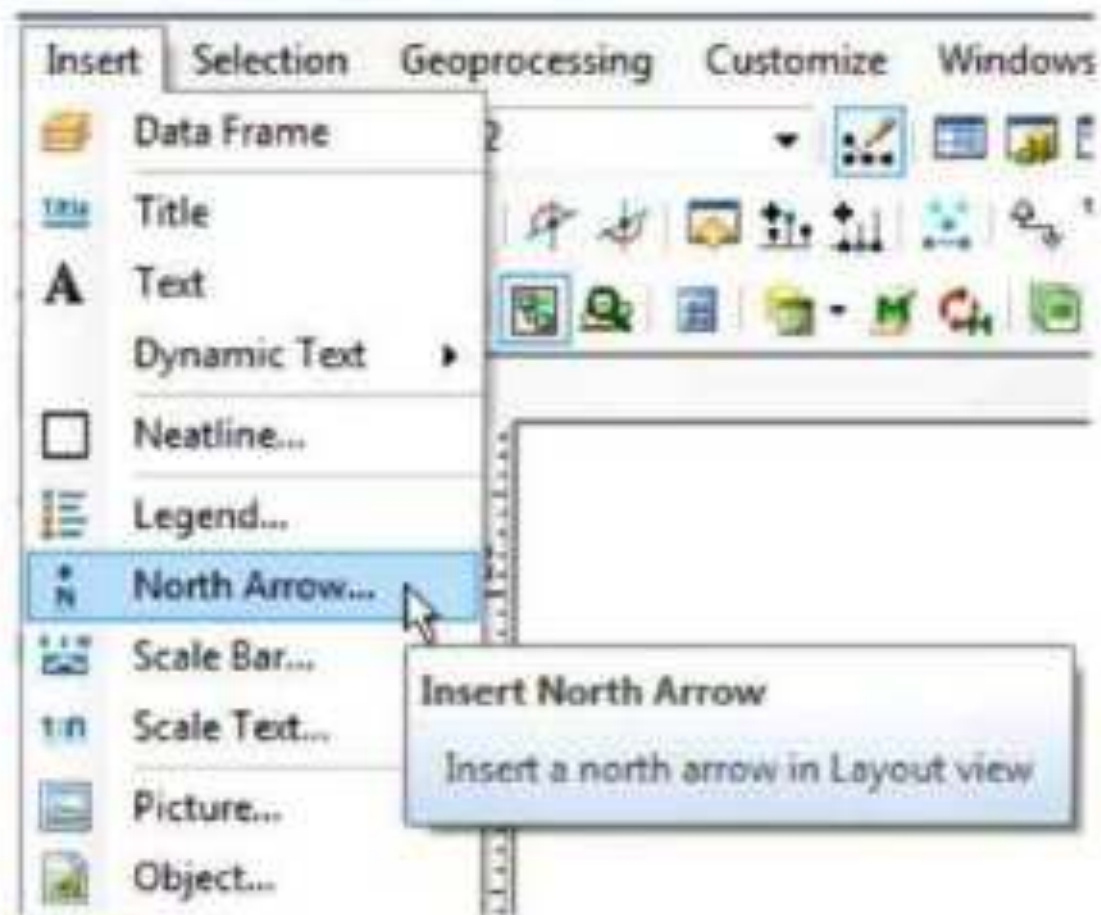


If you want to change the number of divisions, the units, or the spacing of the elements in the scale bar, right click on it and select "Properties". In the form that appears, make sure you are on the "Scale and Units" page. Here you can adjust the number of divisions and subdivisions. Try to do so and watch the scale bar change on the map (click on "Apply" to view these changes). You can also change the units. See what happens to the scale bar when you change to kilometres or miles. However, metres is the sensible unit for this scale of map, so change it back when you are done. You may need to resize the scale bar again when you have finished. Finally, change the spacing of the label from the end of bar to about five or six points.

