

# **GENERAL CARTOGRAPHY- LABORATORY**

**Exercise 1: Construct Map Scales: Graphical, Comparative and Diagonal**

**Exercise 2 Construction of Cylindrical Projection**

:

**Exercise 3 Construction of Conical Projection**

:

**Exercise 4 Construction of Zenithal Projection**

:

**Exercise 5 Prepare Statistical Diagram from a Given Data**

:

**Exercise 6 Make a Choropleth and Isopleth Map from the Given Data**

:

**Exercise 7 Draw Prominent relief Features and Interpret Major Physical and Cultural Features from a given Toposheet**

:

**Exercise 8 Calculation of Slope Gradient by Wentworth's Method from a given Toposheet**

:

**Exercise 9 Prepare Climograph and Hythergraph from a given Data**

:

**Exercise 10 Prepare Wind Rose and Star Diagram from the given Data**

:

**Exercise 11 Interpretation of Indian Daily Weather Map**

:

**Exercise 12 Prepare Simple Thematic Maps from the given Data**

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**Glossary**

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## General Cartography - Laboratory

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The course titled 'General Cartography-Laboratory' (BGGCL-134) is a dedicated 2 credit laboratory course comprising of 12 exercises. This course is designed in such a way that the theoretical components dealt in the 'General Cartography' (BGGCT-133) theory course of the B.Sc. General in Geography Programme integrated mostly in the form of laboratory exercises to enhance the learner skills in the field of cartography. You are required to complete all the exercises given in the Laboratory and submit the same as per the given instructions. It is expected that after the completion of these exercises, you will gain hands-on experience and skills for reading, constructing and solving various aspects of geographical inquiry.

Exercise 1 deals with the map scales which consist of graphical, comparative and diagonal related to the Block 1 of Theory Course (BGGCT 133). The next three exercises are based on Block 2 dealing with the construction of cylindrical projections (Exercise 2), conical projections (Exercise 3) and zenithal projections (Exercise 4). Next two exercises 5 and 6 are developed on the basis of the theory component of Block 5. You will learn to make various types of statistical diagrams like one dimensional, two dimensional and three dimensional diagrams to depict varied nature of geographical data in Exercise 5. In Exercise 6, you will learn to prepare choropleth and isopleth maps from the given data to depict various kinds of geographical data through maps.

Next five Exercises-7, 8, 9, 10 and 11 are developed on the basis of theory component of Block 4. In the first two Exercises i.e. 7 and 8, you will learn to identify and draw prominent relief features along with interpretation of major physical and cultural features as well as calculation of Slope Gradient by Wentworth's method from a given toposheet. In the next two Exercises i.e. 9 and 10, you will learn the preparation of Wind Rose and Star Diagram and Simple Thematic Maps from the given data to depict various elements of weather and different geographical phenomenon. You will learn the interpretation procedures of Indian Daily Weather Map in Exercise 11 to comprehend the various aspects of weather and its importance. Last Exercise-12 is developed on the basis of theory component of Block 5 in which you will learn to prepare choroschematic and diagrammatic maps from the given data to represent varied nature of geographical data.

We hope that after performing the exercises of this laboratory course, you will acquire the basic practical skills to observe, construct and solve various contemporary problems related to geographical nature of inquiry. The skills which you would acquire in this course not only help to learn the basics of cartography and highlight different types of problems but also visualize the same through the art and science of cartography for holistic solutions.

Thus, you will certainly acquire the practical knowledge and skills to identify, draw and interpret various themes and sub-themes of geographical inquiry and will also be able to construct different types of map projections, statistical diagrams and thematic maps.

### **Guidelines for Performing the Exercises**

You must refer to the related units of the theory course along with laboratory manual before carrying out the given exercises. Besides, you are also required to check and explore the references mentioned at the end of units and exercises. There are twelve exercises which need to be completed in a span of six days. In other words, you have to perform and complete twelve laboratory sessions. On each day, two sessions will be conducted. The guidance of counsellor will be made available for performing the exercises. Such exercise will be known as 'Guided Exercises'. Term End Examination will be held on the last day i.e. seventh day in which the assigned exercises will be performed by the student independently. Such assigned exercises

are known as 'Unguided Exercises'. For your ready reference, the details are systematically mentioned in the table given below.

<b>DAY</b>	<b>Session 1</b>	<b>Session 2</b>
1	Exercise 1: Construct Map Scales: Graphical, Comparative and Diagonal	Exercise 2 : Construction of Cylindrical Projection
2	Exercise 3 : Construction of Conical Projection	Exercise 4 : Construction of Zenithal Projection
3	Exercise 5 : Prepare Statistical Diagram from a Given Data	Exercise 6 : Make a Choropleth and Isopleth Map from the Given Data
4	Exercise 7 : Draw Prominent relief Features and Interpret Major Physical and Cultural Features from a given Toposheet	Exercise 8 : Calculation of Slope Gradient by Wentworth's Method from a given Toposheet
5	Exercise 9 : Prepare Climograph and Hythergraph from a given Data	Exercise 10 : Prepare Wind Rose and Star Diagram from the given Data
6	Exercise 11 : Interpretation of Indian Daily Weather Map	Exercise 12 : Prepare Simple Thematic Maps from the given Data
7.	Evaluation and Viva-Voce	

Our best wishes are with you in this endeavour always.

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# EXERCISE 1

## Construct Map Scales: Graphical, Comparative and Diagonal

### Structure

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1.1	Introduction	1.4	Construction of Plain Scale
	Expected Learning Outcomes	1.5	Construction of Comparative Scale
1.2	Requirements	1.6	Construction of Diagonal Scale
1.3	Map Scale	1.7	Suggested Further Reading
	Construction of Primary Divisions		
	Construction of Secondary Divisions		

### 1.1 INTRODUCTION

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You have studied about various aspects and themes of cartography in BGGCT 133 (Theory Course). Now, you will carry out laboratory exercises on significant problems covering various topics of geography in this Course (BGGCL-134). You also need to revisit the theory course for reference and better understanding before performing the exercises.

In this Exercise-1, you will perform the construction of various types of graphical scales. These scales include plain, comparative and diagonal scales. We have introduced and discussed the concept of map scale, types of scales and their importance in Unit 3 of the Block 1 (BGGCT-133). You may refer to the Unit 3 for understanding types of map scales. As we know that the scale is represented by a ratio of map distance to the ground distance. Let us now start to learn the method of construction of various types of map scales.

### Expected Learning Outcomes

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After working through this exercise, you shall be able to:

- understand the method of construction of graphical map scales;
- construct a plain map scale;
- draw a comparative map scale; and
- construct a diagonal map scale.

### 1.2 REQUIREMENTS

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To perform this exercise, you require the following materials.

- Ruler or Scale
- Pencil/Pen
- Sharpener and Eraser
- Compass
- Divider
- Protractor
- Set-squares
- Drawing sheets or White sheets (A3 size or long sheets).

## 1.3 MAP SCALE

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Before proceeding to carry out this exercise, let us recap the basic information about map scales. We all are well aware of expressing scale on a map primarily with the help of three methods such as verbal scale, representative fraction (RF), and graphic or bar scale. As we know, map scale can be expressed as,

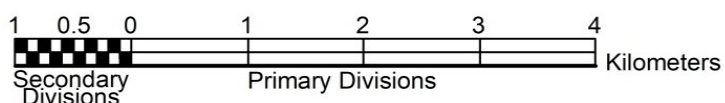
$$\text{Map scale} = \frac{\text{Map distance}}{\text{Ground distance}}$$

- The first method of expressing map scale is verbal scale. Verbal scale is a simple expression on the face of the map which explains the linear relationship. For example, **two centimeters represent one kilometer**. It explains that two centimeters on the map represent one kilometer or one centimeter shows half a kilometer or 500 meters on the ground.
- Representative fraction (RF) scale can generally be written as a numerical ratio using a colon like 1:10,000 (or 1/10,000). The units are to be the same for both numerator and denominator.
- The third method of graphic (linear) or bar scale is usually divided into equally spaced segments. This form of scale can be labeled with the linear units such as miles, kilometers, meters, or feet. This scale represents directly on the map the corresponding ground distance. It is also read same as like RF scale. The graphical scale may be expressed mainly in four forms i.e. plain scale, comparative scale, diagonal scale and vernier scale.

You might have studied different types of map scales including plain scale, comparative scale and diagonal scales. We will now learn as how to construct these scales in a step by step manner. Before starting the construction of map scales, it is very much essential to learn the construction of primary and secondary divisions of a graphical map scale.

### 1.3.1 Construction of Primary Divisions

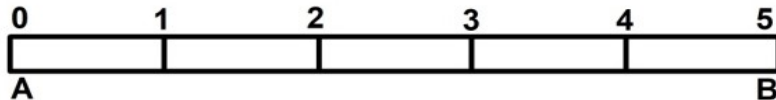
You will understand by referring the following Figure, which shows the primary or fundamental divisions and secondary divisions of a graphical scale.



Here, the primary divisions are zero to 1, and zero to 2, 3, 4. Each division represents 1 kilometer. The extreme left of the primary division (0 to 1) is divided into 10 equal sub-divisions. These are called secondary divisions. Here each secondary division represents 100 meters or 0.1 kilometer.

Generally, the construction of a primary division is to be decided by the Representative Fraction (RF). Now, we will learn how to construct a primary division for a map scale step by step.

**Step 1:** Take a ruler and draw a straight line (AB) with a suitable length. If the line is 10 cm in length, then it could be divided into 5 or 10 equal parts with the help of scale. Each part may be 2 cm or 1 cm with equal divisions.

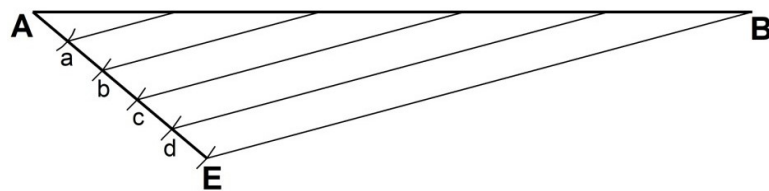


In other case, suppose you need to draw a line of 9.7 cm length and is to be divided into 5 equal parts then what do you do now? Each division will be drawn by the measurement of 1.94 cm. You may or may not find the fraction values on the ordinary scale. In this case or otherwise also, we shall go through the following steps for demarcating equal divisions on a scale for a given length. Let us draw the scale.

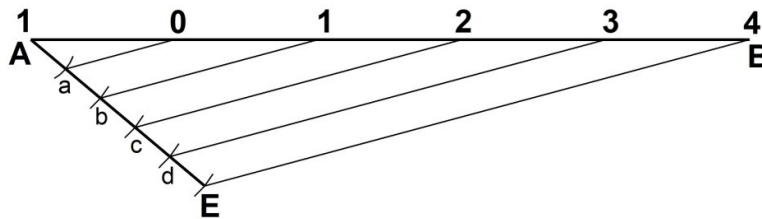
**Step 2:** First, draw a horizontal straight line (AB) in any length with the help of a ruler (scale). Now, draw another line AE with any suitable length in any angle ( $20^\circ$  or  $40^\circ$ ) for marking convenient divisions. Here, AE is a diagonal line. The line AE is divided into 5 equal parts with an arc of radius 0.5 cm using the divider.



**Step 3:** Connect each arc a, b, c, d, and E of the line AE to the line AB with the help of set-squares.



**Step 4:** Now, assign the numeric number for each division on the line AB. These divisions from starting point (A) 1-0, 0-1, 1-2, 2-3, and 3-4 are called primary divisions.



**Step 5:** Finally, the scale may be displayed as per the below given format. Here, 0 to 1 (extreme left of the bar), and 0 to 4 are called primary divisions.



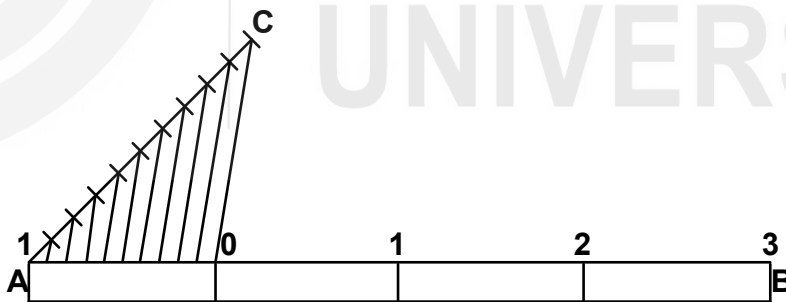
### 1.3.2 Construction of Secondary Divisions

You have understood the construction of primary divisions of a map scale. Let us try to construct the secondary divisions. To do this, the following steps need to be carried out.

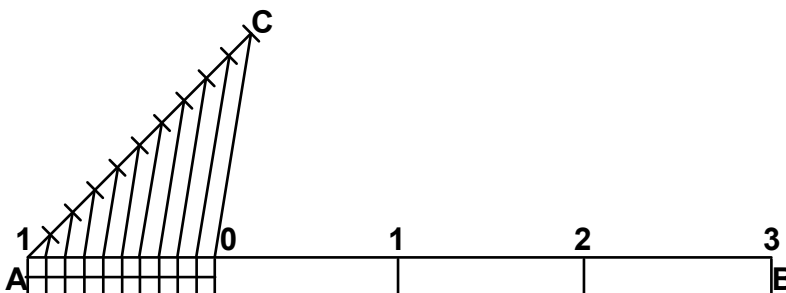
**Step 1:** You should follow the above method for construction of a primary division. Now, we will construct the secondary divisions. Consider the extreme left of primary division (i.e. 0 to 1) for its sub-divisions. It is to be sub-divided into a suitable number of secondary divisions in fractions for desired precision measurement. Let us take a primary division scale as given below.



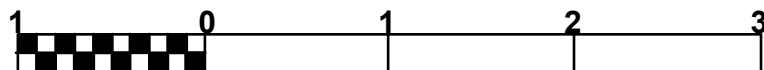
**Step 2:** Let us divide the primary division into 10 equal parts. Draw a line AC with suitable length and any angle. Now, it is sub-divided into 10 equal parts as per the procedure explained above for the division of primary divisions.



**Step 3:** Connect each part of the line AC to the primary division on line AB with the help of set-squares.



**Step 4:** Finally, the scale may be displayed as per the below given format. Here, primary division i.e. 0 to 1 is divided into 10 secondary divisions on the scale.



Now, you have understood the method of construction for primary and secondary divisions of a graphic scale. You must practice this method. You always need to follow this method whenever divisions are required to be marked for constructing a map scale.

## 1.4 CONSTRUCTION OF PLAIN SCALE

**PROBLEM 1:** Construct a plain scale for RF 1:1,00,000 to read kilometres.

**SOLUTION:**

**Step 1:** Calculate the units of the scale.

$$\text{Here, RF} = 1:1,00,000 = \frac{1}{1,00,000}$$

$$\therefore \frac{1_{\text{map}}}{1,00,000_{\text{ground}}} = \frac{1 \text{ cm}_{\text{map}}}{1,00,000 \text{ cm}_{\text{ground}}} \times 100,000 (\text{cm}) = \frac{1 \text{ cm}_{\text{map}}}{1 \text{ km}_{\text{ground}}}$$

where  $1,00,000 \text{ cm} = 1 \text{ km}$

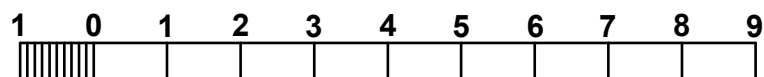
Thus, 1 cm on the map represents 1 km on the ground.

**Step 2:** Now, let us draw the kilometre scale. Take a drawing sheet and place it on a flat surface. With the help of a ruler and pencil, draw a straight line horizontally with a length of 10 cm on the sheet. Divide the line into 10 equal parts. Here, each division of 1 cm will represent 1 km.



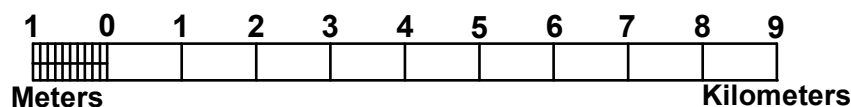
These are called primary divisions. You may also refer to the above Sub.Sec. 1.3.1 for knowing the method of construction of primary divisions.

**Step 3:** Now, we have to construct the secondary divisions. Divide the first primary division into 10 equal parts. Each part will represent 100 meters.



These divisions are called secondary divisions. You may also refer to the above Sub.Sec. 1.3.2 for knowing the method of construction of secondary divisions.

**Step 4:** Finally, the graphic scale is to be displayed in the below format. This scale represents for RF 1:100,000 in kilometres.



Here, primary divisions are shown in kilometres and secondary divisions are represented in meters.

**PROBLEM 2:** Construct a graphical scale (plain scale) to show 1040 kilometres. The RF is 1:10,000,000 and primary division is 200 kilometres.

**SOLUTION:**

**Step 1:** Note the length of a primary division i.e. 200 kms. Now, we need to calculate number of centimetres on the map that represents 200 kilometres on the ground.

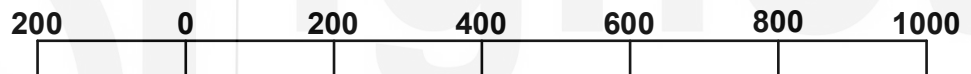
$$\text{Here, } RF = 1:10,000,000 = \frac{1 \text{ cm}_{\text{map}}}{10,000,000 \text{ cm}_{\text{ground}}}$$

$$\therefore 200 \text{ kms on ground} = \frac{200 \times 100,000 \text{ cm}_{\text{map}}}{10,000,000 \text{ cm}_{\text{ground}}} = 2 \text{ cm on map}$$

where 1,00,000 cm = 1 km

The map distance corresponding to 200 kms of the ground distance is 2 cm. Hence, the length of a primary division would be 2 cm.

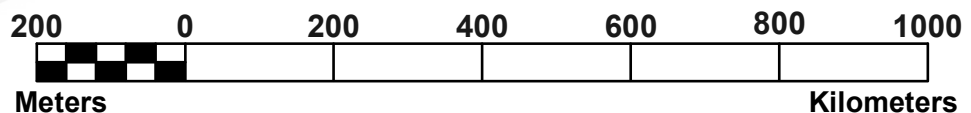
**Step 2:** Now, draw a line of 12 cm with the help of a ruler. Divide the line into 6 equal parts. Here, each division (2 cm) will represent 200 kms.



**Step 3:** Now, we have to construct the secondary divisions. Divide the first primary division into 5 equal parts. Each part will represent 40 meters.



**Step 4:** Finally, the plain scale is to be displayed in the below given format. This scale represents for RF 1:10,000,000 in kilometres.



Here, primary divisions are shown in kilometres and secondary divisions are represented in meters.

## 1.5 CONSTRUCTION OF COMPARATIVE SCALE

You must always remember the following two important points while constructing comparative scales in kilometres-miles and meters-yards, etc.

1. The primary and secondary divisions should represent the equal ground distance.
2. The zero of both scales should exactly match with one and the other.

Let us start with the construction of comparative scale in kilometres-miles unit.

**PROBLEM 3:** Draw a comparative scale to show kilometres and miles when the RF is 1:250,000.

**SOLUTION:**

**Step 1:** First, choose the value for constructing primary and secondary divisions. Here, the primary division is 3 km for kilometre scale and 3 miles for mile scale, and the secondary division is chosen as 300 meters for kilometre scale and 0.3 miles for mile scale.

**Step 2:** For kilometre scale, calculate the number of centimetres on the map that will represent 3 kilometres on the ground.

$$\text{Here, } RF = 1:250,000 = \frac{1 \text{ cm}_{\text{map}}}{250,000 \text{ cm}_{\text{ground}}}$$

$$\therefore 3 \text{ kms on the ground} = \frac{3 \times 100,000 \text{ cm}}{250,000 \text{ cm}} = 1.2 \text{ cm on the map.}$$

where, 1 km = 1,00,000 cm

The map distance corresponding to 3 kms of ground distance is 1.2 cm. Hence, the length of a primary division would be 1.2 cm.

**Step 3:** For mile scale, calculate the number of inches on the map that will represent 3 miles on the ground.

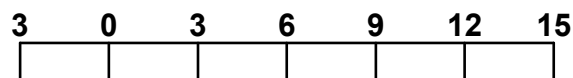
$$RF = 1:250,000 = \frac{1 \text{ inch}_{\text{map}}}{250,000 \text{ inch}_{\text{ground}}}$$

$$\therefore 3 \text{ miles on the ground} = \frac{3 \times 63,360 \text{ inch}}{250,000 \text{ inch}} = 0.76 \text{ inch on the map}$$

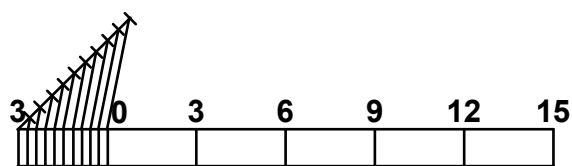
where, 1 mile = 63,360 inch

The map distance corresponding to 3 miles of ground distance is 0.76 inch. Hence, the length of a primary division would be 0.76 inch.

**Step 4:** Now, let us draw the kilometre scale. Take a drawing sheet and place it on a flat surface. With the help of scale and pencil, draw a straight line horizontally with a length of 7.2 cm on the sheet. Then, divide the line with a measurement of 1.2 cm for each part. Each division will represent 3 kms.



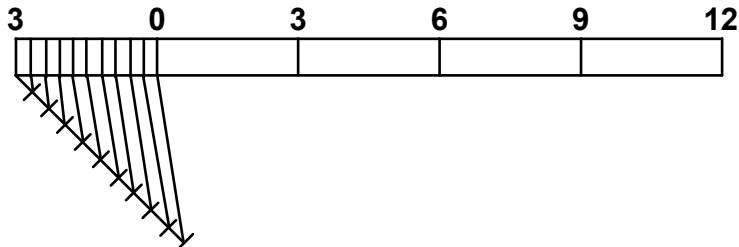
**Step 5:** Now, we have to construct the secondary divisions. Divide the first primary division into 10 equal parts. Each part will represent 300 meters.



**Step 6:** Next, draw the mile scale. Take a ruler and draw a line of 3.8 inches. Divide the line with a measurement of 0.76 inches for each part. Each division will represent 3 miles.

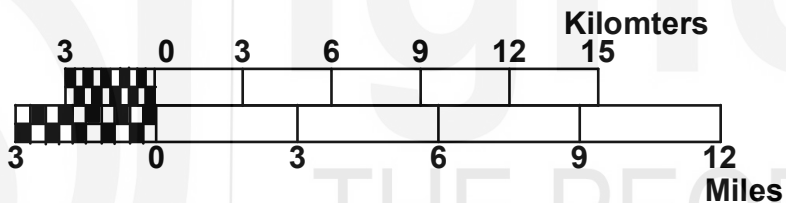


**Step 7:** Now, we have to construct the secondary divisions. Divide the first primary division into 10 equal parts. Each part will represent 0.3 miles.



**Step 8:** Both the kilometre and mile scales put one over the other where the zero points of both the scales must coincide with each other.

**Step 9:** Finally, the comparative scale is to be displayed in the below given format.



**PROBLEM 4:** Draw a comparative scale to show yards and meters. The RF is 1:10,000 and the primary division is 250 yards/meters.

**SOLUTION:**

**Step 1:** For yard scale, calculate the number of inches on the map that will represent 250 yards on the ground.

$$\text{Here, } RF = 1:10,000 = \frac{1 \text{ inch}_{\text{map}}}{10,000 \text{ inch}_{\text{ground}}}$$

$$\therefore 250 \text{ yards on the ground} = \frac{250 \times 36 \text{ inch}}{10,000 \text{ inch}} = 0.9 \text{ inch on the map.}$$

where, 1 yard = 36 inch

The map distance corresponding to 250 yards of ground distance is 0.9 inch. Hence, the length of a primary division would be 0.9 inch.

**Step 2:** For meter scale, calculate the number of centimetres on the map that will represent 250 meters on the ground.

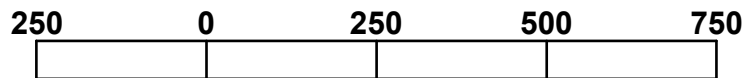
$$RF = 1:10,000 = \frac{1 \text{ cm}_{\text{map}}}{10,000 \text{ cm}_{\text{ground}}}$$

$$\therefore 250 \text{ meters on the ground} = \frac{250 \times 100 \text{ cm}}{10,000 \text{ cm}} = 2.5 \text{ cm on the map.}$$

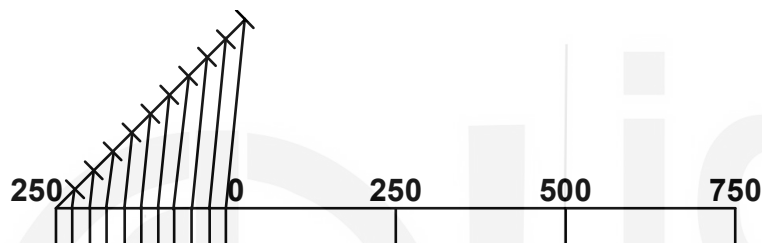
where, 1 meter = 100 cm

The map distance corresponding to 250 meters of the ground distance is 2.5 cms. Hence, the length of a primary division would be 2.5 cm.

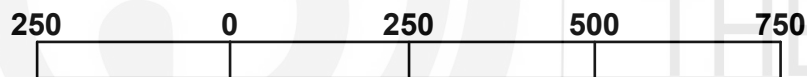
**Step 3:** Now, let us draw the yard scale. Take a ruler and draw a line of 3.6 inch. Divide the line with a measurement of 0.9 inch for each part. Each division will represent 250 yards.



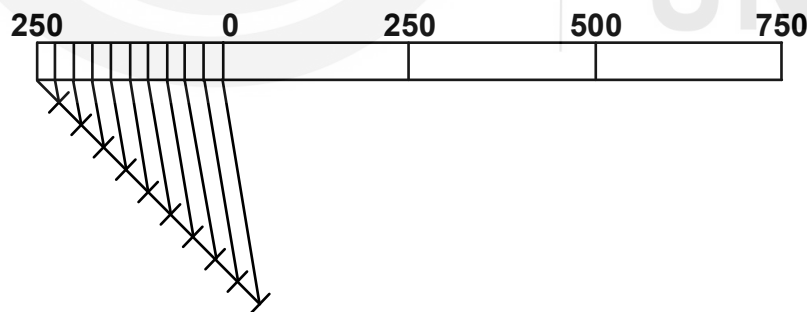
**Step 4:** Now, we have to construct the secondary divisions. Divide the first primary division into 10 equal parts. Each part will represent 50 yards.



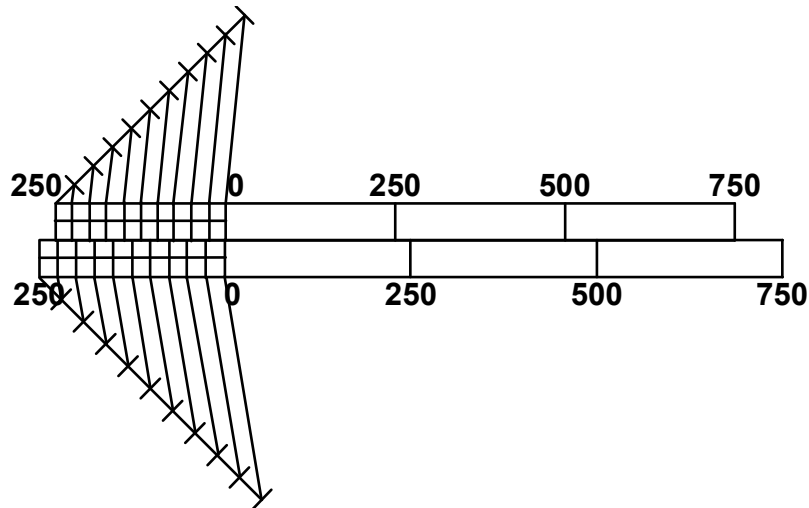
**Step 5:** Next, draw the meter scale. Take a ruler and draw a line of 10 cms. Divide the line with a measurement of 2.5 cms for each part. Each division will represent 250 meters.



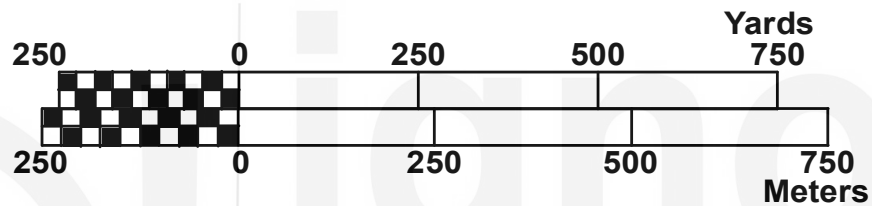
**Step 6:** Now, we have to construct the secondary divisions. Divide the first primary division into 10 equal parts. Each part will represent 25 meters.



**Step 7:** Both the yard and meter scales put one over the other, where the zero points of both the scales must coincide with each other.



**Step 8:** Finally, the comparative scale is to be displayed in the below given format.

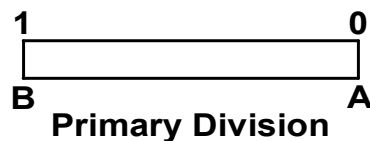


## 1.6 CONSTRUCTION OF DIAGONAL SCALE

Diagonal scale is specially used in large scale maps or cadastral maps. It has an advantage of explaining  $1/100^{\text{th}}$  part of a primary division. A diagonal scale can show primary, secondary and tertiary divisions. The basic principle of a diagonal scale states that the total value of tertiary divisions is equivalent to one secondary division and the sum of secondary divisions is equivalent to one primary division.

Let us learn first the method of construction of diagonal scale and later solve the given problems and exercises.

**Step 1:** Let choose one primary division AB (0 - 1) with a measurement of 1 cm.



**Step 2:** Draw two perpendicular lines AC and BD, and mark them as AB=CD and AC=BD. Next, mark 10 equal divisions on AB and CD. Each division will represent 0.1 cm or 10 mm. These divisions numbered from 0 to 10 are called secondary divisions.



**PROBLEM 5:** Construct a diagonal scale for RF 1:30 to show 3 yards 1 feet 5 inches.

**SOLUTION:**

**Step 1:** Note the reading to be shown on the scale i.e. 3 yards 1 feet 5 inches. So, the primary division would be 1 Yard. Calculate the number of inches on the map that will represent 4 yards on the ground.

Here,  $RF = 1:30 = 1 \text{ inch represents } 30 \text{ inch}$

$$\therefore 1 \text{ yard on the the ground} = \frac{36 \text{ inch}}{30 \text{ inch}} = 1.2 \text{ inch on the map.}$$

where, 1 yard = 36 inch

$$\therefore 4 \text{ yards on the ground} = \frac{4 \times 36 \text{ inch}}{30 \text{ inch}} = 4.8 \text{ inch on the map.}$$

So, the length of primary division would be 1.2 inch and the total length of the scale would be 4.8 inch.

**Step 2:** The secondary division is in feet. Calculate the number of secondary divisions.

$$\therefore \text{Secondary division} = \frac{3 \text{ ft}}{1 \text{ ft}} = 3 \text{ ft}$$

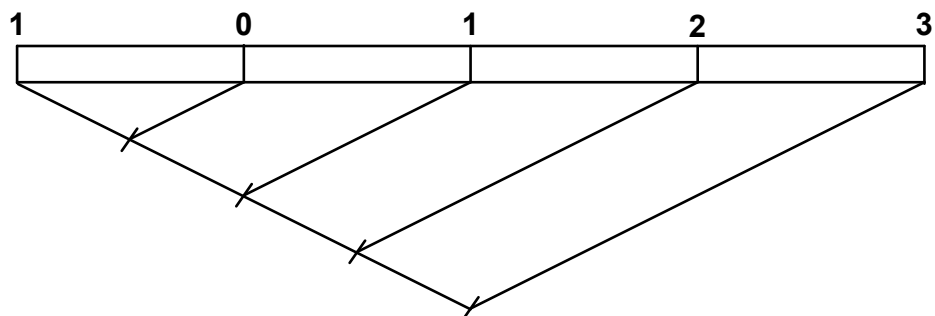
where, 1 yard = 3 feet

**Step 3:** The tertiary division is in inch. Calculate the number of tertiary divisions.

$$\therefore \text{Tertiary division} = \frac{12 \text{ inch}}{12 \text{ inch}} = 1 \text{ inch}$$

where, 1 feet = 12 inch

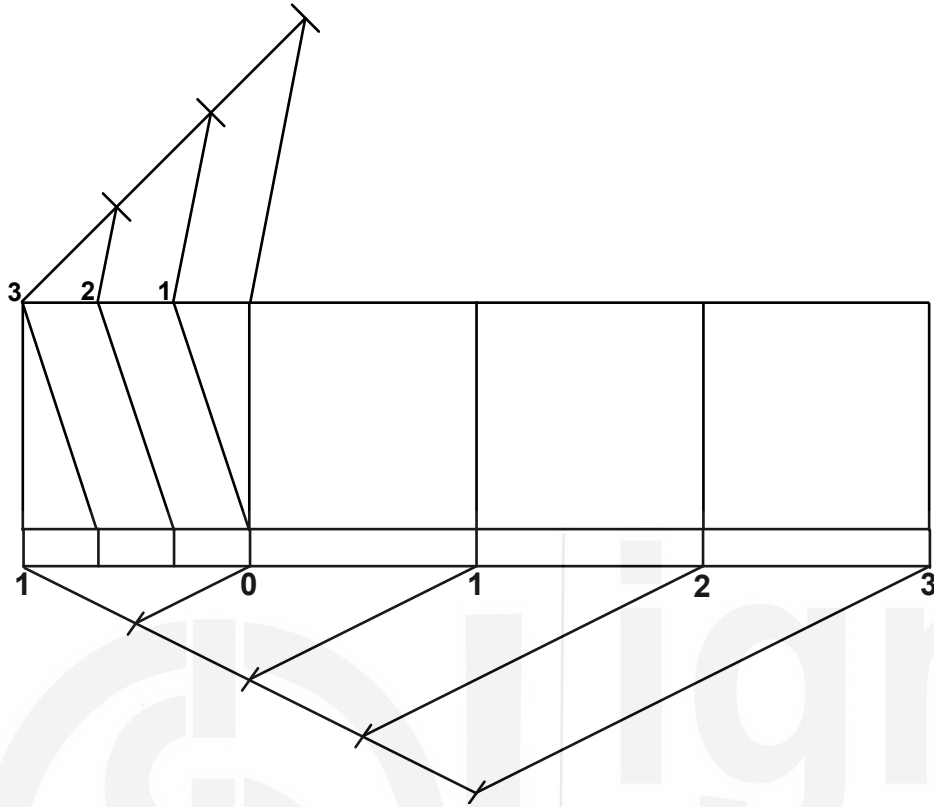
**Step 4:** Let us draw the primary divisions. Take a drawing sheet and place it on a flat surface. With the help of scale and pencil, draw a straight line horizontally with a length of 4.8 inch on the sheet. Then, divide the line into 4 equal parts. Each part will represent 1 Yard.



To divide primary divisions equally, you may refer to Sub.Sec. 1.3.1.

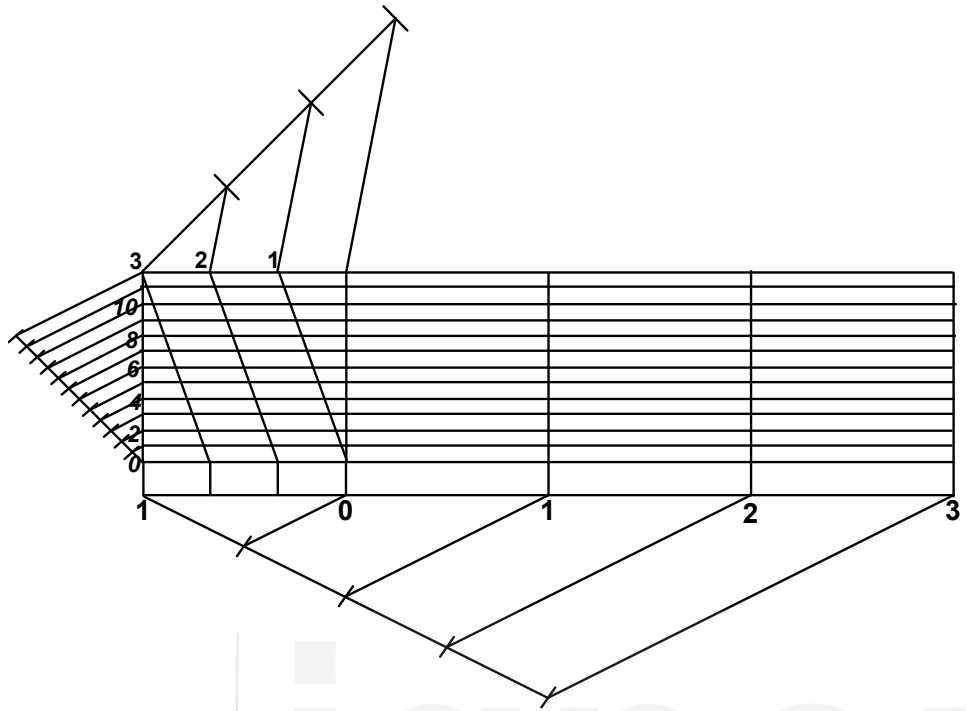
**Step 2:** Mark the secondary divisions for the left primary division i.e. 0 to 1. First, draw two perpendicular lines on the primary scale with any suitable

length. We have to draw 3 secondary divisions. Each division will represent 1 foot. After dividing the line into 3 equal parts, the lines are drawn diagonally.

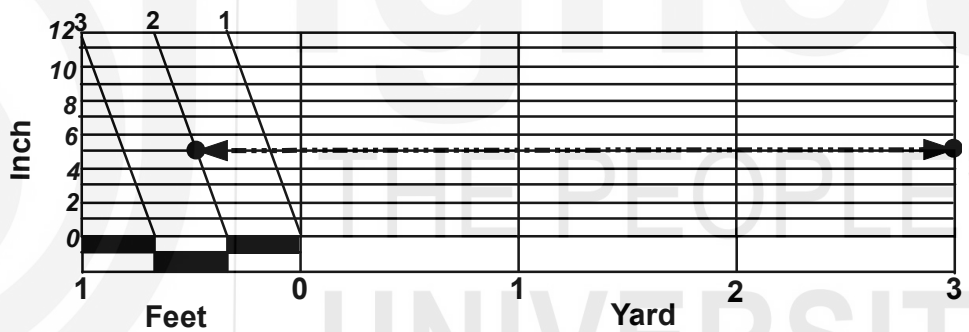


You may refer to Sub.Sec.1.3.2 for the construction of secondary divisions.

**Step 3:** Now, we have to construct the tertiary divisions. Draw a line from far left of primary division with any suitable length or suitable angle. Divide the secondary division into 12 equal parts as 1 feet equivalent to 12 inches. Each part will represent 1 inch.



**Step 4:** The diagonal scale for the given reading 3 yards 1 feet 5 inches is shown as given below.



Finally, the diagonal scale should be presented in the above format for its reading.

**PROBLEM 6:** Construct a diagonal scale for RF 1:25,000 to show 2 kilometres 8 hectometres 80 meters.

**SOLUTION:**

**Step 1:** Note the reading to be shown on the scale i.e. 2 kilometres 8 hectometres 80 meters. So, the primary division would be 1 kilometre. Calculate the number of centimetres on the map that will represent 3 kilometres on the ground.

Here,  $RF = 1:25,000 = 1 \text{ centimeter represents } 25,000 \text{ centimeters}$

$$\therefore 1 \text{ kilometer on the ground} = \frac{1,00,000 \text{ cm}}{25,000 \text{ cm}} = 4 \text{ cm on the map.}$$

where,  $1 \text{ km} = 1,00,000 \text{ cm}$

$$\therefore 3 \text{ kilometers on the ground} = \frac{3 \times 1,00,000 \text{ cm}_{\text{map}}}{25,000 \text{ cm}_{\text{ground}}} = 12 \text{ cm on map.}$$

So, the length of primary division would be 4 cm and the total length of scale would be 12 cm.

**Step 2:** The secondary division is in hectometre. Calculate the number of secondary divisions.

$$\therefore \text{Secondary division} = \frac{10_{\text{hm}}}{1_{\text{hm}}} = 10 \text{ hm}$$

where, 1 km = 10 hm

**Step 3:** The tertiary division is in meter. Calculate the number of tertiary divisions.

$$\therefore \text{Tertiary division} = \frac{100_{\text{m}}}{10_{\text{m}}} = 10 \text{ m}$$

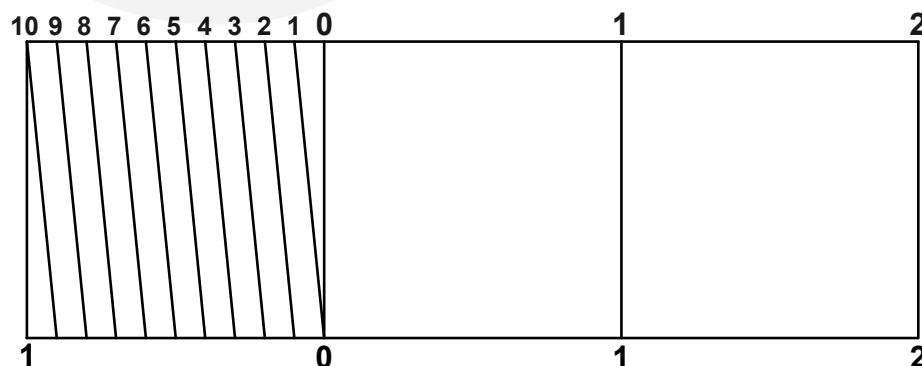
where, 1 hm = 100 m

**Step 4:** Let us draw the primary divisions. Take a drawing sheet and place it on a flat surface. With the help of scale and pencil, draw a straight line horizontally with a length of 12 cm on the sheet. Then, divide the line into 3 equal parts. Each part will represent 1 Kilometre.



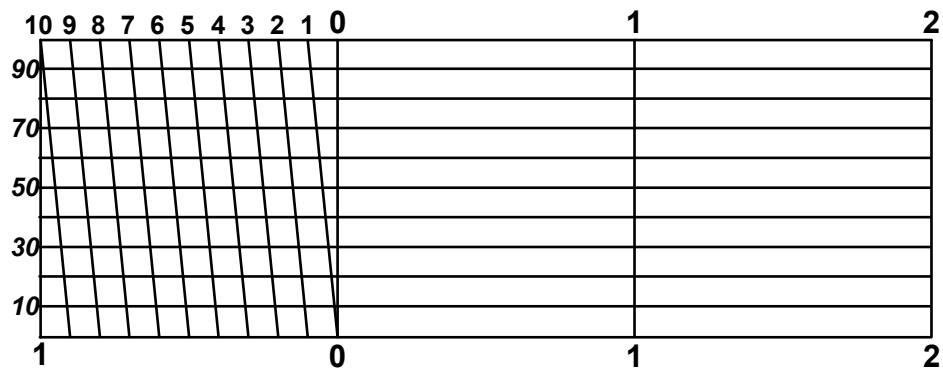
To divide the primary divisions equally, you may refer to Sub.Sec. 1.3.1.

**Step 2:** Mark the secondary divisions for the left primary division i.e. 0 to 1. First, draw two perpendicular lines on the primary divisions scale with any suitable length. We have to draw 10 secondary divisions. Each division will represent 10 hectometres. After dividing the line into 10 equal parts, the lines are drawn diagonally.

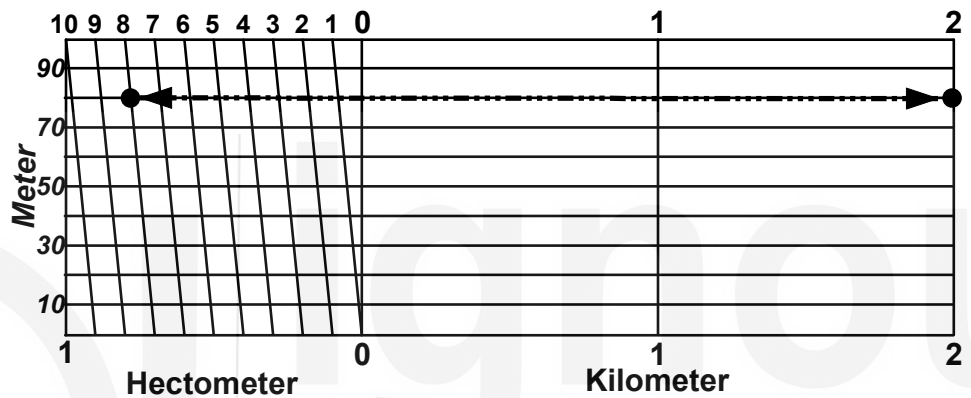


To do this, you can also refer to Sub.Sec.1.3.2.

**Step 3:** Now, we have to construct the tertiary divisions. Draw a line from far left of primary division with any suitable length or suitable angle. Divide the secondary division into 10 equal parts as 1 hm equivalent to 100 m. Each part will represent 10 m.



**Step 4:** The diagonal scale for the given reading 2 km 8 hm 80 m is shown as below.



Now, you have understood the construction of various types of map scales. You should carry out the following laboratory exercises for your practical record for its submission.

**Lab Exercise 1:** Construct a graphical scale to show 150 miles for RF 1:5,000,000.

**Lab Exercise 2:** Construct a comparative scale to show yards and meters. The RF is 1:25,000.

**Lab Exercise 3:** Draw a comparative scale to show kilometres and miles when the RF is 1:750,000.

**Lab Exercise 4:** Construct a diagonal scale for RF 1:50000 to show 3 kilometres 2 hectometres 10 meters.

## 1.7 SUGGESTED FURTHER READING

- Sarkar, A. (2008): *Practical Geography: A Systemtic Approach*, Kolkata: Orient BlackSwan.
- Singh, G. (2004). *Map Work and Practical Geography*, Delhi: Vikas Publication House.
- Robinson, Arthur, H.J., Morrison, P., Muehrke, A., Kimmerling & Guptill, S. (eds.) (1995). *Elements of Cartography*, New York: Wiley.

- Misra, R.P. & Ramesh, A. (1986). *Fundamentals of Cartography*, New Delhi: McMillan.
- Singh, R.L. and Singh, R.P.B. (2003). *Elements of Practical Geography*, Delhi: Kalyani Publishers.



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# EXERCISE 2

## CONSTRUCTION OF CYLINDRICAL PROJECTION

### Structure

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2.1	Introduction Expected Learning Outcomes	2.4	Construction of Mercator's Projection
2.2	Requirements	2.5	Suggested Further Readings
2.3	Construction of Cylindrical Equal Area Projection		

### 2.1 INTRODUCTION

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In the previous Exercise 1, you have learnt to draw various types of map scales. In this exercise, you will learn how to construct the cylindrical map projections. You have studied about map projections and its main types namely cylindrical, conical, and zenithal in the theory course titled General Cartography (BGGCT-133). Before performing the task of Exercise 2, you may refer to Block 2 of BGGCT-133 for the reference and better understanding.

Basically, map projections portray the three dimensional (3D) earth surfaces into two dimensional (2D) features on a sheet. Cylindrical projections are one of the types of map projections. In this kind of projections, the equator is usually its line of tangency. In tangent case, the projection surface contacts the earth's surface at a point or along a line whereas, the projection surface touches the globe along two lines or points in the secant case. The important property of cylindrical projections is that the meridians and parallels represent as straight lines and intersect each other at right angles. The meridians are equally spaced. The spacing between parallel lines of latitude decreases toward the poles.

Let us now learn the construction of cylindrical map projections. Cylindrical map projections are one way of portraying the earth. The well known types of cylindrical map projections include Mercator, Cassini, Plate Carrée, Gauss-Kruger, Miller, Behrmann, Hobo-Dyer, and Gall-Peters projections. In this

**Exercise 2**, you will be trained in constructing map projections such as **Cylindrical Equal Area Projection** and **Mercator's Projections**.

You must always remember that we can use both mathematical and graphical methods in the construction of different map projections. **Graphical method** simply works on basic principles of geometry therefore one can easily understand it but it may provide approximate values for constructing a graticule. On the other hand, **mathematical method** uses trigonometrical formulae for calculating the radii, the length of parallels and meridians, and distances between them. It is necessary to memorize that the construction of projections is sometimes only possible with mathematical methods. Hence, you need to have basic knowledge of trigonometry for successful construction of various types of map projections. Keeping this in mind, we have introduced both the methods wherever necessary for your convenience. You will also find these two methods in the following Exercises 3 and 4. You must refer to the trigonometric formulae and mathematical tables (logarithmic) which are annexed at the end of this exercise for drawing the projection.

## Expected Learning Outcomes \_\_\_\_\_

After working through this exercise, you shall be able to:

- understand the method of construction of cylindrical map projections;
- construct a cylindrical equal area projection; and
- draw a Mercator's projection.

## 2.2 REQUIREMENTS

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To perform this exercise, you require the following materials.

- Ruler or Scale
- Pencil/Pen
- Sharpener and Eraser
- Compass
- Divider
- Protractor
- Set-squares
- Scientific calculator
- Drawing sheets or White sheets (A3 size or long sheets).

## 2.3 CONSTRUCTION OF CYLINDRICAL EQUAL AREA PROJECTION

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In the cylindrical equal area projection, cylinder touches the surface of the globe along the equator. It is derived by projecting the graticule of latitudes (parallels) and longitudes (meridians) as straight lines.

That means longitudes are drawn to equally space vertical lines and the circles of latitudes are arranged to horizontal lines. These horizontal and vertical lines are intersected at  $90^\circ$  angle. The space between the parallels decreases towards the poles but spacing between the meridians is uniform. Importantly, the length of each parallel is equivalent to the length of equator.

Shape of the surface on the sphere is greatly distorted at higher latitudes when it moves from the equator. Near the equator both the shape and area are relatively accurate. This projection is primarily used for preparing world maps covering the equatorial regions.

Let us start to learn the construction of graticules for **Cylindrical Equal Area Projection** through the following exercises. Here, you will learn two methods

i) Method 1: Mathematical Construction and ii) Method 2: Graphical Construction for the construction of graticules of the projections.

**PROBLEM 1:** Construct a cylindrical equal area projection for the globe on RF 1:200,000,000 scale at 10° interval.

### **METHOD-1: MATHEMATICAL CONSTRUCTION**

**SOLUTION:** In the preliminary stage, we have to calculate the values for constructing the map projection. Then, the calculated values are to be used for making the projection in the next stage.

#### **Calculations for Constructing the Projection:**

**Step 1:** Calculate the radius (R) of the generating globe for the given scale. Let us note down the RF.

$$RF = 1:200,000,000 = \frac{1}{200,000,000}$$

$$\text{Radius } R = \frac{1}{200,000,000} (\text{cm}) \times \text{Earth radius}_{\text{cm}}$$

$$= \frac{1}{200,000,000} (\text{cm}) \times 6400,000_{\text{cm}} = \frac{64}{20} = 3.2 \text{ cm}$$

We have now obtained the value of radius i.e. **R = 3.2 cm**.

**Step 2:** Note the longitudinal extent of the globe i.e. 180°W-180°E and the interval between the meridians i.e. 10°. So, the following meridians are to be drawn.

180°W, 170°W, 160°W, 150°W, 140°W, 130°W, 120°W, 110°W, 100°W, 90°W, 80°W, 70°W, 60°W, 50°W, 40°W, 30°W, 20°W, 10°W, 0°, 10°E, 20°E, 30°E, 40°E, 50°E, 60°E, 70°E, 80°E, 90°E, 100°E, 110°E, 120°E, 130°E, 140°E, 150°E, 160°E, 170°E, 180°E.

**Step 3:** Also record the latitudinal extent of the globe i.e. 90°N-90°S and the interval between the parallels i.e. 10°. The following parallels have to be drawn.

90°N, 80°N, 70°N, 60°N, 50°N, 40°N, 30°N, 20°N, 10°N, 0°, 10°S, 20°S, 30°S, 40°S, 50°S, 60°S, 70°S, 80°S, 90°S.

**Step 4:** Calculate the length of division ( $d_1$ ) on the equator at 10° interval using the standard equation as follows.

$$d_1 = \frac{2\pi R}{360^\circ} \times \text{Interval } (^\circ) = \frac{2 \times 3.14 \times 3.2}{360} \times 10 = \frac{20.09}{36} = 0.56 \text{ cm}$$

Where  $\pi = \frac{22}{7} = 3.14$  (Constant)

Now, you got to know **the length of division on each parallel** for spacing the meridians **i.e.  $d_1 = 0.56$  cm.**

**Step 5:** Calculate the length of division ( $d_2$ ) on the central meridian ( $0^\circ$ ) using the standard equation as follows.

$$d_\phi(\text{cm}) = R \sin \phi$$

Where,  $\phi$  = Latitude in degrees,  $R$  = Radius in cm

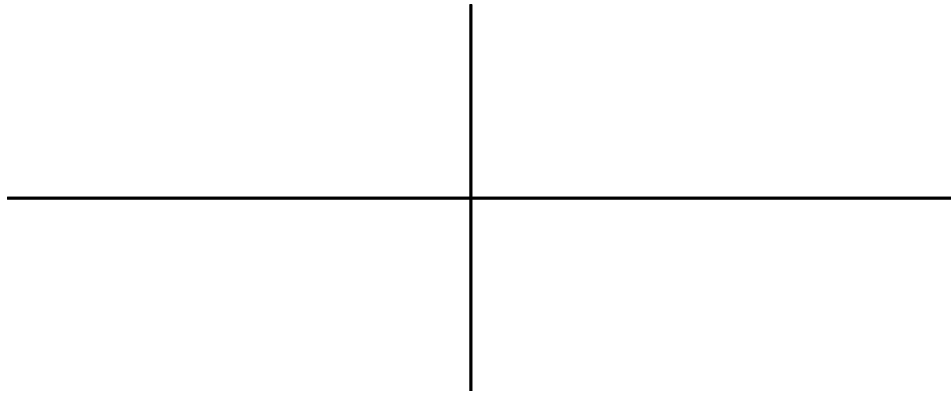
To get the  $d_\phi$  value, you shall prepare the following table with given **interval i.e.  $10^\circ$**  for determining the division using the above equation. You can use the scientific calculator to get the **sin** values directly or refer to the annexures provided at the end of this exercise.

$\phi$	<b>R</b> cm	sin $\phi$	<b>R sin <math>\phi</math></b> cm
<b>90°N/S</b>	3.2	1	<b>3.20</b>
<b>80°N/S</b>	3.2	0.984	<b>3.15</b>
<b>70°N/S</b>	3.2	0.939	<b>3.00</b>
<b>60°N/S</b>	3.2	0.866	<b>2.77</b>
<b>50°N/S</b>	3.2	0.766	<b>2.45</b>
<b>40°N/S</b>	3.2	0.642	<b>2.05</b>
<b>30°N/S</b>	3.2	0.500	<b>1.60</b>
<b>20°N/S</b>	3.2	0.342	<b>1.09</b>
<b>10°N/S</b>	3.2	0.173	<b>0.55</b>

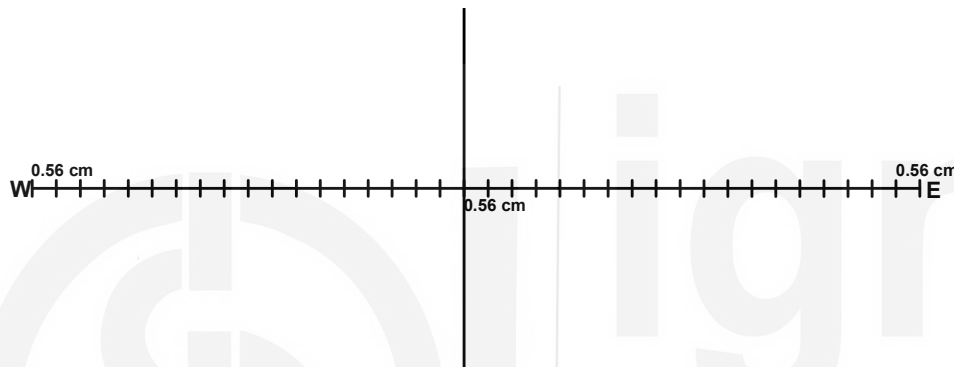
You have now all the calculated values for constructing the map projection. Let us start the construction of the projection. Keep ready with you a drawing sheet, pencil, ruler, protractor and divider etc.

### **Construction of the Projection:**

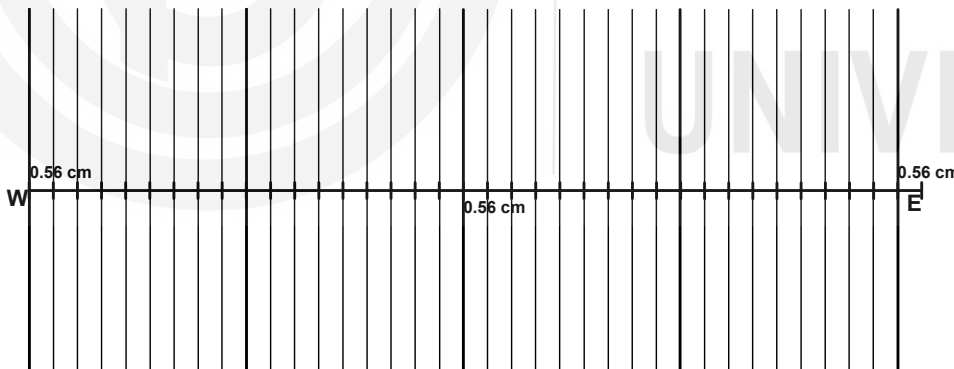
**Step 6:** Take a drawing sheet and place it on plane surface. With the help of pencil and scale, draw a pair of straight lines on centre of the sheet. The lines must be intersected with  $90^\circ$  angle. The horizontal line is to be treated as equator and other vertical line is central meridian.



**Step 7:** Set the divider with a measurement of  $d_1 = 0.56 \text{ cm}$  and mark the divisions on the equator in E and W directions. Now, the equator line is divided by the value of  $d_1$  (refer to **Step 4**) for spacing the meridians.

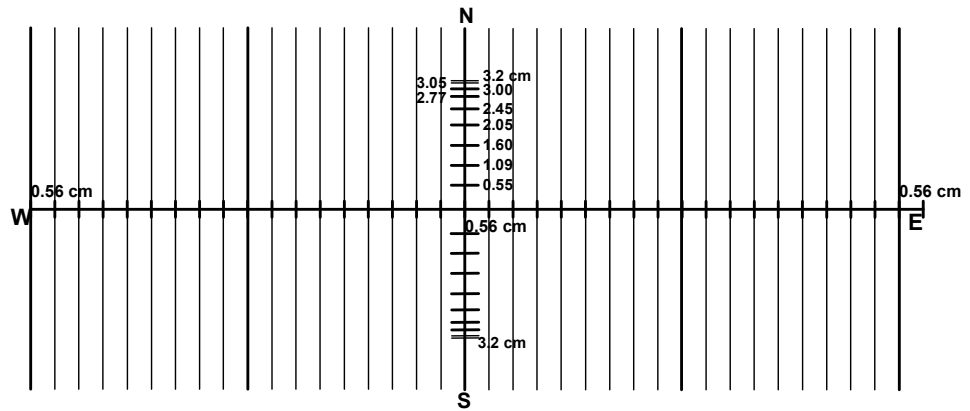


**Step 8:** Take a scale and pencil, and draw straight lines perpendicular to the equator by connecting each of these division points. These lines will represent meridians.

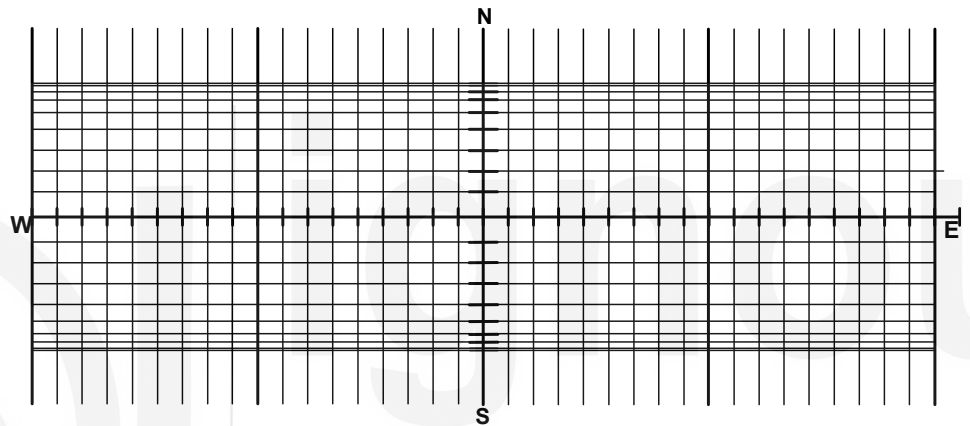


Now, the meridians have been drawn for both W and E directions (From  $0^\circ$  to  $180^\circ$  with  $10^\circ$  interval).

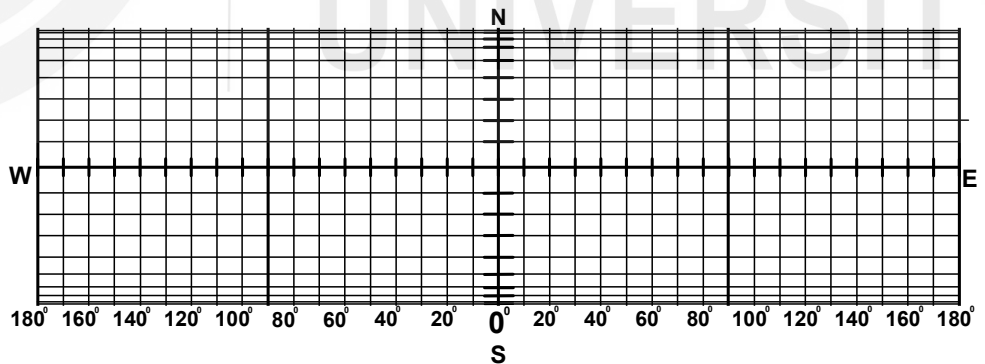
**Step 9:** Let us now start working on the central meridian. Mark the divisions on central meridian in North and South directions with the help of the divider. Using the **values of  $d_\phi$**  from the calculated Table (refer to **Step 5**), the divisions are done for spacing the parallels.



**Step 10:** Straight lines are drawn perpendicular to the central meridian connecting through these divisions. These lines will represent parallels.



**Step 11:** You have now successfully completed the construction of cylindrical equal area projection. But you have to erase the extended lines of the projection and finish it with proper labelling as given below. You must also write the scale of projection.



R.F. 1:200,000,000

### **METHOD-2: GRAPHICAL CONSTRUCTION**

**SOLUTION:** In the preliminary stage, we have to calculate the values for constructing the map projection. Then, the calculated values are to be used for making the projection in the next stage.

## Calculations for Constructing the Projection:

**Step 1:** Calculate the radius (R) of the generating globe for the given scale.  
Let us note down the RF.

$$RF = 1:200,000,000 = \frac{1}{200,000,000}$$

$$\text{Radius } R = \frac{1}{200,000,000} (\text{cm}) \times \text{Earth radius}_{\text{cm}}$$

$$= \frac{1}{200,000,000} (\text{cm}) \times 640,000,000_{\text{cm}} = \frac{64}{20} = 3.2 \text{ cm}$$

We have now obtained the value of radius i.e. **R = 3.2 cm**.

**Step 2:** Note the longitudinal extent of the globe i.e. 180°W-180°E and the interval between the meridians i.e. 10°. So, the following meridians are to be drawn.

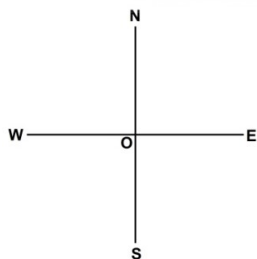
180°W, 170°W, 160°W, 150°W, 140°W, 130°W, 120°W, 110°W, 100°W, 90°W, 80°W, 70°W, 60°W, 50°W, 40°W, 30°W, 20°W, 10°W, 0°, 10°E, 20°E, 30°E, 40°E, 50°E, 60°E, 70°E, 80°E, 90°E, 100°E, 110°E, 120°E, 130°E, 140°E, 150°E, 160°E, 170°E, 180°E.

**Step 3:** Also record the latitudinal extent of the globe i.e. 90°N-90°S and the interval between the parallels i.e. 10°. The following parallels have to be drawn.

90°N, 80°N, 70°N, 60°N, 50°N, 40°N, 30°N, 20°N, 10°N, 0°, 10°S, 20°S, 30°S, 40°S, 50°S, 60°S, 70°S, 80°S, 90°S.

## Construction of the Projection:

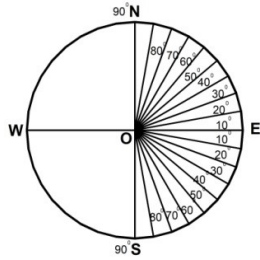
**Step 6:** Take a drawing sheet and place it on plane surface. With the help of pencil and scale, draw a pair of straight lines on the sheet. The lines must be intersected with 90° angle. The horizontal line is to be treated as equator 0° (E-W) and other vertical line 90° (N-S) is central meridian.



**Step 7:** Draw a circle with the measurement of radius **R = 3.2 cm** from the center (O). With the help of protractor, mark the angles on the circle for the given interval (10°) towards north (90°N) and south ((90°S). Then, draw lines through these markings that will represent 10°N, 20°N, 30°N, 40°N, 50°N, 60°N, 70°N, 80°N, and 10°S, 20°S, 30°S, 40°S, 50°S, 60°S, 70°S, 80°S.

Measure the arc length between any two latitudes which will be the value of a division on central meridian.

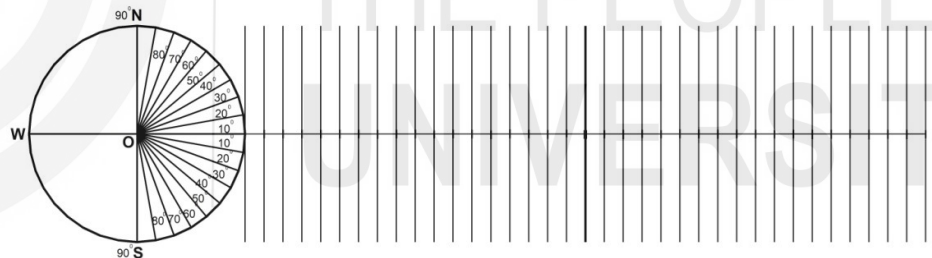
Now, you got to know **the length of a division on the equator** for spacing the meridians i.e.  $d_1 = 0.56 \text{ cm}$ .



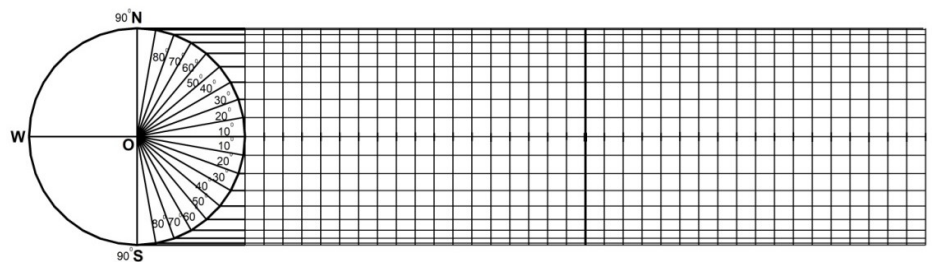
**Step 8:** Draw a line parallel to NS by touching the circle at point E. Now, extend the equator line from where the line touches the circle. Set the divider with the measurement of  $d_1 = 0.56 \text{ cm}$  and mark the divisions on the equator. Now, the equator line (the length of 20.09 cm) is divided equally by the value of  $d_1$  for spacing the meridians.



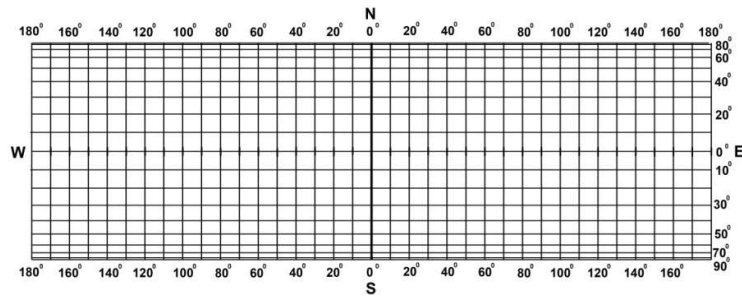
**Step 9:** Take a scale and pencil, and draw straight lines perpendicular to the equator by connecting each of these division points. These lines will represent meridians.



**Step 10:** Draw parallel lines connecting each angle of parallel line in both sides of N and S.



**Step 11:** You have now successfully completed the construction of cylindrical equal area projection. You have to finish with proper labelling and the scale of projection as given below.



R.F. 1:200,000,000

## 2.3 CONSTRUCTION OF MERCATOR'S PROJECTION

Mercator's projection is a cylindrical projection. It is derived by the lines of equally spaced longitudes and horizontal lines of latitudes. The parallels and meridians are intersected at right angles. The distances between the parallels are wide apart moving towards the poles. The poles cannot be shown in this projection. All the parallels are of the same length as the equator. Shapes are represented more accurately whereas areas are distorted greatly toward the polar regions.

Any straight line drawn on this projection represents an actual compass bearing, hence it is useful to sailors. These true direction lines are known as thumb lines. Scale is true along the equator or along the secant latitudes.

The main advantage of this projection is that it can be used to map the regions near the equator.

**PROBLEM 1:** Construct a Mercator's projection for the world map on RF 1:500,000,000 scale at 20° interval.

### METHOD-1: MATHEMATICAL CONSTRUCTION

**Solution:** In the preliminary stage, we have to calculate the values for constructing the map projection. Then, the calculated values are to be used for making the projection in the next stage.

### Calculations of the Projection:

**Step 1:** Calculate the radius (R) of the generating globe for the given scale. Let us note down the RF.

$$RF = 1:500,000,000 = \frac{1}{500,000,000}$$

$$\text{Radius } R = \frac{1}{500,000,000} (\text{cm}) \times \text{Earth radius}_{\text{cm}}$$

$$= \frac{1}{500,000,000} (\text{cm}) \times 640,000,000_{\text{cm}} = \frac{64}{50} = 1.28 \text{ cm}$$

We have now obtained the value of radius i.e. **R = 1.28 cm**.

**Step 2:** Let us note the longitudinal extent of the globe i.e. 180°W-180°E and the interval between the meridians i.e. 20°. So, the following meridians are to be drawn.

180°W, 160°W, 140°W, 120°W, 100°W, 80°W, 60°W, 40°W, 20°W, 0°, 20°E, 40°E, 60°E, 80°E, 100°E, 120°E, 140°E, 160°E, 180°E.

**Step 3:** Also record the latitudinal extent of the globe i.e. 90°N-90°S and the interval between the parallels i.e. 20°. The following parallels have to be drawn.

80°N, 60°N, 40°N, 20°N, 0°, 20°S, 40°S, 60°S, 80°S,.

**Step 4:** Calculate the length of a division ( $d_1$ ) on the equator at 20° interval using the standard equation as follows.

$$d_1 = \frac{2\pi R}{360^\circ} \times \text{Interval } (^\circ) = \frac{2 \times 3.14 \times 1.28}{360} \times 20 = \frac{16.07}{36} = 0.45 \text{ cm}$$

$$\text{Where } \pi = \frac{22}{7} = 3.14 \text{ (Constant)}$$

Now, you got to know **the length of a division on equator** for spacing the meridians i.e.  $d_1 = 0.45 \text{ cm}$ .

**Step 5:** Calculate the length of a division ( $d_2$ ) on the central meridian (0°) using the standard equation as follows.

$$d_\phi (\text{cm}) = 2.3026 \times R \times \log \tan \left( \frac{90^\circ + \phi}{2} \right)$$

Where,  $\phi$  = Latitude in degrees;  $R$  = Radius in cm; Constant value = 2.3026

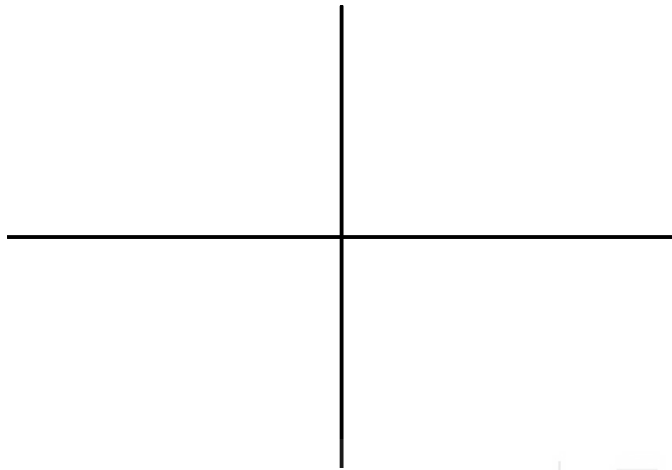
To get the  $d_\phi$  value, you shall prepare the following table with given **interval i.e. 20°** for determining the division using the above equation. You can use the scientific calculator to get the **Logarithmic (log) and Tangent (tan)** values directly or refer to the annexures provided at the end of this exercise.

$\phi$	$\frac{90^\circ + \phi}{2}$	$\tan \left( \frac{90^\circ + \phi}{2} \right)$	$\log \tan \left( \frac{90^\circ + \phi}{2} \right)$	R cm	Constant value	$d_\phi$ cm
<b>20° (N&amp;S)</b>	55	1.4281	0.1547	1.28	2.3026	<b>0.456</b>
<b>40° (N&amp;S)</b>	65	2.1445	0.3313	1.28	2.3026	<b>0.976</b>
<b>60° (N&amp;S)</b>	75	3.7320	0.5719	1.28	2.3026	<b>1.685</b>
<b>80° (N&amp;S)</b>	85	11.430	1.058	1.28	2.3026	<b>3.118</b>

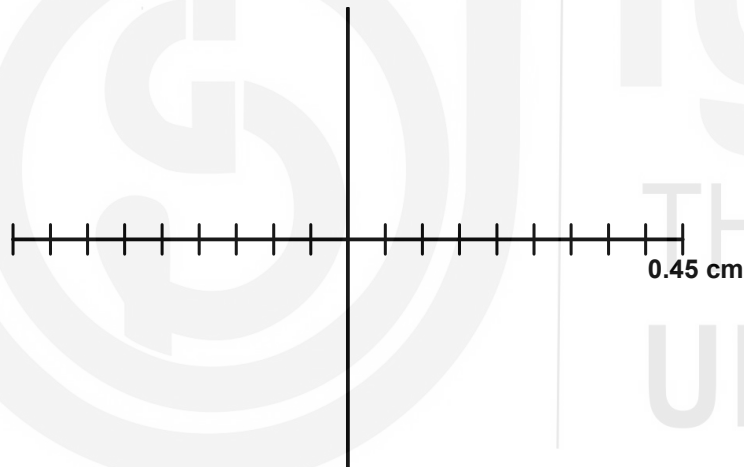
You have now all the calculated values. Let us start the construction of the projection. Keep ready with you a drawing sheet, pencil, ruler, protractor, and divider, etc.

### **Construction of the Projection:**

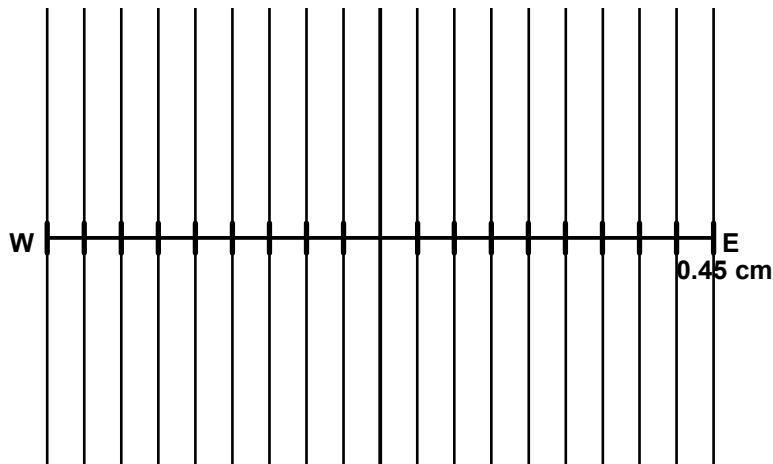
Step 6: Take a drawing sheet and place it on plane surface. With the help of pencil and scale, draw a pair of straight lines on centre of the sheet. The lines must be intersected with  $90^\circ$  angle. A horizontal line is to be treated as equator and other vertical line is central meridian.



Step 7: Set the divider with a measurement of  $d_1 = 0.45 \text{ cm}$  and mark the divisions on the equator in E and W directions. Now, the equator line is divided by the value of  $d_1$  (refer to Step 4) for spacing the meridians.

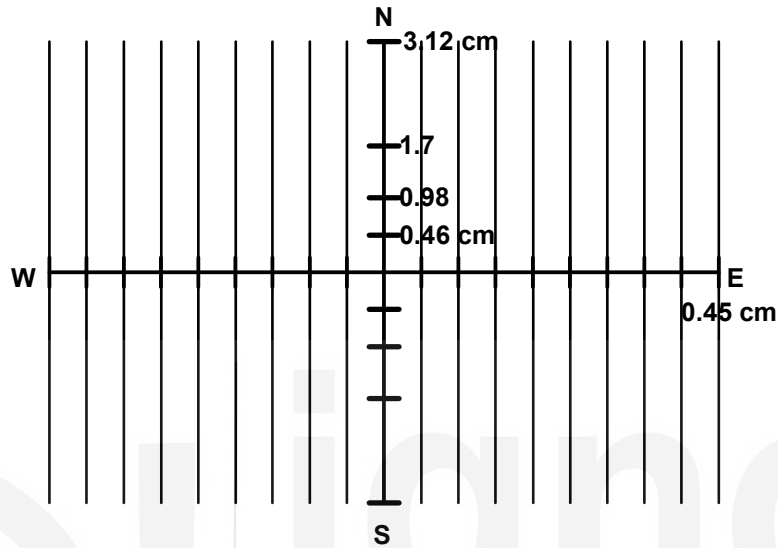


Step 8: Take a scale and pencil, and draw straight lines perpendicular to the equator by connecting each of these division points. These lines will represent meridians.

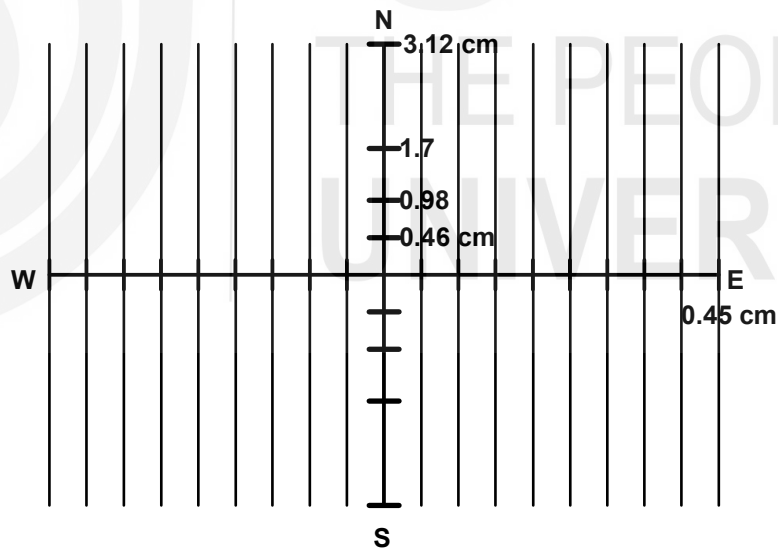


Now, the meridians have been drawn for both W and E directions (From  $0^\circ$  to  $180^\circ$  with  $10^\circ$  interval).

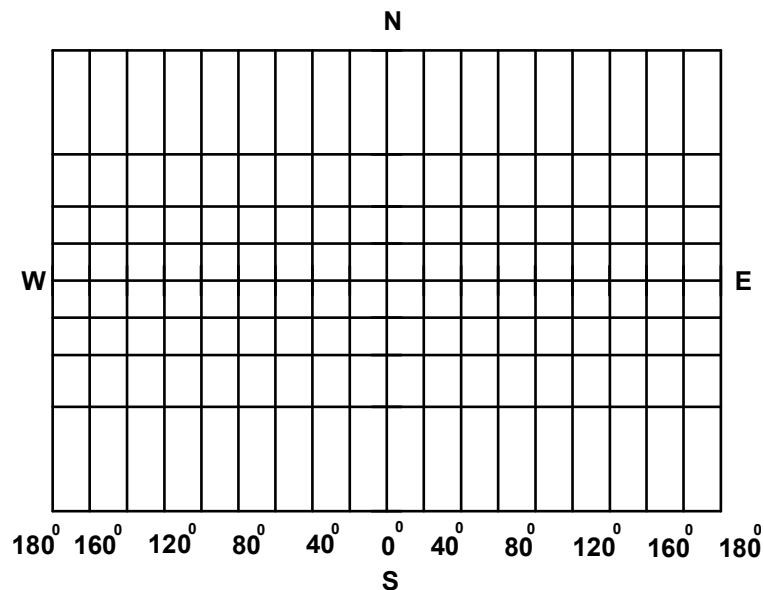
**Step 9:** Let us now start working on the central meridian. Mark the divisions on central meridian in North and South directions with the help of the divider. Using the **values of  $d_\phi$**  from the calculated Table (**refer to Step 5**), the divisions are done for spacing the parallels.



**Step 10:** Straight lines are drawn perpendicular to the central meridian connecting through these divisions. These lines will represent parallels.



**Step 11:** You have now successfully completed the construction of Mercator's projection. But you have to finish it with proper labelling as given below. All the graticules and the scale of projection must be written legibly.



R.F. 1:500,000,000

Now, you have understood both the construction of Cylindrical Equal Area Projection (both mathematical and graphical methods) and Mercator's Projections (Mathematical method). You should carry out the following laboratory exercises for your practical record for its submission.

**Lab Exercise 1:** Construct a cylindrical equal area projection for the globe on RF 1:500,000,000 scale at 30° interval.

**Lab Exercise 2:** Construct a cylindrical equal area projection for the globe on RF 1:750,000,000 scale at 15° intervals.

**Lab Exercise 3:** Construct a Mercator's projection for the globe on RF 1:250,000,000 scale at 15° interval.

**Lab Exercise 4:** Construct a Mercator's projection for the globe on RF 1:100,000,000 scale at 10° interval.

## 2.5 SUGGESTED FURTHER READING

- Sarkar, A. (2008): *Practical Geography: A Systemtic Approach*, Kolkata: Orient BlackSwan
- Singh, G. (2004). *Map Work and Practical Geography*, Delhi: Vikas Publication House
- Robinson, Arthur, H.J., Morrison, P., Muehrke, A., Kimmerling & Guptill, S. (eds.) (1995). *Elements of Cartography*, New York: Wiley.
- Misra, R.P. & Ramesh, A. (1986). *Fundamentals of Cartography*, New Delhi: McMillan.
- Singh, R.L. and Singh, R.P.B. (2003). *Elements of Practical Geography*, Delhi: Kalyani Publishers.

## Annexure 1

<p>Reciprocal Identities :</p> $\sin \theta = \frac{1}{\csc \theta} \quad \csc \theta = \frac{1}{\sin \theta}$ $\cos \theta = \frac{1}{\sec \theta} \quad \sec \theta = \frac{1}{\cos \theta}$ $\tan \theta = \frac{1}{\cot \theta} \quad \cot \theta = \frac{1}{\tan \theta}$	<p>Pythagorean Identities :</p> $\sin^2 \theta + \cos^2 \theta = 1$ $1 + \tan^2 \theta = \sec^2 \theta$ $1 + \cot^2 \theta = \csc^2 \theta$
<p>Cofunction Identities :</p> $\sin \theta = \cos \left( \frac{\pi}{2} - \theta \right), \quad \cos \theta = \sin \left( \frac{\pi}{2} - \theta \right)$ $\sec \theta = \csc \left( \frac{\pi}{2} - \theta \right), \quad \csc \theta = \sec \left( \frac{\pi}{2} - \theta \right)$ $\tan \theta = \cot \left( \frac{\pi}{2} - \theta \right), \quad \cot \theta = \tan \left( \frac{\pi}{2} - \theta \right)$	<p>Even Odd Identities :</p> $\sin(-\theta) = -\sin \theta, \quad \csc(-\theta) = -\csc \theta$ $\tan(-\theta) = -\tan \theta, \quad \cot(-\theta) = -\cot \theta$ $\cos(-\theta) = \cos \theta, \quad \sec(-\theta) = \sec \theta$
	<p>Quotient Identities :</p> $\tan \theta = \frac{\sin \theta}{\cos \theta} \quad \cot \theta = \frac{\cos \theta}{\sin \theta}$

	Trigonometric Functions						
	sin	cos	tan	cot	sec	csc	
0°	0.0000	1.0000	0.0000	....	1.000	...	90°
1°	0.0175	0.9998	0.0175	57.29	1.000	57.30	89°
2°	0.0349	0.9994	0.0349	28.64	1.001	28.65	88°
3°	0.0523	0.9986	0.0524	19.08	1.001	19.11	87°
4°	0.0698	0.9976	0.0699	14.30	1.002	14.34	86°
5°	0.0872	0.9962	0.0875	11.43	1.004	11.47	85°
6°	0.1045	0.9945	0.1051	9.514	1.006	9.567	84°
7°	0.1219	0.9925	0.1228	8.144	1.008	8.206	83°
8°	0.1392	0.9903	0.1405	7.115	1.010	7.185	82°
9°	0.1564	0.9877	0.1584	6.314	1.012	6.392	81°
10°	0.1736	0.9848	0.1763	5.671	1.015	5.759	80°
11°	0.1908	0.9816	0.1944	5.145	1.019	5.241	79°
12°	0.2079	0.9781	0.2126	4.705	1.022	4.810	78°
13°	0.2250	0.9744	0.2309	4.331	1.026	4.445	77°
14°	0.2419	0.9703	0.2493	4.011	1.031	4.134	76°
15°	0.2588	0.9659	0.2679	3.732	1.035	3.864	75°
16°	0.2756	0.9613	0.2867	3.487	1.040	3.628	74°
17°	0.2924	0.9563	0.3057	3.271	1.046	3.420	73°
18°	0.3090	0.9511	0.3249	3.078	1.051	3.236	72°
19°	0.3256	0.9455	0.3443	2.904	1.058	3.072	71°

20°	0.3420	0.9397	0.3640	2.747	1.064	2.924	70°
21°	0.3584	0.9336	0.3839	2.605	1.071	2.790	69°
22°	0.3746	0.9272	0.4040	2.475	1.079	2.669	68°
23°	0.3907	0.9205	0.4245	2.356	1.086	2.559	67°
24°	0.4067	0.9135	0.4452	2.246	1.095	2.459	66°
25°	0.4226	0.9063	0.4663	2.145	1.103	2.366	65°
26°	0.4384	0.8988	0.4877	2.050	1.113	2.281	64°
27°	0.4540	0.8910	0.5095	1.963	1.122	2.203	63°
28°	0.4695	0.8829	0.5317	1.881	1.133	2.130	62°
29°	0.4848	0.8746	0.5543	1.804	1.143	2.063	61°
30°	0.5000	0.8660	0.5774	1.732	1.155	2.000	60°
31°	0.5150	0.8572	0.6009	1.664	1.167	1.942	59°
32°	0.5299	0.8480	0.6249	1.600	1.179	1.887	58°
33°	0.5446	0.8387	0.6494	1.540	1.192	1.836	57°
34°	0.5592	0.8290	0.6745	1.483	1.206	1.788	56°
35°	0.5736	0.8192	0.7002	1.428	1.221	1.743	55°
36°	0.5878	0.8090	0.7265	1.376	1.236	1.701	54°
37°	0.6018	0.7986	0.7536	1.327	1.252	1.662	53°
38°	0.6157	0.7880	0.7813	1.280	1.269	1.624	52°
39°	0.6293	0.7771	0.8098	1.235	1.287	1.589	51°
40°	0.6428	0.7660	0.8391	1.192	1.305	1.556	50°
41°	0.6561	0.7547	0.8693	1.150	1.325	1.524	49°
42°	0.6691	0.7431	0.9004	1.111	1.346	1.494	48°
43°	0.6820	0.7314	0.9325	1.072	1.367	1.466	47°
44°	0.6947	0.7193	0.9657	1.036	1.390	1.440	46°
45°	0.7071	0.7071	1.000	1.000	1.414	1.414	45°
	cos	sin	cot	tan	csc	sec	

Logarithm Table																
	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6
1.0	0	0.0043	0.0086	0.0128	0.017	0.0212	0.0253	0.0294	0.0334	0.0374	4	8	##	##	##	##
1.1	0.0414	0.0453	0.0492	0.0531	0.0569	0.0607	0.0645	0.0682	0.0719	0.0755	4	8	##	##	##	##
1.2	0.0792	0.0828	0.0864	0.0899	0.0934	0.0969	0.1004	0.1038	0.1072	0.1106	3	7	##	##	##	##
1.3	0.1139	0.1173	0.1206	0.1239	0.1271	0.1303	0.1335	0.1367	0.1399	0.143	3	6	##	##	##	##
1.4	0.1461	0.1492	0.1523	0.1553	0.1584	0.1614	0.1644	0.1673	0.1703	0.1732	3	6	9	##	##	##
1.5	0.1761	0.179	0.1818	0.1847	0.1875	0.1903	0.1931	0.1959	0.1987	0.2014	3	6	8	##	##	##
1.6	0.2041	0.2068	0.2095	0.2122	0.2148	0.2175	0.2201	0.2227	0.2253	0.2279	3	5	8	##	##	##
1.7	0.2304	0.233	0.2355	0.238	0.2405	0.243	0.2455	0.248	0.2504	0.2529	2	5	7	##	##	##
1.8	0.2553	0.2577	0.2601	0.2625	0.2648	0.2672	0.2695	0.2718	0.2742	0.2765	2	5	7	9	##	##
1.9	0.2788	0.281	0.2833	0.2856	0.2878	0.29	0.2923	0.2945	0.2967	0.2989	2	4	7	9	##	##
2.0	0.301	0.3032	0.3054	0.3075	0.3096	0.3118	0.3139	0.316	0.3181	0.3201	2	4	6	8	##	##
2.1	0.3222	0.3243	0.3263	0.3284	0.3304	0.3324	0.3345	0.3365	0.3385	0.3404	2	4	6	8	##	##
2.2	0.3424	0.3444	0.3464	0.3483	0.3502	0.3522	0.3541	0.356	0.3579	0.3598	2	4	6	8	##	##
2.3	0.3617	0.3636	0.3655	0.3674	0.3692	0.3711	0.3729	0.3747	0.3766	0.3784	2	4	6	7	9	##
2.4	0.3802	0.382	0.3838	0.3856	0.3874	0.3892	0.3909	0.3927	0.3945	0.3962	2	4	5	7	9	##
2.5	0.3979	0.3997	0.4014	0.4031	0.4048	0.4065	0.4082	0.4099	0.4116	0.4133	2	3	5	7	9	##
2.6	0.415	0.4166	0.4183	0.42	0.4216	0.4232	0.4249	0.4265	0.4281	0.4298	2	3	5	7	8	##
2.7	0.4314	0.433	0.4346	0.4362	0.4378	0.4393	0.4409	0.4425	0.444	0.4456	2	3	5	6	8	9
2.8	0.4472	0.4487	0.4502	0.4518	0.4533	0.4548	0.4564	0.4579	0.4594	0.4609	2	3	5	6	8	9
2.9	0.4624	0.4639	0.4654	0.4669	0.4683	0.4698	0.4713	0.4728	0.4742	0.4757	1	3	4	6	7	9
3.0	0.4771	0.4786	0.48	0.4814	0.4829	0.4843	0.4857	0.4871	0.4886	0.49	1	3	4	6	7	9
3.1	0.4914	0.4928	0.4942	0.4955	0.4969	0.4983	0.4997	0.5011	0.5024	0.5038	1	3	4	6	7	8
3.2	0.5051	0.5065	0.5079	0.5092	0.5105	0.5119	0.5132	0.5145	0.5159	0.5172	1	3	4	5	7	8
3.3	0.5185	0.5198	0.5211	0.5224	0.5237	0.525	0.5263	0.5276	0.5289	0.5302	1	3	4	5	6	8
3.4	0.5315	0.5328	0.534	0.5353	0.5366	0.5378	0.5391	0.5403	0.5416	0.5428	1	3	4	5	6	8
3.5	0.5441	0.5453	0.5465	0.5478	0.549	0.5502	0.5514	0.5527	0.5539	0.5551	1	2	4	5	6	7
3.6	0.5563	0.5575	0.5587	0.5599	0.5611	0.5623	0.5635	0.5647	0.5658	0.567	1	2	4	5	6	7
3.7	0.5682	0.5694	0.5705	0.5717	0.5729	0.574	0.5752	0.5763	0.5775	0.5786	1	2	3	5	6	7
3.8	0.5798	0.5809	0.5821	0.5832	0.5843	0.5855	0.5866	0.5877	0.5888	0.5899	1	2	3	5	6	7
3.9	0.5911	0.5922	0.5933	0.5944	0.5955	0.5966	0.5977	0.5988	0.5999	0.601	1	2	3	4	5	7
4.0	0.6021	0.6031	0.6042	0.6053	0.6064	0.6075	0.6085	0.6096	0.6107	0.6117	1	2	3	4	5	6
4.1	0.6128	0.6138	0.6149	0.616	0.617	0.618	0.6191	0.6201	0.6212	0.6222	1	2	3	4	5	6

4.2	0.6232	0.6243	0.6253	0.6263	0.6274	0.6284	0.6294	0.6304	0.6314	0.6325	1	2	3	4	5	6	7	8	9
4.3	0.6335	0.6345	0.6355	0.6365	0.6375	0.6385	0.6395	0.6405	0.6415	0.6425	1	2	3	4	5	6	7	8	9
4.4	0.6435	0.6444	0.6454	0.6464	0.6474	0.6484	0.6493	0.6503	0.6513	0.6522	1	2	3	4	5	6	7	8	9
4.5	0.6532	0.6542	0.6551	0.6561	0.6571	0.658	0.659	0.6599	0.6609	0.6618	1	2	3	4	5	6	7	8	9
4.6	0.6628	0.6637	0.6646	0.6656	0.6665	0.6675	0.6684	0.6693	0.6702	0.6712	1	2	3	4	5	6	7	7	8
4.7	0.6721	0.673	0.6739	0.6749	0.6758	0.6767	0.6776	0.6785	0.6794	0.6803	1	2	3	4	5	5	6	7	8
4.8	0.6812	0.6821	0.683	0.6839	0.6848	0.6857	0.6866	0.6875	0.6884	0.6893	1	2	3	4	4	5	6	7	8
4.9	0.6902	0.6911	0.692	0.6928	0.6937	0.6946	0.6955	0.6964	0.6972	0.6981	1	2	3	4	4	5	6	7	8
5.0	0.699	0.6998	0.7007	0.7016	0.7024	0.7033	0.7042	0.705	0.7059	0.7067	1	2	3	3	4	5	6	7	8
5.1	0.7076	0.7084	0.7093	0.7101	0.711	0.7118	0.7126	0.7135	0.7143	0.7152	1	2	3	3	4	5	6	7	8
5.2	0.716	0.7168	0.7177	0.7185	0.7193	0.7202	0.721	0.7218	0.7226	0.7235	1	2	2	3	4	5	6	7	7
5.3	0.7243	0.7251	0.7259	0.7267	0.7275	0.7284	0.7292	0.73	0.7308	0.7316	1	2	2	3	4	5	6	6	7
5.4	0.7324	0.7332	0.734	0.7348	0.7356	0.7364	0.7372	0.738	0.7388	0.7396	1	2	2	3	4	5	6	6	7
5.5	0.7404	0.7412	0.7419	0.7427	0.7435	0.7443	0.7451	0.7459	0.7466	0.7474	1	2	2	3	4	5	5	6	7

	Logarithm Table										Mean Difference								
	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
5.6	0.7482	0.749	0.7497	0.7505	0.7513	0.752	0.7528	0.7536	0.7543	0.7551	1	2	2	3	4	5	5	6	7
5.7	0.7559	0.7566	0.7574	0.7582	0.7589	0.7597	0.7604	0.7612	0.7619	0.7627	1	2	2	3	4	5	5	6	7
5.8	0.7634	0.7642	0.7649	0.7657	0.7664	0.7672	0.7679	0.7686	0.7694	0.7701	1	1	2	3	4	4	5	6	7
5.9	0.7709	0.7716	0.7723	0.7731	0.7738	0.7745	0.7752	0.776	0.7767	0.7774	1	1	2	3	4	4	5	6	7
6.0	0.7782	0.7789	0.7796	0.7803	0.781	0.7818	0.7825	0.7832	0.7839	0.7846	1	1	2	3	4	4	5	6	6
6.1	0.7853	0.786	0.7868	0.7875	0.7882	0.7889	0.7896	0.7903	0.791	0.7917	1	1	2	3	4	4	5	6	6
6.2	0.7924	0.7931	0.7938	0.7945	0.7952	0.7959	0.7966	0.7973	0.798	0.7987	1	1	2	3	3	4	5	6	6
6.3	0.7993	0.8	0.8007	0.8014	0.8021	0.8028	0.8035	0.8041	0.8048	0.8055	1	1	2	3	3	4	5	5	6
6.4	0.8062	0.8069	0.8075	0.8082	0.8089	0.8096	0.8102	0.8109	0.8116	0.8122	1	1	2	3	3	4	5	5	6
6.5	0.8129	0.8136	0.8142	0.8149	0.8156	0.8162	0.8169	0.8176	0.8182	0.8189	1	1	2	3	3	4	5	5	6
6.6	0.8195	0.8202	0.8209	0.8215	0.8222	0.8228	0.8235	0.8241	0.8248	0.8254	1	1	2	3	3	4	5	5	6
6.7	0.8261	0.8267	0.8274	0.828	0.8287	0.8293	0.8299	0.8306	0.8312	0.8319	1	1	2	3	3	4	5	5	6
6.8	0.8325	0.8331	0.8338	0.8344	0.8351	0.8357	0.8363	0.837	0.8376	0.8382	1	1	2	3	3	4	4	5	6
6.9	0.8388	0.8395	0.8401	0.8407	0.8414	0.842	0.8426	0.8432	0.8439	0.8445	1	1	2	2	3	4	4	5	6
7.0	0.8451	0.8457	0.8463	0.847	0.8476	0.8482	0.8488	0.8494	0.85	0.8506	1	1	2	2	3	4	4	5	6
7.1	0.8513	0.8519	0.8525	0.8531	0.8537	0.8543	0.8549	0.8555	0.8561	0.8567	1	1	2	2	3	4	4	5	5
7.2	0.8573	0.8579	0.8585	0.8591	0.8597	0.8603	0.8609	0.8615	0.8621	0.8627	1	1	2	2	3	4	4	5	5
7.3	0.8633	0.8639	0.8645	0.8651	0.8657	0.8663	0.8669	0.8675	0.8681	0.8686	1	1	2	2	3	4	4	5	5
7.4	0.8692	0.8698	0.8704	0.871	0.8716	0.8722	0.8727	0.8733	0.8739	0.8745	1	1	2	2	3	4	4	5	5
7.5	0.8751	0.8756	0.8762	0.8768	0.8774	0.8779	0.8785	0.8791	0.8797	0.8802	1	1	2	2	3	3	4	5	5
7.6	0.8808	0.8814	0.882	0.8825	0.8831	0.8837	0.8842	0.8848	0.8854	0.8859	1	1	2	2	3	3	4	5	5
7.7	0.8865	0.8871	0.8876	0.8882	0.8887	0.8893	0.8899	0.8904	0.891	0.8915	1	1	2	2	3	3	4	4	5
7.8	0.8921	0.8927	0.8932	0.8938	0.8943	0.8949	0.8954	0.896	0.8965	0.8971	1	1	2	2	3	3	4	4	5
7.9	0.8976	0.8982	0.8987	0.8993	0.8998	0.9004	0.9009	0.9015	0.902	0.9025	1	1	2	2	3	3	4	4	5
8.0	0.9031	0.9036	0.9042	0.9047	0.9053	0.9058	0.9063	0.9069	0.9074	0.9079	1	1	2	2	3	3	4	4	5
8.1	0.9085	0.909	0.9096	0.9101	0.9106	0.9112	0.9117	0.9122	0.9128	0.9133	1	1	2	2	3	3	4	4	5
8.2	0.9138	0.9143	0.9149	0.9154	0.9159	0.9165	0.917	0.9175	0.918	0.9186	1	1	2	2	3	3	4	4	5
8.3	0.9191	0.9196	0.9201	0.9206	0.9212	0.9217	0.9222	0.9227	0.9232	0.9238	1	1	2	2	3	3	4	4	5
8.4	0.9243	0.9248	0.9253	0.9258	0.9263	0.9269	0.9274	0.9279	0.9284	0.9289	1	1	2	2	3	3	4	4	5
8.5	0.9294	0.9299	0.9304	0.9309	0.9315	0.932	0.9325	0.933	0.9335	0.934	1	1	2	2	3	3	4	4	5
8.6	0.9345	0.935	0.9355	0.936	0.9365	0.937	0.9375	0.938	0.9385	0.939	1	1	2	2	3	3	4	4	5
8.7	0.9395	0.94	0.9405	0.941	0.9415	0.942	0.9425	0.943	0.9435	0.944	0	1	1	2	2	3	3	4	4
8.8	0.9445	0.945	0.9455	0.946	0.9465	0.9469	0.9474	0.9479	0.9484	0.9489	0	1	1	2	2	3	3	4	4

8.9	0.9494	0.9499	0.9504	0.9509	0.9513	0.9518	0.9523	0.9528	0.9533	0.9538	0	1	1	2	2	3	3	4	4
9.0	0.9542	0.9547	0.9552	0.9557	0.9562	0.9566	0.9571	0.9576	0.9581	0.9586	0	1	1	2	2	3	3	4	4
9.1	0.959	0.9595	0.96	0.9605	0.9609	0.9614	0.9619	0.9624	0.9628	0.9633	0	1	1	2	2	3	3	4	4
9.2	0.9638	0.9643	0.9647	0.9652	0.9657	0.9661	0.9666	0.9671	0.9675	0.968	0	1	1	2	2	3	3	4	4
9.3	0.9685	0.9689	0.9694	0.9699	0.9703	0.9708	0.9713	0.9717	0.9722	0.9727	0	1	1	2	2	3	3	4	4
9.4	0.9731	0.9736	0.9741	0.9745	0.975	0.9754	0.9759	0.9763	0.9768	0.9773	0	1	1	2	2	3	3	4	4
9.5	0.9777	0.9782	0.9786	0.9791	0.9795	0.98	0.9805	0.9809	0.9814	0.9818	0	1	1	2	2	3	3	4	4
9.6	0.9823	0.9827	0.9832	0.9836	0.9841	0.9845	0.985	0.9854	0.9859	0.9863	0	1	1	2	2	3	3	4	4
9.7	0.9868	0.9872	0.9877	0.9881	0.9886	0.989	0.9894	0.9899	0.9903	0.9908	0	1	1	2	2	3	3	4	4
9.8	0.9912	0.9917	0.9921	0.9926	0.993	0.9934	0.9939	0.9943	0.9948	0.9952	0	1	1	2	2	3	3	4	4
9.9	0.9956	0.9961	0.9965	0.9969	0.9974	0.9978	0.9983	0.9987	0.9991	0.9996	0	1	1	2	2	3	3	3	4



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# EXERCISE 3

## CONSTRUCTION OF CONICAL PROJECTION

### Structure

3.1	Introduction Expected Learning Outcomes		Construction of Simple Conical Projection with Two Standard Parallels
3.2	Requirements		Construction of Bonne's Projection
3.3	Construction of Conical Projection Construction of Simple Conical Projection with One Standard Parallel	3.4	Suggested Further Readings

### 3.1 INTRODUCTION

You have learned the techniques of constructing different types of cylindrical map projections in Exercise 2. In this Exercise 3, you will learn the methods of construction of conical map projections for representing the earth's surface areas. There are several conical projections developed for mapping the surface of the globe.