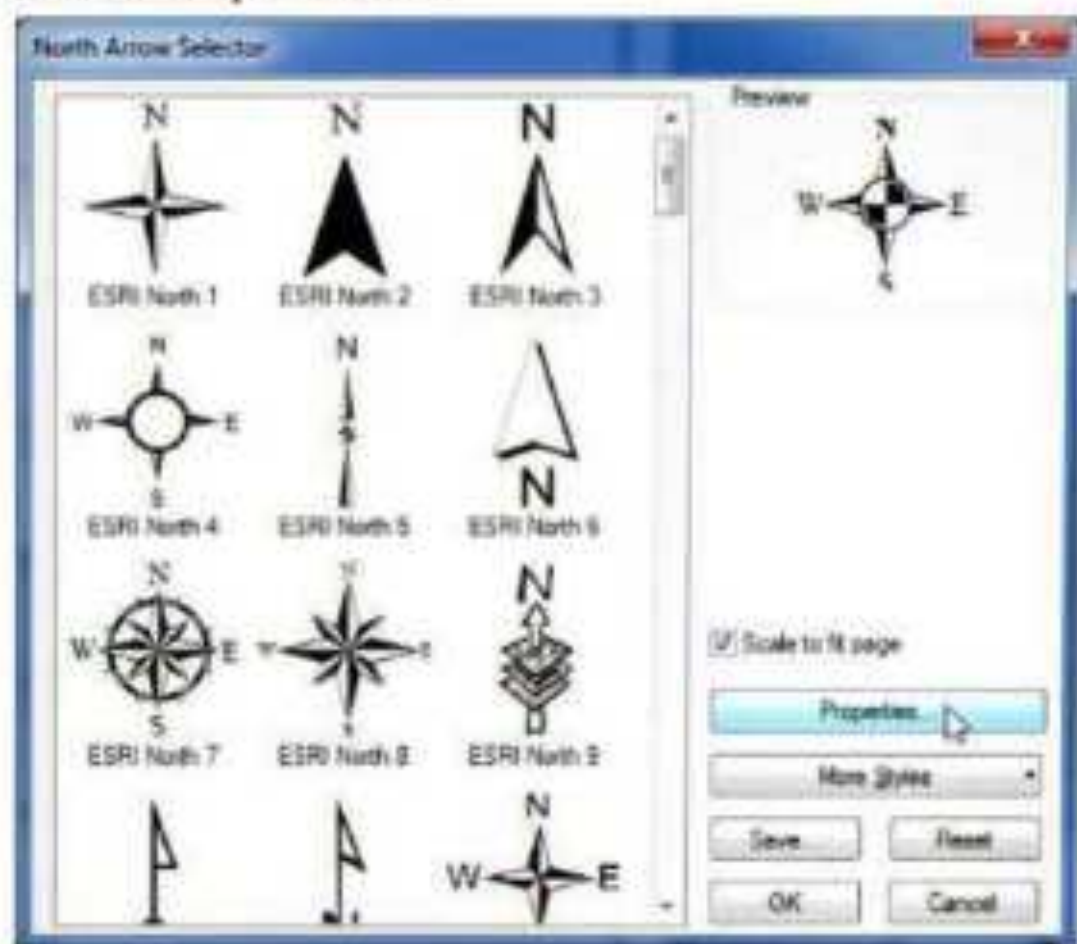


On the other pages of this properties window, you can change which subdivisions and divisions are labelled, and the fonts used. Feel free to experiment. When you are done, click on "OK".