Here, we have explained you particularly about the construction of **Simple Conical Projection with One Standard Parallel**, **Simple Conical Projection with Two Standard Parallels** and **Bonne's Projections**. To perform the construction of map projections, we have introduced two methods of construction i.e. Method 1-Mathematical and Method 2-Graphical for your convenience. You will also find these two methods in the next Exercise 4. You must refer to the trigonometric formulae and mathematical tables which are annexed at the end of this exercise for drawing the projection.

Before performing the task of Exercise 3, you may refer to Block 2 of BGGCT-133 for the reference and better understanding of basics of conical projections.

### Expected Learning Outcomes

After working through this exercise, you shall be able to:

- understand the method of construction of conical projections;
- construct a simple conical projection with one standard parallel;
- draw simple conical projection with two standard parallels; and
- make Bonne's projection.

## 3.2 REQUIREMENTS

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To perform this exercise, you require the following materials.

- Ruler or Scale
- Pencil/Pen
- Sharpener and Eraser
- Compass
- Divider
- Protractor
- Set-squares
- Scientific calculator
- Drawing sheets or White sheets (A3 size or long sheets).

## 3.3 CONSTRUCTION OF SIMPLE CONICAL PROJECTION WITH ONE STANDARD PARALLEL

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In the conical projection, the cone touches the globe along a line of latitude is called the *standard parallel*. Parallel lines of latitude are projected as concentric arcs of circles onto the cone. The meridians are projected onto the conical surface, meeting at the apex, or point, of the cone.

The distortion is almost nothing along the standard parallel. The distortion increases when you move away from the standard parallel(s). The pole is represented by an arc of circle.

Let us start to learn the construction of graticules for **Simple Conical Projection with One Standard Parallel** through the following exercises. Here, you will learn two methods i) Method 1: Mathematical Construction and ii) Method 2: Graphical Construction for the construction of graticules of the projections.

**PROBLEM 1:** Construct a graticule at  $10^\circ$  interval on simple conical projection with one standard parallel on RF 1:150,000,000 for the extensions,  $10^\circ\text{N}$ - $50^\circ\text{N}$  and  $60^\circ\text{E}$ - $100^\circ\text{E}$ .

### METHOD-1: MATHEMATICAL CONSTRUCTION

**SOLUTION:** In the preliminary stage, we have to calculate the values for constructing the map projection. Then, the calculated values are to be used for making the projection in the next stage.

### Calculations for Constructing the Projection:

**Step 1:** Calculate the radius (R) of the generating globe for the given scale. Let us note down the RF.

$$RF = 1:150,000,000 = \frac{1}{150,000,000}$$

$$\text{Radius } R = \frac{1}{150,000,000} (\text{cm}) \times \text{Earth radius}_{\text{cm}}$$

$$= \frac{1}{150,000,000} (\text{cm}) \times 640,000,000_{\text{cm}} = \frac{64}{15} = 4.26 \text{ cm}$$

We have now obtained the value of radius i.e. **R = 4.26 cm**

**Step 2:** Let us choose the standard parallel. Note the latitudinal extent i.e. from 10°N to 50°N and the interval between the parallels i.e. 10°. So, the following parallels are to be drawn.

10°N, 20°N, 30°N, 40°N, 50°N.

Hence, **the standard parallel** would be **30°N**.

**Step 3:** Also record the longitudinal extent of the area i.e. from 60°E to 100°E and the interval between the meridians i.e. 10°. Thus, the following meridians have also to be drawn.

60°E, 70°E, 80°E, 90°E, 100°E.

**The central meridian** would be **80°E**.

**Step 4:** Calculate the length of the radius ( $r_1$ ) of the standard parallel (**30°N**) using the standard equation as follows:

$$r_1 = R \cot \phi = 4.26 \times \cot 30^\circ = 4.26 \times 1.732 = \mathbf{7.38 \text{ cm}}$$

**Step 5:** Calculate the length of a division ( $d_1$ ) on the central meridian at 10° interval using the standard equation as follows.

$$d_1 = \frac{2\pi R}{360^\circ} \times \text{Interval } (^\circ) = \frac{2 \times 3.14 \times 4.26}{360} \times 10 = 0.74 \text{ cm}$$

where  $\pi = \frac{22}{7} = 3.14$  (Constant);  $R = 4.26 \text{ cm}$  (From Step 1)

Now, you got to know **the length of a division on central meridian** for spacing the parallels i.e.  **$d_1 = 0.74 \text{ cm}$** .

**Step 6:** Calculate the length of a division ( $d_2$ ) on the standard parallel (**30°N**) at 10° interval using the standard equation as follows.

$$d_2 = \frac{2\pi R \cos \phi}{360^\circ} \times \text{Interval } (^\circ)$$

$$= \frac{2 \times 3.14 \times 4.26 \times \cos 30^\circ}{360} \times 10 = \frac{26.75 \times 0.866}{36} = \frac{23.16}{36} = 0.64 \text{ cm}$$

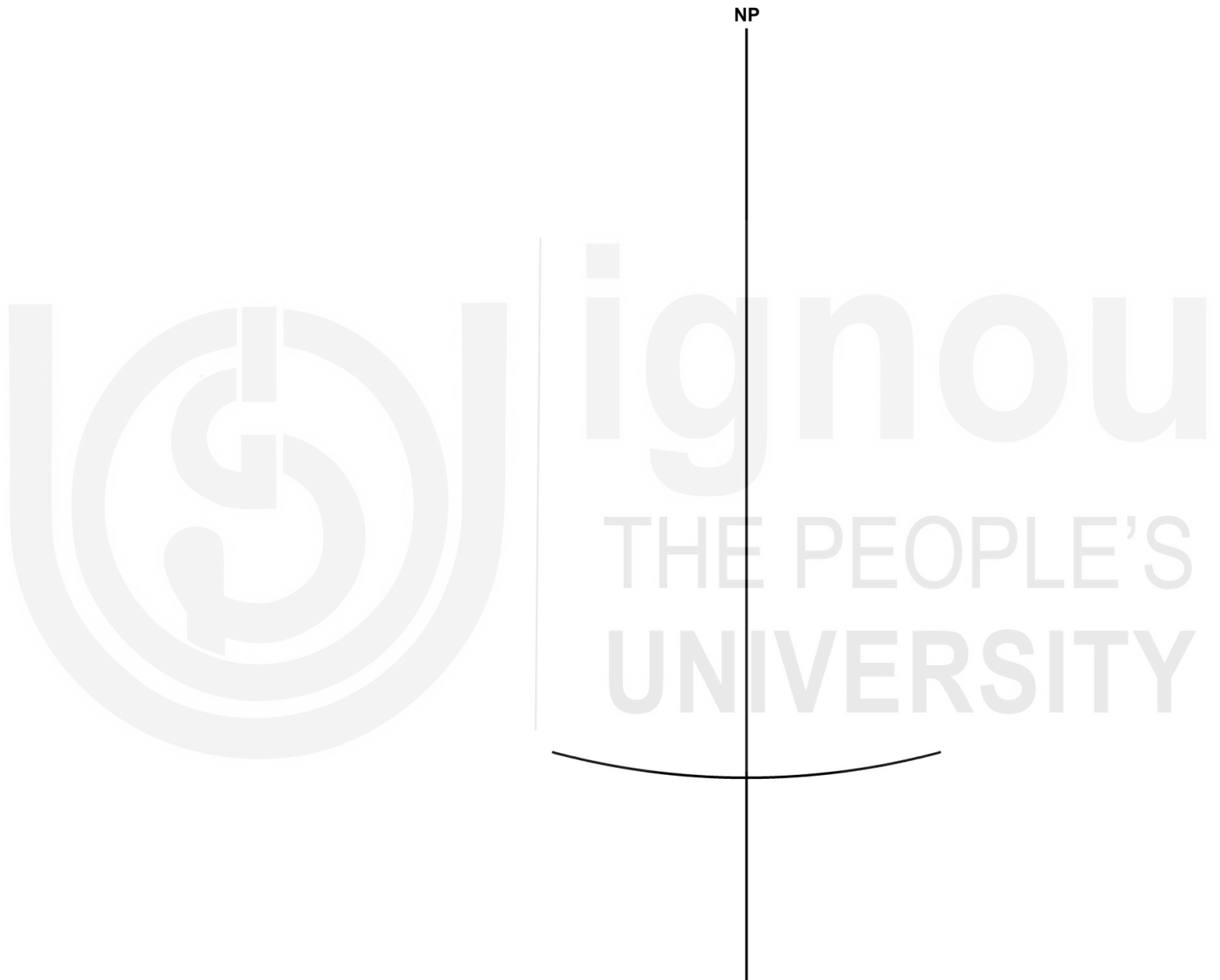
Now, you got to know **the length of division on the standard parallel** at 10° interval for spacing the meridians i.e.  **$d_2 = 0.64 \text{ cm}$** .

You have now all the calculated values for constructing the projection. Let us start the construction of the projection. Keep ready with you a drawing sheet, pencil, ruler, compass, protractor and divider etc.

### Construction of the Projection:

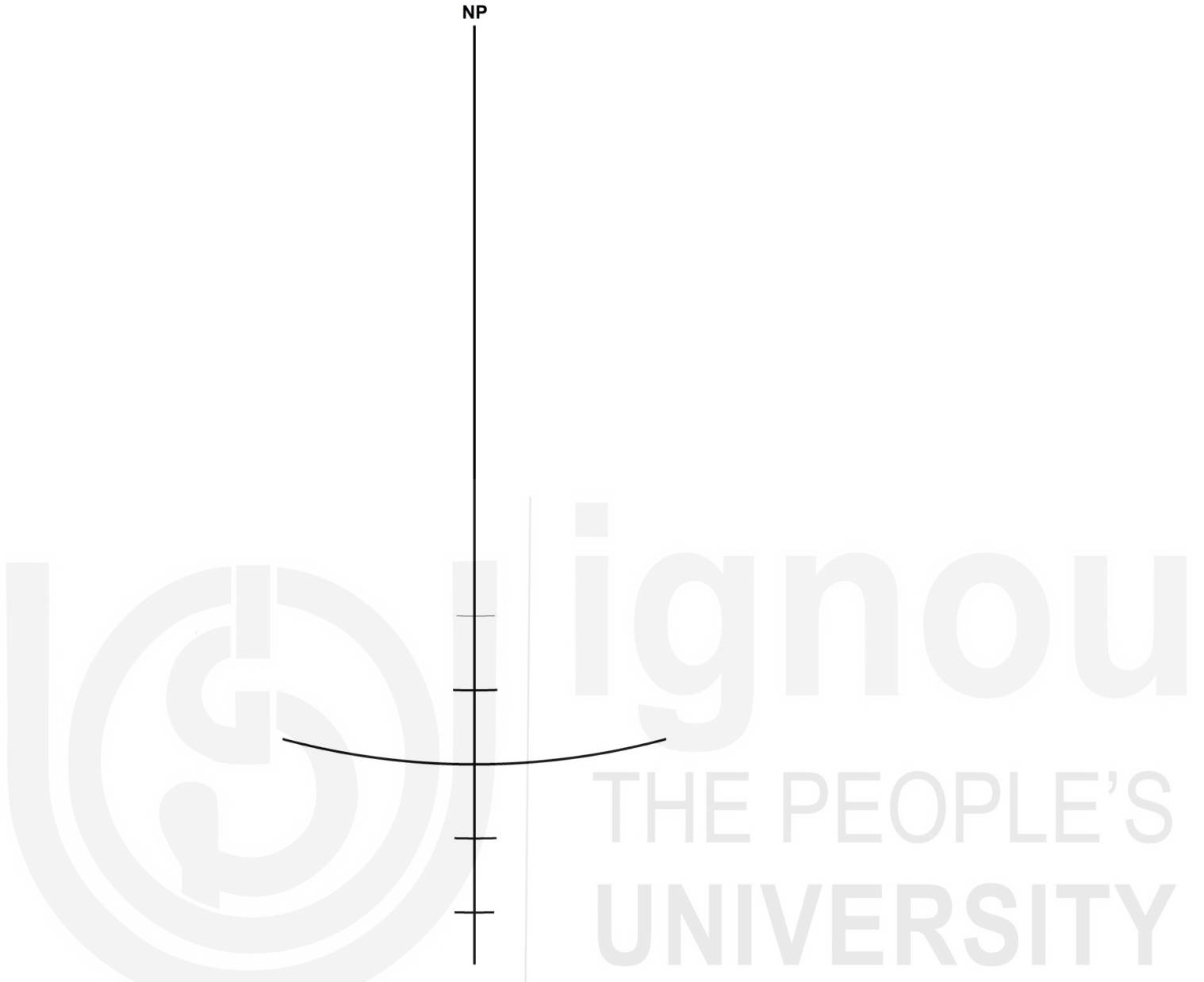
**Step 7:** Take a drawing sheet and place it on plane surface. With the help of pencil and scale, draw a straight line vertically on centre of the sheet that is to be represented as central meridian.

**Step 8:** Set a compass with the calculated value of radius i.e.  $r_1 = 7.38 \text{ cm}$  and draw an arc of circle going through the central meridian from NP. This arc will be the **standard parallel of  $30^\circ\text{N}$** .

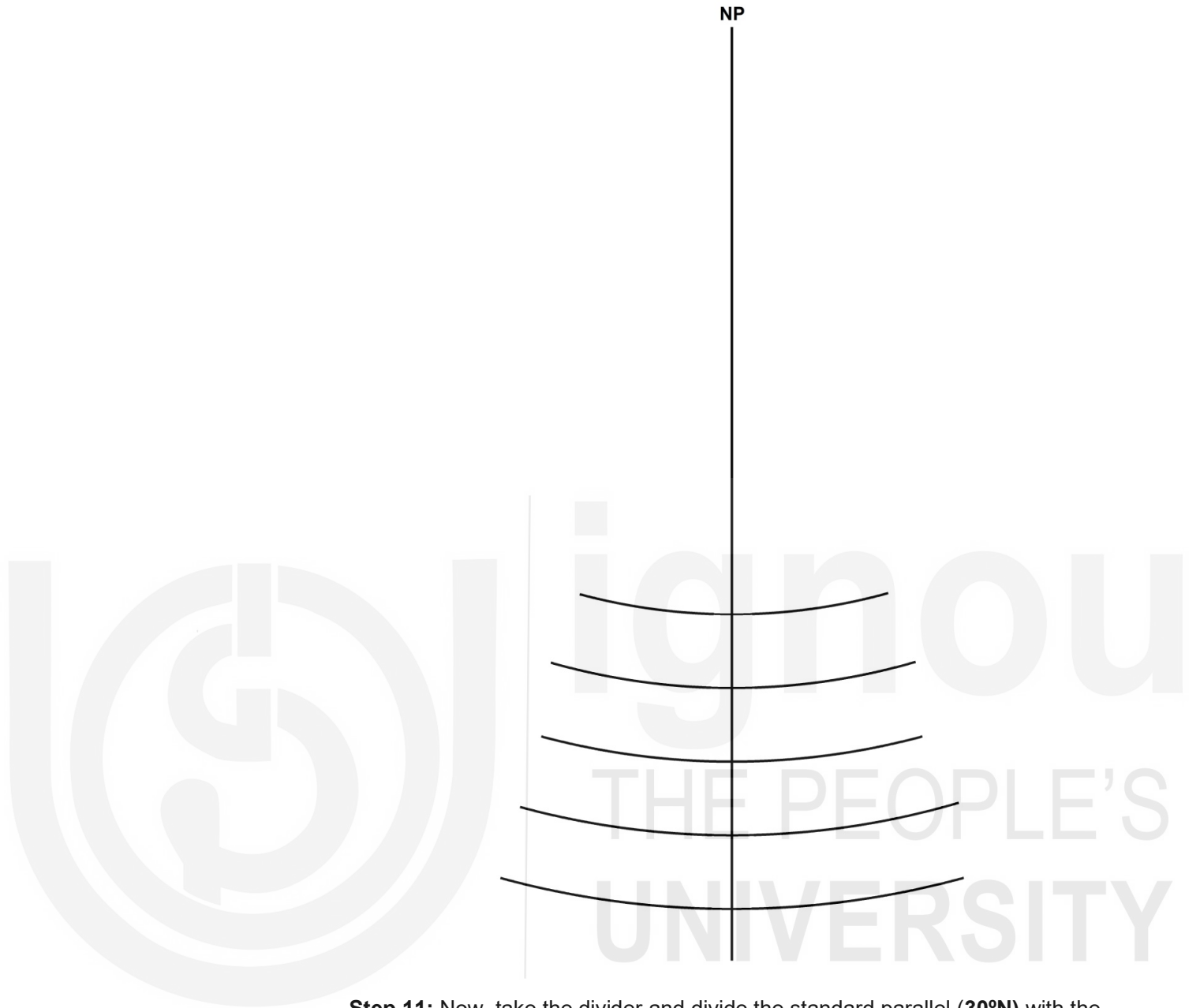


**Step 9:** Set the divider with a measurement of  $d_1 = 0.74 \text{ cm}$  (from Step 5) and mark the divisions on the central meridian starting from the arc of standard parallel for spacing the parallels.

NP

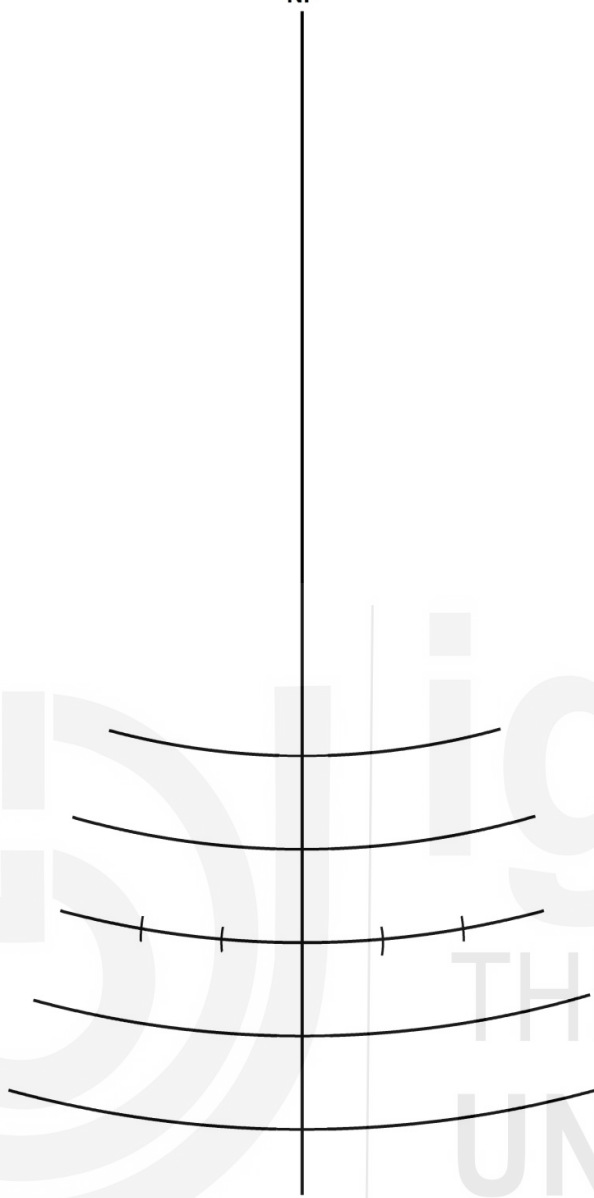


**Step 10:** Draw other concentric arcs by connecting each division on the central meridian. These arcs will represent all other parallels.

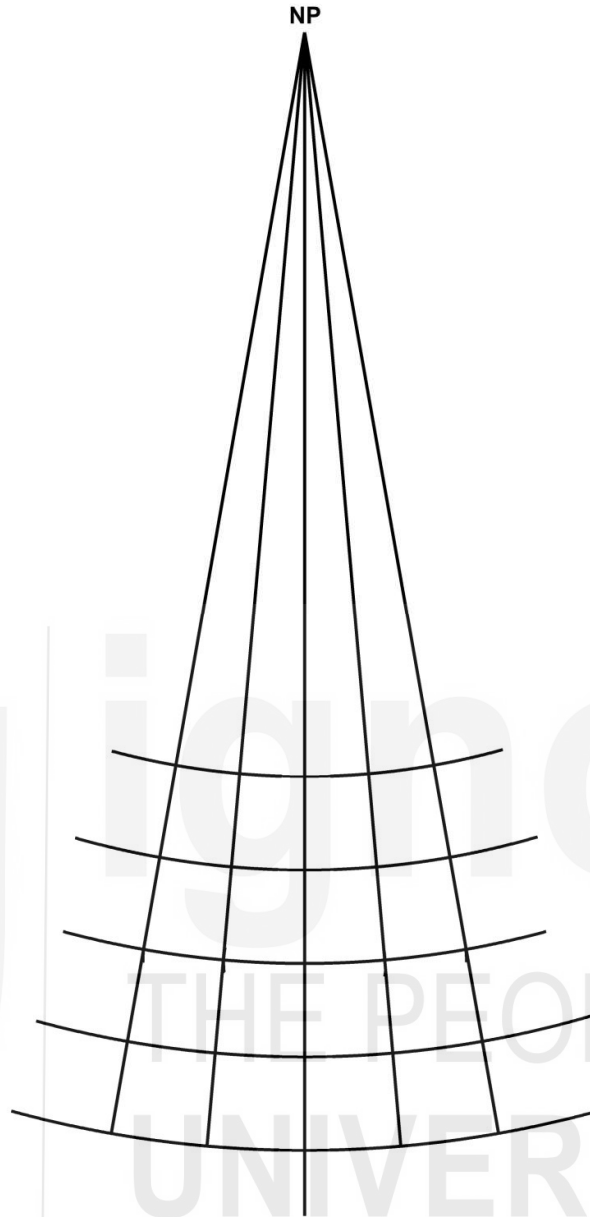


**Step 11:** Now, take the divider and divide the standard parallel (**30°N**) with the measurement of  **$d_2 = 0.64$  cm** (refer to **Step 6**) for spacing the meridians.

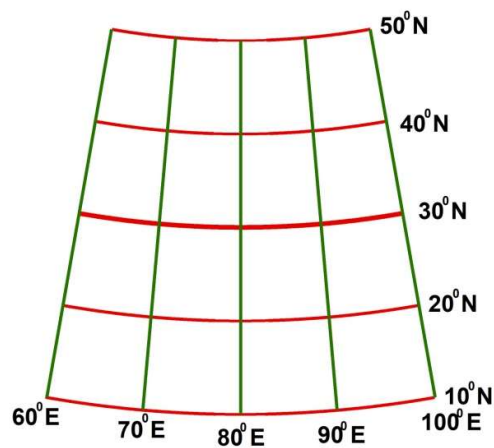
NP



**Step 12:** With the help of scale or setsquares, straight lines are drawn by touching each of these division points joining to the pole point of central meridian. These lines are meridians.



**Step 13:** You have now successfully completed the construction of graticules of simple conical projection with one standard parallel. But you have to erase the extended lines of the projection and finish it with proper labelling as given below. You must also write the scale of projection.



## METHOD-2: GRAPHICAL CONSTRUCTION

**Solution:** In the preliminary stage, we have to calculate the values for constructing the map projection. Then, the calculated values are to be used for making the projection in the next stage.

### Calculations for Constructing the Projection:

**Step 1:** Calculate the radius (R) of the generating globe for the given scale. Note down the RF.

$$RF = 1:150,000,000 = \frac{1}{150,000,000}$$

$$\begin{aligned} \text{Radius } R &= \frac{1}{150,000,000} (\text{cm}) \times \text{Earth radius}_{\text{cm}} \\ &= \frac{1}{150,000,000} (\text{cm}) \times 6400,000 \text{ cm} = \frac{64}{15} = 4.26 \text{ cm} \end{aligned}$$

We have now obtained the value of radius i.e. **R = 4.26 cm**

**Step 2:** Let us choose the standard parallel. Note the latitudinal extent i.e. from 10°N to 50°N and the interval between the parallels i.e. 10°. So, the following parallels are to be drawn.

10°N, 20°N, 30°N, 40°N, 50°N.

Hence, **the standard parallel** would be **30°N**.

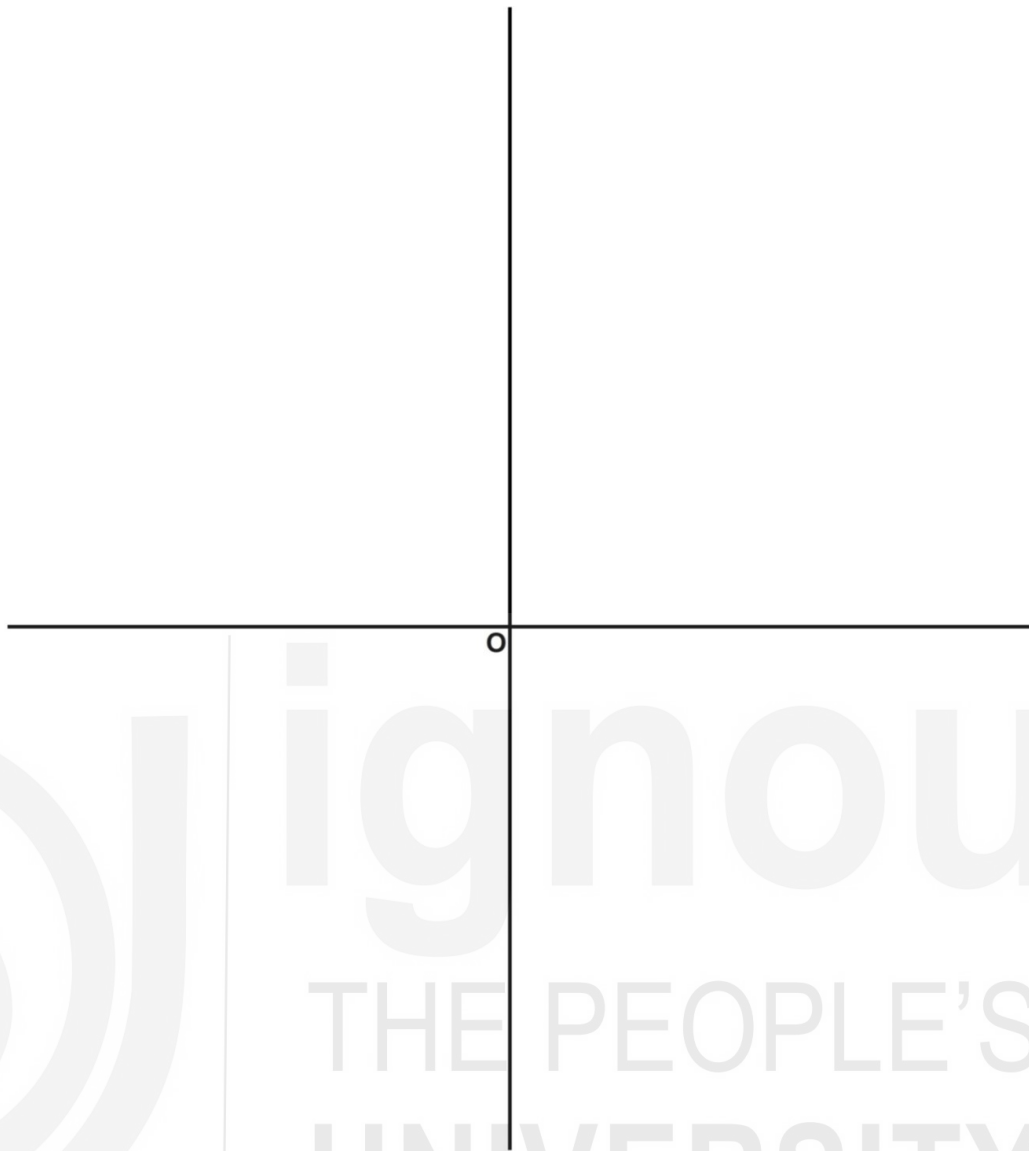
**Step 3:** Also record the longitudinal extent of the area i.e. from 60°E to 100°E and the interval between the meridians i.e. 10°. Thus, the following meridians have also to be drawn.

60°E, 70°E, 80°E, 90°E, 100°E.

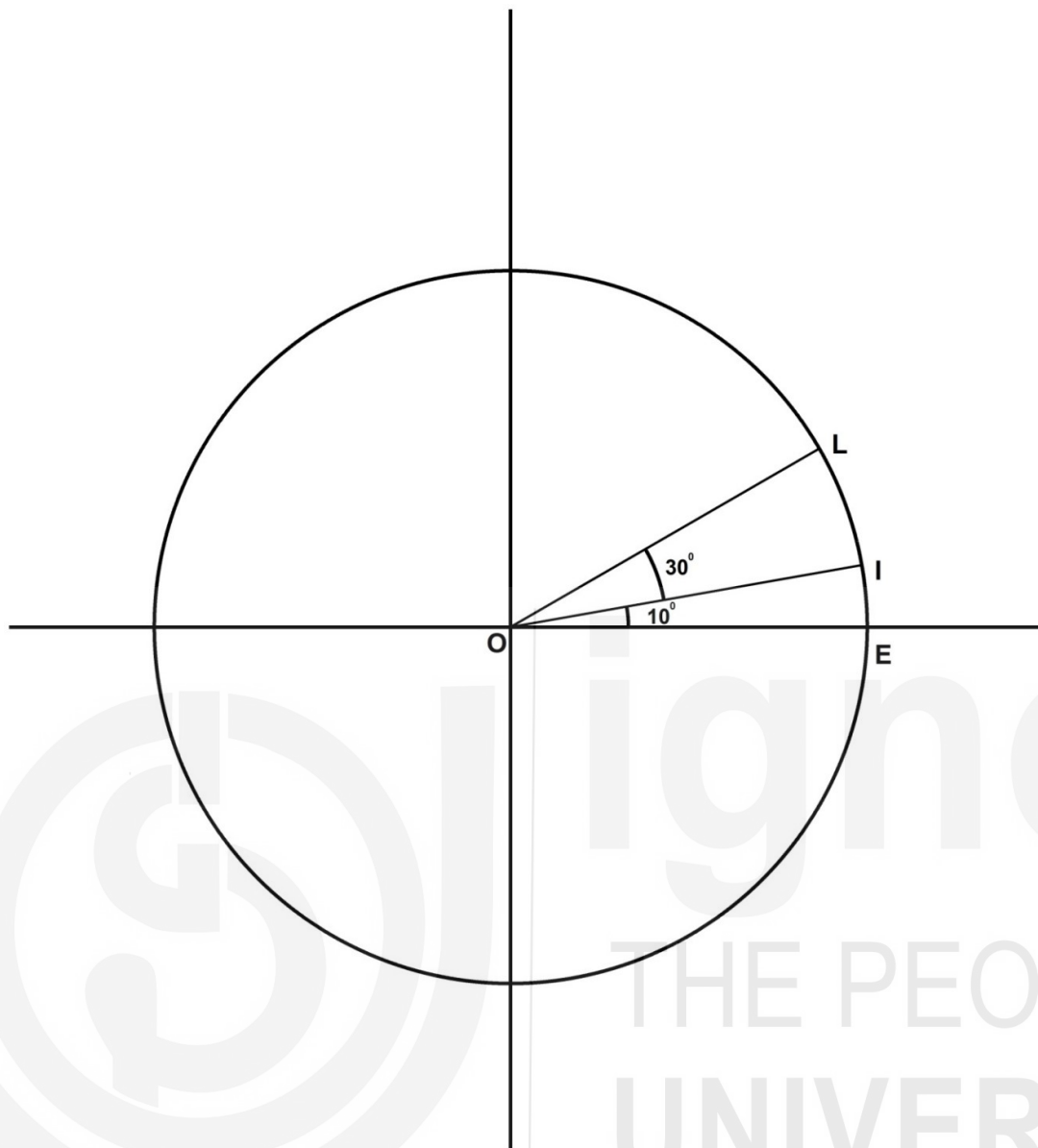
**The central meridian** would be **80°E**.

**Step 4:** Now, we have to calculate the value of the radius of the standard parallel (30°N), the length of a division ( $d_1$ ) on the central meridian (80°E), and the length of a division ( $d_2$ ) on the standard parallel.

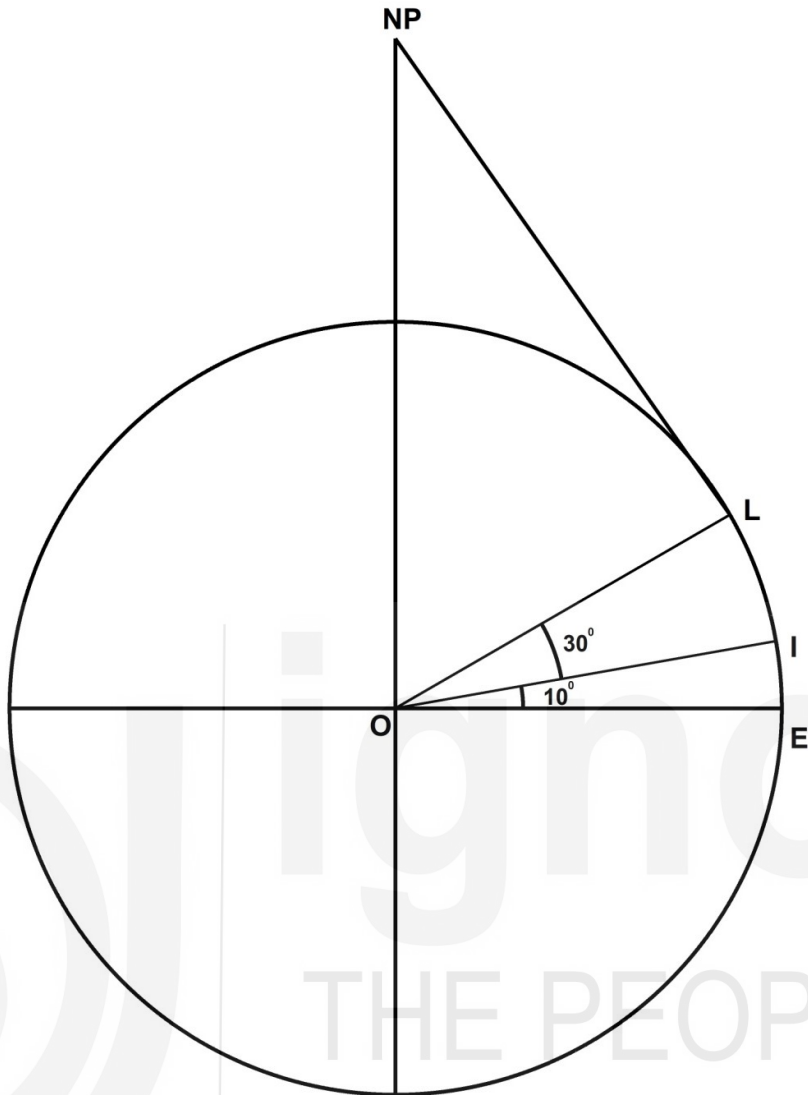
Take a drawing sheet and place it on plane surface. With the help of pencil and scale, draw a pair of straight lines on the sheet. The lines must be intersected with 90° angle. The intersection point is named as O.



**Step 5:** Draw a circle with the measurement of radius  $R = 4.26 \text{ cm}$  from the center (O). With the help of protractor, mark the angles of  $10^\circ$  (given interval) as OEI and  $30^\circ$  (standard parallel) as OEL on the circle. Then, draw lines OI for the given interval and OL for the standard parallel through these markings from O.



**Step 6:** Draw a tangent line from the standard parallel point (L) to meet the vertical line at polar point (NP). Now, the length of LNP will be the radius of standard parallel ( $30^\circ$ ).

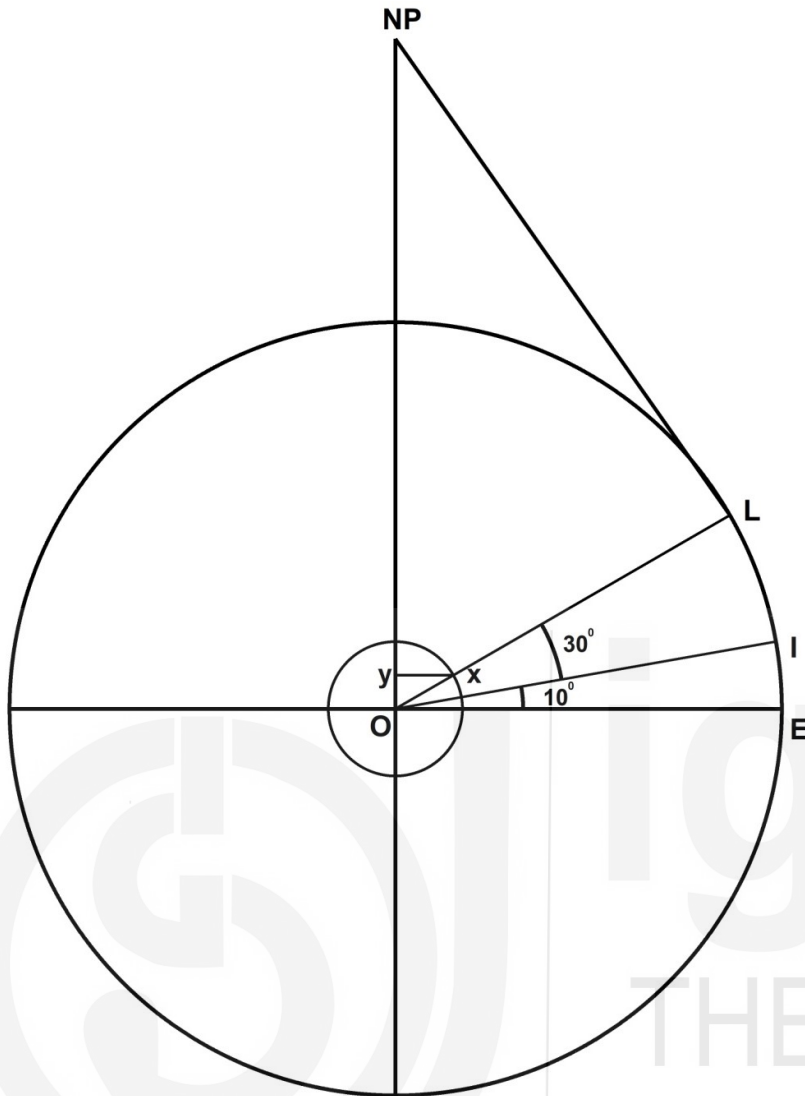


Now, you got the value of **the radius of standard parallel** i.e.  $LNP = 6.4 \text{ cm}$ .

**Step 7:** Measure the arc distance of IE which will be the value of the division on central meridian. Hence, IE is the true distance between two parallels at  $10^\circ$  interval.

Now, you got to know **the length of division on central meridian** for spacing the parallels i.e.  $d_1 = 0.74 \text{ cm}$ .

**Step 8:** Now, you have to calculate the value of division on the standard parallel. Draw an inner circle with the measurement of  $IE=0.74$  from the center O. Draw a line xy parallel to OE. Now, measure the length of xy and it will be the value of division of the standard parallel for spacing the meridians.



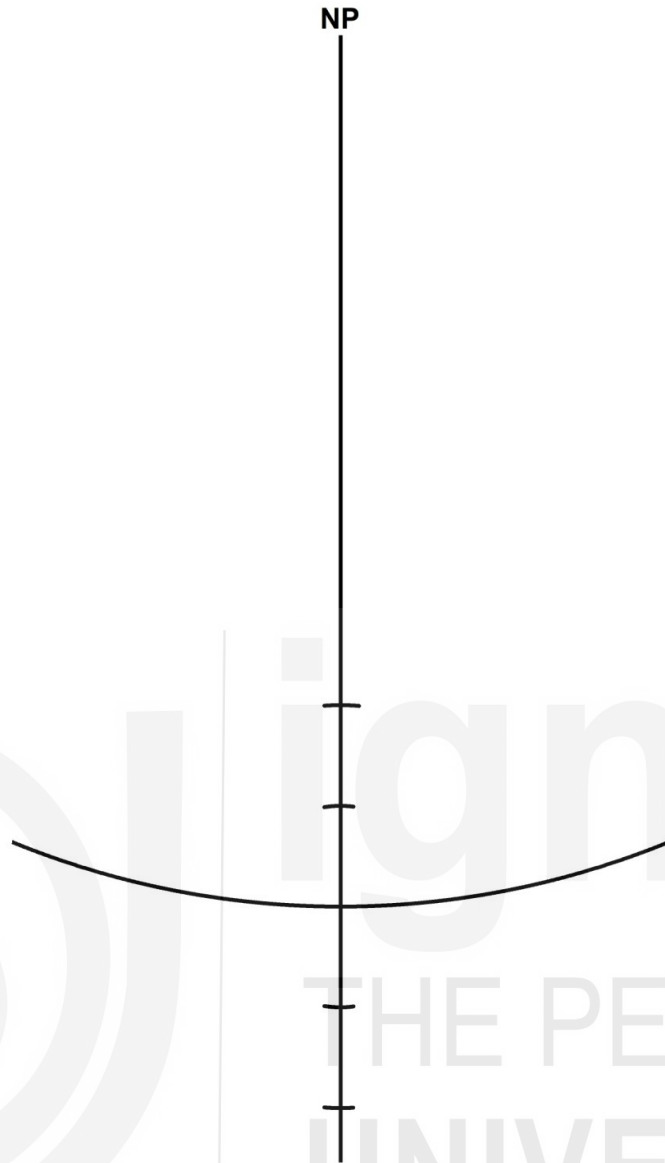
Now, you have the value of **the length of division on the standard parallel (30°N)** for spacing the meridians i.e.  $d_2 = 0.64$  cm.

### **Construction of the Projection:**

**Step 9:** Take a drawing sheet and place it on plane surface. With the help of pencil and scale, draw a straight line vertically on centre of the sheet.

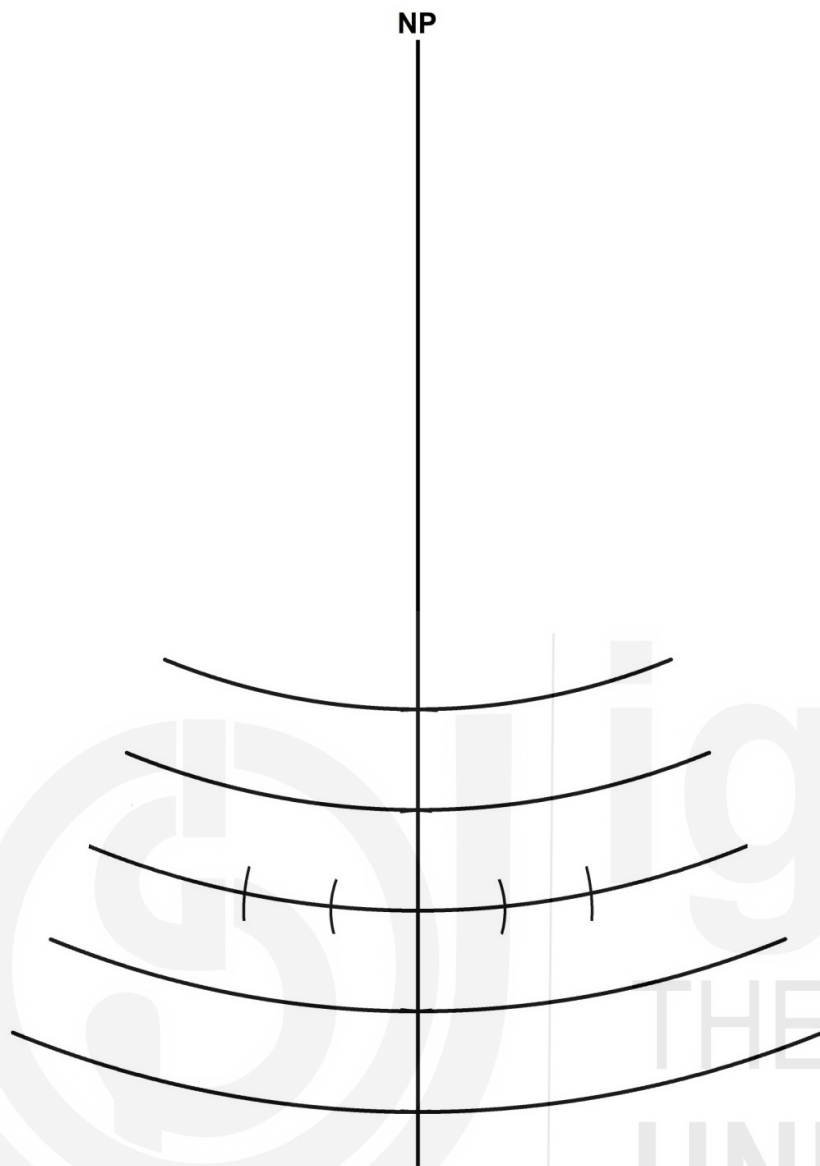
**Step 10:** Set a compass with the calculated value of radius i.e. **LP = 6.4 cm** and draw an arc of circle going through the central meridian from point NP. This arc will be the standard parallel of 30°N.

**Step 11:** Set the divider with a measurement of  **$d_1 = 0.74$  cm (from Step 7)** and mark the divisions on the central meridian starting from the arc of standard parallel for spacing the parallels.