1. In ArcMap on the layout view select *Insert > North Arrow*



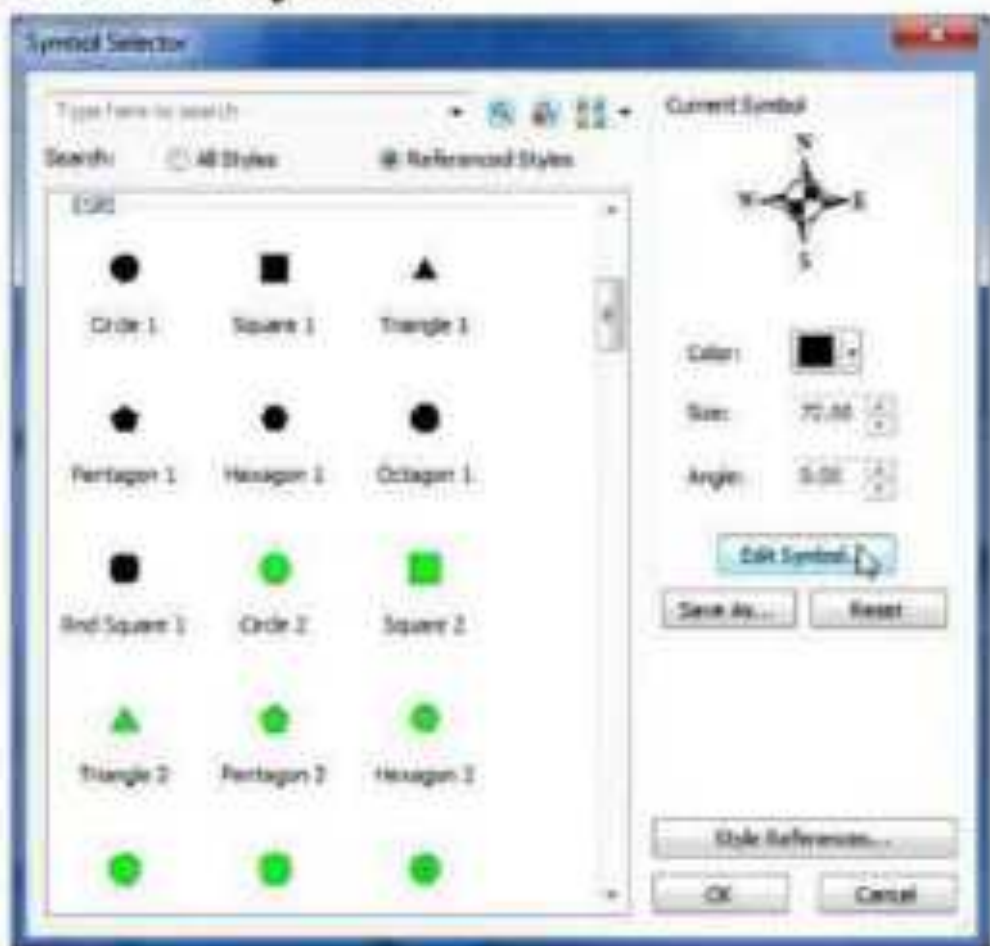
2. Click *Properties*



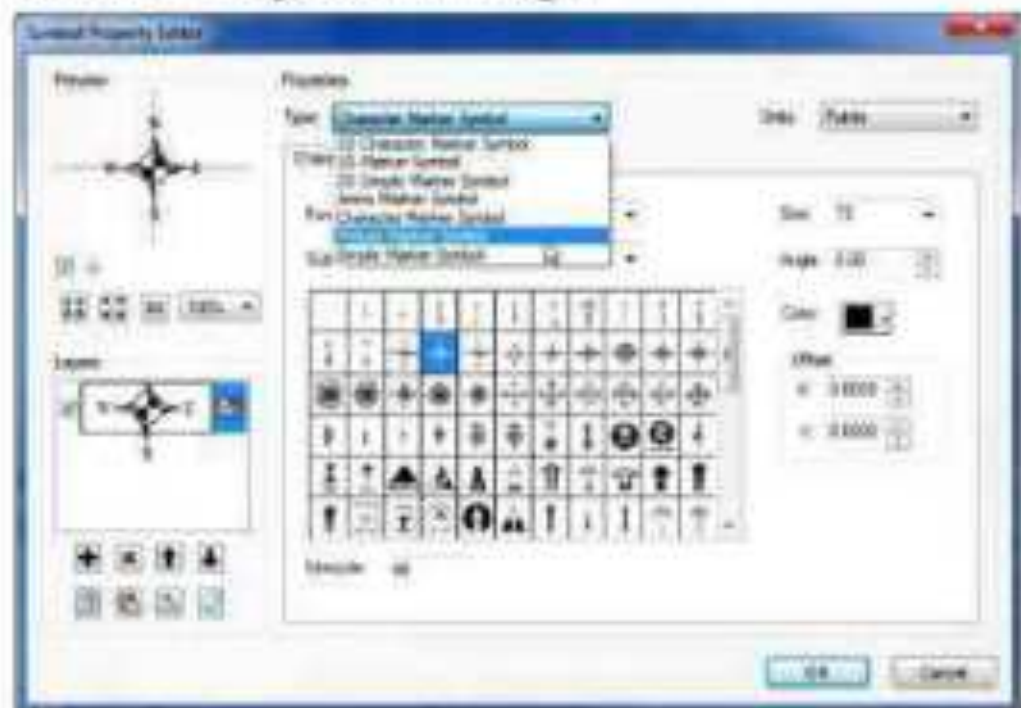
### 3. Click Symbol



### 4. Click Edit Symbol



5. Select *Picture Marker Symbol* and browse to your image



6. Set the size of your North Arrow



7. OK all the way back to your map