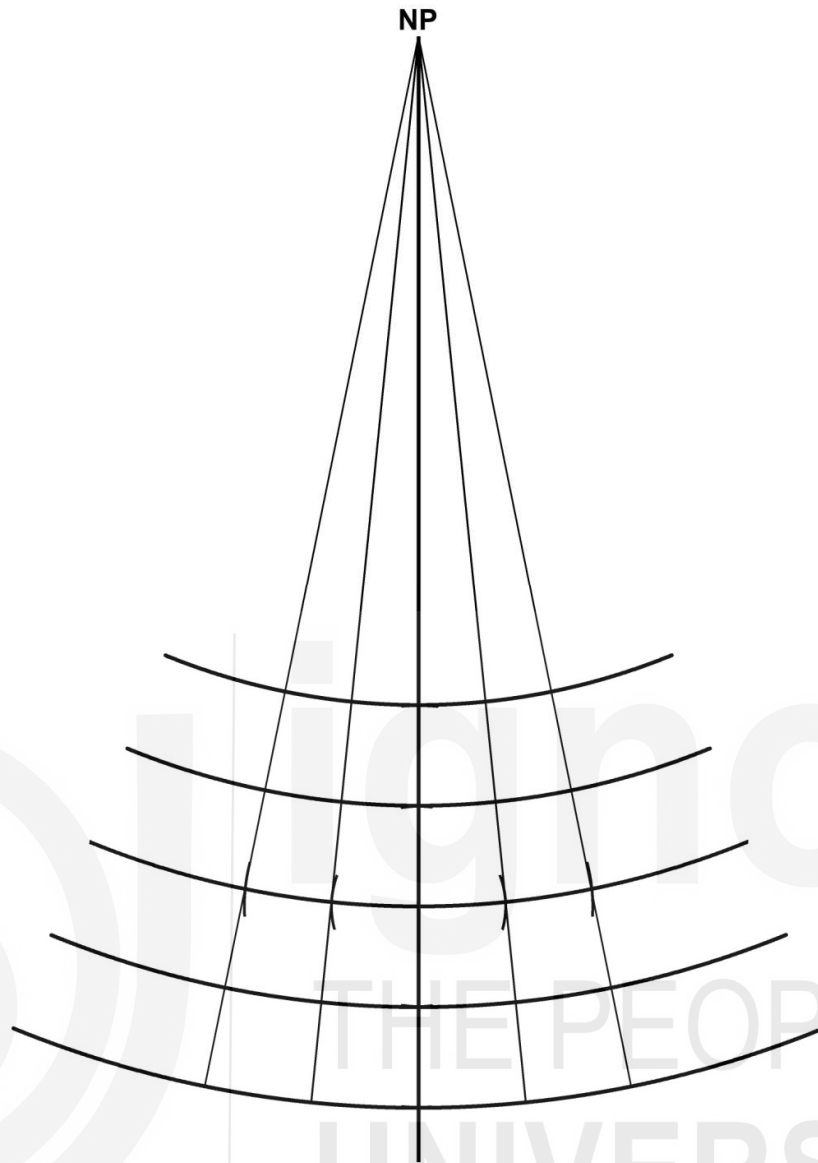


**Step 12:** Draw other concentric arcs by connecting each division on the central meridian. These arcs will represent all other parallels.

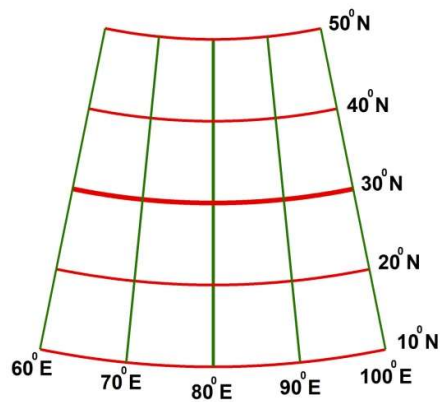
**Step 13:** Now, take the divider and divide the standard parallel (**30°N**) with the measurement of  **$d_2 = 0.64$  cm** (refer to **Step 6**) for spacing the meridians.



**Step 14:** With the help of scale or setsquares, straight lines are drawn by touching each of these division points joining to the central meridian pole point. These lines are meridians.



**Step 15:** You have now successfully completed the construction of graticules of simple conical projection with one standard parallel. But you have to erase the extended lines of the projection and finish it with proper labelling as given below. You must also write the scale of projection.



**R.F. 1:150,000,000**

### 3.3 CONSTRUCTION OF SIMPLE CONICAL PROJECTION WITH TWO STANDARD PARALLELS

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In this conical projection, two circles of the cone correspond to two standard parallels of the globe and form an ordinary cone independent of the globe.

Parallel lines of latitude are projected as concentric arcs of circles onto the cone. The meridians are projected onto the conical surface, meeting at the apex, or point, of the cone.

The distortion is close to zero along the standard parallels. The distortion increases when you move away from the standard parallel(s). The pole is represented by an arc of circle. The scale is true along these standard parallels. The distance between the parallels is equal.

Let us start to learn the construction of graticules for **Simple Conical Projection with Two Standard Parallels** through the following exercises. Here, you will learn two methods i) Method 1: Mathematical Construction and ii) Method 2: Graphical Construction for the construction of graticules of the projections.

**PROBLEM 1:** Construct graticules at 5° interval on simple conical projection with two standard parallel on RF 1:200,000,000 for covering an area 20°N-65°N and 60°E to 100°E.

#### **METHOD-1: MATHEMATICAL CONSTRUCTION**

**Solution:** In the preliminary stage, we have to calculate the values for constructing the map projection. Then, the calculated values are to be used for making the projection in the next stage.

#### **Calculations for Constructing the Projection:**

**Step 1:** Calculate the radius (R) of the generating globe for the given scale. Note down the RF.

$$RF = 1:200,000,000 = \frac{1}{200,000,000}$$

$$\text{Radius } R = \frac{1}{200,000,000} (\text{cm}) \times \text{Earth radius}_{\text{cm}}$$

$$= \frac{1}{200,000,000} (\text{cm}) \times 640,000,000_{\text{cm}} = \frac{64}{20} = 3.2 \text{ cm}$$

We have now obtained the value of radius i.e. **R = 3.2 cm**

**Step 2:** Let us choose the two standard parallels. Note the latitudinal extent i.e. from 20°N to 65°N and the interval between the parallels i.e. 5°. So, the following parallels are to be drawn.

20°N, 25°N, 30°N, 35°N, 40°N, 45°N, 50°N, 55°N, 60°N, 65°N

Standard parallels can be chosen as follows:

$$\phi_1 = 65 - \frac{(65 - 20)}{3} = 65 - \frac{45}{3} = 65 - 15 = 50^\circ N$$

$$\phi_2 = 20 + \frac{(65 - 20)}{3} = 20 + \frac{45}{3} = 20 + 15 = 35^\circ N$$

Hence, the chosen standard parallels are  $50^\circ N$  and  $35^\circ N$ .

**First standard parallel is  $50^\circ N$**

**Second standard parallel is  $35^\circ N$**

**Step 3:** Note the extent of meridians i.e. from  $60^\circ E$  to  $100^\circ E$  and the interval i.e.  $5^\circ$ . Thus, the following meridians have also to be drawn.

$60^\circ E, 65^\circ E, 70^\circ E, 75^\circ E, 80^\circ E, 85^\circ E, 90^\circ E, 95^\circ E, 100^\circ E$ .

**The central meridian is  $80^\circ E$ .**

**Step 4:** Calculate the length of a division (d) on the central meridian at  $5^\circ$  interval using the standard equation as follows.

$$d = \frac{2\pi R}{360^\circ} \times \text{Interval } (^\circ)$$

$$= \frac{2 \times 3.14 \times 3.2}{360} \times 5 = \frac{20.09}{360} \times 5 = 0.056 \times 5 = 0.28 \text{ cm}$$

$$\text{where } \pi = \frac{22}{7} = 3.14 \text{ (Constant); } R = 3.2 \text{ cm (From Step 1)}$$

Now, you got to know **the length of division on central meridian** for spacing the parallels i.e. **d = 0.28 cm**.

**Step 5:** Calculate the distance between the standard parallels using the formula as follows:

$$d_{(\phi_1 - \phi_2)} = \frac{2\pi R}{360^\circ} \times \text{Interval of Standard Parallels } ((\phi_1 - \phi_2))$$

$$= \frac{2 \times 3.14 \times 3.2}{360} \times (50 - 35) = \frac{20.09}{360} \times 15 = 0.055 \times 15 = 0.84 \text{ cm}$$

Now, you have the value of **the distance between two standard parallels** ( $50^\circ N$  and  $35^\circ N$ ) i.e.  **$d_{(50^\circ - 35^\circ)} = 0.84 \text{ cm}$** .

**Step 6:** Calculate the length of the radius of the first standard parallel ( $r_1$ ) using the standard equation as follows:

$$r_1 = d_{(\phi_1 - \phi_2)} \times \frac{\cos \phi_1}{\cos \phi_2 - \cos \phi_1} = d_{(50^\circ - 35^\circ)} \times \frac{\cos 50^\circ}{\cos 35^\circ - \cos 50^\circ} =$$

$$= 0.84 \times \frac{0.642}{0.819 - 0.642} = 0.84 \times \frac{0.642}{0.177} = 0.84 \times 3.62 = 3.0 \text{ cm.}$$

Where,

$$r_1 = r_{50^\circ N} = \text{Radius of first standard parallel}$$

$$d_{(\phi_1 - \phi_2)} = \text{Distance between two standard parallels} = 0.84 \text{ cm}$$

Now, you got the value of **the radius of the first standard parallel (50°N)**  
i.e.  $r_1 = 3.0 \text{ cm}$ .

**Step 7:** Calculate the length of the radius of the second standard parallel ( $r_2$ )  
using the standard equation as follows:

$$r_2 = d_{(\phi_1 - \phi_2)} + r_1 = d_{(50^\circ - 35^\circ)} + 3.0 = 0.84 + 3.0 = 3.84 \text{ cm}$$

where,

$r_2 = \text{Radius of second standard parallel}$

$d_{(\phi_1 - \phi_2)} = \text{Distance between two standard parallels} = 0.84 \text{ cm}$

$r_1 = \text{Radius of first standard parallel} = 3.0 \text{ cm}$

Now, you got the value of **the radius of the second standard parallel (35°N)**  
i.e.  $r_2 = 3.84 \text{ cm}$ .

**Step 8:** Calculate the length of a division ( $d_1$ ) on the first standard parallel  
(50°N) at 5° interval using the standard equation as follows.

$$d_1 = \frac{2\pi R \cos \phi}{360^\circ} \times \text{Interval } (^\circ)$$
$$= \frac{2 \times 3.14 \times 3.2 \times \cos 50^\circ}{360} \times 5 = \frac{20.09 \times 0.642}{360} \times 5 = \frac{12.89}{72} = 0.18 \text{ cm}$$

Now, you have the value of **the length of division on the standard parallel (50°N)** for spacing the meridians i.e.  $d_1 = 0.18 \text{ cm}$ .

**Step 9:** Calculate the length of a division ( $d_2$ ) on the second standard parallel  
(35°N) at 5° interval using the standard equation as follows.

$$d_2 = \frac{2\pi R \cos \phi}{360^\circ} \times \text{Interval } (^\circ)$$
$$= \frac{2 \times 3.14 \times 3.2 \times \cos 35^\circ}{360} \times 5 = \frac{20.09 \times 0.819}{360} \times 5 = \frac{16.45}{72} = 0.23 \text{ cm}$$

Now, you have the value of **the length of division on the standard parallel (35°N)** for spacing the meridians i.e.  $d_2 = 0.23 \text{ cm}$ .

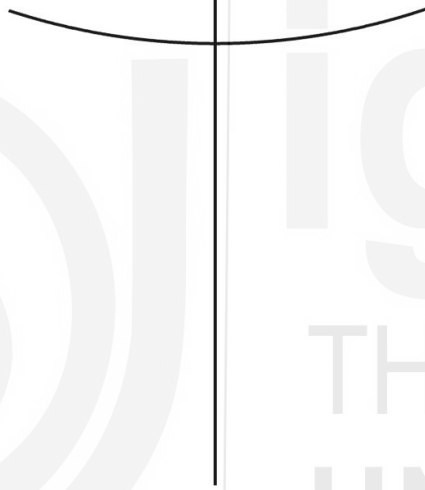
You have now all the calculated values for constructing the map projection.  
Let us start the construction of the projection. Keep ready with you a drawing  
sheet, pencil, ruler, compass, protractor, and divider, etc.

### **Construction of the Projection:**

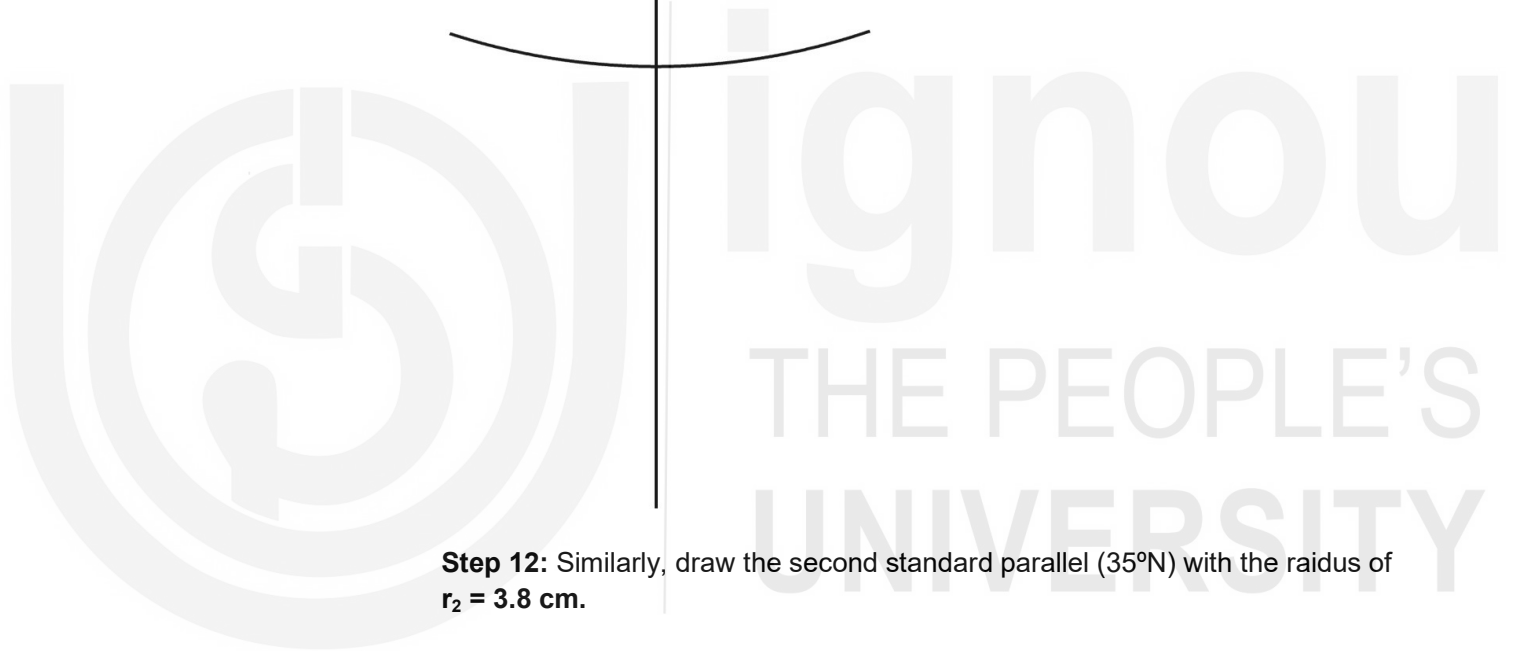
**Step 10:** Take a drawing sheet and place it on plane surface. With the help of  
pencil and scale, draw a straight line vertically on centre of the sheet that is to  
be represented as central meridian.

**Step 11:** Set compass with the calculated value of radius i.e.  $r_1 = 3 \text{ cm}$  and  
draw an arc of circle going through the central meridian from north pole point  
NP. This arc will be the standard parallel of 50°N.

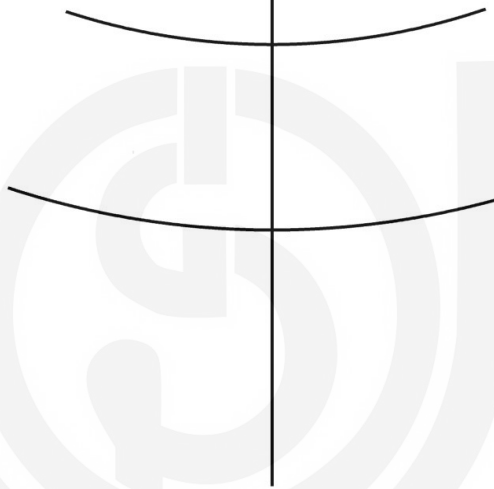
NP



**Step 12:** Similarly, draw the second standard parallel ( $35^{\circ}\text{N}$ ) with the radius of  $r_2 = 3.8 \text{ cm}$ .

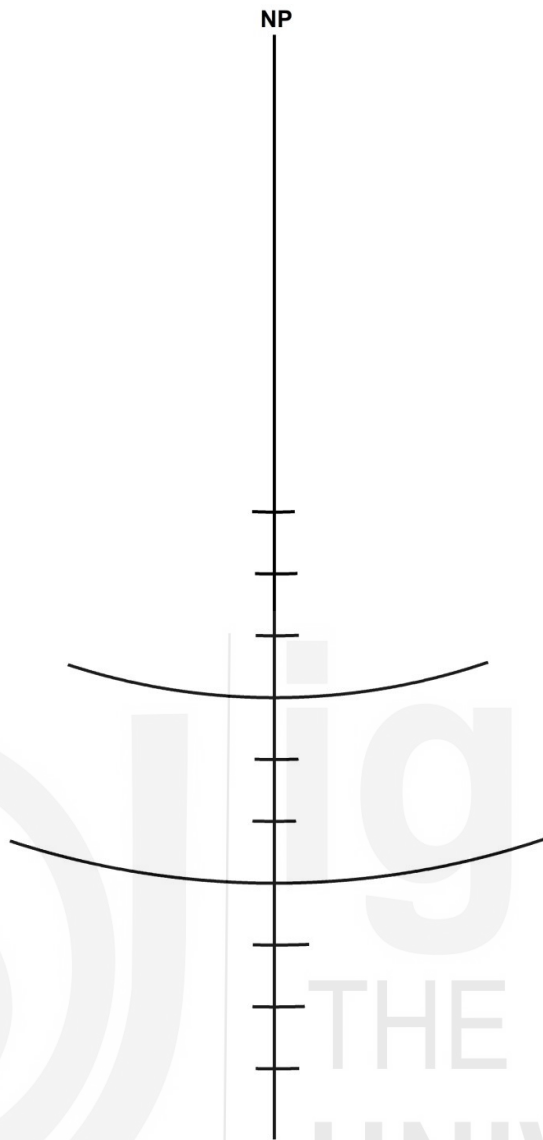


NP

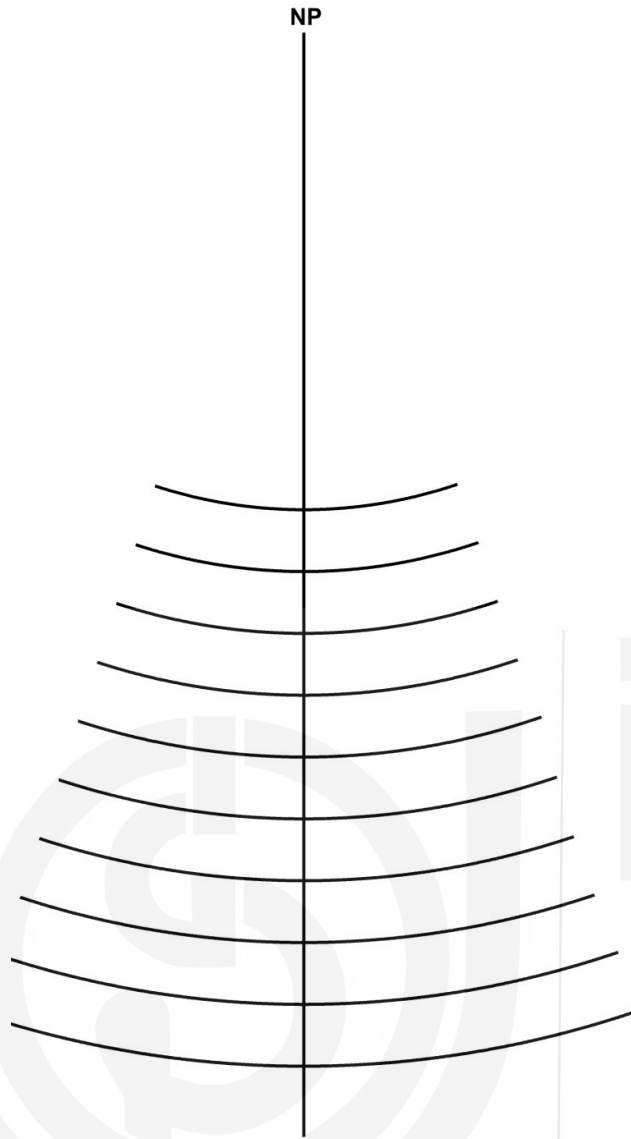


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**Step 13:** Using the divider, mark the divisions starting from the standard parallel on the central meridian (**80°E**) with the measurement of **d = 0.28 cm** (refer to **Step 4**) for spacing parallels.

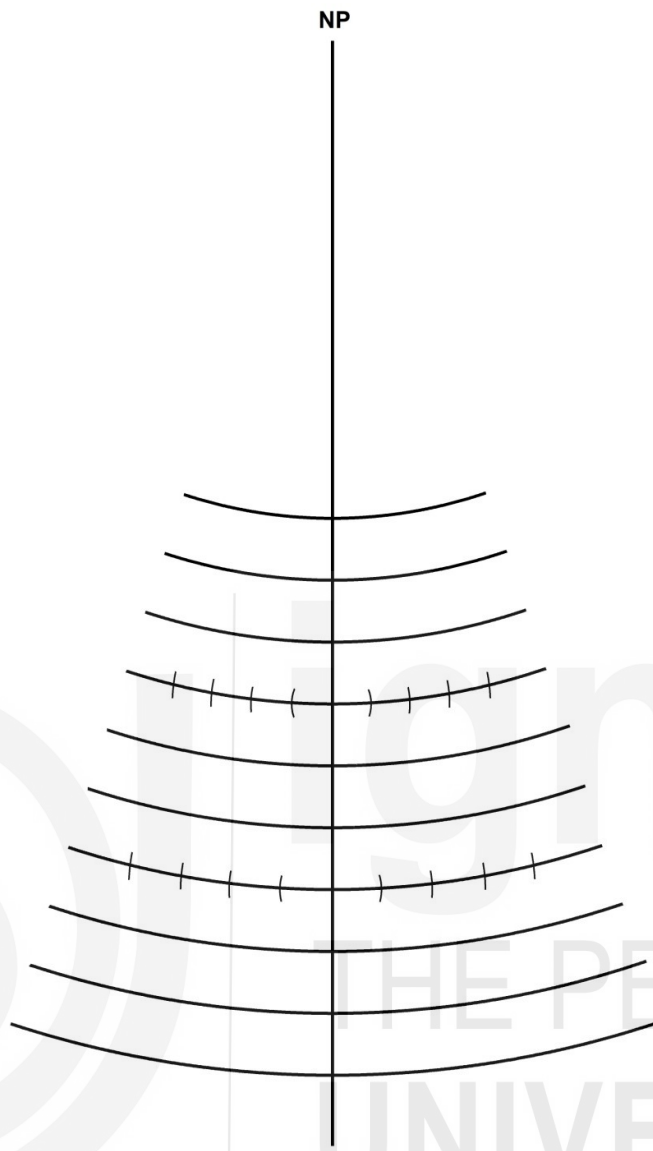


**Step 14:** Draw the remaining arcs of circle by connecting division-marks from the pole point NP. These will represent other parallels.

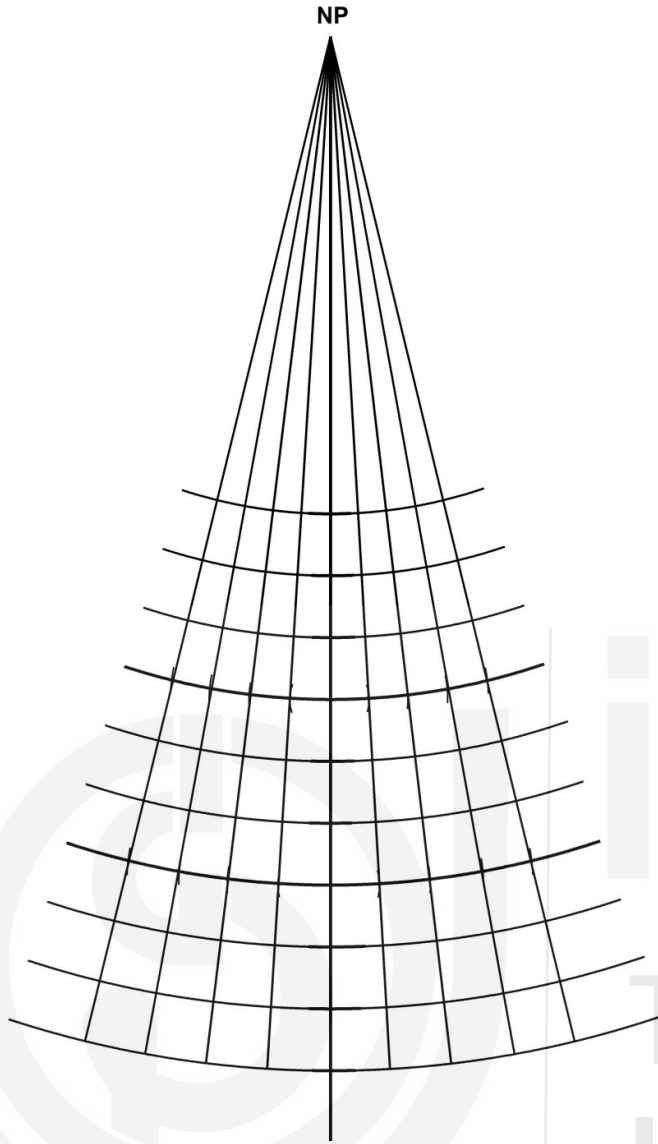


**Step 15:** Using the divider, the first standard parallel **50°N** is divided into 8 parts with the measurement of **0.18 cm ( $d_1$ )** (refer to **Step 8**) for spacing the meridians.

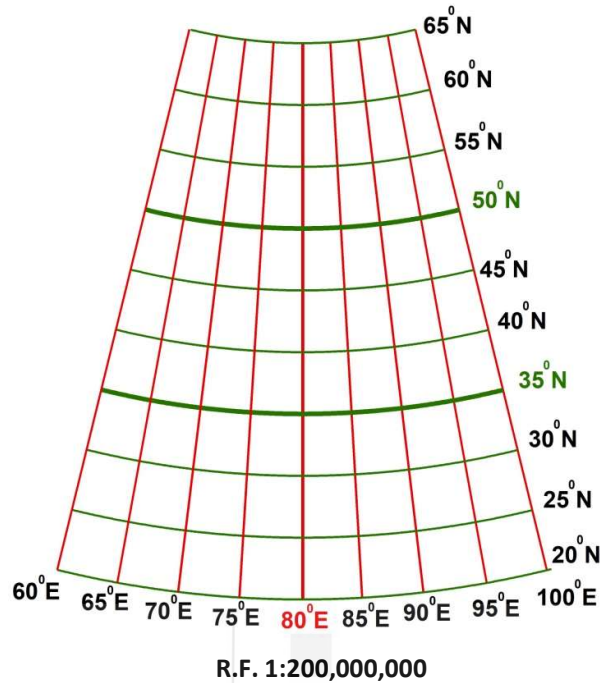
**Step 16:** Similarly, divide the second standard parallel **35°N** into 8 parts with the measurement of  **$d_2 = 0.23$  cm** (refer to **Step 9**) for spacing the meridians.



**Step 17:** With the help of setsquares or scale, straight lines are drawn by touching each of these divisional points of standard parallels joining to the central meridian pole point. These lines are meridians.



**Step 18:** You have now successfully completed the construction of graticules of simple conical projection with two standard parallels. But you have to erase the extended lines of the projection and finish it with proper labelling as given below. You must also write the scale of projection.



### METHOD-2: GRAPHICAL CONSTRUCTION

**Solution:** In the preliminary stage, we have to calculate the values for constructing the map projection. Then, the calculated values are to be used for making the projection in the next stage.

#### Calculations for Constructing the Projection:

**Step 1:** Calculate the radius (R) of the generating globe for the given scale. Note down the RF.

$$RF = 1:200,000,000 = \frac{1}{200,000,000}$$

$$\text{Radius } R = \frac{1}{200,000,000} (\text{cm}) \times \text{Earth radius}_{\text{cm}}$$

$$= \frac{1}{200,000,000} (\text{cm}) \times 640,000,000_{\text{cm}} = \frac{64}{20} = 3.2 \text{ cm}$$

We have now obtained the value of radius i.e. **R = 3.2 cm**

**Step 2:** Let us choose the two standard parallels. Note the latitudinal extent i.e. from 20°N to 65°N and the interval between the parallels i.e. 5°. So, the following parallels are to be drawn.

20°N, 25°N, 30°N, 35°N, 40°N, 45°N, 50°N, 55°N, 60°N, 65°N

Standard parallels can be chosen as follows:

$$\phi_1 = 65 - \frac{(65 - 20)}{3} = 65 - \frac{45}{3} = 65 - 15 = 50^\circ N$$

$$\phi_2 = 20 + \frac{(65 - 20)}{3} = 20 + \frac{45}{3} = 20 + 15 = 35^\circ N$$

Hence, the chosen standard parallels are  $50^{\circ}\text{N}$  and  $35^{\circ}\text{N}$ .

**First standard parallel is  $50^{\circ}\text{N}$**

**Second standard parallel is  $35^{\circ}\text{N}$**

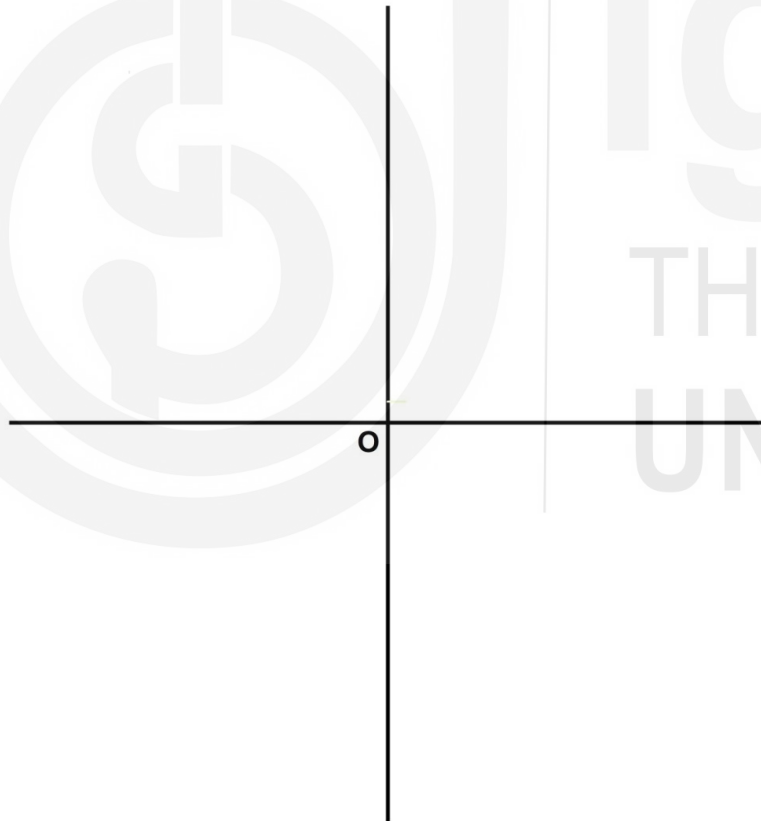
**Step 3:** Note the extent of meridians i.e. from  $60^{\circ}\text{E}$  to  $100^{\circ}\text{E}$  and the interval i.e.  $5^{\circ}$ . Thus, the following meridians have also to be drawn.

$60^{\circ}\text{E}$ ,  $65^{\circ}\text{E}$ ,  $70^{\circ}\text{E}$ ,  $75^{\circ}\text{E}$ ,  $80^{\circ}\text{E}$ ,  $85^{\circ}\text{E}$ ,  $90^{\circ}\text{E}$ ,  $95^{\circ}\text{E}$ ,  $100^{\circ}\text{E}$ .

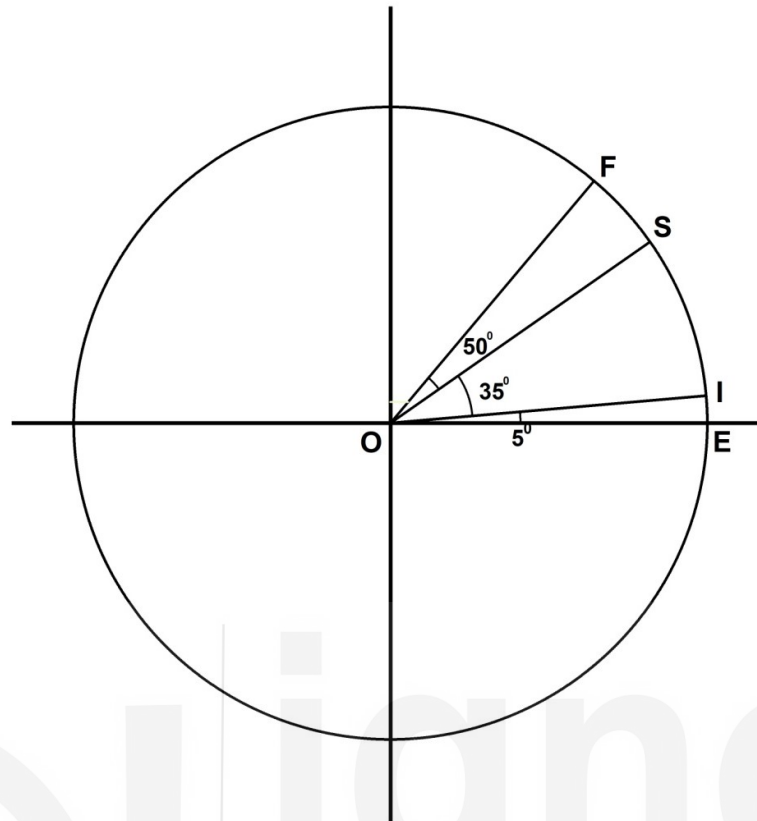
**The central meridian is  $80^{\circ}\text{E}$ .**

**Step 4:** Now, we have to calculate the value of the radius of the first and second standard parallels, the length of a division (d) on the central meridian ( $80^{\circ}\text{E}$ ), and the length of a divisions ( $d_1$  and  $d_2$ ) on the standard parallels ( **$50^{\circ}\text{N}$**  and  **$35^{\circ}\text{N}$** ).

Take a drawing sheet and place it on plane surface. With the help of pencil and scale, draw a pair of straight lines on the sheet. The lines must be intersected with  $90^{\circ}$  angle. The intersection point is named as O.



**Step 5:** Draw a circle with the measurement of radius  $R = 3.2$  cm from the center (O). With the help of protractor, mark the angles of  $5^{\circ}$  (given interval) as OEI,  $50^{\circ}$  (first standard parallel) as OEF, and  $35^{\circ}$  (second standard parallel) as OES on the circle. Then, draw lines OI for the given interval, and OF and OS for both the standard parallels through these markings from O.



**Step 6:** Measure the arc distance of IE which will be the value of the division on central meridian. Hence, IE is the true distance between two parallels at 5° interval.

Now, you got to know **the length of division on central meridian** for spacing the parallels i.e.  $d_1 = 0.28 \text{ cm}$ .

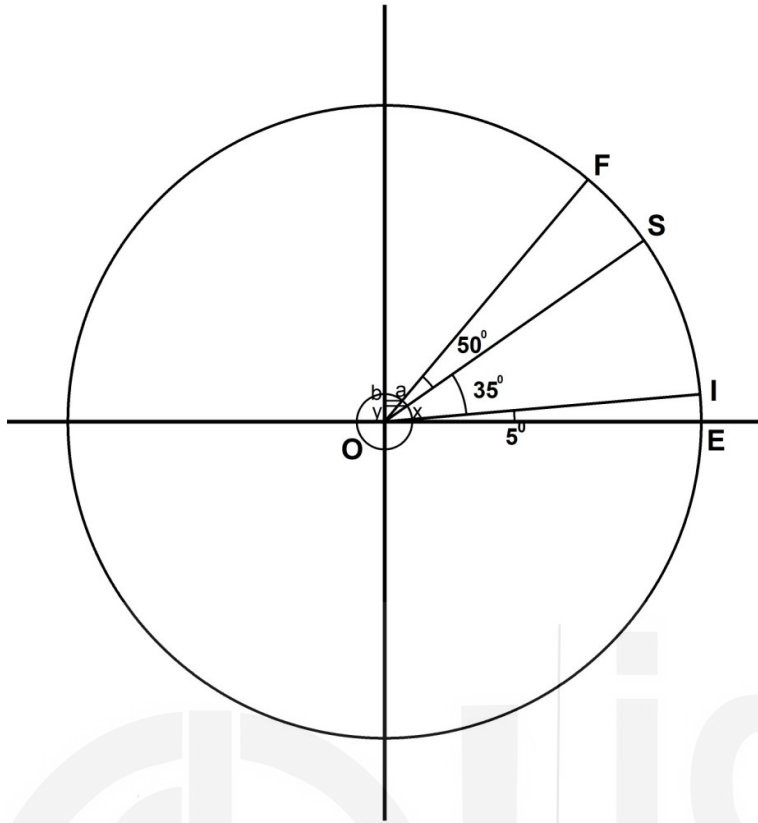
**Step 7:** Now, you have to calculate the value of division on the standard parallel. Draw an inner circle with the measurement of  $IE = 0.28 \text{ cm}$  from the center O.

Draw a line  $ab$  parallel to OE. Now, measure the length of  $ab$  and it will be the value of division of the first standard parallel (50°N) for spacing the meridians.

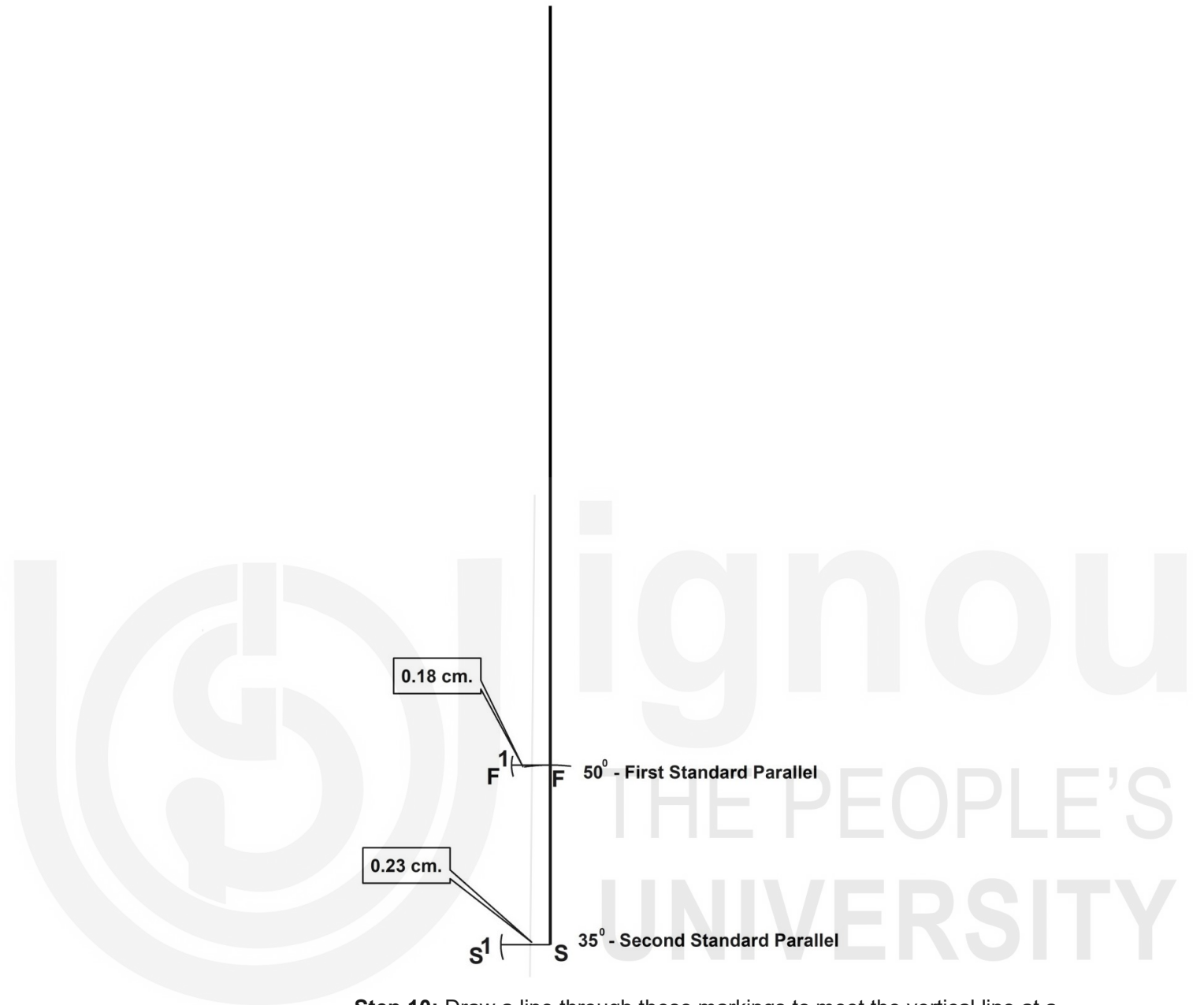
Now, you have the value of **the length of division on the first standard parallel (50°N)** for spacing the meridians i.e.  $d_1 = 0.18 \text{ cm}$ .

**Step 8:** Similarly, draw a line  $xy$  parallel to OE and measure it.

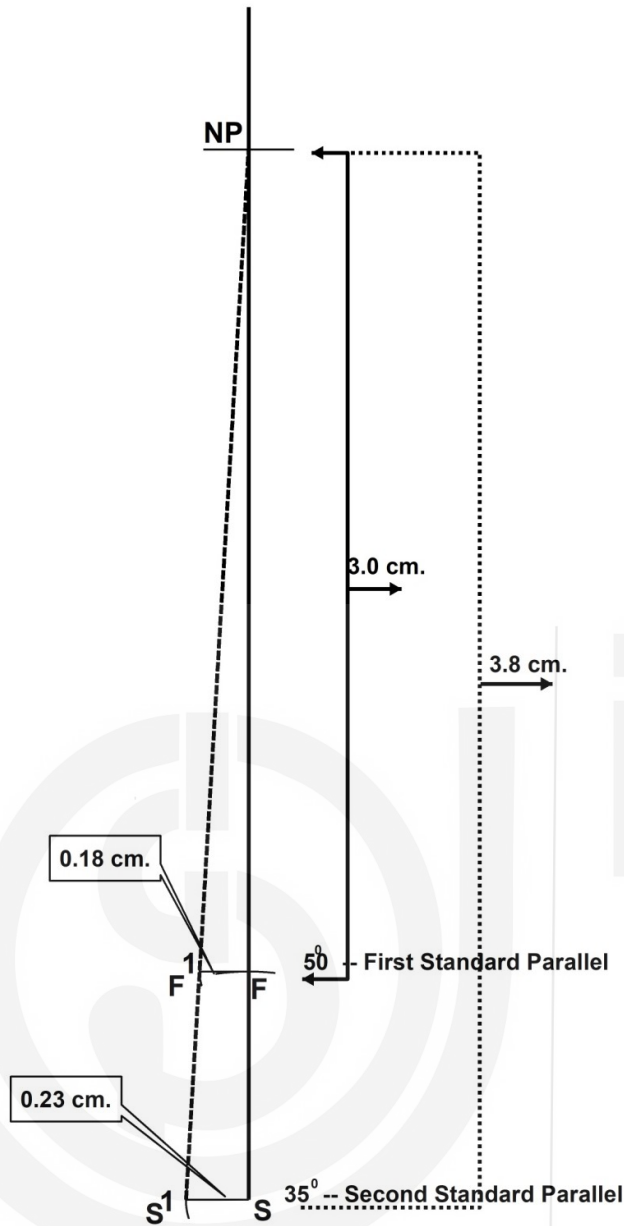
Now, you have the value of **the length of division on the second standard parallel (35°N)** for spacing the meridians i.e.  $d_2 = 0.23 \text{ cm}$ .



**Step 9:** Now, calculate the radii of the standard parallels. Draw a vertical line with any suitable length. Measure the arc distance of SF and with this measurement, mark the division on vertical line. Then, draw the line  $SS^1$  perpendicular to SF with the length of  $xy=0.23$  cm and similarly draw another line as  $FF^1$  with  $ab=0.18$  cm.



**Step 10:** Draw a line through these markings to meet the vertical line at a point NP. Now, measure the distance from point NP to F, it will be the radius of first standard parallel (50°N) and the length from NP to S will be the radius of second parallel (35°N).



Now, you got to know the value of **the radius of 50°N standard parallel i.e. 3.0 cm** and **the radius of 35°N standard parallel i.e. 3.8 cm**.

### Construction of the Projection:

You can follow the procedure of construction as explained in above **Method-1**.

**Step 11:** Take a drawing sheet and place it on the plane surface. With the help of pencil and scale, draw a straight line vertically on centre of the sheet that is to be represented as central meridian.

**Step 12:** Set compass with the calculated value of radius i.e.  $r_1 = 3$  cm and draw an arc of circle going through the central meridian from north pole point NP. This arc will be standard parallel of 50°N.

**Step 13:** Similarly, draw the second standard parallel (35°N) with the radius of  $r_2 = 3.8$  cm.

**Step 14:** Using the divider, mark the divisions starting from the standard parallel on the central meridian ( $80^{\circ}\text{E}$ ) with the measurement of  $d = 0.28 \text{ cm}$  (refer to Step 4) for spacing the parallels.

**Step 15:** Draw the remaining arcs of circle by connecting division-marks from the pole point NP. These will represent other parallels.

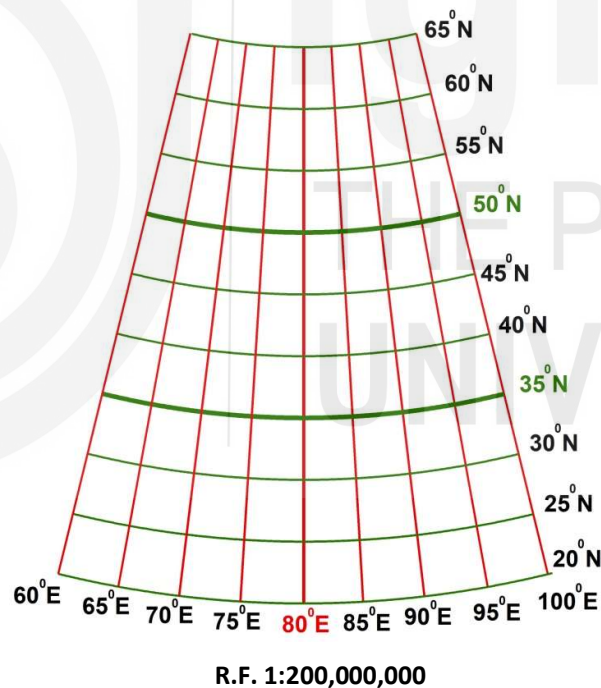
**Step 16:** Using the divider, the first standard parallel  $50^{\circ}\text{N}$  is divided into 8 parts with the measurement of  $0.18 \text{ cm}$  ( $d_1$ ) (refer to Step 8) for spacing the meridians.

**Step 17:** Similarly, divide the second standard parallel  $35^{\circ}\text{N}$  into 8 parts with the measurement of  $d_2 = 0.23 \text{ cm}$  (refer to Step 6) for spacing the meridians.

**Step 18:** With the help of setsquares or scale, straight lines are drawn by touching each of these divisional points of standard parallels joining to the central meridian pole point. These lines are meridians.

**Step 19:** Now, you have successfully completed the construction of graticules of simple conical projection with two standard parallels. Finally, you have to mark labels properly and all the graticules also to be written as shown below.

You must also write the scale of projection.



### 3.4 CONSTRUCTION OF BONNE'S PROJECTION

**Bonne's projection** is a simple conical equal area projection. This projection represents true scale along all parallels and the central meridian. In this projection, one standard parallel is chosen for determining the radius and meridians are constructed based on the true values of each parallel. The divided points on parallels are connected as smooth curves. Central meridian is a straight line and remaining meridians are smooth curves. It can be used to map large areas like continents.

**PROBLEM 3:** Construct graticule on Bonne's projection on RF 1:150,000,000 with an interval of 10° for covering an area 5°S-65°S and 20°W-80°W.

### **METHOD-1: MATHEMATICAL CONSTRUCTION**

**Solution:** In the preliminary stage, we have to calculate the values for constructing the map projection. Then, the calculated values are to be used for making the projection in the next stage.

#### **Calculations for Constructing the Projection:**

**Step 1:** Calculate the radius of the generating globe (R) for the given scale.

$$RF = 1:150,000,000 = \frac{1}{150,000,000}$$

$$\text{Radius } R = \frac{1}{150,000,000} (\text{cm}) \times \text{Earth radius}_{\text{cm}}$$

$$= \frac{1}{150,000,000} (\text{cm}) \times 640,000,000_{\text{cm}} = \frac{64}{15} = 4.26 \text{ cm}$$

We have now obtained the value of radius i.e. **R = 4.26 cm.**

**Step 2:** Let us choose the standard parallel. Note the latitudinal extent i.e. from 5°S to 65°S and the interval i.e. 10°. So, the following parallels are to be drawn.

5°S, 15°S, 25°S, 35°S, 45°S, 55°S, 65°S

Hence, the **standard parallel** chosen is **35°S**.

**Step 3:** Note the extent of meridians i.e. from 20°W to 80°W and the interval is 10°. Thus, the following meridians have also to be drawn.

20°W, 30°W, 40°W, 50°W, 60°W, 70°W, 80°W

**The central meridian is 50°W.**

**Step 4:** Calculate the length of a division (d) on the central meridian using the standard equation as follows.

$$d = \frac{2\pi R}{360^\circ} \times \text{Interval } (^\circ) = \frac{2 \times 3.14 \times 4.26}{360} \times 10 = \frac{26.75}{36} = 0.74 \text{ cm}$$

where  $\pi = \frac{22}{7} = 3.14$  (Constant);  $R = 4.26 \text{ cm}$  (From Step 1)

Now, you got to know **the length of division on central meridian** for spacing the parallels at 10° interval i.e. **d = 0.74 cm.**

**Step 5:** Calculate the length of the radius of the standard parallel ( $r_1$ ) using the standard equation as follows:

$$r_1 = R \cot \phi = 4.26 \times \cot 35^\circ = 4.26 \times 1.428 = 6.08 \text{ cm}$$

Now, you got the value of **the radius of standard parallel (35°S)** i.e.  **$r_1 = 6.08 \text{ cm}$ .**

**Step 6:** Calculate the length of a division ( $d_1$ ) on the parallel at the given interval using the standard equation as follows.

$$d_1 = \frac{2\pi R \cos \phi}{360^\circ} \times \text{Interval } (^\circ) = \frac{2\pi R}{360^\circ} \times \text{Interval } (^\circ) \times \cos \phi$$
$$= \frac{2 \times 3.14 \times 4.26}{360} \times 10 \times \cos \phi = \mathbf{0.74} \times \cos \phi$$

Where,  $R = 4.26$  cm;  $\pi = 3.14$ ; Interval =  $10^\circ$ .

Now we can calculate the length of division on the each  $5^\circ$ S,  $15^\circ$ S,  $25^\circ$ S,  $35^\circ$ S,  $45^\circ$ S,  $55^\circ$ S,  $65^\circ$ S parallels using the above formula.

$$d_{5^\circ} = 0.74 \times \cos \phi = 0.74 \times \cos 5^\circ = 0.74 \times 0.996 = 0.73 \text{ cm}$$

$$d_{15^\circ} = 0.74 \times \cos \phi = 0.74 \times \cos 15^\circ = 0.74 \times 0.965 = 0.71 \text{ cm}$$

$$d_{25^\circ} = 0.74 \times \cos \phi = 0.74 \times \cos 25^\circ = 0.74 \times 0.906 = 0.67 \text{ cm}$$

$$d_{35^\circ} = 0.74 \times \cos \phi = 0.74 \times \cos 35^\circ = 0.74 \times 0.819 = 0.60 \text{ cm}$$

$$d_{45^\circ} = 0.74 \times \cos \phi = 0.74 \times \cos 45^\circ = 0.74 \times 0.707 = 0.52 \text{ cm}$$

$$d_{55^\circ} = 0.74 \times \cos \phi = 0.74 \times \cos 55^\circ = 0.74 \times 0.573 = 0.42 \text{ cm}$$

$$d_{65^\circ} = 0.74 \times \cos \phi = 0.74 \times \cos 65^\circ = 0.74 \times 0.422 = 0.31 \text{ cm}$$

Now, you have the values of **the length of division on each parallel** for spacing the meridians at  $10^\circ$  interval.

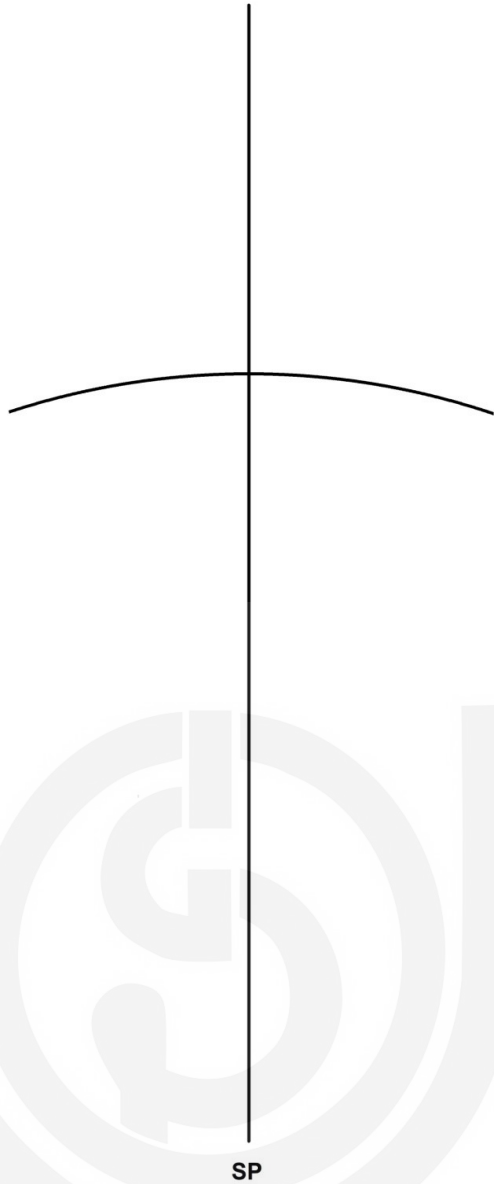
You have now all the calculated values for constructing the map projection.

Let us start the construction of the projection. Keep ready with you a drawing sheet, pencil, ruler, compass, protractor and divider etc.

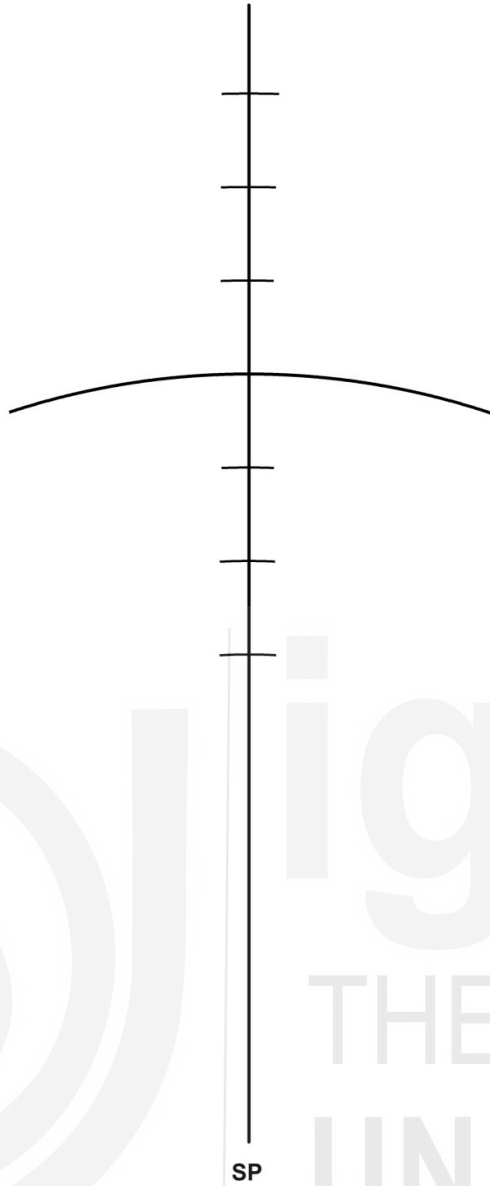
### **Construction of the Projection:**

**Step 7:** Take a drawing sheet and place it on a plane surface. With the help of pencil and scale, draw a straight line vertically on centre of the sheet that is to be represented as central meridian.

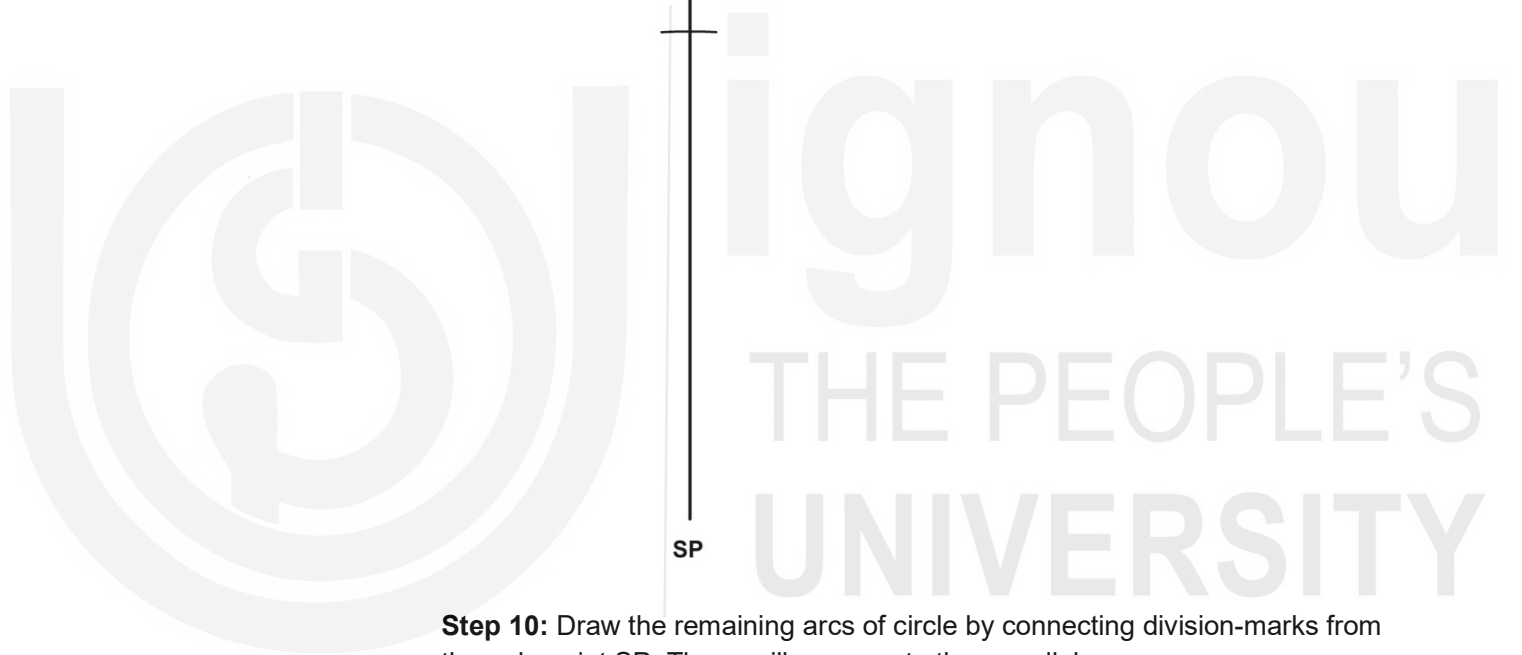
**Step 8:** Set compass with the calculated value of radius i.e.  $r_1 = 6.08$  cm and draw an arc of circle going through the central meridian from south pole point SP. This arc will be the standard parallel of  $35^\circ$ W.

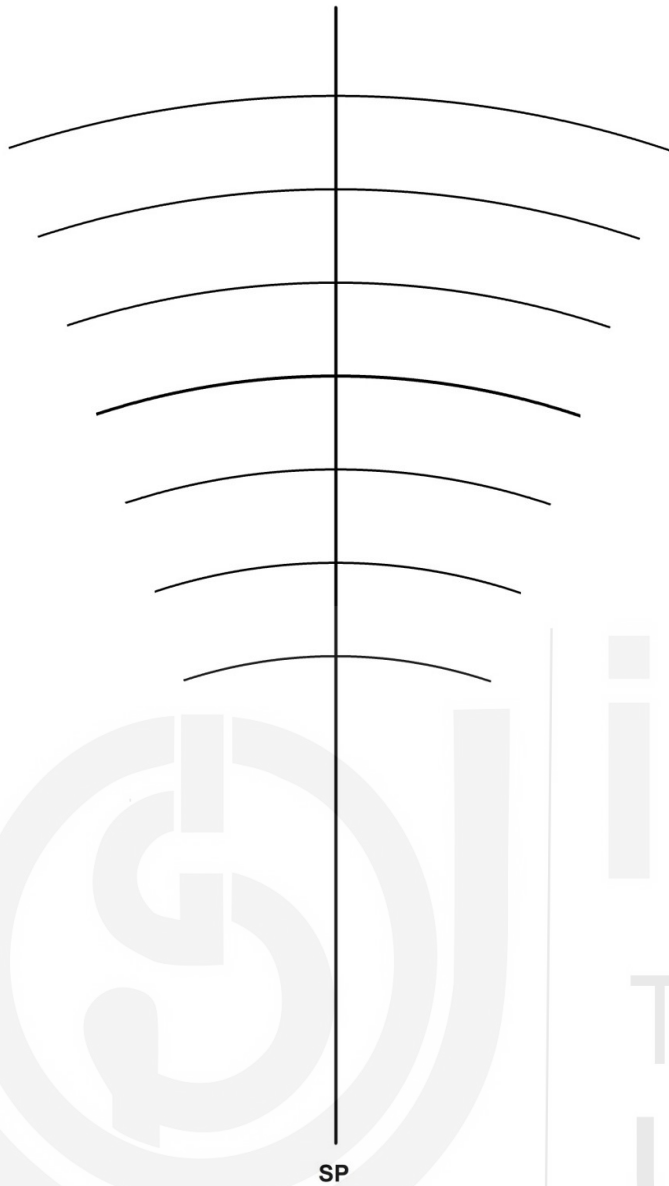


**Step 9:** Using the divider, mark the divisions starting from the standard parallel on the central meridian (**50°W**) with the measurement of **d = 0.74 cm** (refer to **Step 4**) for spacing the parallels.



**Step 10:** Draw the remaining arcs of circle by connecting division-marks from the pole point SP. These will represent other parallels.

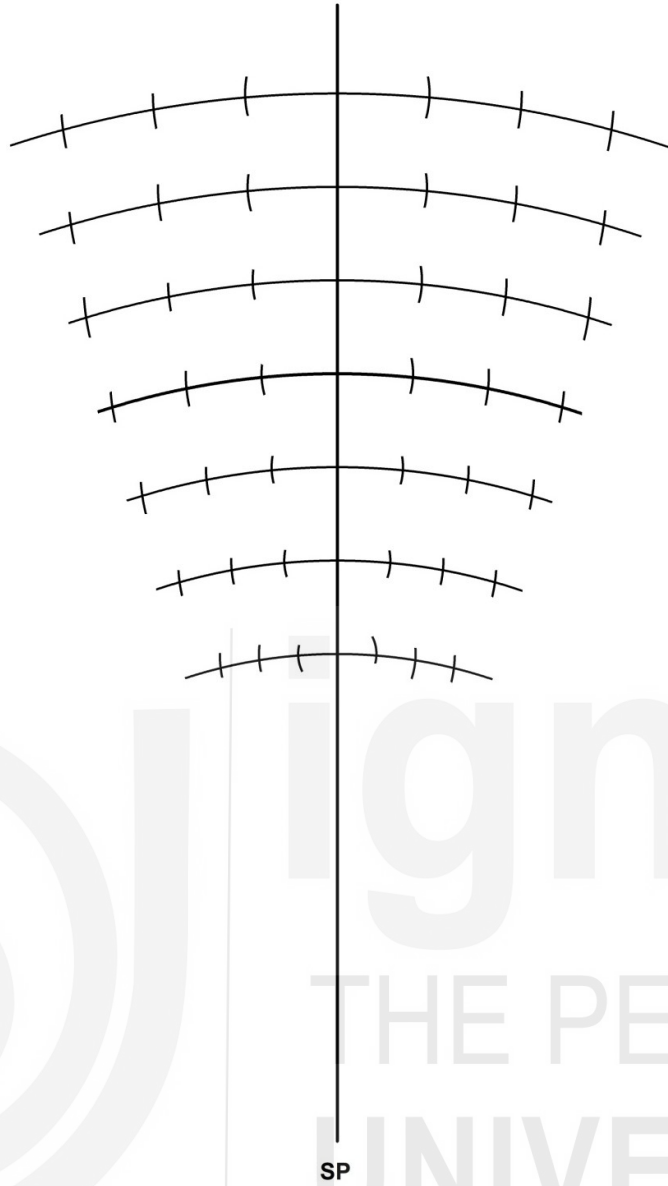




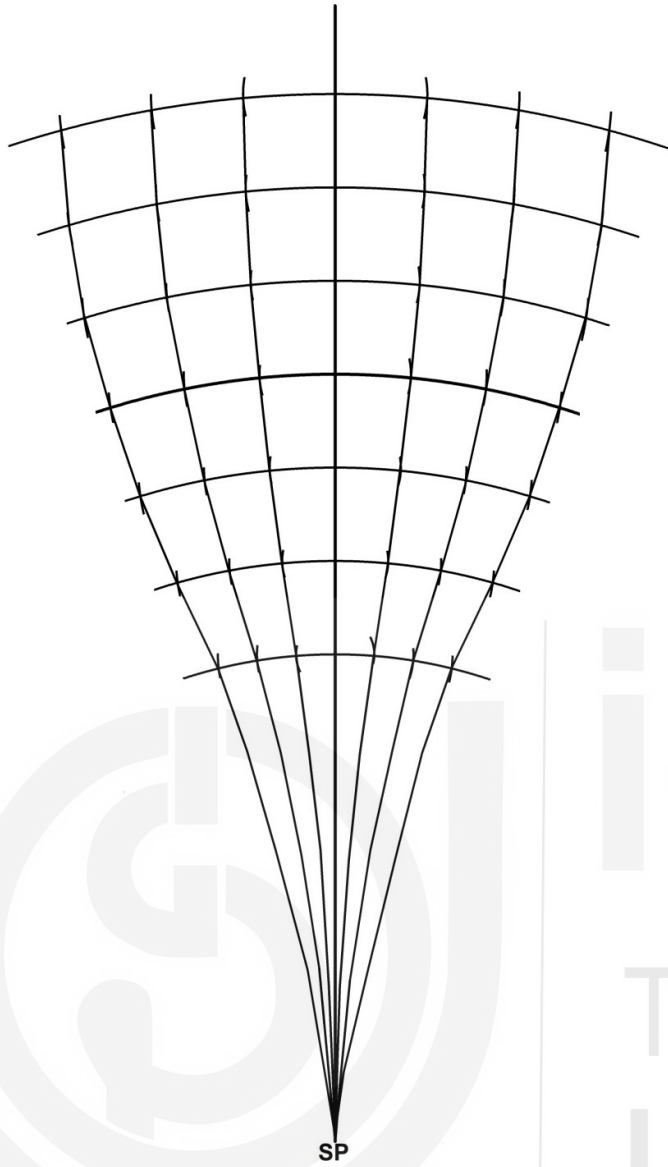
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**Step 11:** Using the divider, mark the divisions with the measurement of **0.60 cm ( $d_1$ )** (refer to Step 5) on the standard parallel **35°W** for spacing the meridians.

**Step 12:** Similarly, divide all the remaining parallels i.e. 25°, 15°, 5°, 45°, 55°, and 65° with their corresponding measurements 0.67 cm, 0.71 cm, 0.73 cm, 0.52 cm, 0.42 cm, 0.31 cm (refer to Step 6) for spacing the meridians.

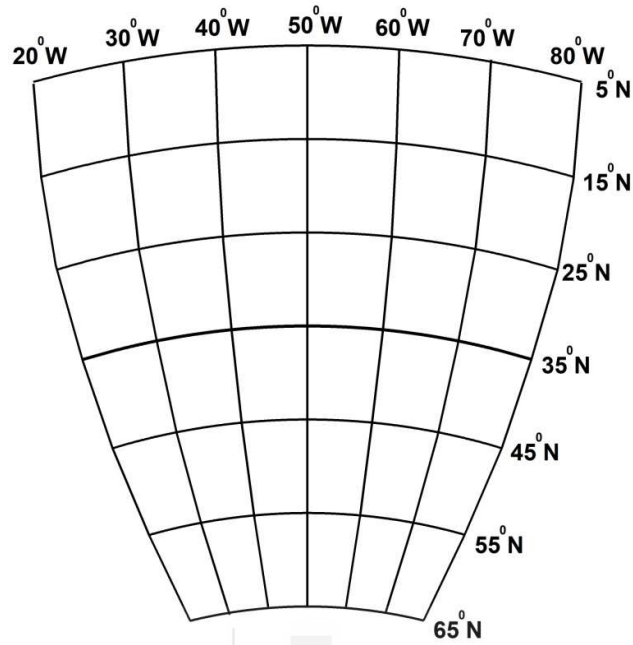


**Step 13:** Now, draw smooth free-hand curves by connecting through corresponding division points on the parallels to represent the meridians.



**Step 14:** You have completed the construction of graticules of Bonne's projection. Finally, you have to mark proper labels as given below. All the graticules and the scale of projection must be written on the drawing.

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R.F. 1:150,000,000

### METHOD-2: GRAPHICAL CONSTRUCTION

**Solution:** In the preliminary stage, we have to calculate the values for constructing the map projection. Then, the calculated values are to be used for making the projection in the next stage.

#### Calculations for Constructing the Projection:

**Step 1:** Calculate the radius of the generating globe (R) for the given scale.

$$RF = 1:150,000,000 = \frac{1}{150,000,000}$$

$$\begin{aligned} \text{Radius } R &= \frac{1}{150,000,000} (\text{cm}) \times \text{Earth radius}_{\text{cm}} \\ &= \frac{1}{150,000,000} (\text{cm}) \times 640,000,000_{\text{cm}} = \frac{64}{15} = 4.26 \text{ cm} \end{aligned}$$

We have now obtained the value of radius i.e. **R = 4.26 cm**.

**Step 2:** Let us choose the standard parallel. Note the latitudinal extent i.e. from 5°S to 65°S and the interval i.e. 10°. So, the following parallels are to be drawn.

5°S, 15°S, 25°S, 35°S, 45°S, 55°S, 65°S

Hence, the **standard parallel** chosen is **35°S**.

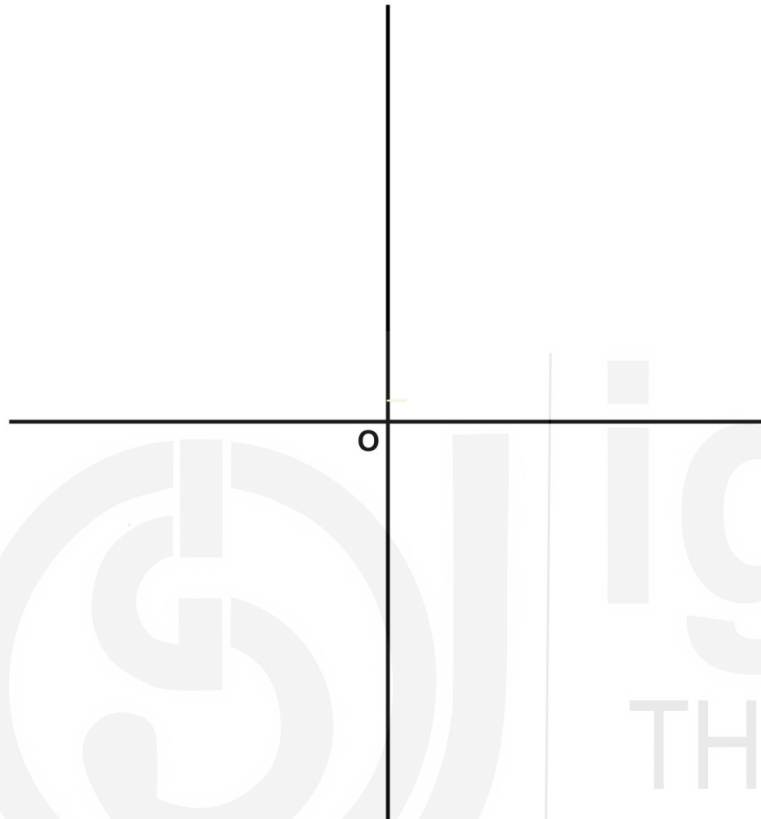
**Step 3:** Note the extent of meridians i.e. from 20°W to 80°W and the interval is 10°. Thus, the following meridians have also to be drawn.

20°W, 30°W, 40°W, 50°W, 60°W, 70°W, 80°W

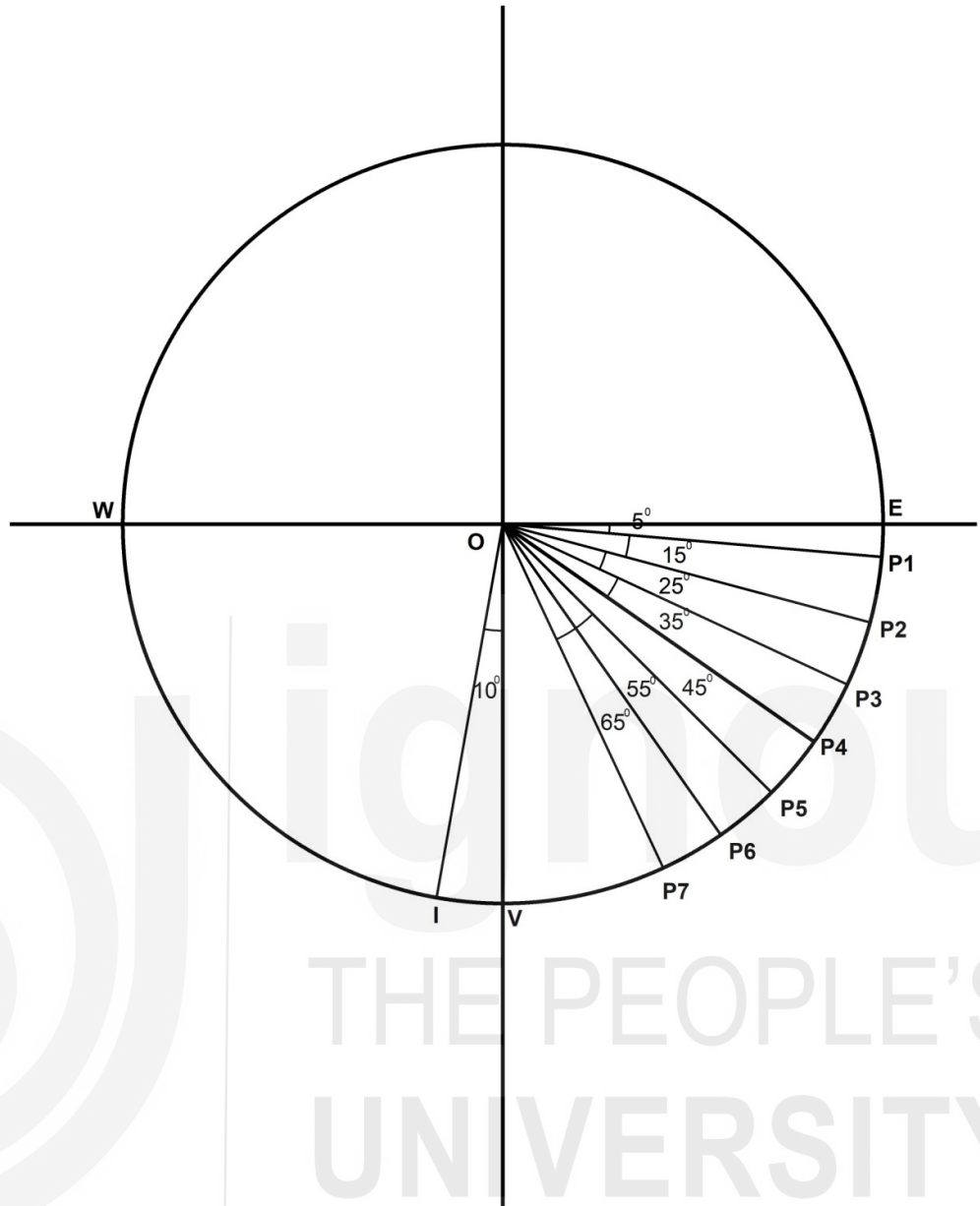
**The central meridian is 50°W.**

**Step 4:** Now, we have to calculate the value of the radius of the standard parallel (**35°S**), the length of a division ( $d_1$ ) on the central meridian (**50°W**), and the length of a division ( $d_2$ ) on each parallel.

Take a drawing sheet and place it on plane surface. With the help of pencil and scale, draw a pair of straight lines on the sheet. The lines must be intersected with  $90^\circ$  angle. The intersection point is named as O.



**Step 5:** Draw a circle with the measurement of radius  $R = 4.26$  cm from the center (O). With the help of protractor, mark the angle of  $10^\circ$  for given interval as OVI. Also mark other angles of parallels  $5^\circ\text{S}$ ,  $15^\circ\text{S}$ ,  $25^\circ\text{S}$ ,  $35^\circ\text{S}$ ,  $45^\circ\text{S}$ ,  $55^\circ\text{S}$ ,  $65^\circ\text{S}$  for making lines through these markings. The standard parallel is  $35^\circ\text{S}$  marked as OEP4.

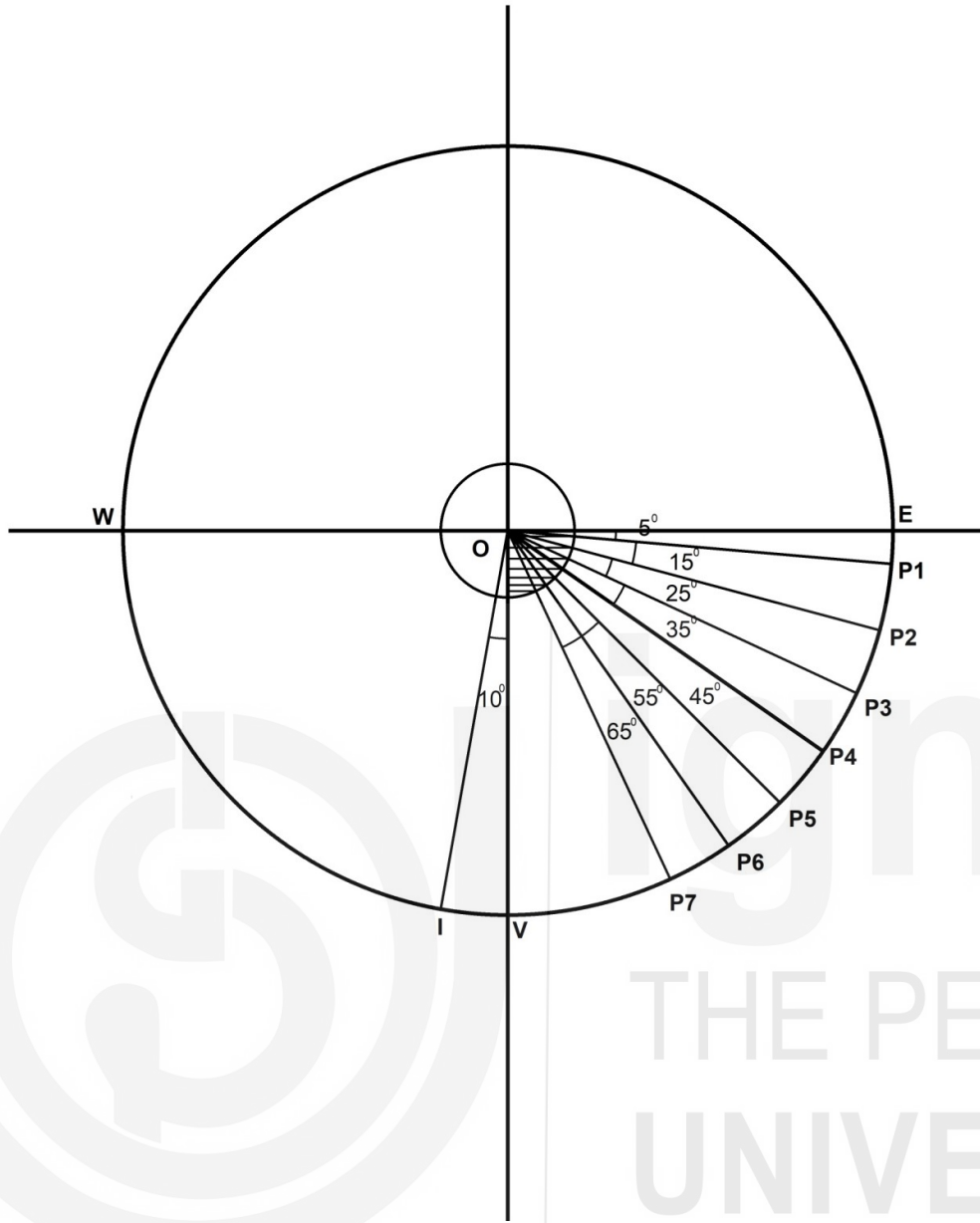


**Step 6:** Measure the arc distance of IV which will be the value of the division on central meridian. Hence, IV is the true distance between two parallels at 10° interval.

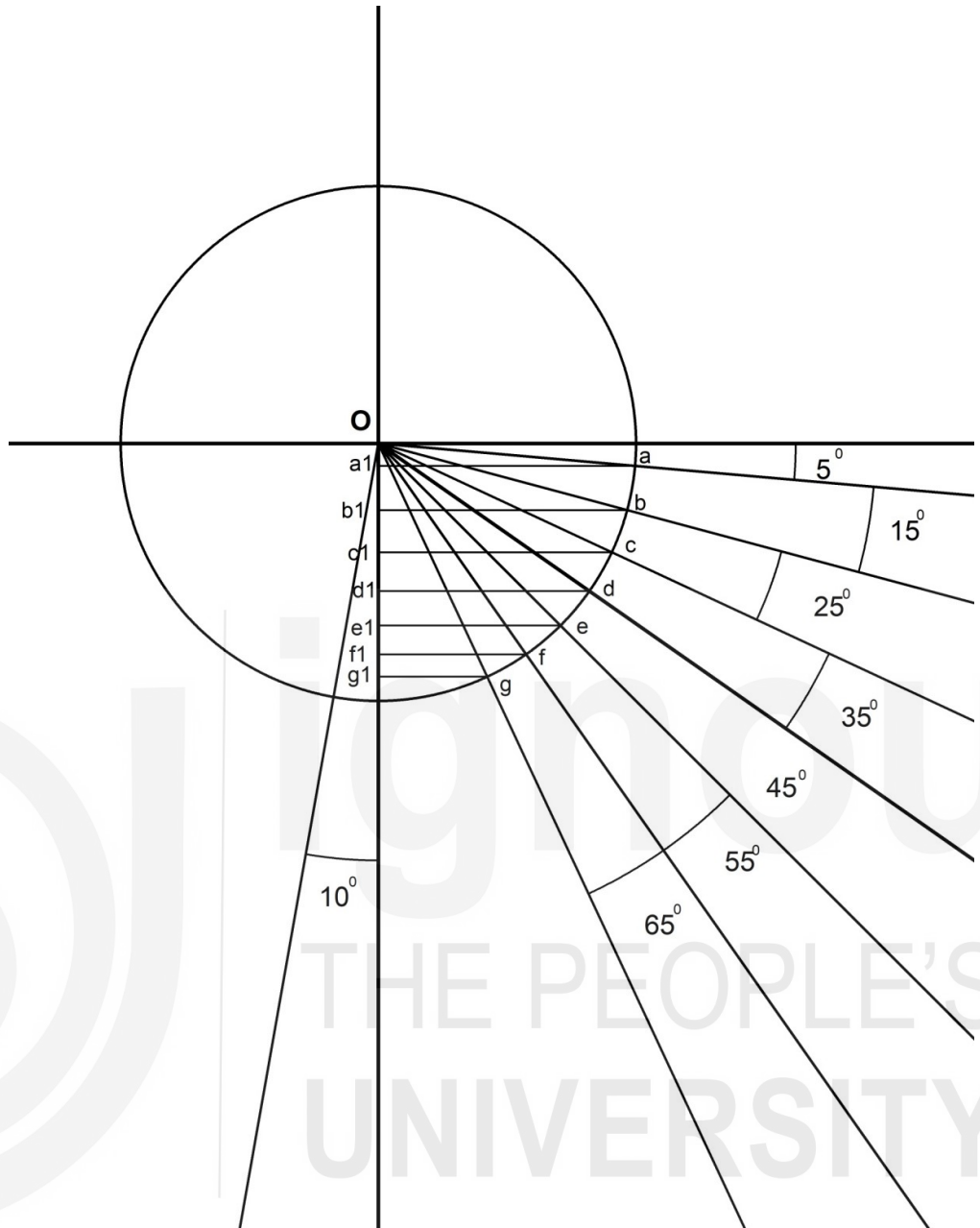
Now, you got to know **the length of division on central meridian** for spacing the parallels i.e.  $d_1 = 0.74 \text{ cm}$ .

**Step 7:** Now, you have to calculate the value of division on the standard parallel (35°S). Draw an inner circle with the measurement of IV=0.74 cm from the center O.

Draw lines parallel to OE by connecting each parallel line in the inner circle.



**Step 8:** The lines are a-a1, b-b1, c-c1, d-d1, e-e1, f-f1, and g-g1 corresponding to the parallels of P1, P2, P3, P4, P5, P6, and P7. Now, measure each line with the help of divider and scale.



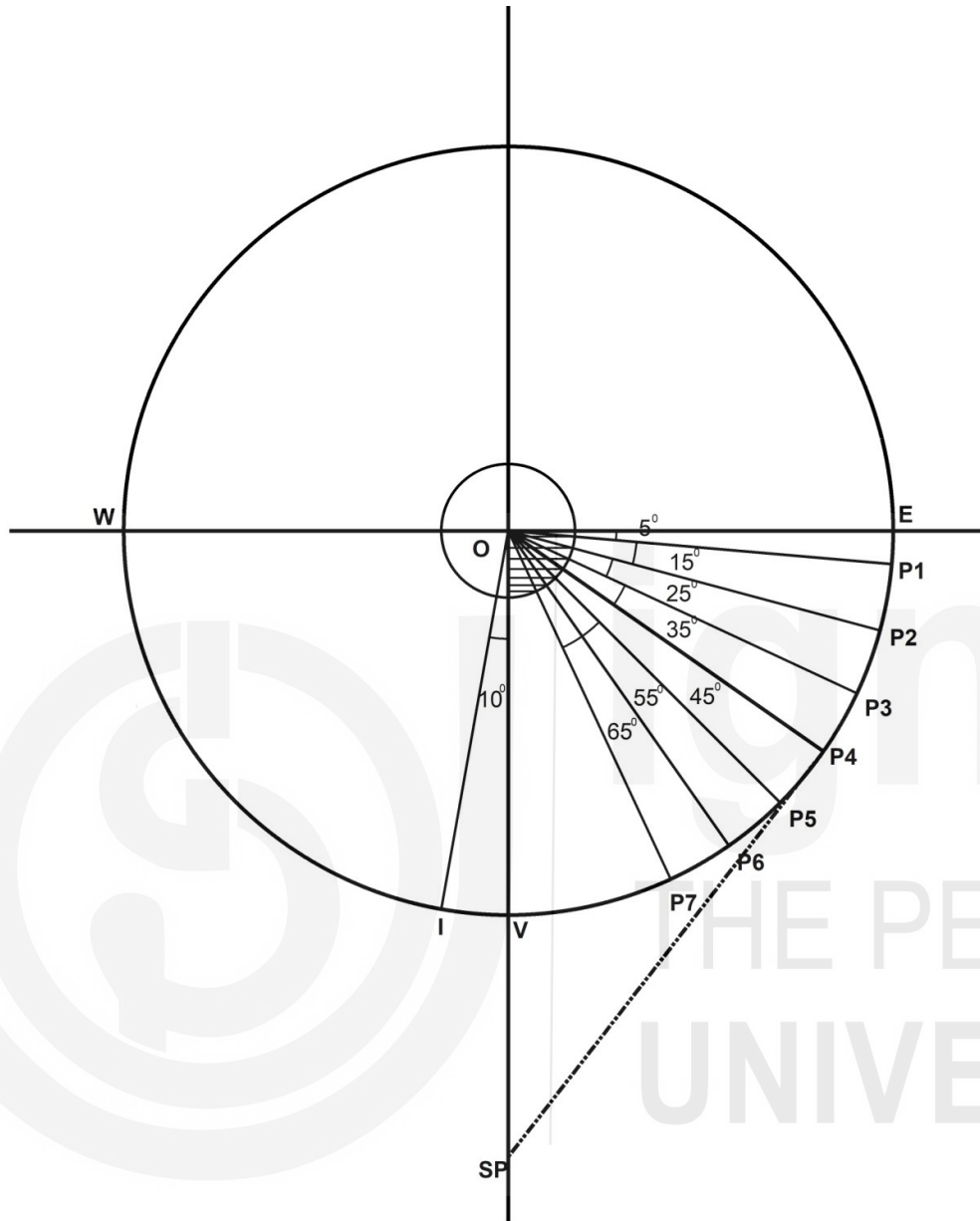
These values will represent **the length of division on each parallel**.

Name	Parallel	Marking	Length cm
P1	5°S	a-a1	0.74
P2	15°S	b-b1	0.71
P3	25°S	c-c1	0.67
P4	35°S	d-d1	0.60
P5	45°S	e-e1	0.52
P6	55°S	f-f1	0.42
P7	65°S	g-g1	0.31

Now, you have the value of **the length of division on each parallel** for spacing the meridians.

**Step 9:** Now, calculate the radius of the standard parallel. Draw a tangent line from the standard parallel point (P4) to meet the vertical line at polar point

(SP). Now, measure the length of P4SP and it will be the radius of standard parallel (35°S).



Now, you got the value of the radius of standard parallel i.e.  $P4SP = 0.57$  cm.

### Construction of the Projection:

You can follow the procedure of construction as explained in above **Method-1**.

**Step 10:** Take a drawing sheet and place it on a plane surface. With the help of pencil and scale, draw a straight line vertically on centre of the sheet that is to be represented as central meridian.

**Step 11:** Set compass with the calculated value of radius i.e.  $r_1 = 6.1$  cm and draw an arc of circle going through the central meridian from south pole point SP. This arc will be the standard parallel of 35°W.

**Step 12:** Using the divider, mark the divisions starting from the standard parallel on the central meridian ( $50^{\circ}\text{W}$ ) with the measurement of  $d = 0.74 \text{ cm}$  for spacing the parallels.

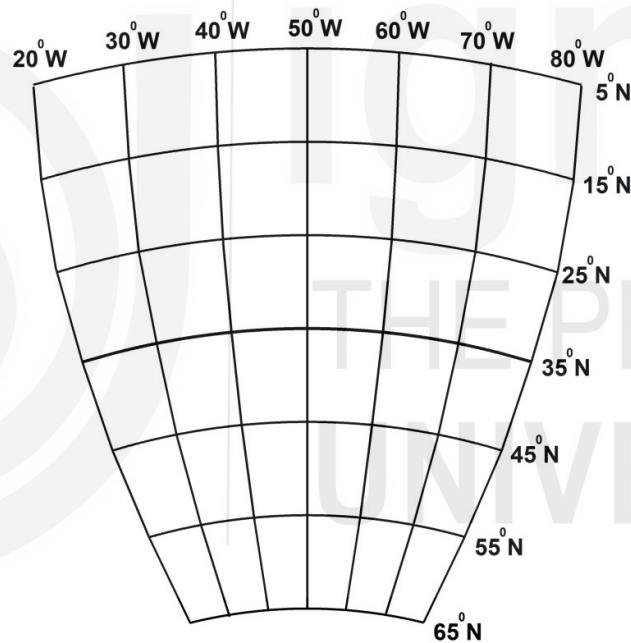
**Step 13:** Draw the remaining arcs of circle by connecting division-marks from the pole point SP. These will represent other parallels.

**Step 14:** Using the divider, mark the divisions with the measurement of  $0.60 \text{ cm}$  ( $d_1$ ) on the standard parallel  $35^{\circ}\text{W}$  for spacing the meridians.

**Step 15:** Similarly, divide all the remaining parallels i.e.  $25^{\circ}$ ,  $15^{\circ}$ ,  $5^{\circ}$ ,  $45^{\circ}$ ,  $55^{\circ}$ , and  $65^{\circ}$  with their corresponding measurements  $0.67 \text{ cm}$ ,  $0.71 \text{ cm}$ ,  $0.73 \text{ cm}$ ,  $0.52 \text{ cm}$ ,  $0.42 \text{ cm}$ ,  $0.31 \text{ cm}$  for spacing the meridians.

**Step 16:** Now, draw smooth free-hand curves by connecting through corresponding division points on the parallels to represent the meridians.

**Step 13:** You have completed the construction of graticules of Bonne's projection. Finally you have to mark proper labels as given below. All the graticules must be written on the drawing.



**Lab Exercise 1:**

Construct graticules at  $5^{\circ}$  interval on conical projection with one standard parallel on RF 1:250,000,000 for covering the area  $10^{\circ}\text{N}$ - $45^{\circ}\text{N}$  and  $20^{\circ}\text{W}$ - $60^{\circ}\text{W}$ .

**Lab Exercise 2:**

Construct graticules at  $10^{\circ}$  interval on conical projection with one standard parallel on RF 1:100,000,000 for the extensions,  $10^{\circ}\text{S}$ - $60^{\circ}\text{S}$  and  $100^{\circ}\text{E}$ - $160^{\circ}\text{E}$ .

**Lab Exercise 3:**

Construct graticule on simple conical projection with two standard parallel on the 1:150,000,000 scale with an interval of 5° for covering an area 30°S-60°S and 40°W-80°W.

**Lab Exercise 4:**

Construct graticules at 10° interval on conical projection with two standard parallel on RF 1:300,000,000 for covering an area 20°N-60°N and 110°W to 170°W.

**Lab Exercise 5:**

Construct Bonne's projection for covering an area 20°N-60°N and 0°E-60°E. The RF is 1:100,000,000 and the interval is 10°.

### **3.6 SUGGESTED FURTHER READINGS**

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- Sarkar, A. (2008): *Practical Geography: A Systemtic Approach*, Kolkata: Orient BlackSwan
- Singh, G. (2004). *Map Work and Practical Geography*, Delhi: Vikas Publication House
- Robinson, Arthur, H.J., Morrison, P., Muehrke, A., Kimmerling & Guptill, S. (eds.) (1995). *Elements of Cartography*, New York: Wiley.
- Misra, R.P. & Ramesh, A. (1986). *Fundamentals of Cartography*, New Delhi: McMillan.
- Singh, R.L. and Singh, R.P.B. (2003). *Elements of Practical Geography*, Delhi: Kalyani Publishers.

### Annexure 1

	Trigonometric Functions						
	sin	cos	tan	cot	sec	csc	
0°	0.0000	1.0000	0.0000	....	1.000	...	90°
1°	0.0175	0.9998	0.0175	57.29	1.000	57.30	89°
2°	0.0349	0.9994	0.0349	28.64	1.001	28.65	88°
3°	0.0523	0.9986	0.0524	19.08	1.001	19.11	87°
4°	0.0698	0.9976	0.0699	14.30	1.002	14.34	86°
5°	0.0872	0.9962	0.0875	11.43	1.004	11.47	85°
6°	0.1045	0.9945	0.1051	9.514	1.006	9.567	84°
7°	0.1219	0.9925	0.1228	8.144	1.008	8.206	83°
8°	0.1392	0.9903	0.1405	7.115	1.010	7.185	82°
9°	0.1564	0.9877	0.1584	6.314	1.012	6.392	81°
10°	0.1736	0.9848	0.1763	5.671	1.015	5.759	80°
11°	0.1908	0.9816	0.1944	5.145	1.019	5.241	79°
12°	0.2079	0.9781	0.2126	4.705	1.022	4.810	78°
13°	0.2250	0.9744	0.2309	4.331	1.026	4.445	77°
14°	0.2419	0.9703	0.2493	4.011	1.031	4.134	76°
15°	0.2588	0.9659	0.2679	3.732	1.035	3.864	75°
16°	0.2756	0.9613	0.2867	3.487	1.040	3.628	74°
17°	0.2924	0.9563	0.3057	3.271	1.046	3.420	73°
18°	0.3090	0.9511	0.3249	3.078	1.051	3.236	72°
19°	0.3256	0.9455	0.3443	2.904	1.058	3.072	71°
20°	0.3420	0.9397	0.3640	2.747	1.064	2.924	70°
21°	0.3584	0.9336	0.3839	2.605	1.071	2.790	69°
22°	0.3746	0.9272	0.4040	2.475	1.079	2.669	68°
23°	0.3907	0.9205	0.4245	2.356	1.086	2.559	67°

24°	0.4067	0.9135	0.4452	2.246	1.095	2.459	66°
25°	0.4226	0.9063	0.4663	2.145	1.103	2.366	65°
26°	0.4384	0.8988	0.4877	2.050	1.113	2.281	64°
27°	0.4540	0.8910	0.5095	1.963	1.122	2.203	63°
28°	0.4695	0.8829	0.5317	1.881	1.133	2.130	62°
29°	0.4848	0.8746	0.5543	1.804	1.143	2.063	61°
30°	0.5000	0.8660	0.5774	1.732	1.155	2.000	60°
31°	0.5150	0.8572	0.6009	1.664	1.167	1.942	59°
32°	0.5299	0.8480	0.6249	1.600	1.179	1.887	58°
33°	0.5446	0.8387	0.6494	1.540	1.192	1.836	57°
34°	0.5592	0.8290	0.6745	1.483	1.206	1.788	56°
35°	0.5736	0.8192	0.7002	1.428	1.221	1.743	55°
36°	0.5878	0.8090	0.7265	1.376	1.236	1.701	54°
37°	0.6018	0.7986	0.7536	1.327	1.252	1.662	53°
38°	0.6157	0.7880	0.7813	1.280	1.269	1.624	52°
39°	0.6293	0.7771	0.8098	1.235	1.287	1.589	51°
40°	0.6428	0.7660	0.8391	1.192	1.305	1.556	50°
41°	0.6561	0.7547	0.8693	1.150	1.325	1.524	49°
42°	0.6691	0.7431	0.9004	1.111	1.346	1.494	48°
43°	0.6820	0.7314	0.9325	1.072	1.367	1.466	47°
44°	0.6947	0.7193	0.9657	1.036	1.390	1.440	46°
45°	0.7071	0.7071	1.000	1.000	1.414	1.414	45°
	cos	sin	cot	tan	csc	sec	

# EXERCISE 4

## CONSTRUCTION OF ZENITHAL PROJECTION

### Structure

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4.1	Introduction Expected Learning Outcomes		Construction of Polar Zenithal Gnomonic Projection
4.2	Requirements		Construction of Polar Zenithal Stereographic Projection
4.3	Construction of Zenithal Projection	4.4	Suggested Further Readings

### 4.1 INTRODUCTION

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In Exercise 3, you have been introduced to the method of construction of conical map projections in various kinds by covering the specific areal extents. In this Exercise 4, you will be learn how the zenithal map projections can be constructed for representing the earth's surface areas. The important property of zenithal projections is that they show the correct bearings/directions or azimuths of all the points from the centre of the globe.