You should now see your north arrow on your layout, ready to be positioned and sized as required.












Bookmarks

Insert

Selection

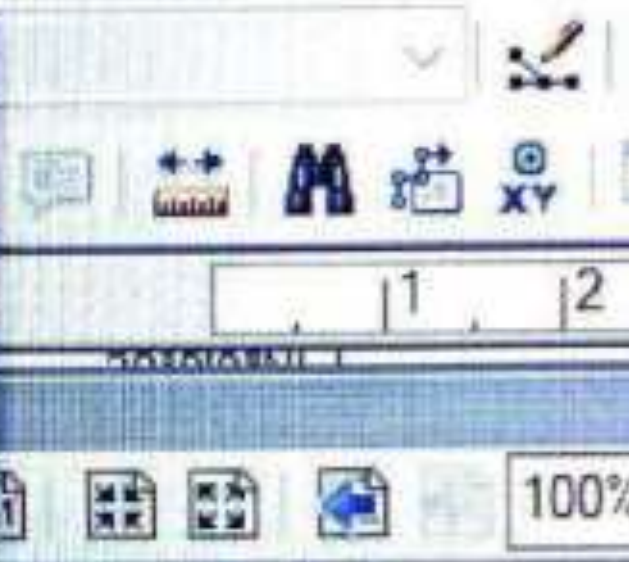
Geoprocessing

Customize

-  Data Frame
-  Title
-  **A** Text
-  Dynamic Text
-  Neatline...
-  Legend...
-  North Arrow...
-  Scale Bar...
-  Scale Text...
-  Picture...
-  Object...