You will learn the construction of Polar Zenithal Gnomonic Projection and Polar Zenithal Stereographic Projections through this exercise. You may refer to Block 2 of BGGCT-133 course for understanding the properties and uses of zenithal projections.

### Expected Learning Outcomes

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After working through this exercise, you shall be able to:

- understand the method of construction of zenithal projections;
- construct a Polar Zenithal Gnomonic Projection; and
- construct a Polar Zenithal Stereographic Projection.

### 4.2 REQUIREMENTS

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To perform this exercise, you require the following materials.

- Ruler or Scale
- Pencil/Pen
- Sharpener and Eraser
- Compass
- Divider
- Protractor
- Set-squares
- Scientific calculator
- Drawing sheets or White sheets (A3 size or long sheets).

### 4.3 CONSTRUCTION OF POLAR ZENITHAL GNOMONIC PROJECTION

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**Polar Zenithal Gnomonic Projection**, is one of the perspective zenithal projections. It is a 2-dimensional plane of projection. In this projection, the source of light lies at the center of the earth as its perspective point. Gnomonic projections can be any aspect but in the polar aspect the tangent touches either north pole or south pole. Meridians are straight lines and parallels are concentric circles.

In this projection, particularly shape is distorted greatly from the center and areal distortion is increased with distance from the center. Distances between parallels increase rapidly with an increase in distance from the central point. However, direction is accurate from the center. All great circles are straight lines, regardless of the aspect. The main use of this projection is for navigation because great circles highlight routes with the shortest distance.

Let us start to learn the construction of graticules for **Polar Zenithal Gnomonic Projection** through the following exercises. Here, you will learn two methods for constructing graticules of the projections a) Method 1: Mathematical construction, and b) Method 2: Graphical construction.

**PROBLEM 1:** Construct a graticule at 10° interval on polar zenithal gnomonic projection on scale 1:150,000,000 for covering an area 90°N-40°N.

#### **METHOD-1: MATHEMATICAL CONSTRUCTION**

**SOLUTION:** In the preliminary stage, we have to calculate the values for constructing the map projection. Then, the calculated values are to be used for making the projection in the next stage.

#### **Calculations for Constructing the Projection:**

**Step 1:** Calculate the radius (R) of the generating globe for the given scale.

$$RF = 1:150,000,000 = \frac{1}{150,000,000}$$

$$RadiusR = \frac{1}{150,000,000} (cm) \times Earthradius_{cm}$$

$$= \frac{1}{150,000,000} (cm) \times 640,000,000_{cm} = \frac{64}{15} = 4.27 \text{ cm}$$

We have now obtained the value of radius i.e. **R = 4.27 cm**

**Step 2:** Let us note the latitudinal extent i.e. from 90°N to 40°N and the interval i.e. 10°. So, the following parallels are to be drawn.

90°N, 80°N, 70°N, 60°N, 50°N, 40°N.

**Step 3:** Calculate the length of the radius ( $r_\phi$ ) of a parallel using the standard equation as follows:

$$\text{Radius } (r_\phi) = R \cot \phi$$

$$\text{Radius of } 80^\circ \text{ parallel } (r_1) = R \cot \phi = 4.27 \times \cot 80^\circ$$

$$= 4.27 \times 0.176 = 0.75 \text{ cm}$$

$$\text{Radius of } 70^\circ \text{ parallel } (r_2) = R \cot \phi = 4.27 \times \cot 70^\circ$$

$$= 4.27 \times 0.363 = 1.55 \text{ cm}$$

$$\text{Radius of } 60^\circ \text{ parallel } (r_3) = R \cot \phi = 4.27 \times \cot 60^\circ$$

$$= 4.27 \times 0.577 = 2.46 \text{ cm}$$

$$\text{Radius of } 50^\circ \text{ parallel } (r_4) = R \cot \phi = 4.27 \times \cot 50^\circ$$

$$= 4.27 \times 0.839 = 3.58 \text{ cm}$$

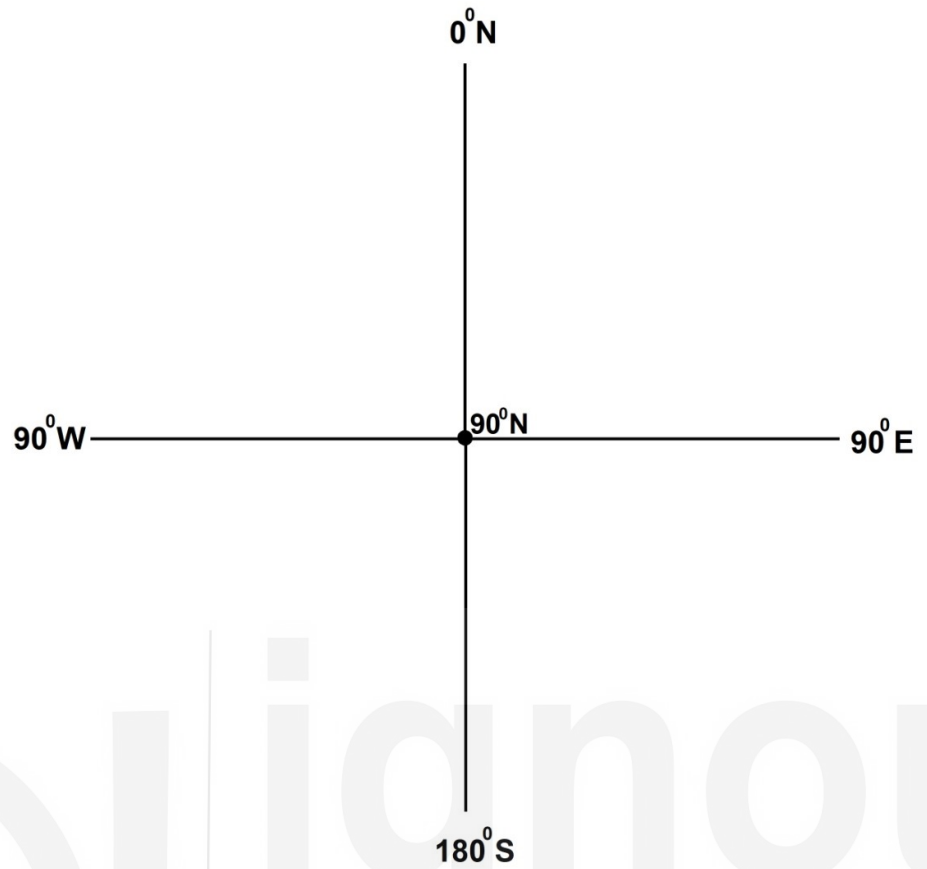
$$\text{Radius of } 40^\circ \text{ parallel } (r_5) = R \cot \phi = 4.27 \times \cot 40^\circ$$

$$= 4.27 \times 1.191 = 5.08 \text{ cm}$$

You have now all the calculated values for constructing the projection. Let us start the construction of the projection. Keep ready with you a drawing sheet, pencil, ruler, protractor, and divider, etc.

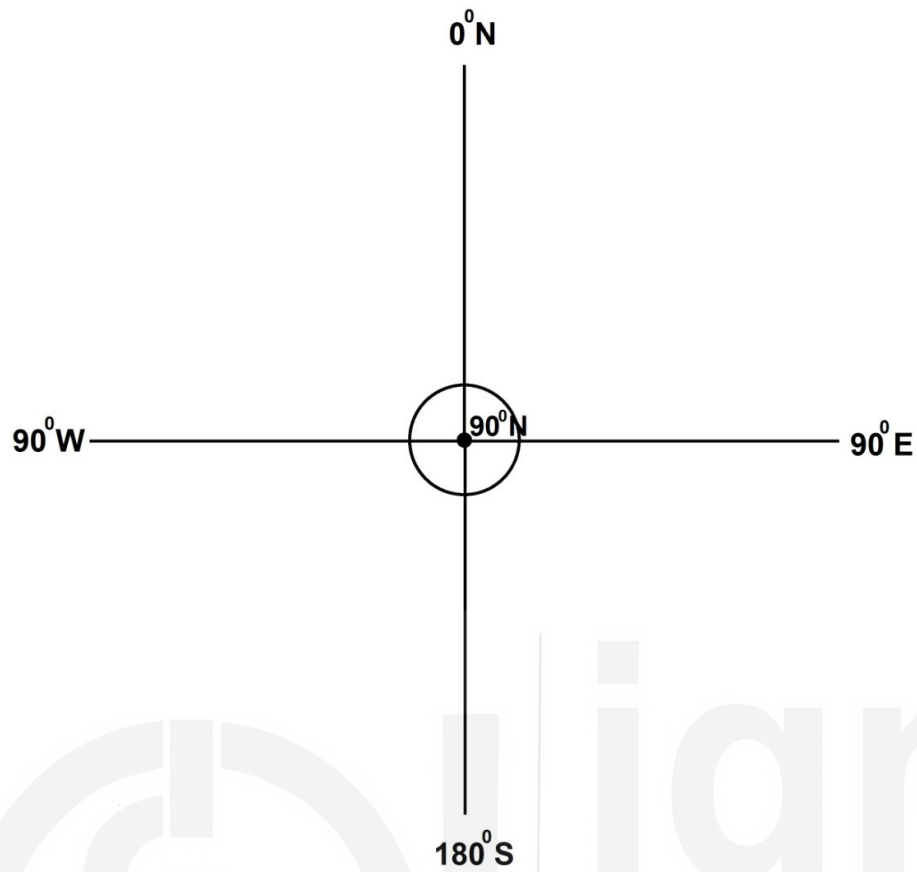
### **Construction of the Projection:**

**Step 4:** Take a drawing sheet and place it on a plane surface. With the help of pencil and scale, draw a pair of straight lines on centre of the sheet. The lines must be intersected with 90° angle. The horizontal line represents 90° E 90° W and the other vertical line indicates 0° N-180° S meridians. The point of intersection represents 90° N pole.



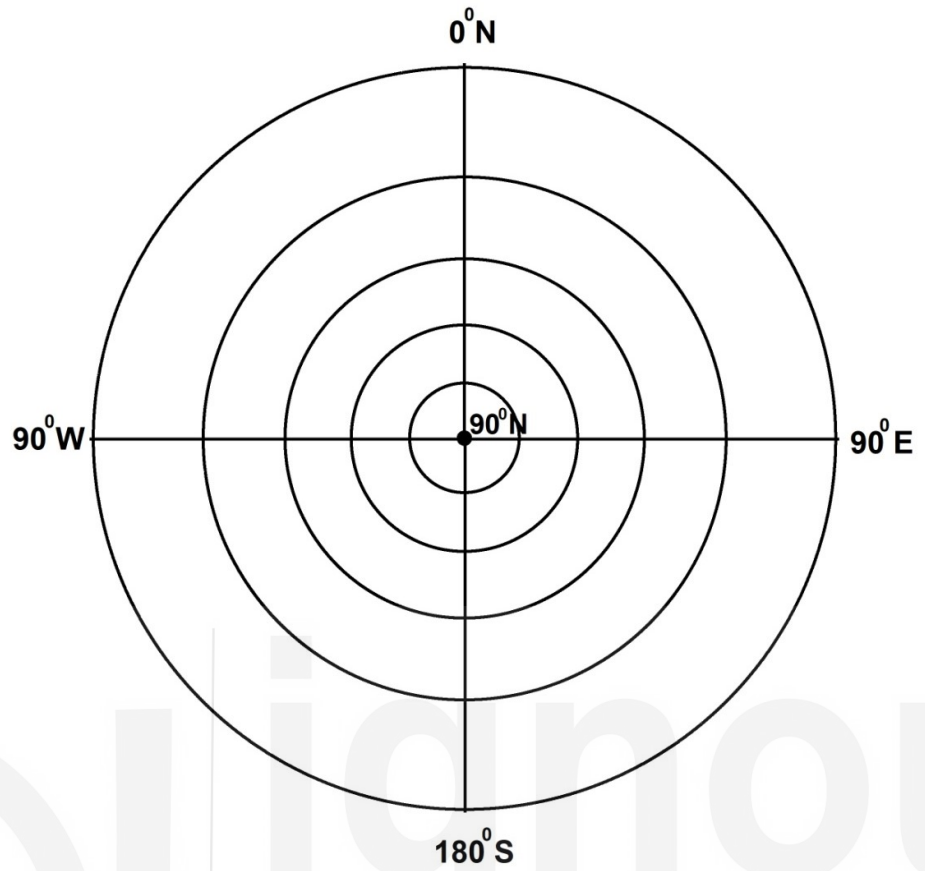
**Step 5:** Now, with the help of compass from the intersection point ( $90^\circ\text{N}$ ), the concentric circle is drawn by the calculated value of radius  $r_1 = 0.75\text{ cm}$  (refer to Step 3). This circle would be  $80^\circ\text{N}$ .

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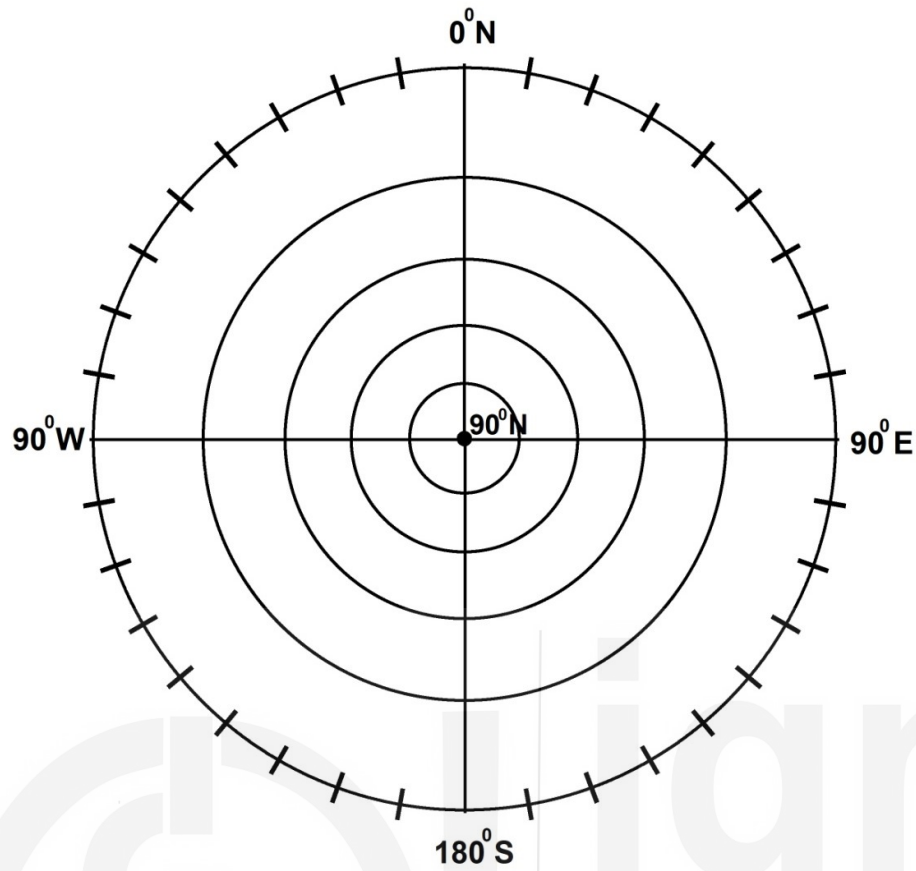


**Step 6:** Repeat the same procedure for drawing all the other concentric circles with the radius values of **1.55 cm, 2.46 cm, 3.58 cm, 5.08 cm** for **70°N, 60°N, 50°N, 40°N**, respectively (refer to Step 4). You must always remember that all of these concentric circles are parallels.

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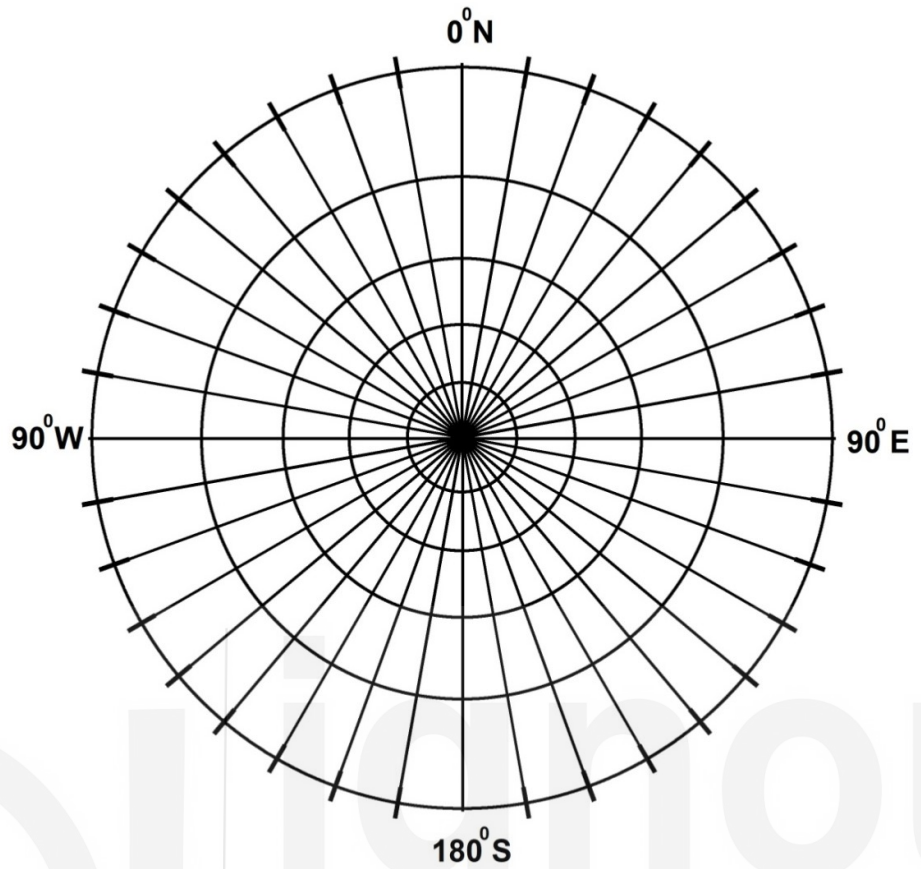


**Step 7:** Take a protractor and place it by matching with the center point of intersection i.e. pole ( $90^{\circ} \text{N}$ ). Then, mark the divisions of required angles for all the concentric circles.



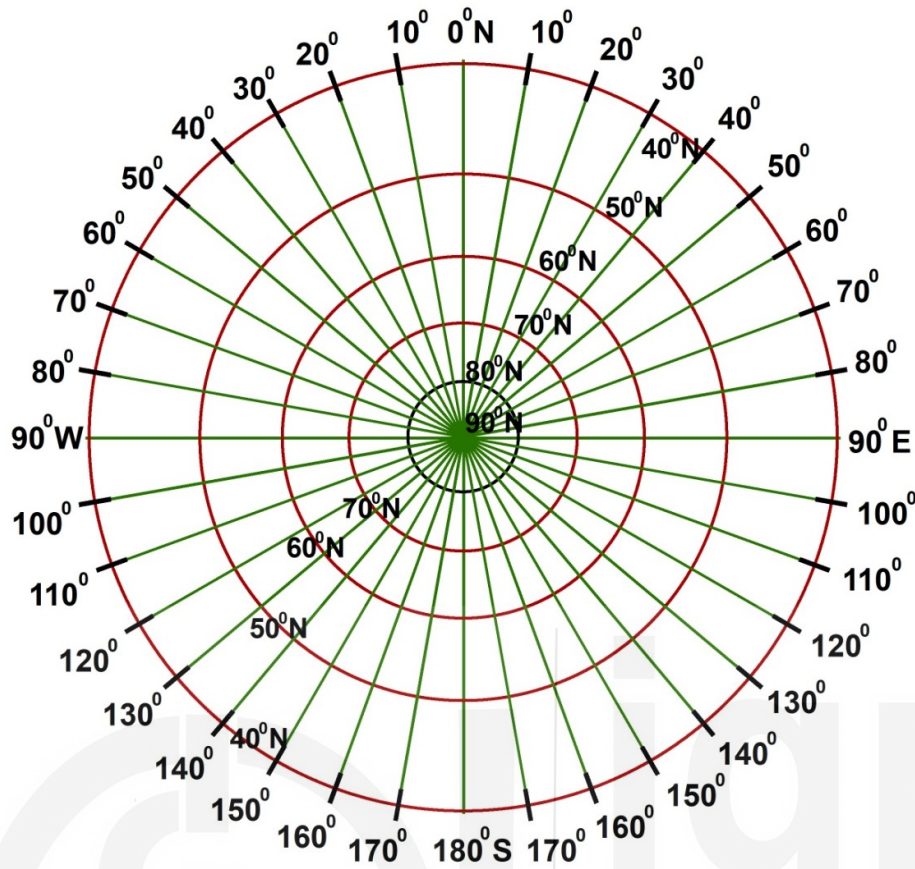
**Step 8:** With the help of setsquares or scale, straight lines are drawn by touching each of these division points joining to the pole point. These lines are meridians.

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**Step 9:** You have now successfully completed the construction of graticules of polar zenithal gnomonic projection. But you have to erase the extended lines of the projection and finish it with proper labelling as given below. You must also write the scale of projection.

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R.F. 1:150,000,000

### METHOD-2: GRAPHICAL CONSTRUCTION

**SOLUTION:** In the preliminary stage, we have to calculate the values for constructing the map projection. Then, the calculated values are to be used for making the projection in the next stage.

#### Calculations for Constructing the Projection:

**Step 1:** Calculate the radius (R) of the generating globe for the given scale.

$$RF = 1:150,000,000 = \frac{1}{150,000,000}$$

$$\text{Radius } R = \frac{1}{150,000,000} (\text{cm}) \times \text{Earth radius}_{\text{cm}}$$

$$= \frac{1}{150,000,000} (\text{cm}) \times 640,000,000_{\text{cm}} = \frac{64}{15} = 4.27 \text{ cm}$$

We have now obtained the value of radius i.e. **R = 4.27 cm ~ 4.3 cm**

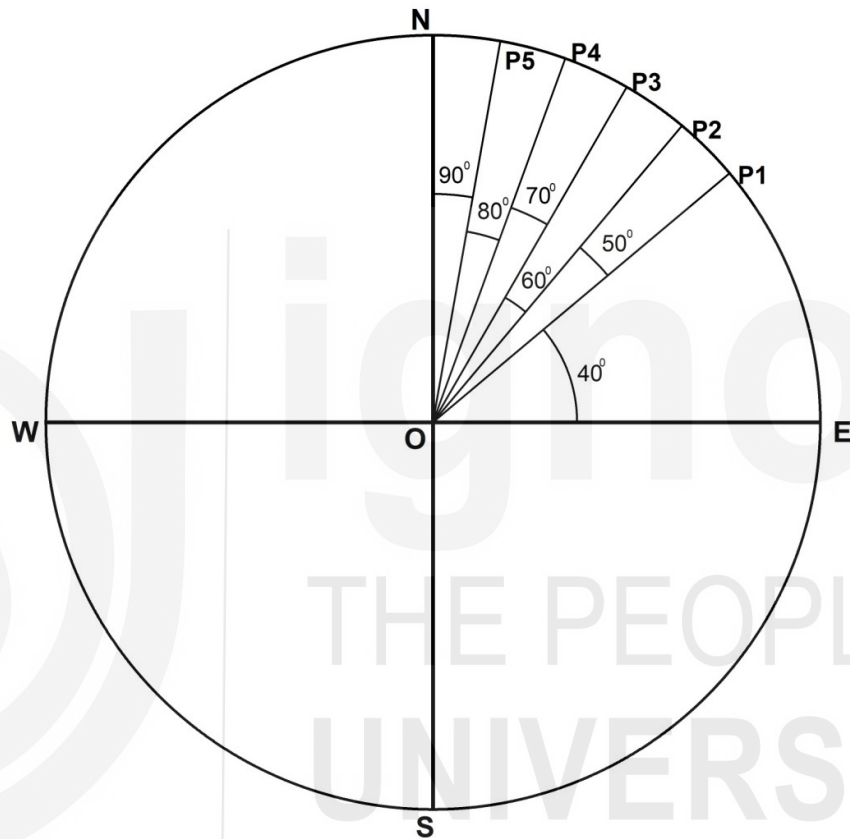
**Step 2:** Let us note the latitudinal extent i.e. from 90°N to 40°N and the interval i.e. 10°. So, the following parallels are to be drawn.

90°N, 80°N, 70°N, 60°N, 50°N, 40°N.

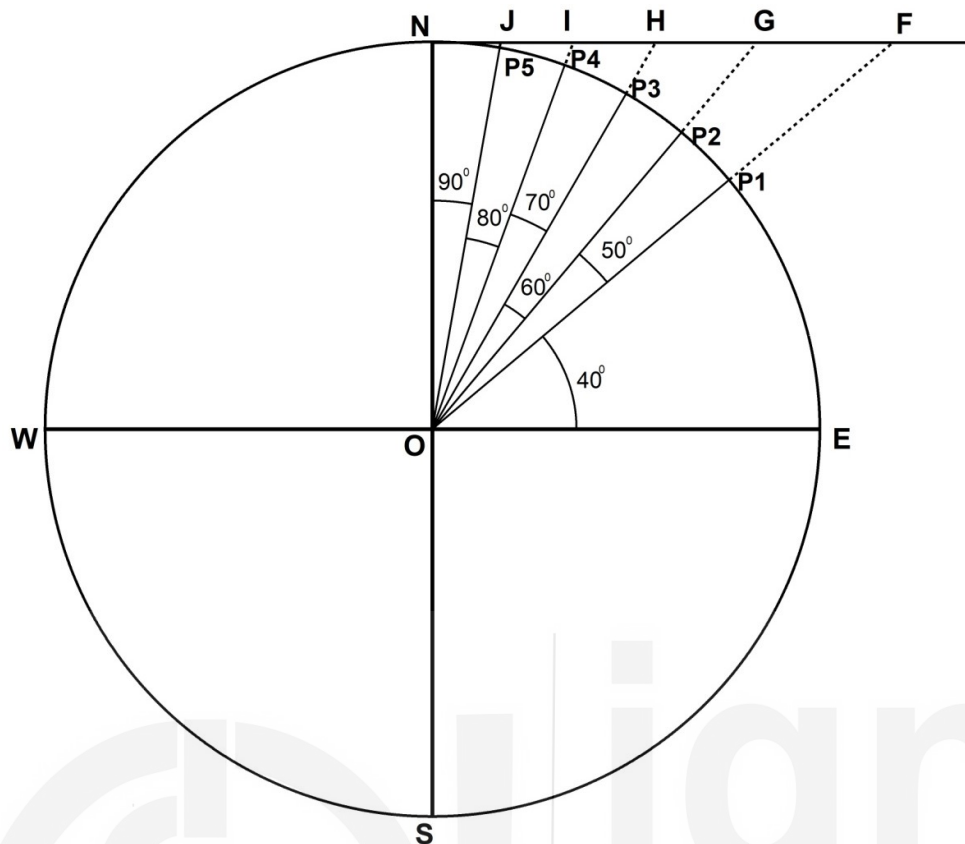
**Step 3:** Now, we have to calculate the value of the radius of all the parallels.

Take a drawing sheet and place it on a plane surface. With the help of pencil and scale, draw a pair of straight lines on the sheet. The lines must be intersected with  $90^\circ$  angle. The interaction point is named as O.

**Step 4:** Draw a circle with the measurement of radius  $R = 4.27$  cm from the center (O). With the help of protractor, mark the angles of parallels  $40^\circ$  (OP5N),  $50^\circ$  (OP4N),  $60^\circ$  (OP3N),  $70^\circ$  (OP2N),  $80^\circ$  (OP1N), and  $90^\circ$  (ON), Then, draw lines of OP1, OP2, OP3, OP4, OP5 through these markings from O.



**Step 5:** Draw a tangent line from the pole point N parallel to the equator line OE. Now, extend every line (for example OP1) corresponding to the tangent line as P1F, P2G, P3H, P4I, P5J. Measure the lengths of NF, NG, NH, NI and NJ which will represent the value of the radius of  $40^\circ$ N,  $50^\circ$ N,  $60^\circ$ N,  $70^\circ$ N and  $80^\circ$ N parallels respectively.



Now, you got to know the value of the radius of all the parallels.

*Radius of 80° parallel = 0.75cm*

*Radius of 70° parallel = 1.55 cm*

*Radius of 60° parallel = 2.46 cm*

*Radius of 50° parallel = 3.58 cm*

*Radius of 40° parallel = 5.08 cm*

### **Construction of the Projection:**

**Step 6:** Take a drawing sheet and place it on a plane surface. With the help of pencil and scale, draw a pair of straight lines on centre of the sheet. The lines must be intersected with 90° angle. The horizontal line represents 90° E-90° W and the other vertical line indicates 0° N-180° S meridians.

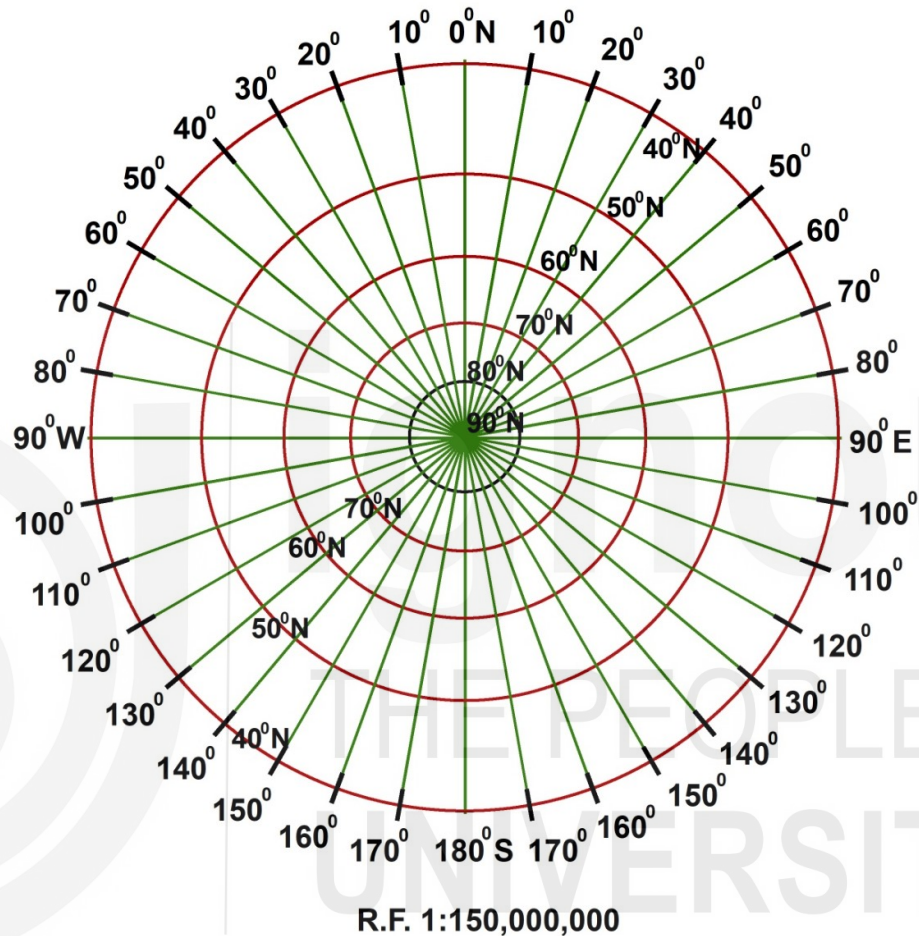
**Step 7:** The point of intersection is represented by 90° N. Now, with the help of compass, from the intersection point the concentric circle is drawn by the calculated value of radius for **80°N = 0.75 cm**.

**Step 8:** Repeat the same procedure for drawing all the other concentric circles with the radius values of **1.55 cm, 2.46 cm, 3.58 cm, 5.08 cm** for **70°N, 60°N, 50°N, 40°N** respectively.

**Step 9:** Take a protractor and place it by matching with the center point of intersection i.e. pole (90° N). Then, mark the divisions of required angles for all the concentric circles.

**Step 10:** With the help of setsquares or scale, straight lines are drawn by touching each of these division points joining to the pole point. These lines are meridians.

**Step 11:** You have now successfully completed the construction of graticules of polar zenithal gnomonic projection. But you have to erase the extended lines of the projection and finish it with proper labelling as given below. You must also write the scale of projection.



#### 4.4 CONSTRUCTION OF POLAR ZENITHAL STEREOGRAPHIC PROJECTION

This projection is planar perspective projection. It can be viewed from the point on the globe opposite the point of tangency. In the polar aspect of this projection, the tangent touches either north pole or south pole. Meridians are straight lines and parallels are concentric circles.

This is a conformal projection and has no local shape distortion. Area is true at center with distortion increasing with distance and directions are accurate from the center.

Polar zenithal stereographic projection is normally limited to one hemisphere.

Let us start to learn the construction of graticules for **Polar Zenithal Stereographic Projection** through the following exercises. Here, you will

learn two methods for constructing graticules of the projections a) Method 1: Mathematical construction, and b) Method 2: Graphical construction.

**PROBLEM 1:** Construct graticules at 5° interval on polar zenithal stereographic projection on scale 1:250,000,000 for covering an area 90°S-50°S.

### **METHOD-1: MATHEMATICAL CONSTRUCTION**

**SOLUTION:** In the preliminary stage, we have to calculate the values for constructing the map projection. Then, the calculated values are to be used for making the projection in the next stage.

**Step 1:** Calculate the radius (R) of the generating globe for the given scale. Note down the RF.

$$RF = 1:250,000,000 = \frac{1}{250,000,000}$$

$$\begin{aligned} \text{Radius } R &= \frac{1}{250,000,000} (\text{cm}) \times \text{Earth radius}_{\text{cm}} \\ &= \frac{1}{250,000,000} (\text{cm}) \times 6400,000 \text{ cm} = \frac{64}{25} = 2.56 \text{ cm} \end{aligned}$$

We have now obtained the value of radius i.e. **R = 2.56 cm**.

**Step 2:** Let us note the latitudinal extent i.e. from 90°S to 50°S and the interval i.e. 5°. So, the following parallels are to be drawn.

90°S, 85°S, 80°S, 75°S, 70°S, 65°S, 60°S, 55°S, 50°S.

**Step 3:** Calculate the length of the radius of a parallel ( $r_\phi$ ) using the standard equation as follows:

$$r_\phi = 2R \tan\left(\frac{90^\circ - \phi}{2}\right)$$

Where,  $\phi$  = Latitude in degrees, R = Radius in cm

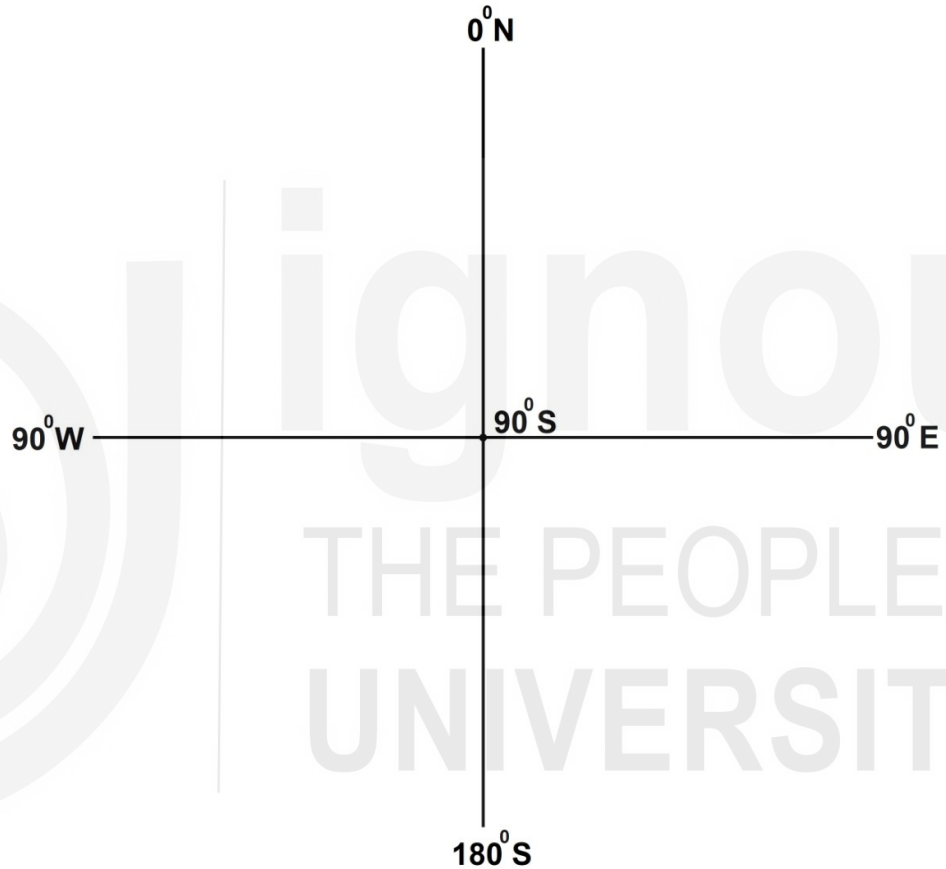
To get the  $r_\phi$  value, you shall prepare the following table with given **interval i.e. 5°** for determining the radius of each parallel using the above equation. You can use the scientific calculator to get the **Tangent (tan)** values directly or refer to the annexures provided at the end of this exercise.

$\phi$	$\frac{90^\circ - \phi}{2}$	$\tan\left(\frac{90^\circ - \phi}{2}\right)$	R cm	2R cm	$r_\phi = 2R \tan\left(\frac{90^\circ - \phi}{2}\right)$ cm
90°S	0	0	2.56	5.12	0
85°S	2.5	0.043	2.56	5.12	0.22
80°S	5.0	0.087	2.56	5.12	0.44
75°S	7.5	0.131	2.56	5.12	0.67
70°S	10.0	0.176	2.56	5.12	0.90
65°S	12.5	0.221	2.56	5.12	1.13
60°S	15.0	0.267	2.56	5.12	1.36
55°S	17.5	0.315	2.56	5.12	1.61
50°S	20.0	0.363	2.56	5.12	1.85

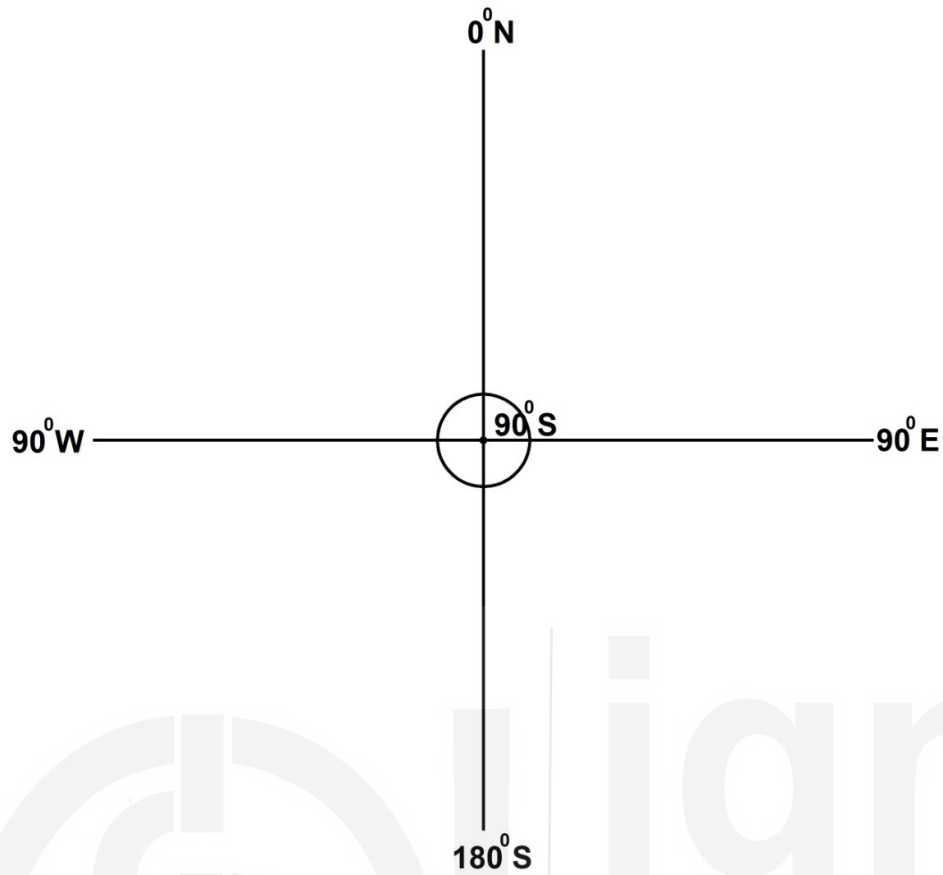
You have now all the calculated values. Let us start the construction of the projection. Keep ready with you a drawing sheet, pencil, ruler, protractor and divider etc.

### **Construction of the Projection:**

**Step 4:** Take a drawing sheet and place it on a plane surface. With the help of pencil and scale, draw a pair of straight lines on centre of the sheet. The lines must be intersected with  $90^\circ$  angle. The horizontal line represents  $90^\circ$  E- $90^\circ$  W and the other vertical line indicates  $0^\circ$  N- $180^\circ$  S meridians. The point of intersection represents  $90^\circ$  S pole.

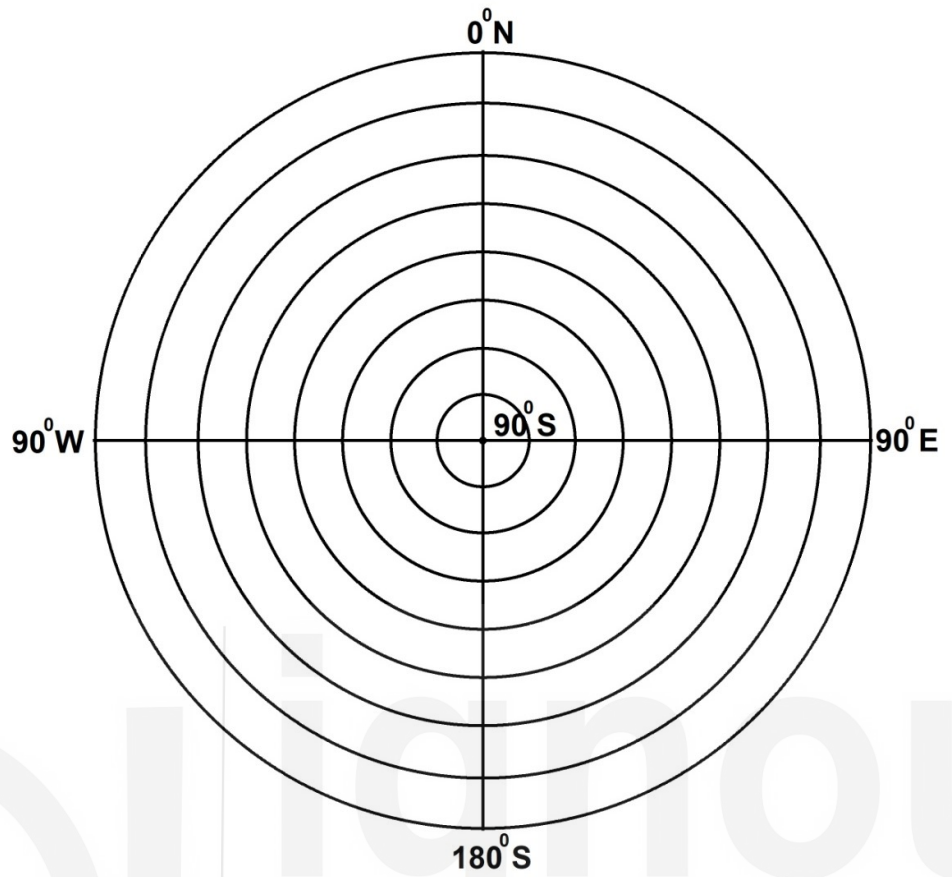


**Step 5:** Now, with the help of compass, from intersection point the concentric circle is drawn by the calculated value of radius  $r_{85^\circ} = 0.22$  cm (refer to Step 3). This circle would be  $85^\circ$  S parallel.



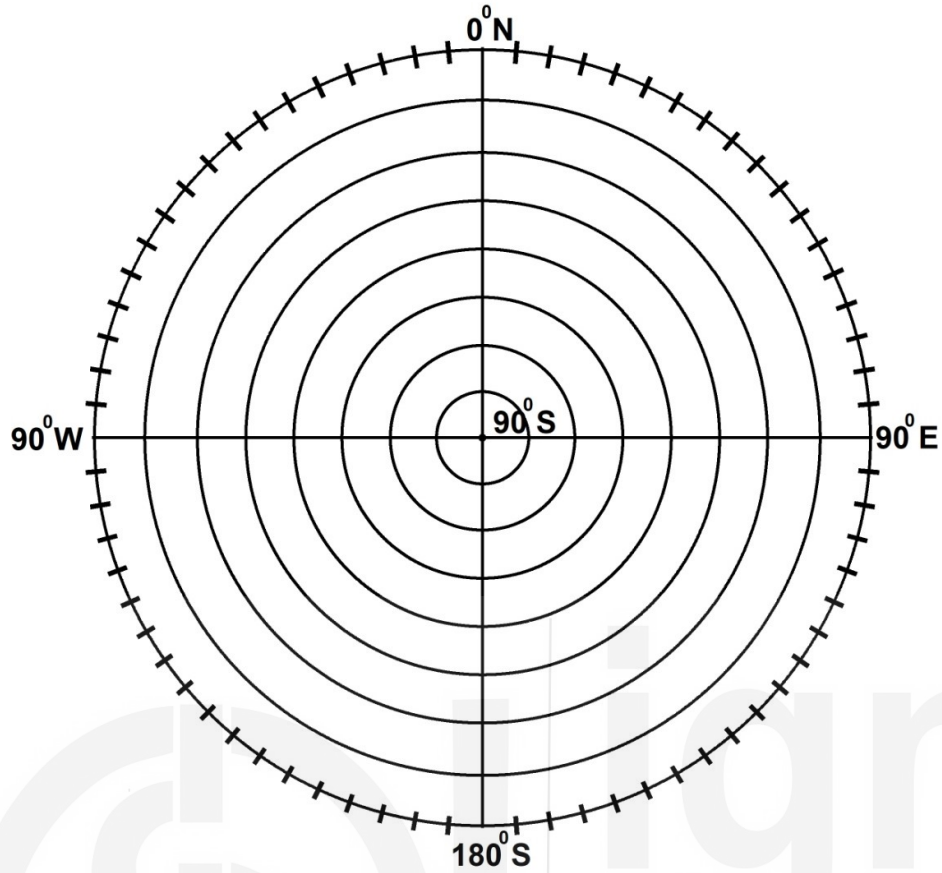
**Step 6:** Repeat the same procedure for drawing all the other concentric circles with the radius values of **0.44 cm, 0.67 cm, 0.90 cm, 1.13 cm, 1.36 cm, 1.61 cm, and 1.85 cm** for **80°S, 75°S, 70°S, 65°S, 60°S, 55°S, and 50°S**, respectively (refer to Step 3-Table). You must always remember that all of these concentric circles are parallels.

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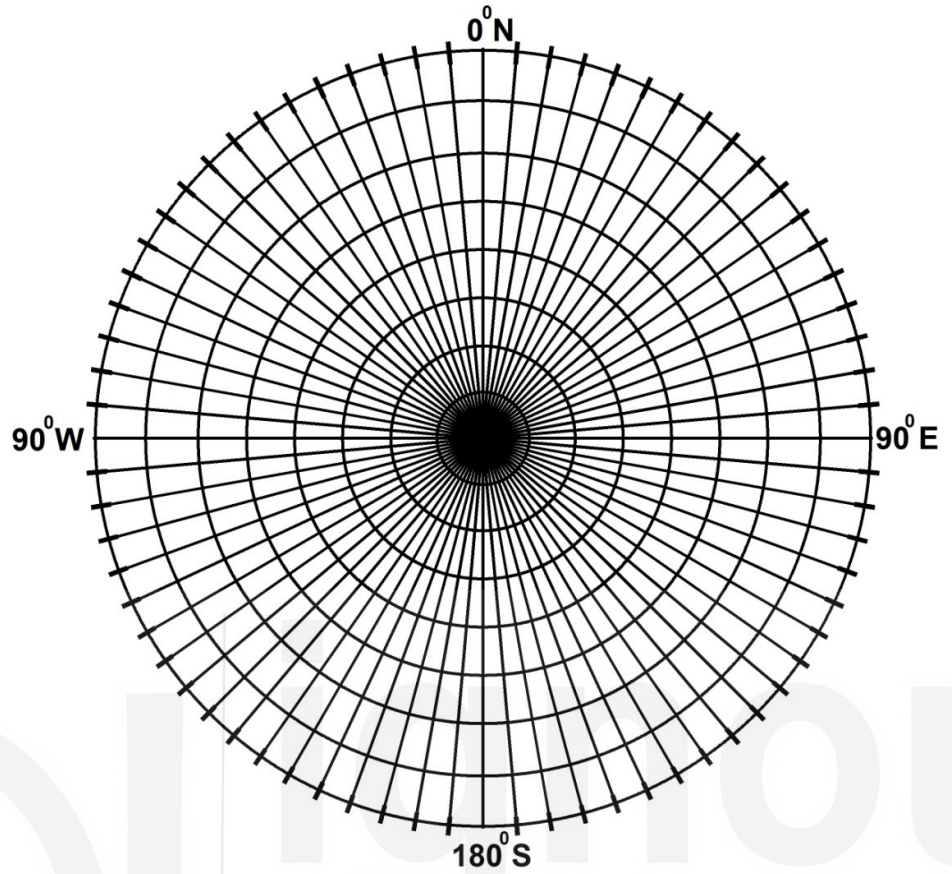


**Step 7:** Take a protractor and place it by matching with the center point of intersection i.e. pole ( $90^{\circ} \text{ S}$ ). Then, mark the divisions of required angles for all the concentric circles.