ANJAN\De  
Events

ANJAN\De  
tes



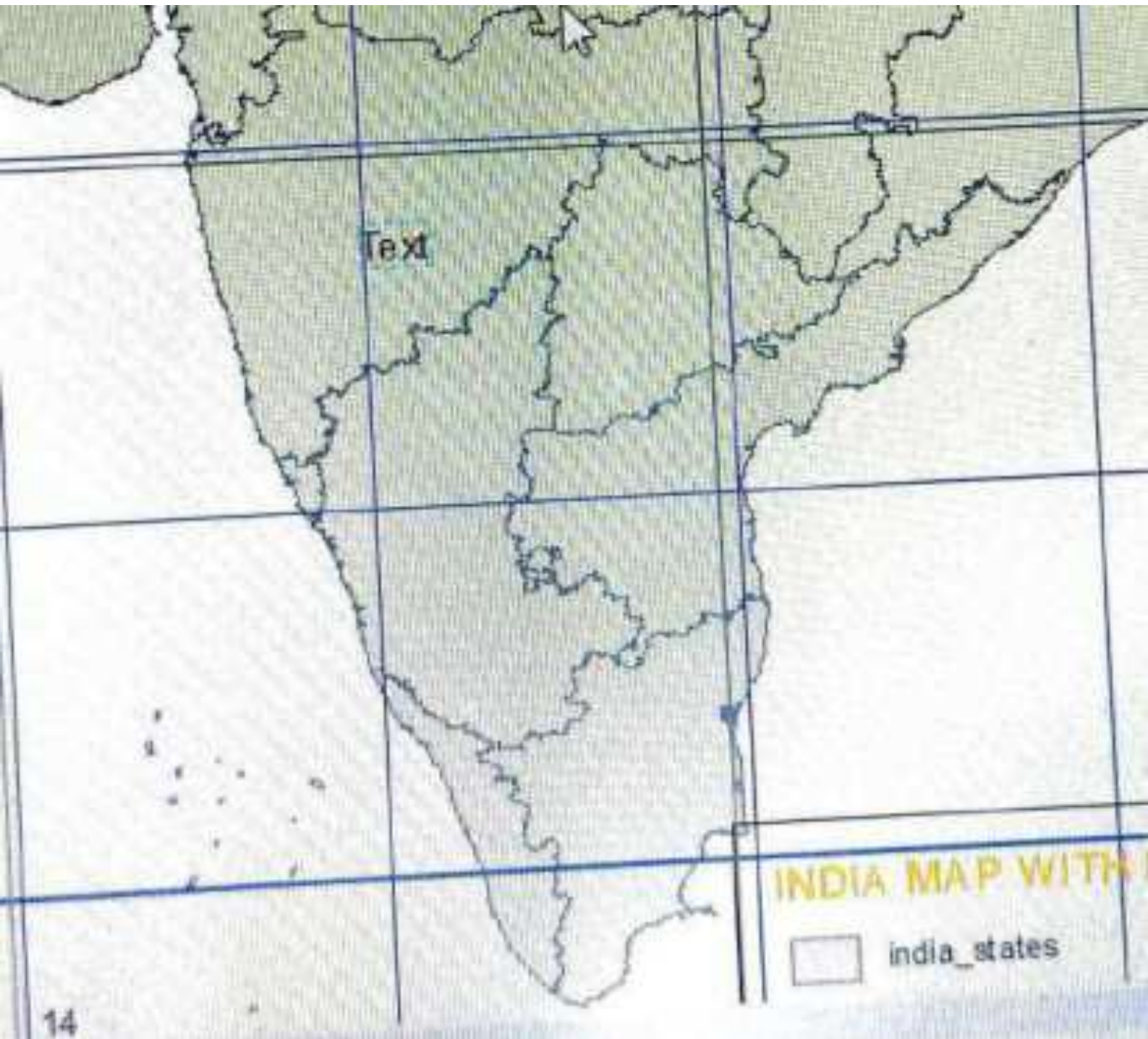
Map navigation toolbar with icons for Home, Previous View, Next View, Full Screen, and XY coordinates. A scale bar is visible below the toolbar.