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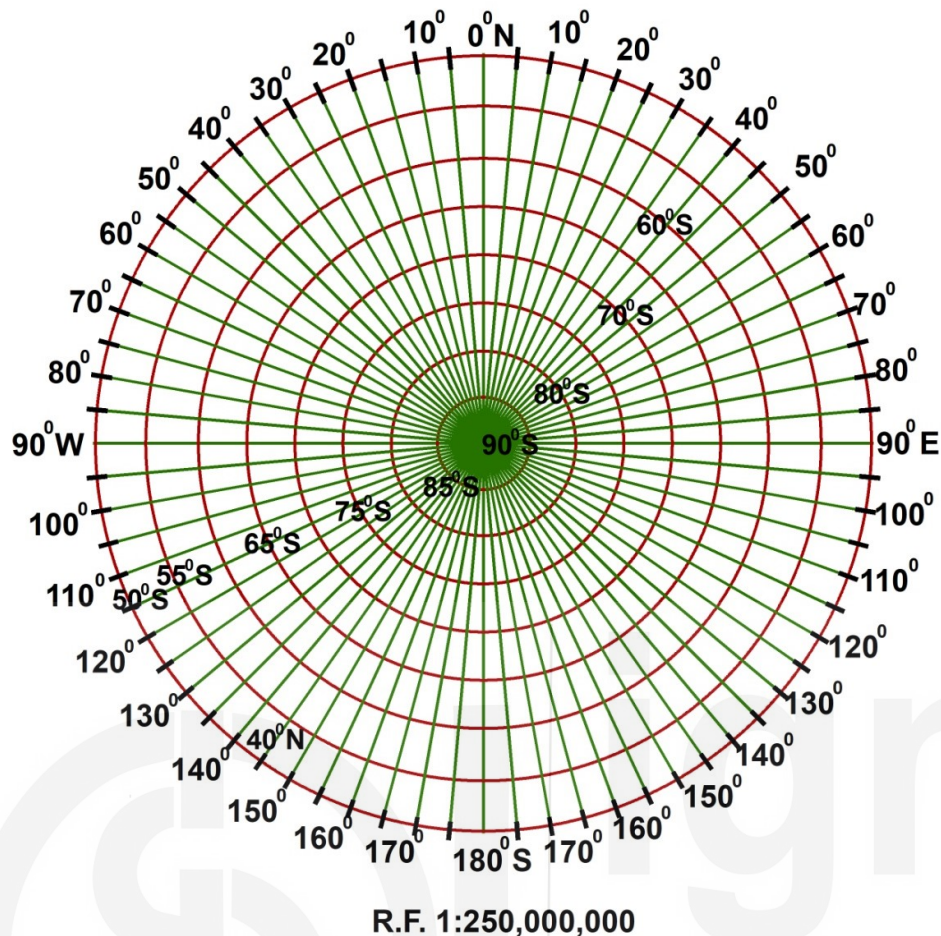


**Step 8:** With the help of setsquares or scale, straight lines are drawn by touching each of these division points joining to the pole point. These lines are meridians.



**Step 9:** You have now successfully completed the construction of graticules of polar zenithal stereographic projection. But you have to erase the extended lines of the projection and finish it with proper labelling as given below. You must also write the scale of projection.

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### METHOD-2: GRAPHICAL CONSTRUCTION

**Solution:** In the preliminary stage, we have to calculate the values for constructing the map projection. Then, the calculated values are to be used for making the projection in the next stage.

**Step 1:** Calculate the radius (R) of the generating globe for the given scale. Note down the RF.

$$RF = 1:250,000,000 = \frac{1}{250,000,000}$$

$$\text{Radius } R = \frac{1}{250,000,000} (\text{cm}) \times \text{Earth radius}_{\text{cm}}$$

$$= \frac{1}{250,000,000} (\text{cm}) \times 640,000,000 \text{cm} = \frac{64}{25} = 2.56 \text{ cm}$$

We have now obtained the value of radius i.e. **R = 2.56 cm**.

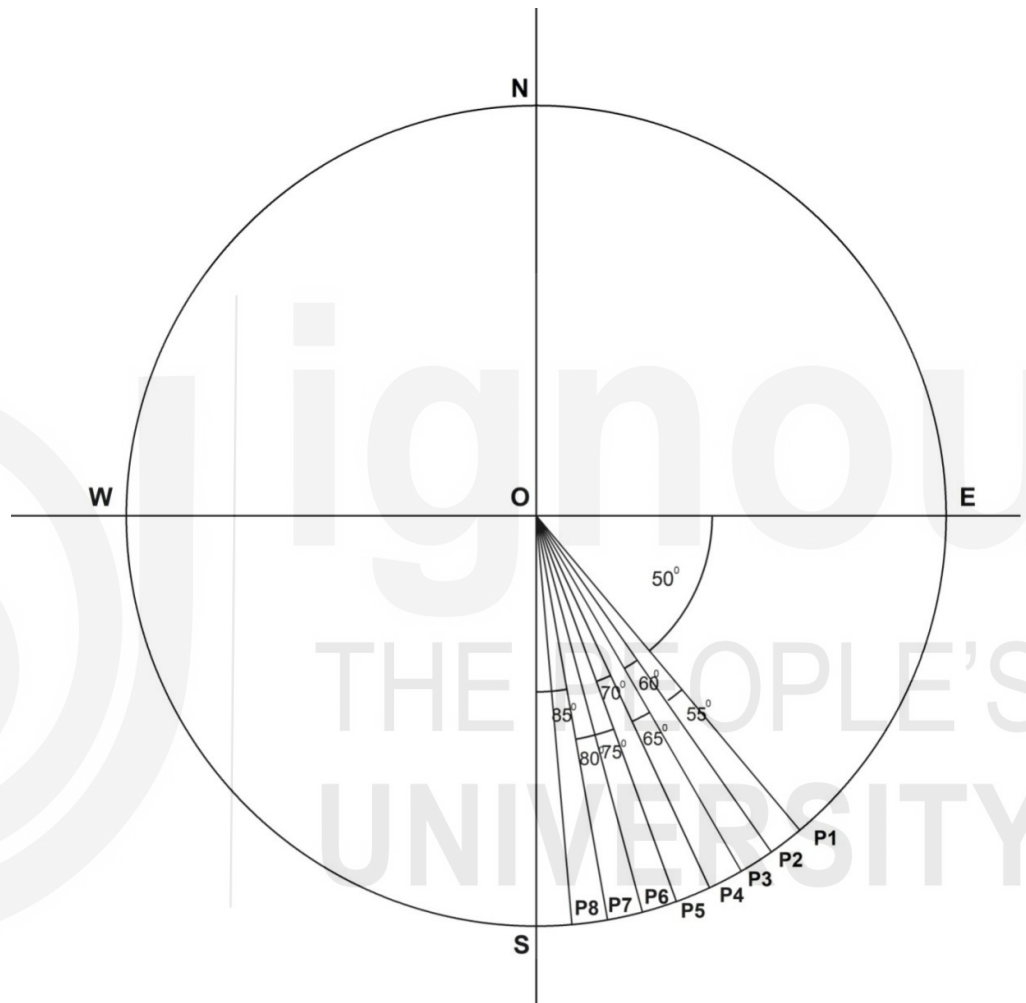
**Step 2:** Let us note the latitudinal extent i.e. from 90°S to 50°S and the interval i.e. 5°. So, the following parallels are to be drawn.

90°S, 85°S, 80°S, 75°S, 70°S, 65°S, 60°S, 55°S, 50°S.

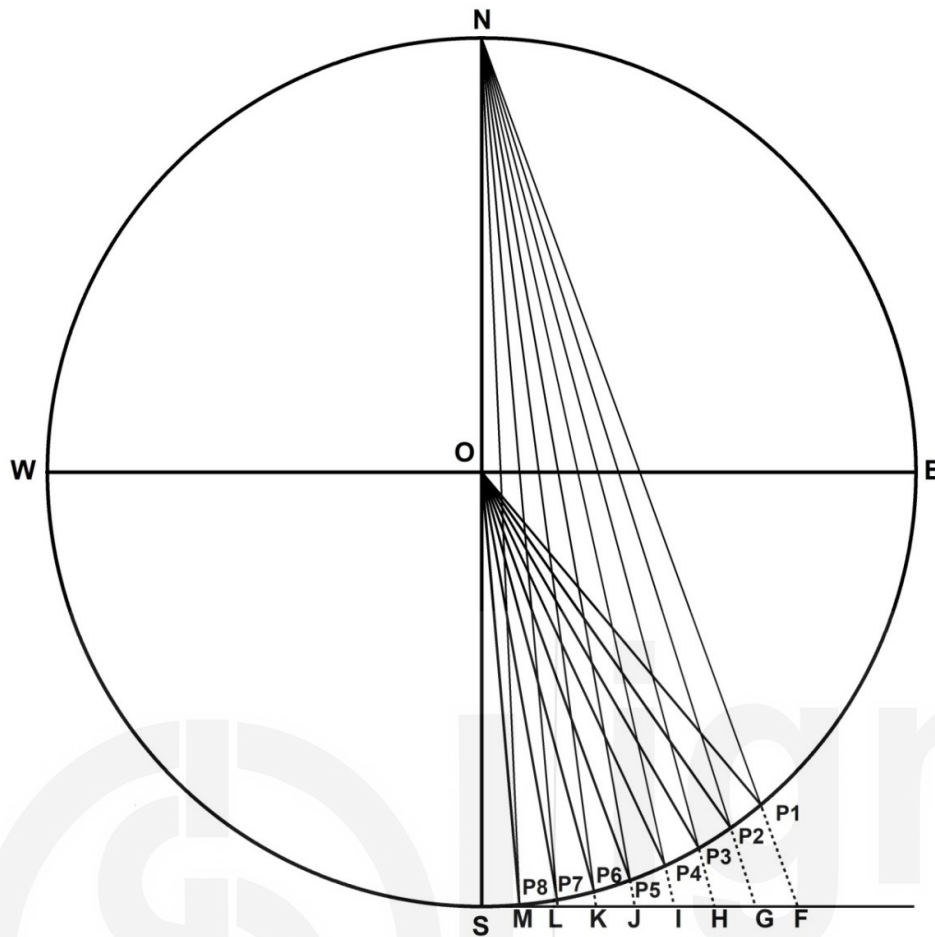
**Step 3:** Now, we have to calculate the value of the radius of each parallel.

Take a drawing sheet and place it on plane surface. With the help of pencil and scale, draw a pair of straight lines on the sheet. The lines must be intersected with  $90^\circ$  angle. The intersection point is named as O.

**Step 4:** Draw a circle with the measurement of radius  $R = 2.56$  cm from the center (O). With the help of protractor, mark the angles of parallels  $50^\circ$  (OEP1S),  $55^\circ$  (OEP2S),  $60^\circ$  (OEP3S),  $65^\circ$  (OEP4S),  $70^\circ$  (OEP5S),  $75^\circ$  (OEP6S),  $80^\circ$  (OEP7S),  $85^\circ$  (OEP8S). Then, draw lines of OP1, OP2, OP3, OP4, OP5, OP6, OP7, OP8 through these markings from O.



**Step 5:** Draw a tangent line from the pole point S parallel to the equator line OE. Now, extend the each line corresponding to the point of tangent line as P1F, P2G, P3H, P4I, P5J, P6K, P7L, P8M. Measure the lengths of SF, SG, SH, SI, SJ, SK, SL, SM which will represent the value of the radius of  $50^\circ$ S,  $55^\circ$ S,  $60^\circ$ S,  $65^\circ$ S,  $70^\circ$ S,  $75^\circ$ S,  $80^\circ$ S,  $85^\circ$ S, respectively.



Now, you got to know the value of the radius of all parallels.

*Radius of 85° parallel = 0.2 cm*

*Radius of 80° parallel = 0.4 cm*

*Radius of 75° parallel = 0.7 cm*

*Radius of 70° parallel = 0.9 cm*

*Radius of 65° parallel = 1.1 cm*

*Radius of 60° parallel = 1.3 cm*

*Radius of 55° parallel = 1.6 cm*

*Radius of 50° parallel = 1.8 cm*

### **Construction of the Projection:**

**Step 6:** Take a drawing sheet and place it on a plane surface. With the help of pencil and scale, draw a pair of straight lines on centre of the sheet. The lines must be intersected with 90° angle. The horizontal line represents 90°E-90°W and the other vertical line indicates 0°N-180°S meridians.

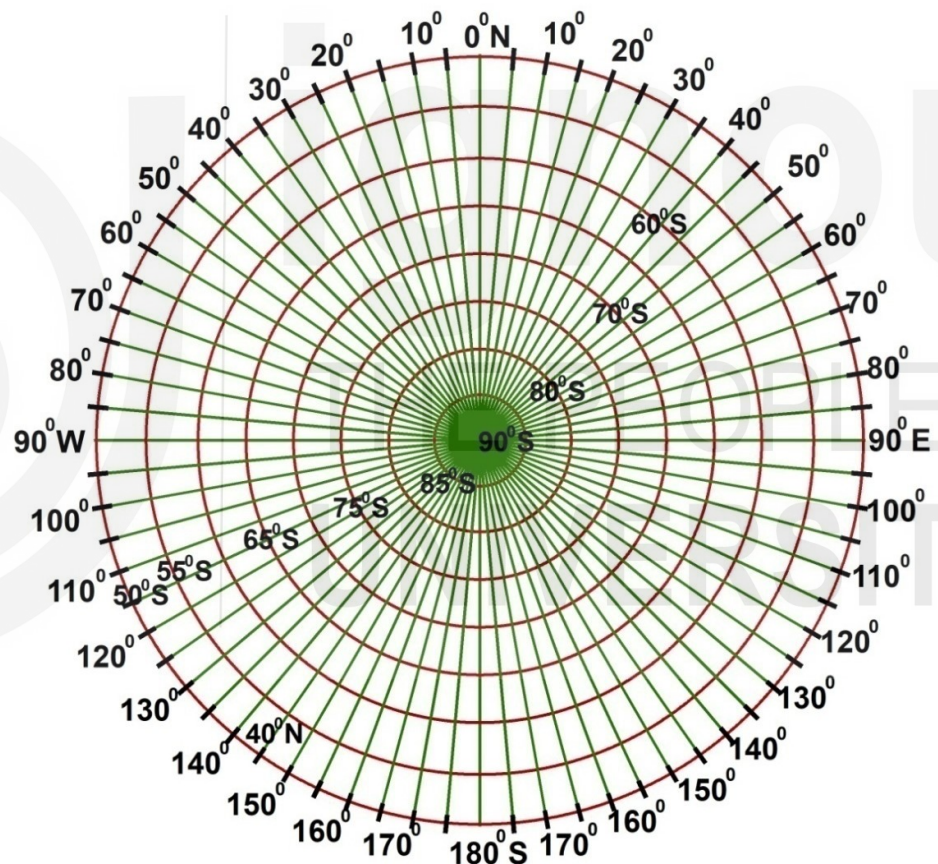
**Step 7:** The point of intersection is represented by 90°S. Now, with the help of compass, from intersection point the concentric circle is drawn by the calculated value of radius  $r_{85} = 0.22 \text{ cm}$ . This circle would be 85°S parallel.

**Step 8:** Repeat the same procedure for drawing all the other concentric circles with the radius values of **0.44cm, 0.67cm, 0.90cm, 1.13cm, 1.36cm, 1.61cm and 1.85cm** for **80°S, 75°S, 70°S, 65°S, 60°S, 55°S, and 50°S** respectively. You must always remember that all of these concentric circles are parallels.

**Step 9:** Take a protractor and place it by matching with the center point of intersection i.e. pole (90°S). Then, mark the divisions of required angles for all the concentric circles.

**Step 10:** With the help of set-squares or scale, straight lines are drawn by touching each of these division points joining to the pole point. These lines are meridians.

**Step 11:** You have completed the construction of graticules of polar zenithal gnomonic projection. Finally, you have to mark labels properly and all the graticules also to be written as given below.



R.F. 1:250,000,000

#### Lab Exercise 1:

Construct a graticule at 10° interval on polar zenithal gnomonic projection on scale 1:250,000,000 for covering an area of 90°N-60°N.

#### Lab Exercise2:

Construct a graticule at 5° interval on polar zenithal gnomonic projection on scale 1:150,000,000 for covering an area of 90°S-60°S.

### Lab Exercise 3:

Construct graticules at 20° interval on polar zenithal stereographic projection on scale 1:100,000,000 for covering an area of 90°N-50°N.

Latitude ( $\phi$ )	90°N	70°N	50°N
Radius of parallel( $r_\phi$ )	0 cm	2.25 cm	4.64 cm

### Lab Exercise 4:

Construct graticules at 10° interval on polar zenithal stereographic projection on scale 1:180,000,000 for covering an area of 90°S-40°S.

## 4.5 SUGGESTED FURTHER READINGS

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- Sarkar, A. (2008): *Practical Geography: A Systematic Approach*, Kolkata: Orient Black Swan
- Singh, G. (2004). *Map Work and Practical Geography*, Delhi: Vikas Publication House
- Robinson, Arthur, H.J., Morrison, P., Muehrke, A., Kimmerling & Guptill, S. (eds.) (1995). *Elements of Cartography*, New York: Wiley.
- Misra, R.P. & Ramesh, A. (1986). *Fundamentals of Cartography*, New Delhi: McMillan.
- Singh, R.L. and Singh, R.P.B. (2003). *Elements of Practical Geography*, Delhi: Kalyani Publishers.

### Annexure 1

	Trigonometric Functions						
	sin	cos	tan	cot	sec	csc	
0°	0.0000	1.0000	0.0000	....	1.000	...	90°
1°	0.0175	0.9998	0.0175	57.29	1.000	57.30	89°
2°	0.0349	0.9994	0.0349	28.64	1.001	28.65	88°
3°	0.0523	0.9986	0.0524	19.08	1.001	19.11	87°
4°	0.0698	0.9976	0.0699	14.30	1.002	14.34	86°
5°	0.0872	0.9962	0.0875	11.43	1.004	11.47	85°
6°	0.1045	0.9945	0.1051	9.514	1.006	9.567	84°
7°	0.1219	0.9925	0.1228	8.144	1.008	8.206	83°
8°	0.1392	0.9903	0.1405	7.115	1.010	7.185	82°
9°	0.1564	0.9877	0.1584	6.314	1.012	6.392	81°
10°	0.1736	0.9848	0.1763	5.671	1.015	5.759	80°
11°	0.1908	0.9816	0.1944	5.145	1.019	5.241	79°
12°	0.2079	0.9781	0.2126	4.705	1.022	4.810	78°
13°	0.2250	0.9744	0.2309	4.331	1.026	4.445	77°
14°	0.2419	0.9703	0.2493	4.011	1.031	4.134	76°
15°	0.2588	0.9659	0.2679	3.732	1.035	3.864	75°
16°	0.2756	0.9613	0.2867	3.487	1.040	3.628	74°
17°	0.2924	0.9563	0.3057	3.271	1.046	3.420	73°
18°	0.3090	0.9511	0.3249	3.078	1.051	3.236	72°
19°	0.3256	0.9455	0.3443	2.904	1.058	3.072	71°
20°	0.3420	0.9397	0.3640	2.747	1.064	2.924	70°
21°	0.3584	0.9336	0.3839	2.605	1.071	2.790	69°
22°	0.3746	0.9272	0.4040	2.475	1.079	2.669	68°
23°	0.3907	0.9205	0.4245	2.356	1.086	2.559	67°

24°	0.4067	0.9135	0.4452	2.246	1.095	2.459	66°
25°	0.4226	0.9063	0.4663	2.145	1.103	2.366	65°
26°	0.4384	0.8988	0.4877	2.050	1.113	2.281	64°
27°	0.4540	0.8910	0.5095	1.963	1.122	2.203	63°
28°	0.4695	0.8829	0.5317	1.881	1.133	2.130	62°
29°	0.4848	0.8746	0.5543	1.804	1.143	2.063	61°
30°	0.5000	0.8660	0.5774	1.732	1.155	2.000	60°
31°	0.5150	0.8572	0.6009	1.664	1.167	1.942	59°
32°	0.5299	0.8480	0.6249	1.600	1.179	1.887	58°
33°	0.5446	0.8387	0.6494	1.540	1.192	1.836	57°
34°	0.5592	0.8290	0.6745	1.483	1.206	1.788	56°
35°	0.5736	0.8192	0.7002	1.428	1.221	1.743	55°
36°	0.5878	0.8090	0.7265	1.376	1.236	1.701	54°
37°	0.6018	0.7986	0.7536	1.327	1.252	1.662	53°
38°	0.6157	0.7880	0.7813	1.280	1.269	1.624	52°
39°	0.6293	0.7771	0.8098	1.235	1.287	1.589	51°
40°	0.6428	0.7660	0.8391	1.192	1.305	1.556	50°
41°	0.6561	0.7547	0.8693	1.150	1.325	1.524	49°
42°	0.6691	0.7431	0.9004	1.111	1.346	1.494	48°
43°	0.6820	0.7314	0.9325	1.072	1.367	1.466	47°
44°	0.6947	0.7193	0.9657	1.036	1.390	1.440	46°
45°	0.7071	0.7071	1.000	1.000	1.414	1.414	45°
	cos	sin	cot	tan	csc	sec	

**Reciprocal Identities:**

$$\begin{aligned}\sin \theta &= \frac{1}{\csc \theta} & \csc \theta &= \frac{1}{\sin \theta} \\ \cos \theta &= \frac{1}{\sec \theta} & \sec \theta &= \frac{1}{\cos \theta} \\ \tan \theta &= \frac{1}{\cot \theta} & \cot \theta &= \frac{1}{\tan \theta}\end{aligned}$$

**Pythagorean Identities:**

$$\begin{aligned}\sin^2 \theta + \cos^2 \theta &= 1 \\ 1 + \tan^2 \theta &= \sec^2 \theta \\ 1 + \cot^2 \theta &= \csc^2 \theta\end{aligned}$$

**Even Odd Identities:**

$$\begin{aligned}\sin(-\theta) &= -\sin \theta & \csc(-\theta) &= -\csc \theta \\ \tan(-\theta) &= -\tan \theta & \cot(-\theta) &= -\cot \theta \\ \cos(-\theta) &= \cos \theta & \sec(-\theta) &= \sec \theta\end{aligned}$$

**Quotient Identities:**

$$\tan \theta = \frac{\sin \theta}{\cos \theta} \quad \cot \theta = \frac{\cos \theta}{\sin \theta}$$

**Co-function Identities:**

$$\begin{aligned}\sin \theta &= \cos \left( \frac{\pi}{2} - \theta \right) & \cos \theta &= \sin \left( \frac{\pi}{2} - \theta \right) \\ \sec \theta &= \csc \left( \frac{\pi}{2} - \theta \right) & \csc \theta &= \sec \left( \frac{\pi}{2} - \theta \right) \\ \tan \theta &= \cot \left( \frac{\pi}{2} - \theta \right) & \cot \theta &= \tan \left( \frac{\pi}{2} - \theta \right)\end{aligned}$$

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# EXERCISE 5

## PREPARATION OF STATISTICAL DIAGRAMS

### Structure

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5.1	Introduction	5.5	Practical Exercises
	Expected Learning Outcomes	5.6	Summary
5.2	Requirements	5.6	Experimental Exercises
5.3	Fundamentals	5.7	References/Suggested
5.4	Solved Exercises		Further Readings

### 5.1 INTRODUCTION

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You have already studied and learnt about the representation methods of geographical data represented through diverse array of statistical diagrams in Unit 14 of the theory course on 'General Cartography'. This exercise is a part of the lab component corresponding to Unit 14 in which you have already learnt the construction techniques with reference to such diagrams. Along with this, you have also learnt about varied categories of diagrams encompassing one, two and three dimensional diagrams along with their importance in visually portraying an array of geographical and non-geographical data. By now, you must have understood that the purpose of diagrams is to facilitate the visual representation of huge amounts of raw data at a glance without going into the lengthy written text and data tables in a document. Besides geographers and earth scientists, economists, mathematicians and statisticians more prominently and other social scientists along with physical and natural scientists also frequently employ such diagrams to visually exhibit myriad of data, more importantly, huge datasets or in today's time we can say mega data (huge amounts of data in size as huge as in tens and hundreds of gigabytes and terabytes) etc. Now, you are well aware that

such diagrams are used to represent myriad nature and voluminous amount of data to give a visual representation to learners, intended users, varied stakeholders or clientele as per the applicable case.

In this exercise 5, you will learn about the key methods with detailed steps to prepare many categories of statistical diagrams. The idea is to equip you to learn the skills of construction for showing the geographical data for area of interest on a piece of paper. Before embarking onto the learning of such techniques, we will briefly make you learn about the requisite apparatus along with nature and types of geographical data in Section 5.2. You have already learnt that geographical representation of data is performed through statistical diagrams to represent the distribution of commodities per unit area, average values and percentages etc. which we will discuss in section 5.2. By now, we assume that you are already well versed that the purpose of all such kinds of graphs and diagrams along with mapping techniques employed in the study of geographical entities and phenomenon's is basically to lend a visual appeal to its diverse categories of intended learners, users, stakeholders or clientele etc.

In simple words, needless to mention, you are also very well familiar that maps, graphs and diagrams are also known as short hand script of a geographer that enables them to represent thousand words in one single piece of paper with the help of one or more than one corresponding methods of representation.

## **Expected Learning Outcomes**

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After completing exercise 5, you should be able to learn the following skills:

- To chalk out a list of requisite sets of apparatus along with particular sets of data with its sources for making various types of statistical and geographical diagrams;
- To select the appropriate type of diagrams according to the type of data;
- To manually construct various categories of one, two and three dimensional diagrams in a graph paper; and
- To apply such skills in the graphical portrayal of geographical data for other courses of your programme, which may enable you to expand your skills wherever you may deem it to be fit for applying.

## **5.2 REQUIREMENTS**

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Before you start solving the given exercises, it is important for you to know about the requisite sets of apparatus and varied sources of secondary data as important requirements to proceed further.

We will discuss about such important requirements one by one in a clear manner. You are familiar that in earlier times, statistical diagrams used to be prepared manually with the help of a map drawing equipments which you have studied and

learnt in Unit 2. However, with the passage of time, such manual mapping techniques were replaced with the computer enabled mapping techniques evolved through different periods of time and space corresponding to the advancements in science and technology. It is popularly known as 'quantitative revolution' in the academic field of geography. As you have studied that the purpose of such diagrams is to show the spatial distribution of quantity in context of human parameters of any geographical area on the surface of the earth in which you are interested. You will learn to make these manually as explained earlier in the introduction. All of the diagrams have more or less common sets of requirements for the preparation of the chosen diagrams as discussed below:

### **Data**

Secondary data related to various aspects of geography (which may be collected from host of government and other sources with which you became familiar in Units 8 and 9 of the Theory course of General Cartography. You may explore and make use of such sources to solve the experimental or suggestive exercises given at the end).

### **Apparatus**

- Scale and protractor
- Ruled graph paper or graph notebook
- Drawing sheets
- HB pencil and black pen
- Sharpener and eraser

**(Note:** It is compulsory for you to thoroughly complete the reading and learn the study material of Unit 14 before embarking onto performing the set of exercises given under this exercise no. 5).

## **5.3 FUNDAMENTALS**

As mentioned earlier, you have already studied and learnt in Unit 14 about the statistical diagrams being used to show the distribution of geographical data graphically. It is of utmost importance to quickly recapitulate the key fundamentals which you have learnt in theory course to apply the same before you proceed to perform the given exercises.

### **5.3.1 General Rules or Principles for Representation of Geographical Data: Diagrams and its Types**

You will agree that without thoroughly understanding and learning about the general rules or principles for making a diagram, it will not be tangibly feasible for anyone to practically perform it correctly. In simple words, you may understand it with that of driving a motorized vehicle. Hence, it is very important for you to recapitulate such general rules before going into the preparation of different

categories of diagrams which you have already studied and by now learnt in Unit 14. We are discussing the key concepts and points related to three main general rules or principles in brief so you can recollect and recapitulate these. This will make it easier and smooth for you to learn the skills to construct the various categories of diagrams meant to graphically represent the geographical data in given exercises in the next sub-sections.

1. **To Select Suitable Method:** It is one of the first and most important general rules to be taken into consideration before proceeding to exhibit geographical data with the help of one or other types of statistical diagrams. As you have learnt that there are myriad of sources from where geographical data are collected in respect of physical and human aspects of geography.
2. **Selection of Appropriate Scale:** After selecting the suitable diagrammatic method of representation, you are required to select an appropriate scale so as to graphically measure the given data. We are sure that you can correctly evoke the scale and its types along with usage and importance which you studied in Unit-3 of Block 1 in the theory component of same course. You have learnt that scale is a unit of measurement for graphically representing the numerical data in the form of map or diagram in a piece of paper. The key point which should be followed is the selection of suitable scale as per the nature of data provided in the exercise or otherwise. The thumb rule is to do so by selecting a moderate scale and avoid the selection of either too large or too small scale so as to capture the variations as well as entire range of data fittingly.
3. **Appropriate Design:** You have learnt that design is a very important aspect to make diagrams and maps in the domain of cartography. Appropriate design refers to the way we arrange the diagrams and their associated attributes while making it. You came to know that unlike earlier rules, design also has three more features namely title, legend and scale. You may also remember that design refers to the principal feature of direction in the subject domain of geography in case of maps used to represent varied nature of geographical data. You also learnt that design has three sub-features including title, legend or index and scale.

### **5.3.2 Types of Diagrams**

Along with learning the general rules of data representation, you have also read about three main types and their sub-types of diagrams to be prepared fittingly on the basis of heterogeneous nature of geographical data.

These are broadly categorized as one, two and three dimensional diagrams. You also learnt that each type of diagram is further divided into several sub-types of diagrams. For example, line diagram and bar diagram are the major sub-types of one-dimensional diagrams which can be further subdivided on the basis of its

various forms. Like, line diagram can be divided into simple line diagrams, multiple line diagrams and band diagram etc. In the second category i.e. two-dimensional diagrams which are primarily used to convey the statistical data in terms of area. By now, all of you are well versed that area is characterized by two dimensions comprising length and breadth. Circular diagram, square diagram and rectangular diagram etc. are some important sub-types in this second category. Lastly, you learnt about the more refined category of three-dimensional diagrams in the third category. These are also known as volumetric diagrams. Such diagrams are characterized by three dimensions comprising length, breadth and depth etc. Some of the important examples are cube and spherical diagrams in this last category. Now, you are well aware about the various categories of diagrams as well as their sub-types. You know that such diagrams are being drawn to show numerical or statistical data visually and graphically to capture a bird's eye view of the content given in the graph without reading and glancing on the lengthy text and data tables printed in an assignment, textbook or in a document etc.

Let us attempt to solve some exercises on the basis of what you have learnt so far in Unit 14 so as to obtain the practical skills aimed to enhance your knowledge base as well in the succeeding section.

## 5.4 SOLVED EXERCISES

You have already studied and learnt about the range of diagrams dealing with all the three major categories spanning one, two and three dimensional diagrams respectively in Unit 14 of Theory course BGGCT 133. Therefore, here in this exercise, we are discussing one exercise each with solution related to these three categories some of which are not covered in the theory Unit 14. First exercise pertains to pyramid diagrams which are a unique type of bar diagram known for representing age and sex structure of population, urban growth and occupational structure etc. In this type, bars are horizontally arranged in a pyramidal form. It includes three sub-categories i.e. simple, compound and superimposed pyramid diagrams. Among the two dimensional diagrams, we are solving one exercise on proportional circle diagram as you have already learnt about other types in the theory unit. Finally, we have solved one exercise on cube diagram belonging to the last category of three dimensional diagrams.

1. Draw a suitable diagram from the category of one dimensional diagram to represent the age and sex-wise population of India as per the data of Census 2011 period given in Table 5.1.

**Table 5.1**

Sr. No.	Age Groups (Years)	Percentage of Total Population	
		Male	Female

1	0-4	4.84	4.47
2	5-9	5.48	5.01
3	10-14	5.73	5.23
4	15-19	5.28	4.67
5	20-24	4.76	4.45
6	25-29	4.24	4.14
7	30-34	3.69	3.63
8	35-39	3.54	3.49
9	40-44	3.10	2.88
10	45-49	2.65	2.49
11	50-54	2.13	1.92
12	55-59	1.61	1.63
13	60-64	1.54	1.57
14	65-69	1.07	1.12
15	70 +	1.60	1.68

Source: Census of India, 2011.

### **Step-wise Solution to Calculate and Arrange the Data:**

Let us proceed step by step to solve this exercise. As you can examine from Table 5.1 that data is already given in the percentage form in case of total 15 different age-groups. It starts from the 0-4 years representing the juvenile segment of population and 70 + years representing the senile segment of population in the skip counting of four. Hence, no calculation and data arrangement are required in this case.

### **Details of Step-wise Construction:**

1. Firstly, you have to choose a suitable scale in the vertical column to represent the different age groups in the bottom central portion of the ruled graph paper.
2. Secondly, you have to mark the given age groups from the bottom by marking the juvenile age group in the base to the top by marking the senile age group in an ascending order at suitable chosen scale.
3. Thirdly, you have to draw a horizontal line at the base of the column and select a suitable scale keeping in consideration the span of minimum and maximum percentage values. This is required to show the percentages of

population falling under different age-groups in case of both the genders i.e. males and females.

4. Fourthly, you have to keep drawing horizontal bars in proportion to the percentage of the population for each age group on left and right sides of the vertical column (representing different age groups) for males and females alike till you finish.
5. Lastly, the above-mentioned steps will eventually lead you to the completion of the exercise and the resultant diagram will appear like Fig. 5.1 as shown below with more or less broad bottom and tapering top.

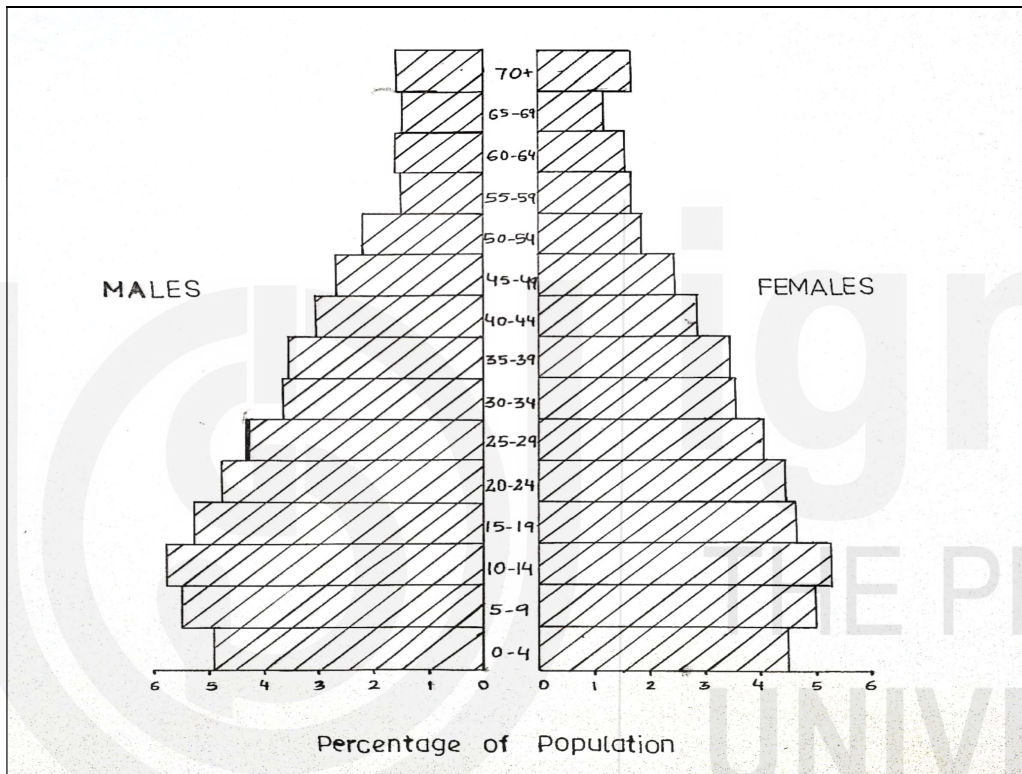


Fig. 5.1: Pyramid Diagram Representing Age and Sex-Wise Population, India, 2011.

2. Draw a proportional circle diagram from the category of two dimensional diagrams to depict the projected population of some select Indian states by 2026 as per the data of Sample Registration System 2026 given in Table 5.2.

**Table 5.2**

Sr. No.	States	Population (in '000 by 2026)
1	Rajasthan	83, 642, 000
2	West Bengal	100, 522, 000

3	Bihar	132, 265, 000
4	Karnataka	68, 962, 000
5	Uttar Pradesh	242, 859, 000

Source: Sample Registration System (SRS), Census of India, 2018.

### Step-wise Solution to Calculate and Arrange the Given Data:

1. First of all, you have to convert the given absolute population data into round figures.
2. Secondly, after conversion, you have to arrange the given data in descending order.
3. Thirdly, you have to select a suitable scale closely keeping in consideration the size of the paper and the amount of given data that needs a graphical presentation.
4. Fourthly, after data arrangement, you have to assume that a circle with 1 centimeter radius will represent a population of 2.5 crores.
5. Lastly, you have to calculate the radius of the circle for each state beginning with the state having largest size of population followed by other given states in descending order. The formulae to calculate the same is as under:

$$\text{Formulae} = 1.0 \text{ cm} \times \sqrt{\text{population in round figures} / 2.5} = 3.11$$

**Table 5.3: Calculated and Arranged Data for Construction of Proportional Circle Diagram**

Name of the State	Population (Actual)	Population in round figures (in Crores)	Length of the radius of the concerned circle (in centimetres)
Uttar Pradesh	2, 42, 859, 000	24.28	$= 1.0 \sqrt{24.28 / 2.5} = 3.11$
Bihar	1, 32, 265, 000	13.22	$= 1.0 \sqrt{13.22 / 2.5} = 2.28$
West Bengal	100, 522, 000	10.05	$= 1.0 \sqrt{10.05 / 2.5} = 2.00$
Rajasthan	83, 642, 000	8.36	$= 1.0 \sqrt{8.36 / 2.5} = 1.82$
Karnataka	68, 962, 000	6.89	$= 1.0 \sqrt{6.89 / 2.5} = 1.65$

### Details of Step-wise Construction:

Before proceeding, you must be careful and ensure that all the circles should be drawn in such a manner that their centers are in a straight line and placed at equal distance from each other.

1. In first step, you have to draw a horizontal line AB half way through north and south in a ruled graph paper. Then, you have to mark a suitable scale in the drawn line AB to ensure that circles lie in a straight horizontal line and are positioned equidistant to each other.
2. In second step, you have to draw the equivalent number of circles corresponding to the number of states (as given in the exercise) according to the calculated radii figures derived in the above table.
3. In third step, you have to write the name of each state on top centre of the respective circles.
4. In fourth step, you have to draw a circle of 1 cm radius (this is taken to represent 2.5 crores population in this exercise) to show the scale either in the bottom left or right corner or in the bottom centre of the diagram.
5. At last, the shape of final diagram to represent the population figures in a decreasing order from left towards the right side will look like as depicted in figure 5.2 below.

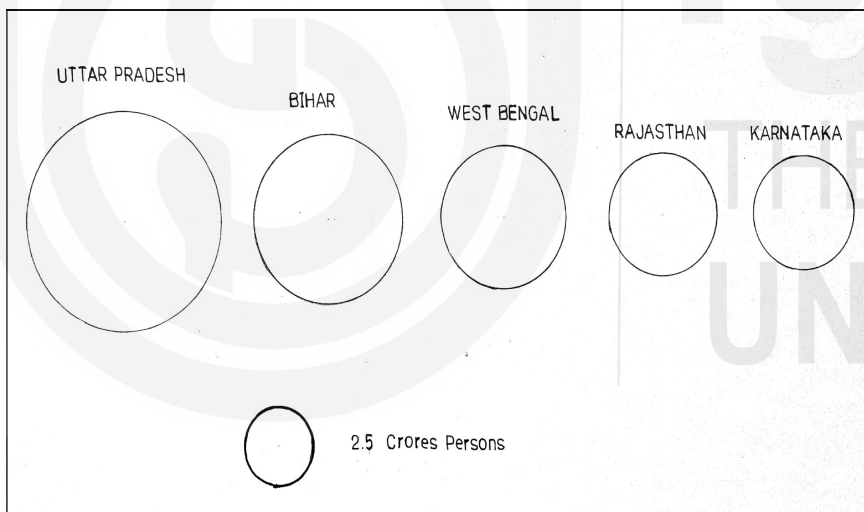


Fig. 5.2: Proportional Circle Diagram Representing Projected Population of Select Indian States, 2026.

3. Draw a cube diagram to exhibit the given data in terms of area of major wetlands located in different states of India belonging to the category of three dimensional diagrams as given in Table 5.4.

#### Table 5.4

Sr. No.	Name of Wetland	Location	Area (in hectares)
1	Sunderban	West Bengal	4, 23, 000
2	Vembanad Kol	Kerala	1, 51, 250
3	Chilika	Odisha	1,16, 500
4	Kolleru	Andhra Pradesh	90, 100
5	Bhitarkanika	Odisha	65, 000

Source: Annual Report, 2019-20, Ministry of Environment, Forests and Climate Change.

### Step-wise Solution to Calculate and Arrange the Given Data:

As per the data in the given exercise, in order to show the difference between minimum and maximum figures, the cube diagram from the category of three dimensional diagrams is considered as best suited.

1. Firstly, you have to select a suitable scale so as to determine the size of the cube.
2. Secondly, you have to select another scale to represent the area of the wetlands in a cube diagram. In this case, we have chosen 1 cm size of the cube to represent 15, 000 hectares area of the wetlands.
3. Thirdly, you have to carry out the calculation for ascertaining the length of the cubes to mark and show areas of different wetlands as per the formulae given under:

**Formulae:** Assumed scale  $\times 3 \sqrt{\text{area of the wetland} / 15, 000}$

**Table 5.5**

Sr. No.	Name of Wetland	Area (in hectares)	Length of the side of the cube on a scale of 1 cm : 15, 000 hectares
1	Sunderban	4, 23, 000	$= 1.0 \times 3 \sqrt{4, 23, 000 / 15, 000} = 3.04 \text{ cm}$
2	Vembanad kol	1, 51, 250	$= 1.0 \times 3 \sqrt{1, 51, 250 / 15, 000} = 2.16 \text{ cm}$
3	Chilika	1,16, 500	$= 1.0 \times 3 \sqrt{1, 16, 500 / 15, 000} = 1.97 \text{ cm}$
4.	Kolleru	90, 100	$= 1.0 \times 3 \sqrt{90, 100 / 15, 000} = 1.81 \text{ cm}$
5.	Bhitarkanika	65, 000	$= 1.0 \times 3 \sqrt{65, 000 / 15, 000} = 1.62 \text{ cm}$

### Details of Step-wise Construction:

1. As a first step, you have to draw five cubes as described earlier in order to represent the calculated areas of five wetlands with the help of a cube diagram.
2. As a second step, while drawing the cubes, a proper care should be adopted to ensure that the bases of each cube lie in the same straight line.
3. As a third step, you have to precisely ensure that the distance between two successive cubes should also be the same in continuity of second step.
4. As a fourth step, you have to write down the names of each wetland in the bottom of respective cubes so as to complete the process of construction of cube diagram.
5. In the last, the scale should be written below the cube diagram either at the left and right side or central portion at the bottom of a figure.

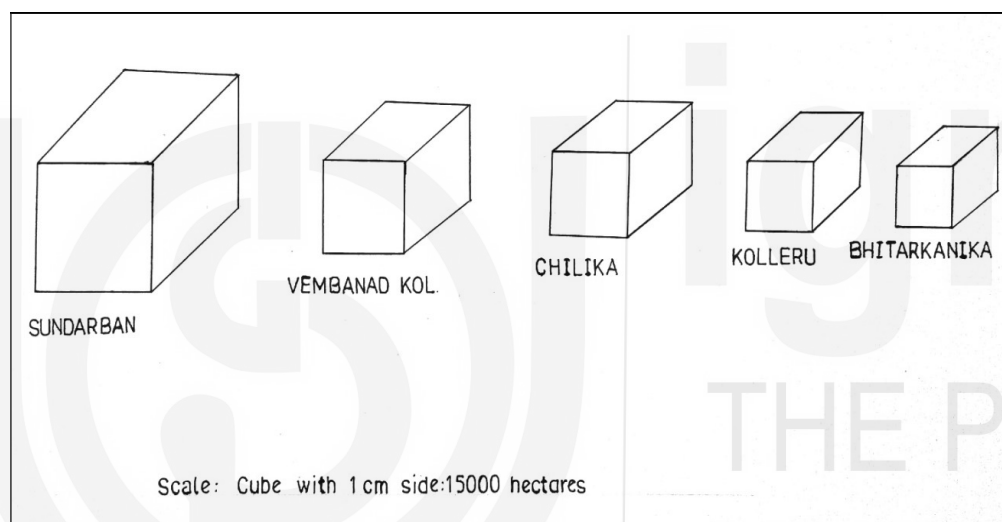


Fig. 5.3: Cube Diagram Representing Areas of Major Wetlands of India.

## 5.5 PRACTICAL EXERCISES

Now, we are giving below some practical exercises under each of the three categories with choices (you may choose any two in the one dimensional and any one from the two and three dimensional categories) to solve with pertinent answers and must include the interpretation of detailed steps and procedures. You are compulsorily required to submit four exercises in total (under this exercise no. 5) in your practical record book to the respective counsellor in your Study Centre falling under the Regional Centre of IGNOU.

**(Note:** You are required to systematically adopt the steps as mentioned in detail in the related theory exercises in Unit 14 and the solved exercises given in this exercise 5).

One dimensional diagram:

1. a) Construct a suitable diagram to represent the rainfall data of Mysore district of Karnataka state, India as given in table below.

**Table 5.6**

Months	Ja n	Fe b	M ar	Ap r	M ay	Ju n	Ju l	Au g	Se p	Oct	No v	D ec	Ann ual
<b>Rainfall (in millimet res)</b>	1. 8	0. 0	3. 9	114 .5	90 .4	81 .8	87 .0	103 .6	73 .8	122 .7	201 .7	2. 3	883. 4

**Source:** Normal Climatological Tables, India Meteorological Department (IMD), Pune.

- b) Construct a suitable diagram to represent the data for Indian Union Territories in case of the absolute number of child population in 0-6 years age group by gender as per 2011 Census period.

(Hint: Instead of time series, the name of places is given that needs to be shown in x axis).

**Table 5.7**

Sr. No.	Union Territories (UT's), India	Absolute Number of Child population in the age group of 0-6 years		
		Persons	Males	Females
1	Chandigarh	117,953	63,187	54,766
2	NCT of Delhi	1,970,510	1,055,735	914,775
3	Daman and Diu	25,880	13,556	12,324
4	Dadra and Nagar Haveli	49,196	25,575	23,621
5	Lakshadweep	7,088	3,715	3,373
6	Puducherry	127,610	64,932	62,678
7	Andaman and Nicobar Islands	39,497	20,094	19,403

Source: [https://www.censusindia.gov.in/\(Sesr3lm45pksguc451d45sp55\)\)/2011census/populationenumeration.aspx](https://www.censusindia.gov.in/(Sesr3lm45pksguc451d45sp55))/2011census/populationenumeration.aspx) accessed on 10/07/2020.

- c) Draw a suitable diagram to represent the age-sex wise percent population distribution of India according to the Sample Registration data for the year 2018 as given in below table.

**Table 5.8**

Sr. No.	Age-Groups	Percentage of Male	Percentage of Female
1	0-4	6.0	7.1
2	5-9	8.2	8.6
3	10-14	8.7	8.1
4	15-19	10.1	8.7
5	20-24	13.2	11.8
6	25-29	13.9	13.9
7	30-34	9.4	10.5
8	35-39	8.3	7.5
9	40-44	5.7	6.0
10	45-49	4.4	4.9
11	50-54	3.4	3.1
12	55-59	3.2	3.0
13	60-64	2.3	2.6
14	65-69	1.4	1.6
15	70-74	1.0	1.0
16	75-79	0.4	0.8
17	80-84	0.4	0.4
18	85+	0.2	0.4

Source: [https://censusindia.gov.in/Vital\\_Statistics/SRS\\_Report\\_2018/SRS\\_Statistical\\_Report\\_2018.pdf](https://censusindia.gov.in/Vital_Statistics/SRS_Report_2018/SRS_Statistical_Report_2018.pdf) accessed on 09.07.2020.

**Two dimensional diagrams:**

2. a) Draw a suitable diagram to depict the percentage distribution of births by type of medical attention availed at delivery as per the Sample Registration Data (SRS), 2018 for India as given in below table.