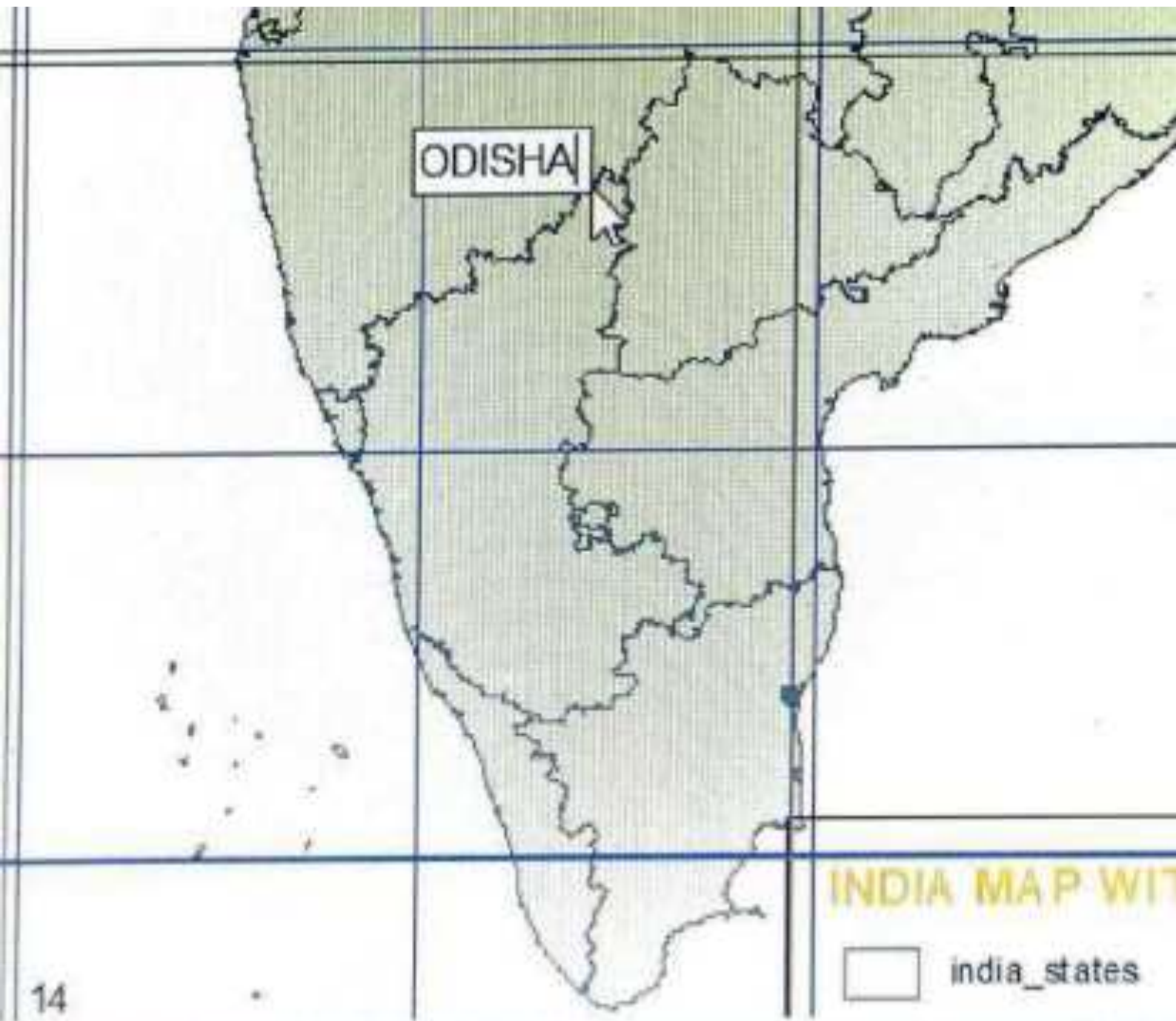
9... | 10... | 11

20°0'0"

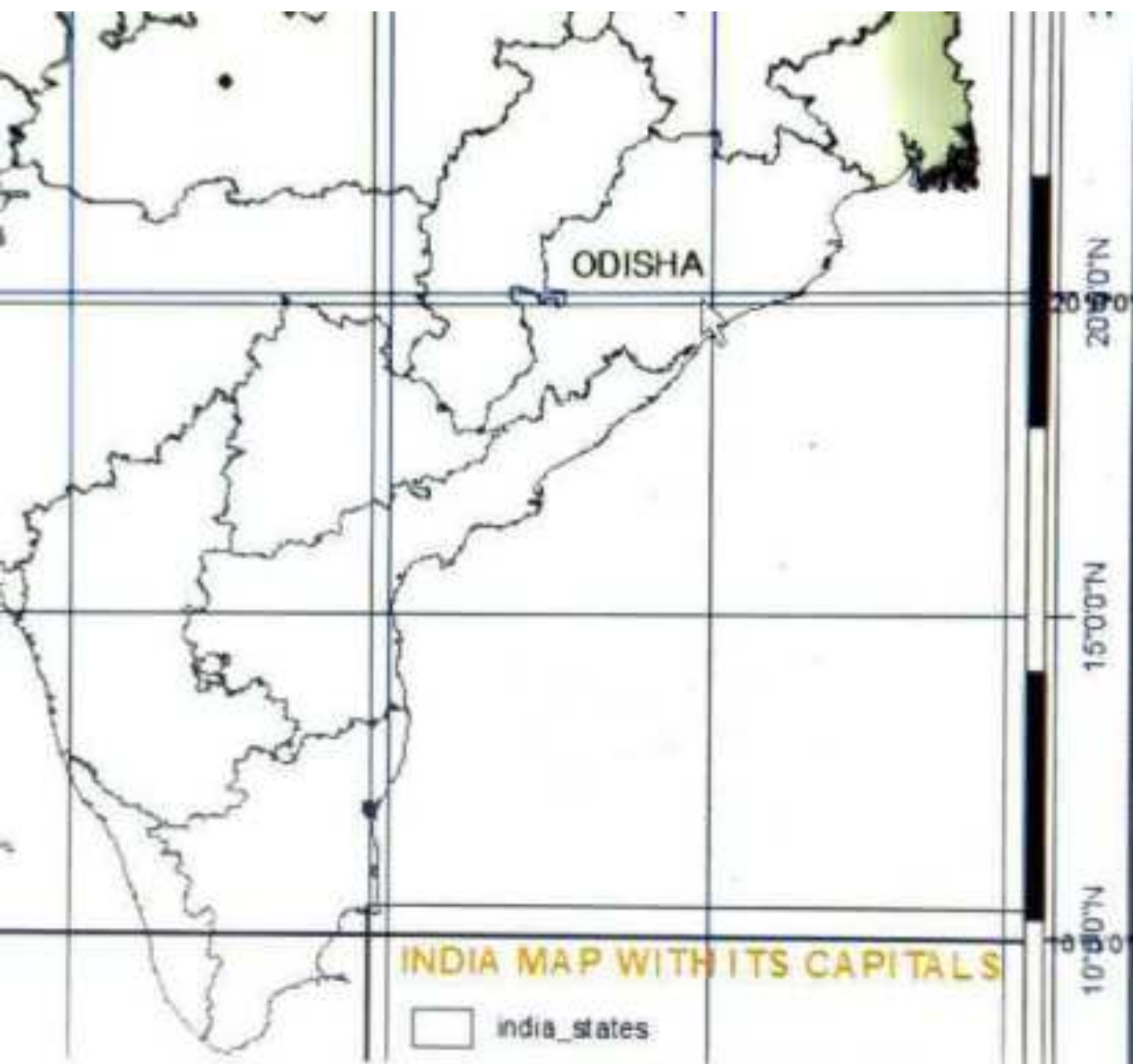
25°0'0"N

20°0'0"N









84.849 19.893 Decimal Degrees

16.67 9.55 C



- New... Ctrl+N
- Open... Ctrl+O
- Save Ctrl+S
- Save As...
- Save A Copy...
- Share As ▶
- Add Data ▶
- Sign In...
- ArcGIS Online...
- Page and Print Setup...
- Print Preview...
- Print...

**Export Map...**

- Analy...
- Map
- 1 C:\M
- 2 C:\M
- 3 C:\M
- 4 C:\M
- 5 C:\M

**Export Map**

Export this map to a file, such as a PNG, EPS, JPEG or PDF file. If you are in Data view, only your current map display extent will be exported. If you are in Layout view, your entire page layout will be exported.

ArcGIS



Name

Date modified

AddIns

25-10-2019 13:15

Default.gdb

10-06-2021 21:08

File name:

6th Sem Classes

Save as type:

EMF

EMF

EPS

AI

PDF

SVG

BMP

JPEG

PNG

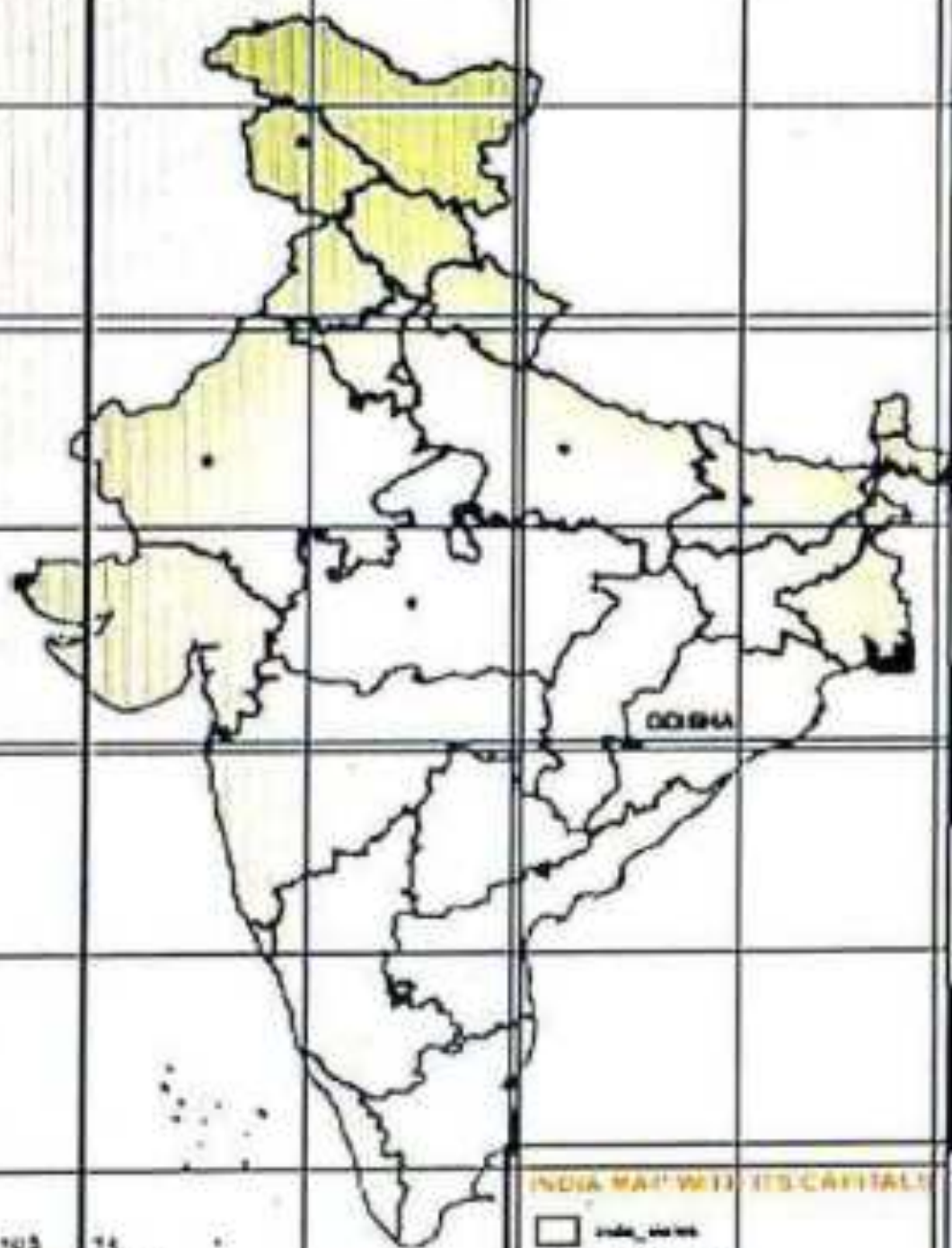
TIFF

GIF

300

Quality (Resample Ra

# MAP OF INDIA



INDIA MAP WITH ITS CAPITAL

- India, states
- Major cities

© 1992 7 103 14  
Scale: 1:100,000

**THANK YOU...!**

**For any query, contact through:**

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