**Table 5.9**

Sr. No.	Particulars	Percentage
1	Government Hospitals	54.5
2	Private Hospitals	28.0
3	Qualified Professional	9.7

4	Untrained Functionary and Others	7.8
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**Source:** [https://censusindia.gov.in/Vital\\_Statistics/SRS\\_Report\\_2018/SRS\\_Statistical\\_Report\\_2018.pdf](https://censusindia.gov.in/Vital_Statistics/SRS_Report_2018/SRS_Statistical_Report_2018.pdf) accessed on 09.07.2020.

- b) On the basis of data given in table 5.10, draw a suitable diagram to represent the percentage of female agricultural workers to total workers in some select districts of eastern Uttar Pradesh for census period 2011 as given in below table.

**Table 5.10**

Sr. No.	Districts	Percentage of Female Agricultural Workers
1	Deoria	18.13
2	Faizabad	19.11
3	Ghazipur	23.73
4	Gonda	18.60
5	Gorakhpur	14.26
6	Jaunpur	26.14

**Three dimensional diagrams:**

3. a) Draw a suitable diagram to show the distribution of number of households on the basis of deprivation based poverty among the top five states of India as per the data of vision document 2019-24 as given in below table.

**Table 5.11**

Sr. No.	States	No. of Deprived Households
1	Uttar Pradesh	1,03, 81, 355
2	Madhya Pradesh	6, 74, 8026
3	Bihar	1, 08, 76, 054
4	West Bengal	1,00, 56,266
5	Maharashtra	6, 06, 4157

**Source:** [https://nhm.gov.in/New\\_Updates\\_2018/Report\\_Population\\_Projection\\_2019.pdf](https://nhm.gov.in/New_Updates_2018/Report_Population_Projection_2019.pdf) accessed on 09.07.2020.

- b) Draw a suitable diagram to represent the number of Mahila Kisan (women farmer) under the flagship programme titled 'Mahila Kisan Sashaktikaran Pariyojana' (women farmer's empowerment scheme) of Govt. of India in top five states of India according to the 2019-20 data as given in below table.

**Table 5.12**

Sr. No.	States	No. of Mahila Kisan
1	Andhra Pradesh	1, 30, 1107
2	Telangana	10, 22, 291

<b>3</b>	Kerala	401, 118
<b>4</b>	Maharashtra	1, 81, 348
<b>5</b>	Bihar	1, 35, 012

Source: <http://moef.gov.in/wp-content/uploads/2017/06/ENVIRONMENT-AR-ENGLISH-2020.pdf> accessed on 09.07.2020.

Besides if you are interested and would like to further strengthen your diagrammatic, statistical and geographical skills, you may explore and attempt to solve the below suggested exercises. For this purpose, you are free to collect the requisite set of data for your area of interest (AOI) from a variety of secondary sources online about which you have read in Units 8 to 9 and can do so by yourself. Additionally, you may also explore the website links given at the end of this exercise to gain and expand your knowledge on such crucial variables of human and natural resources.

1. You may collect the data of population of your native district or state from 1951 to 2011 census period and draw a simple, vertical, compound or multiple bar diagram and age-sex pyramids etc. Besides, you may yourself take up the data for any other aspects of human geography like gross cropped area, production of crops, fruits and vegetables, and livestock population, educational institutions by type etc. These suggestive exercises pertain to the first category i.e. one dimensional diagram.
2. Similarly, you may try to construct square, rectangle, triangle and circle diagrams in the second category of two dimensional diagrams by taking the data for any suitable aspects of human and physical geography.
3. You may also try to construct cube and sphere diagrams for the third and last category of three dimensional diagrams by taking the data for any suitable aspects of human and physical geography.

## 5.6 SUMMARY

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In this exercise, you have precisely learnt the following skills:

- Learnt about the general rules like selection of an appropriate method, selection of suitable scale, appropriate title, proper legend and design as a skill to represent geographical data through statistical as well as geographical diagrams.
- Learnt three major categories and their sub-categories of each diagrams viz. one-dimensional, two-dimensional and three-dimensional to represent myriad of geographical data spanning both human and physical features.

- You came to know that one dimensional diagram is best suited to represent one dimension only i.e. length of a geographical phenomenon. Among this, bar and line diagrams are the best examples.
- Next, you explored about two dimensional diagrams which are characterized by two dimensions of length and breadth and also known as area diagrams. In this diagram, area is proportional to the quantity represented by them thereby having an advantage over one dimensional diagram as it covers comparatively less space and is able to capture greater variations of data. Square diagram, rectangular diagram and circular diagrams are some important types.
- Lastly, you learnt that three dimensional diagrams are characterized by three dimensions in which height gets added along with length and breadth dimensions. Cubes and spheres are important ones among this category. In this type, the volume is proportional to the represented quantities. As they cover very less space as compared to earlier two types and hence are considered important and more useful to show the greater variations in the values of given quantities under any particular geographical phenomenon being studied.
- As a whole, you have learnt to make different types of diagrams graphically with proper scale to represent diverse array of geographical data for visual representation.

## 5.7 REFERENCES/SUGGESTED FURTHER READINGS

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1. Khullar, D.R. (2003), *Essentials of Practical Geography*, Jalandhar: New Academic Publishing Co.
2. Mishra, R. P. and Ramesh, A. (1989) *Fundamentals of Cartography*, Concept Publishing Company, New Delhi.
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6. Singh R. L. and Singh, R. P. B. (1991) *Elements of Practical Geography*, Kalyani Publishers, Ludhiana.

# EXERCISE 6

## CONSTRUCTION OF CHOROPLETH AND ISOPLETH MAPS

### Structure

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6.1	Introduction	6.5	Practical Exercises
	Expected Learning Skills	6.6	Summary
6.2	Requirements	6.7	References/Suggested Further
6.3	Fundamentals		Readings
6.4	Solved Exercises		

### 6.1 INTRODUCTION

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As you have already studied and learnt about the maps and its various types in **Units 2** (acquainted with various forms of maps and their importance) and **15** of the **Theory course (BGCCT 133)** titled '**General Cartography**'. Now, you are well acquainted with the meaning and definition of maps and learnt about their characteristics, importance and utilization along with limitations as well in geographical studies. This exercise is a part of the lab component corresponding to Unit 15 demonstrated through the construction techniques of two exercises. In addition, you have also studied and learnt about varied categories of maps including general purpose maps, distribution maps, thematic maps and strategic maps etc. along with their use in geographical and non-geographical studies and importance in day-to-day activities of life. You may think of travel, location of natural resources and industries, planning and administrative purposes etc.

In this exercise 6, you will learn about the key methods to prepare two of the main kinds of distribution maps. These two kinds of maps are known as choropleth and isopleths maps. After learning these mapping methods, you will

learn the practical skills to portray the theoretical concepts and related geographical phenomenon which you have learnt in the above-mentioned Units concerning a geographical entity for your area of interest (AOI) on the globe. Before learning these mapping techniques, we will briefly make you learn about the requisite set of apparatus along with nature, type and variety of geographical data in Section 6.2. You have already learnt that choropleth is a mapping technique that helps to represent the distribution of commodities per unit area, average values and percentages etc. which we will discuss in section 6.3. You are familiar that it is also known as shading method in which the phenomenon under study is represented through the shades of different scale which helps to visually distinguish the spatial variations and distributional aspects. Furthermore, we will also discuss about the isopleth mapping technique that will make you skillful to represent identical climatic conditions like temperature values, amount of precipitation and atmospheric pressure of two places or more than two places of area of interest (AOI) or investigation. You will study the solved exercises discussed in Section 6.4 and then yourself try hands-on to solve practical exercises in Section 6.5 (which needs to be submitted in practical record book). By now, we assume that you are already well versed that the purpose of all such kinds of mapping techniques along with statistical graphs and diagrams employed in the study of geographical entities and phenomenon's is basically to lend a visual appeal to its diverse categories of intended users or clientele. You know that such methods are employed in a meticulous and scientific manner to delineate the intangible inferences from the given set of data for multitude of purposes.

## **Expected Learning Outcomes**

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After completing this exercise, you should be able to learn the following skills:

- To chalk out a list of requisite sets of apparatus along with particular sets of data with its sources before solving the given laboratory exercises.
- To manually construct the choropleth and isopleth map for a given geographical data of interest.
- To visually examine and emphasize upon the key points or provide an excerpt idea to interpret the portrayed phenomenon's in terms of both tangible as well as intangible aspects in both the choropleth and isopleth maps.

## **6.2 REQUIREMENTS**

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Before you start solving the given exercises, it is important for you to know about the requisite sets of apparatus and varied sources of data as important requirements to proceed further.

These are discussed in a systematic manner. As you have studied that the purpose of both map types is to visually show the spatial distribution and

variation of given data quantity in the context of human parameters of any geographical area on the surface of the earth in which you are interested. Hence, these two mapping methods are also called quantitative areal or thematic or distribution maps. Both map types have more or less common set of requirements to solve the exercise and construct the maps as discussed under:

### **Data**

- Secondary data matching with that of a selected outline map (as explained in preceding exercise 5).
- One of the first prerequisites is to obtain an outline map showing administrative boundaries for the chosen area of interest or study. It could be at three administrative levels: district, state and national levels.
- However, in case of isopleth maps, it may be represented without boundary map also. The commonest example is the depiction of contour lines schematically (which you have studied in Unit 11 of theory course BGGCT 133 and Exercise 7 also).

### **Apparatus**

- Drawing equipments like scale, set squares, protractor
- Tracing sheets and drawing sheet paper
- HB Pencils, black pen, eraser and sharpener
- Drawing board and stencil pens

(Note: It is compulsory for you to complete the reading of Units 2 and 14 before embarking onto solving the exercises given under this exercise 6.)

## **6.3 FUNDAMENTALS**

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As discussed in the preceding sections, you have already studied and learnt in Units 2 and 14 about the meaning and importance of choropleth and isopleth maps along with other map types. Some of these will be discussed in Exercise 12. Undoubtedly, you will agree with us that the recapitulation of the key fundamentals learnt in theory course is inevitably indispensable before a learner attempts to solve the given exercises.

### **6.3.1 Choropleth Maps**

The key points which you studied and learnt in Unit 15 in the context of choropleth maps are highlighted below for the purpose of recapitulation as under:

It is used to represent density, percent and average values or quantities of an event or contextualized spatial feature of a geographic region of interest. Hence,

it comes under the category of quantitative areal maps, other being the qualitative areal maps. You learnt that chronological coloring as well as shading scheme is applied to exhibit either rising or declining trends as well as positive or negative trends in the data values of the phenomenon under consideration. Besides, you learnt the basic principle which states that intensity of shading is directly proportional to the density of elements portrayed. Basically, it is a quantitative areal map to depict the spatial distribution in terms of intensity or density of any geographical phenomenon. It is drawn along the boundary lines of the administrative units of a chosen geographical region under study. This map is suitable to show the average data distributions over large administrative units like state, country, continent or world. As a whole, you came to know that choropleth maps are considered as a basic tool of the human geographers. The other popular technique is known as isopleth method mostly being used by physical geographers (particularly climatologists and meteorologists).

As a whole, you have learnt that choropleth maps are used to portray the distribution of a phenomenon with the help of a shaded grading with texture or with single colour method. Basically, this method helps its user to show the general distribution and doesn't indicate the finer details as such. The selection of data class interval and areal unit may determine the visual impact of a constructed map for the given exercise. Therefore, it requires two-fold skills; first one requires the academic dexterity to carefully examine the data to select the proper class intervals and secondly it requires the mapping skills to correctly portray the spatial variation present in the data.

### **6.3.2 Isopleth Maps**

The excerpts of main points related to isopleths map which you have studied in Unit 15 are recapitulated below as under:

As you have learnt in theory part that isopleth map is a kind of quantitative areal map like earlier one. It consists of two words known as '*iso*' which means equal and '*Plethron*' meaning a measurable multitude or crowd. You came to know that the main purpose is to show the quantities with the help of lines drawn based on equal values for an area of interest (AOI), commonly known as '*isolines*'. Some important examples of such lines to denote equal values includes isohypses or contours (equal altitude above mean sea level) isobars (equal atmospheric pressure), isotherm (equal temperature), isohalines (equal oceanic salinity) isoneph (equal cloudiness), isobaths (equal depths), isoseismal lines (equal earthquake intensity) and many others (refer a classic book titled 'Maps and Diagrams' by Monkhouse and Wilkinson mentioned in the reading list at the end of this exercise). Isopleth maps may be drawn in case of many other aspects including both natural and human wherever point data is available. These lines serve as a handy tool as well as important method to represent any parameters or components related to weather and climatology being chiefly put into use by the meteorologist, climatologist and geographers alike frequently.

As a thumb rule, you learnt that the value of class intervals should be very carefully chosen based on general range of quantities to be mapped (as explained earlier, this demands subject knowledge and academic dexterity). It could be either isarithmic, geometric and based on usual splits in a frequency distribution. Both the frequency and density of evaluated points are dependent on the size of the enumeration unit. These two factors decide and control the interpolation of isopleths. You learnt that these invariably determine the quality and precision level of the final maps. The situation and plotting of the points on a map are determined by the form of the areal units. Prior to interpolation, as a practice, areal centres are first marked as 'x' in the map or schematic diagram. However, you have also studied that the actual principle of interpolation is based on the assumption that values consistently increase between any two points over the earth's surface. Consequently, the isopleths are proportionally placed from each other. You learnt that both the absolute as well as indexed values of any kind of information could be mapped into isopleth (having same value) which entails spatial variation. The graded shading and colours can be used between two isopleths to achieve fine distinction. Isopleths maps can also be prepared for different time periods in order to see the change in the regional pattern of any geographical elements like temperature and precipitation etc. Finally, you came to know that the quality of isopleth maps depends on the number of point data given in the question (larger the range of numbers, better will be the map quality).

## 6.4 SOLVED EXERCISES

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By now, we believe that you must have efficiently recapitulated the fundamentals which you have learnt in the corresponding theory Unit. We are discussing the stepwise details of techniques to construct one case of choropleth and two cases of isopleth maps illustrated with simple examples as below:

Exercise 1: Draw a choropleth map of India to represent the population density visually according to the data of Census 2011 period as given in Table 6.1.

### Stepwise Solution to Calculate and Arrange the Given Data:

- Firstly, as you can observe from the table that the data of population density in case of all the States/Union Territories are already arranged in a descending order. Therefore, it is not required to arrange the given data into order. You may proceed further.
- Secondly, you are required to select or choose a suitable representative class interval and then classify the States/Union territories under each respective class intervals in which they fall.



**Table 6.1**

Sr. No.	States/Union Territories	Population Density (persons per sq. km.)
1	Delhi*	11292
2	Chandigarh*	9252
3	Puducherry*	2598
4	Daman & Diu*	2169
5	Lakshadweep*	2013
6	Bihar	1102
7	West Bengal	1029
8	Kerala	859
9	Uttar Pradesh	828
10	Dadar & Nagar Haveli*	698
11	Haryana	573
12	Tamil Nadu	555
13	Punjab	550
14	Jharkhand	414
15	Assam	397
16	Goa	394
17	Maharashtra	365
18	Tripura	350
19	Karnataka	319
29	Andhra Pradesh	308
21	Gujarat	308
22	Orissa	269
23	Madhya Pradesh	236
24	Rajasthan	201
25	Uttarakhand	189
26	Chhattisgarh	189
27	Meghalaya	132
28	Jammu & Kashmir	124
29	Himachal Pradesh	123
30	Manipur	122
31	Nagaland	119
32	Sikkim	86
33	Mizoram	52
34	Andaman & Nicobar*	46
35	Arunachal Pradesh	17

\*Union Territory

Source: Census of India, 2011.

**Table 6.2: Classified and Tabulated Data**

Sr. No.	Class Intervals (No. of persons per sq. km.)	Chosen Suitable Shades (lighter to darker shade showing the increasing value)	Name of States and Union Territories (in each class intervals)
1	Below 99	..... ..... .....	Arunachal Pradesh, Andaman and Nicobar, Mizoram and Sikkim
2	100-249	- - - - - - - - - - - -	Nagaland, Manipur, Himachal Pradesh, Jammu and Kashmir*, Meghalaya, Chhattisgarh, Uttarakhand, Rajasthan and Madhya Pradesh
3	250-499	===== ===== =====	Orissa, Gujarat, Andhra Pradesh, Karnataka, Tripura, Maharashtra, Goa, Assam and Jharkhand
4	500-1000		Punjab, Tamil Nadu, Haryana, Dadra and Nagar Haveli, Uttar Pradesh and Kerala
5	Above 1000		West Bengal, Bihar, Lakshadweep, Daman and Diu, Puducherry, Chandigarh and Delhi

**Details of Stepwise Construction:**

- In first step, you have to very carefully fill these chosen suitable shades in the states and union territories falling in each of the five chosen class intervals (you may require some practice to do so and may be able to do so in more than one attempt).
- In second step (after completion of the first step), it will help you to show and club the respective States/Union Territories falling under each class interval visually.
- This will provide a quick glimpse to observe and discern the shown quantity of population density visually as per the chosen class intervals (without perusing the written text).

- In third step, you are required to show these shades in a legend or index either in left or right-side corner of the map as per the available suitable space by following standard cartographic procedures.
- Finally, the drawn choropleth map will look like as shown in Figure 6.1.
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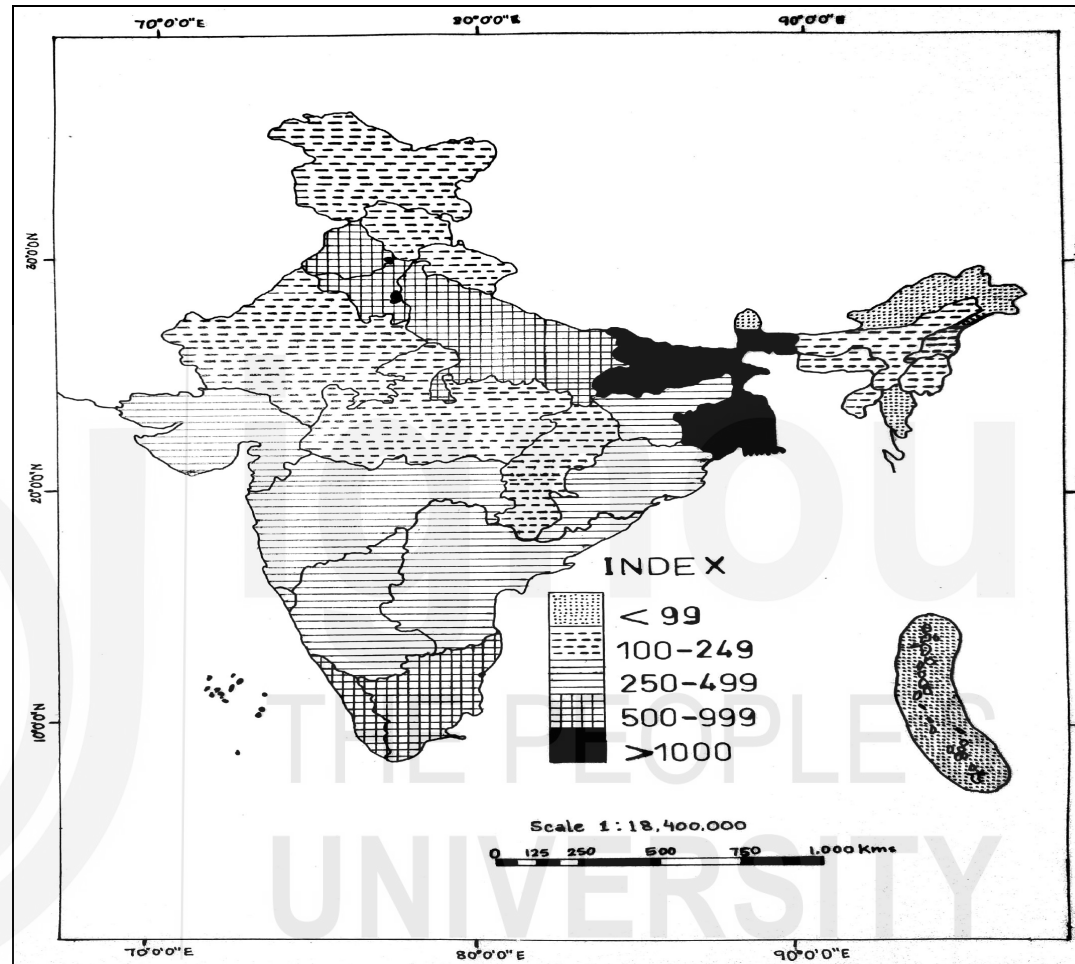


Fig. 6.1: Choropleth Map showing Density of Population in India, 2011

**Merits:** The choropleth technique has following merits:

- It is one of the simplest techniques to show at glimpse the comparative distribution as well as spatial variations present in the geographical phenomenon under study.
- It is considered as a best technique to study and show the distribution and comparison of relative data.
- Relative type of data may include human phenomenon and its myriad types. Some common examples like sex ratio particularly child sex ratio (0-6 years age-group), male and female literacy to total literacy, proportion of

rural and urban population to total population, density of population, percentage of cropped area under different crops in different seasons (rice, wheat and mustard etc.) spanning various agro-ecological regions and other myriad aspects.

- In short, this method is appropriate to show the sharp fluctuations present in the given data at a glance like the above-mentioned aspects of human geography along with its many branches.

**Demerits:** Alongside merits, this method has certain demerits discussed as under:

- In this method, you must have observed that the construction rests upon the division of administrative units (like nation, state and districts etc.). However, in reality, many of the human phenomenon differs according to their natural divisions (on the basis of agro-ecological zones which in turn are inescapably determined by climatic and edaphic factors along with labour and market facility etc.) like the cultivation of various crops. Such situation may lead to chaos and over generalization.
- While preparing a choropleth map, a map maker swiftly switches over from one shade to another which gives birth to ambiguous level of understanding. In actual vista, the changes in the intensity, density or percentage of the phenomena being studied are perceived to be sluggish.
- In order to prepare class intervals (with an intention to create and classify the given data into manageable parts), two ends of farthest values falling under same class interval are depicted with the same chosen shade. However, this aspect may lead to indistinct interpretation as in reality the situation is somewhat different.

Exercise 2: Based on the given data in the Figure 6.2, draw an isopleth map for showing the elevation points (in metres) for the state of Jharkhand, India.

**General Rule:**

As you know that outline map of the given area for which data is provided in the exercise is a first prerequisite. While making an isopleth map, you may come across two contrasting situations as under:

- In one instance, suppose the given data is not representing too much spatial variation. In such case, the equal values passing through different portions or places on a map will simply be joined to complete an isopleth map. However, such simple cases are infrequent to come across and usually one needs to espouse and apply the data interpolation technique for drawing the isolines as per the nature and variation therein in the given data.

- Generally, in second instance, due to the size and variable nature of the given data, the application of interpolation technique becomes essential. You are required to choose a median value between two proportional given values (ex: in case of isotherm, isobar or isohyete lines etc., suppose you choose a line to represent the two values of 40 and 50, you may choose a line to connect all the places having value of 45 as median value and so on to complete such exercise). This will help to come up with a suitable quality isopleth map which needs to be followed and adopted.

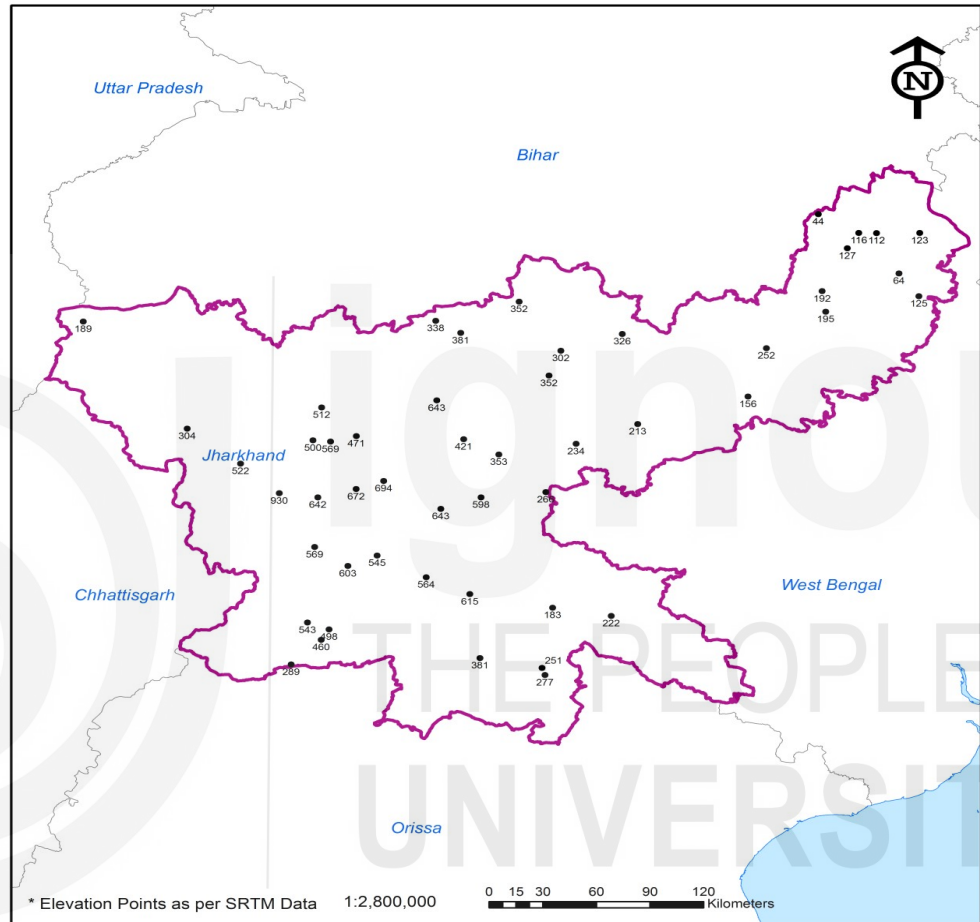


Fig. 6.2: (a) Elevation Points in the State of Jharkhand, India (in metres).  
Source: Shuttle Radar Topographic Mission (SRTM) Data, 2000.

**Stepwise Solution to Calculate and Arrange the Given Data:**

After following the above-mentioned general rules, you are required to choose a suitable class interval based on given data to denote the lines of equal value in a map. There are some definite rules to do so and rest of the process as under:

- Firstly, you must very carefully observe the nature and size or quantity along with range of variation in the given data.

- Secondly, you must examine and locate the minimum and maximum data values given in a data in an exercise. In this case, it is 44 and 930.
- Thirdly, you need to choose a median value to join the different places having same values as explained earlier. The chosen value is 400 at an interval of 100 metres.

#### **Details of Stepwise Construction:**

After carefully following the general rule and steps to arrange the data, now you are required to proceed to plot the isopleth lines on a given map as under:

- As a first step, you must locate all the points as per the chosen suitable class intervals one by one (refer Fig. 6.3 a).
- In second step, you must draw a line to represent the chosen median value first and mark 'x' in the given map to make the process of drawing easier. You have to follow the same step to draw rest of the lines at chosen intervals. Then you have to join all the places with a same value in the entire map to complete the construction process (refer Fig. 6.3 b).
- In third step, you are required to repeat this procedure till you finish drawing all the points with the help of isopleth lines in the given exercise on a map (refer Fig. 6.3 c).
- In fourth step, you are required to shade these different class intervals to bring more clarity on a map.
- Finally, the drawn isopleth map will look like as shown in Figure 6.3 d.

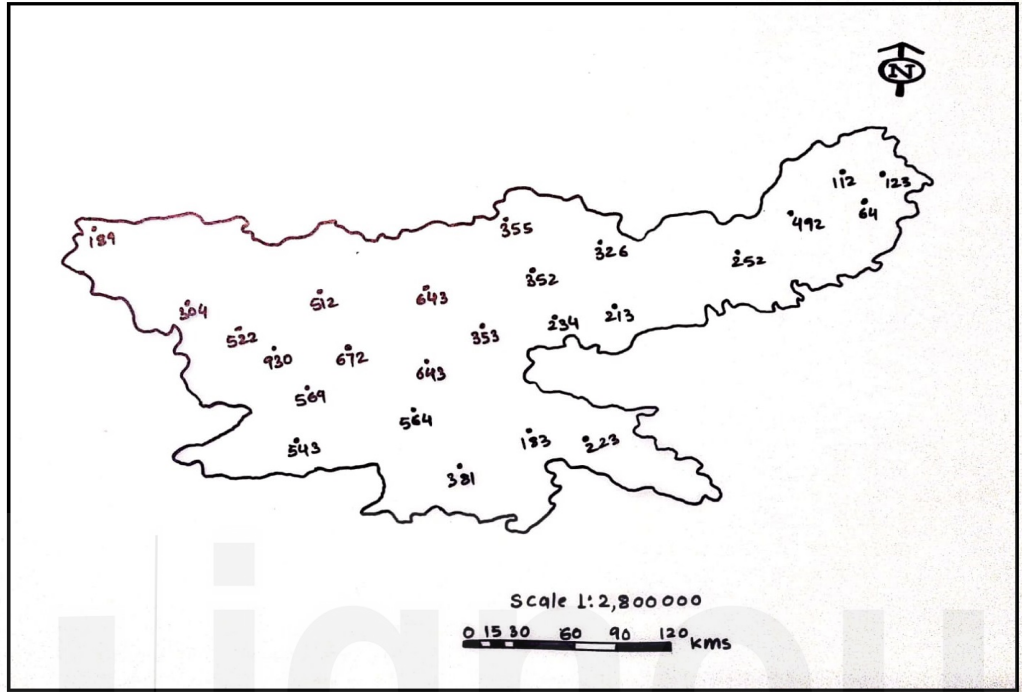


Fig. 6.1 b

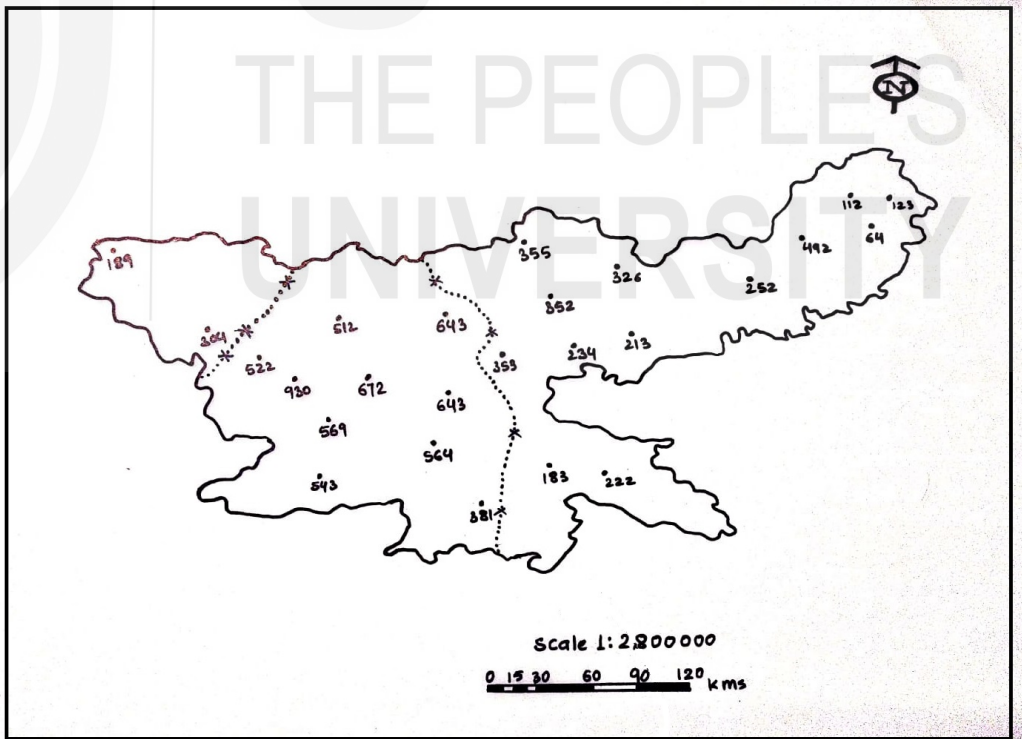


Fig. 6.1 c

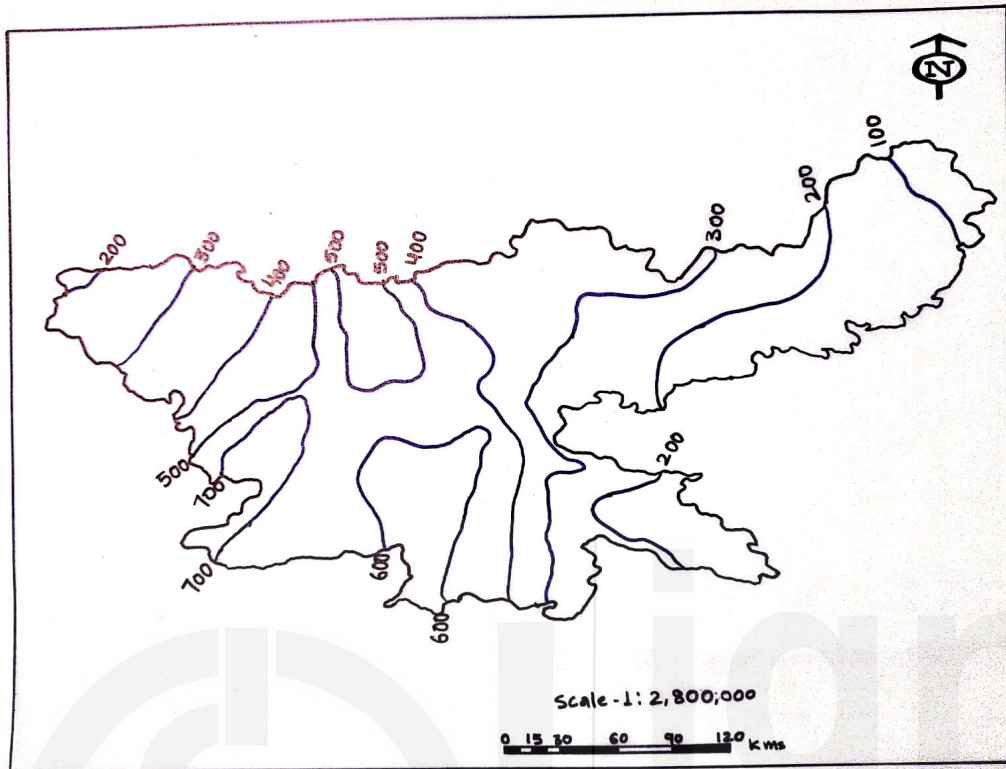


Fig 6.3 (d): Isopleth Map showing the elevation points (in metres) for the state of Jharkhand, India.

**Merits:** This method has following merits:

- First and foremost, it is considered as accurate and more systematic technique to exemplify both the distribution and spatial variations present in the given data.
- They frequently employ it to explain the different vital weather and climatic parameters (which plays a decisive and paramount role in the lives and economy of people and nations) as explained earlier in preceding sections.
- This method helps us to effectively exhibit the inclines or gradients present in the given data. In simple words, when the isopleths lines are spaced close to each other, it shows high incline or gradient whereas when they are spaced farthest from each other, then it shows low incline or gradient. This may help us to understand both its nature and rigor to cope up with the impending risks or benefits alike.
- Unlike choropleth technique, the lines of equal values known as isopleth lines in isopleths techniques remain independent of administrative or

political boundaries as they are transitional elements which generally follow the natural pattern and boundaries.

- On this account, hence, isopleth technique is considered as a best technique to represent the distribution and spatial variation of already explained weather and climatic elements.

**Demerits:** As like other mapping techniques, it also has some demerits as highlighted below:

- As explained earlier, you may confront two types of instances while making an isopleths map. First instance is simple in which you may simply examine the point data and join the lines having equal value to complete the map (such instances are infrequent in reality).
- In second instance, the given data is such that it necessitates adopting and applying the data interpolation technique which is a challenging task as it demands both academic resourcefulness and dexterity on the part of a map maker.
- As this technique demands the point data to make a map, in some cases, the resultant map may portray some inaccuracies especially related to the direction of isopleths lines along with the warped distribution.
- Such lines signifying equal values (of weather and climatic elements) may lose their significance in two instances. First one when the transitional belt is not wide enough and secondly when there is swift transformation in the distribution pattern of the given point data.

## 6.5 PRACTICAL EXERCISES

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In the below given exercises, you may choose and attempt any one exercise from each question given under two map types i.e. choropleth and isopleth respectively. You are compulsorily required to solve these and write pertinent answers and must include the interpretation of detailed steps and procedures.

You are compulsorily required to solve and submit the two exercises in total (under this exercise no. 6) in your practical record book to the respective counsellor in your Study Centre falling under the Regional Centre of IGNOU.

**(Note:** You are required to systematically adopt the steps as mentioned in detail in the solved exercises of this exercise 6).

1. a) and b) Draw a choropleth map to show the proportion of urban or rural population (you may choose any one variable, i.e., urban or rural) to the total population as per the latest Census data of 2011 of India given in below Table 6.4.

**Table 6.3**

<b>Sr. No.</b>	<b>Name of the State and Union Territory</b>	<b>Proportion of Urban Population</b>	<b>Proportion of Rural Population</b>	<b>Total Population (in percentage)</b>
1	Jammu and Kashmir	27.4	72.6	100
2	Himachal Pradesh	10.0	90.0	100
3	Punjab	37.5	62.5	100
4	Chandigarh	97.3	2.7	100
5	Uttarakhand	30.2	69.8	100
6	Haryana	34.9	65.1	100
7	NCT	97.5	2.5	100
8	Rajasthan	24.9	75.1	100
9	Uttar Pradesh	22.3	77.7	100
10	Bihar	11.3	88.7	100
11	Sikkim	25.2	74.8	100
12	Arunachal Pradesh	22.9	77.1	100
13	Nagaland	28.9	71.1	100
14	Manipur	32.5	67.5	100
15	Mizoram	52.1	47.9	100
16	Tripura	26.2	73.8	100
17	Meghalaya	20.1	79.9	100
18	Assam	14.1	85.9	100
19	West Bengal	31.9	68.1	100
20	Jharkhand	24.0	76.0	100
21	Odisha	16.7	83.3	100
22	Chhattisgarh	23.2	76.8	100
23	Madhya Pradesh	27.6	72.4	100
24	Gujarat	42.6	57.4	100
25	Daman and Diu	75.2	24.8	100
26	Dadra and Nagar Haveli	46.7	53.3	100
27	Maharashtra	45.2	54.8	100

28	Andhra Pradesh	33.4	66.6	100
29	Karnataka	38.7	61.3	100
30	Goa	62.2	37.8	100
31	Lakshadweep	78.1	21.9	100
32	Kerala	47.7	52.3	100
33	Tamil Nadu	48.4	51.6	100
34	Puducherry	68.3	31.7	100
35	Andaman and Nicobar Islands	37.7	62.3	100

Source: Census of India, 2011.

You may further strengthen mapping skills to benefit and augment your geographical knowledge by exploring the suggested experimental exercises as mentioned below:

- You may collect the requisite sets of data for your area of interest (AOI) from a variety of secondary sources online about which you have read in Theory Units 8 and 9 in this third semester integrated course titled 'General Cartography' (as explained in earlier exercises).
- You may like to make choropleth and isopleth maps to represent variety of both human and physical variables as learnt in theory Units 2 and 15 and some others as well. Additionally, the ones which you have read in first and second semester courses along with courses of the forthcoming semesters as well of your Bachelor's programme.
- Besides, the website links given at the end of this exercise may also be explored to accomplish the said purpose as mentioned in preceding sections.

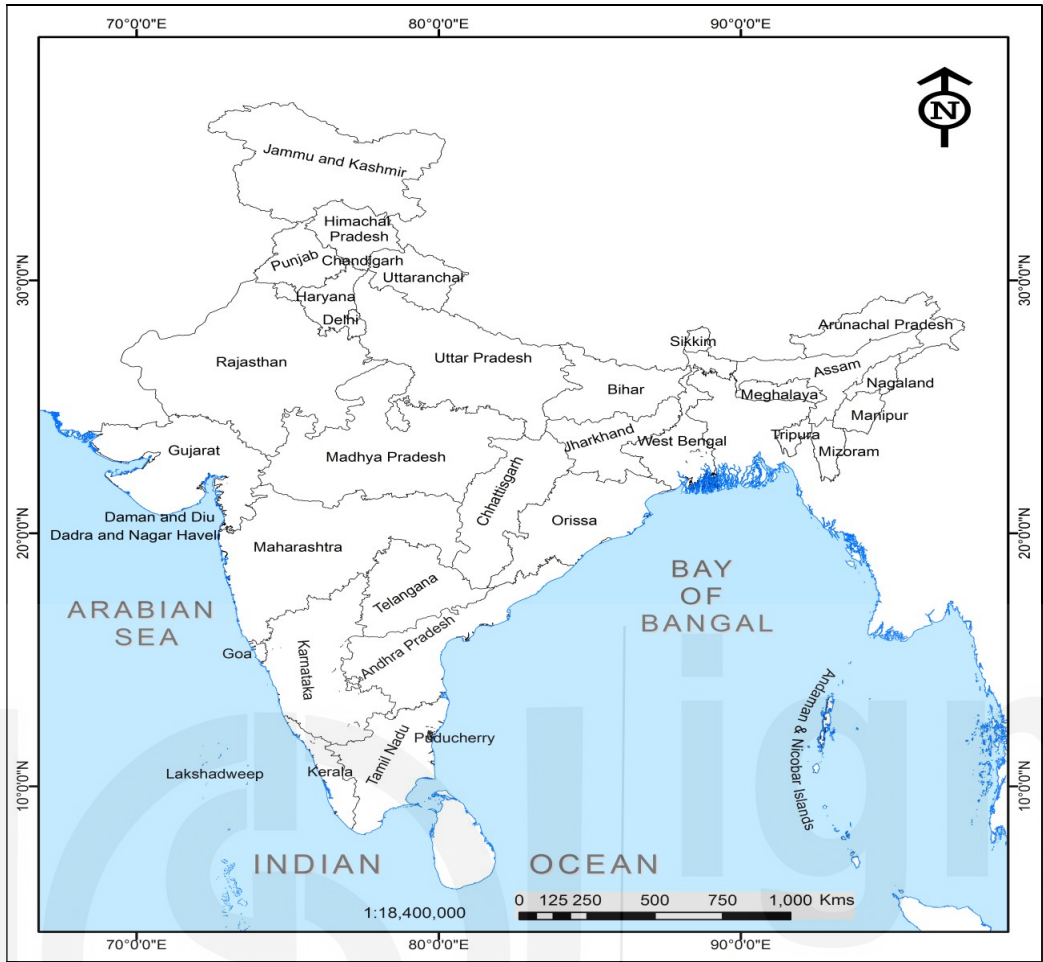


Fig. 6.3: Outline Map of India.

2) Draw an isopleths map to show the spot heights (in metres) as per the below given data in Figure 6.6.



Fig 6.4: Point data depicting Spot Heights (in metres) for drawing an Isopleth Map. (Dummy to be replaced)

## 6.6 SUMMARY

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In this exercise, you have learnt and may further strengthen the following skills as emphasized below:

- The requirement and details concerning the prerequisites before proceeding to make the choropleth and isopleth maps.
- About outline boundary maps with district and state boundaries, secondary sources of data, and set of apparatus etc.
- The techniques of making choropleth map to show the distribution of chosen geographical phenomenon for a particular areal unit concerning the area of interests (AOI's).
- The techniques of making isopleths map to show the distribution of weather and climatic along with other human phenomenon for a particular areal unit concerning the area of interests (AOI's).
- You have aptly learnt to show the visualization of portrayed phenomenon without reading the lengthy text material through varied types of the quantitative, thematic or distribution maps.

## 6.7 REFERENCES/SUGGESTED FURTHER READINGS

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1. Khullar, D.R. (2003), *Essentials of Practical Geography*, Jalandhar: New Academic Publishing Co.
2. Mishra, R. P. and Ramesh, A. (1989) *Fundamentals of Cartography*, Concept Publishing Company, New Delhi.
3. Monkhouse and Wilkinson '*Maps and Diagrams*'
4. Robinson, Arthur, H.J., Morrison, P., Muehrke, A., Kimmerling & Guptill, S. (eds.) (1995), *Elements of Cartography*, New York: Wiley
5. Sarkar, A. (2009) *Practical Geography A Systematic Approach*, Orient Blackswan Private Limited, Kolkata.
6. Singh, L.R. & Singh, R. (1973), *Map Work and Practical Geography*, Allahabad: Central Book Depot.
7. Singh R. L. and Singh, R. P. B. (1991) *Elements of Practical Geography*, Kalyani Publishers, Ludhiana.

# EXERCISE 7

## Draw Prominent Relief Features and Interpret Major Physical and Cultural Features from a given Toposheet

### Structure

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7.1	Introduction Expected Learning Outcomes		Marginal Information
7.2	Requirements		Physical Features
7.3	Relief Features Cross-section of Relief features	7.5	Cultural Features Suggested Further Readings
7.4	Interpretation of Toposheet		

### 7.1 INTRODUCTION

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You have learned the methods for preparation of Choropleth and Isopleth maps in Exercise 6. Now, in this exercise, you will learn to draw various relief features, and to interpret physical and cultural features from the Survey of India toposheet. Toposheet provides accurate and authenticated information with regard to relief and various physical and cultural features. As an interpreter, you must understand the techniques that are involved in map reading and interpretation. You should refer to Unit 11 of Block 4 (BGGCT 133) for the reference and better understanding.

### Expected Learning Outcomes

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After working through this exercise, you shall be able to:

- draw predominant relief features from the toposheet;
- interpret major physical and cultural features from the toposheet.

### 7.2 REQUIREMENTS

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To perform this exercise, you require the following materials.

- Ruler or Scale
- Pencil/Pen

- Sharpener and Eraser
- Scientific calculator
- Survey of India toposheet
- Drawing sheets or White sheets (A3 size or long sheets).

## 7.3 RELIEF FEATURES

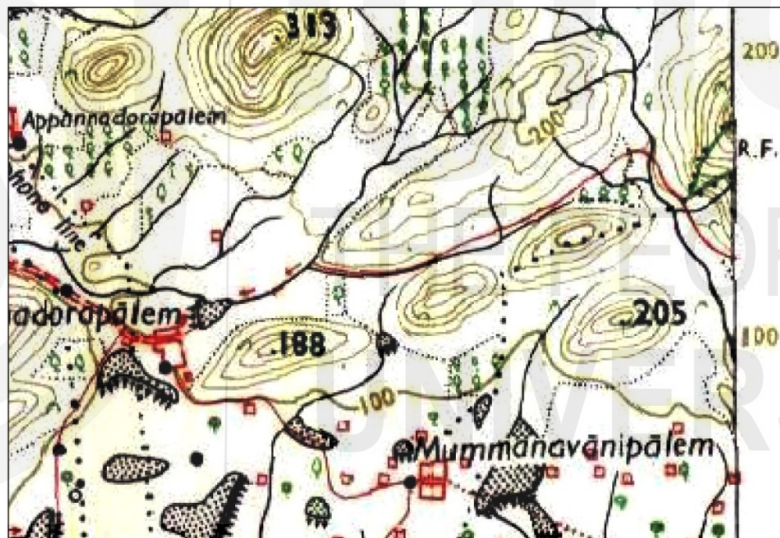
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The earth's relief features are generally referred to as elevated or depressive areas of the earth's surface. The map showing these features is called a relief map.

As you studied, contours and spot heights can represent the relief on topographical map. The equal height of places in an area connected by a line is called contour. You have studied about relief features which are drawn from contours in the theory course (BGGCT 133). Before you start doing the following exercises, you may refer to Unit 11.

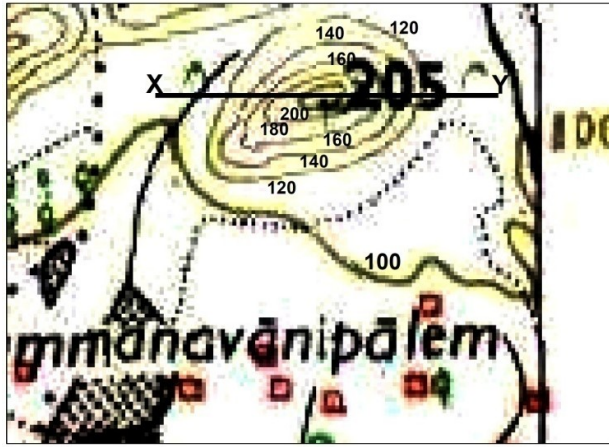
### 7.3.1 Cross-section of Relief Features

Let us learn how to draw a cross-section of relief features from the contours drawn on the toposheet as given below. The contour interval is 20 meters.



We will explain this to you by taking one relief feature as an example from the above toposheet. You have to go through the following steps for drawing relief features from the toposheet.

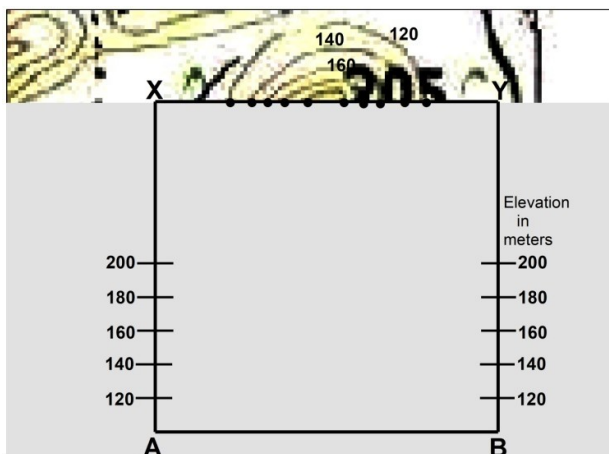
**Step 1:** Draw a straight line XY across the desired contours and write their respective elevations on the sheet.



**Step 2:** Now, take a graph sheet or white sheet and carefully place it just below the line XY by touching its edges. Mark the points where contours are crossing the line XY.

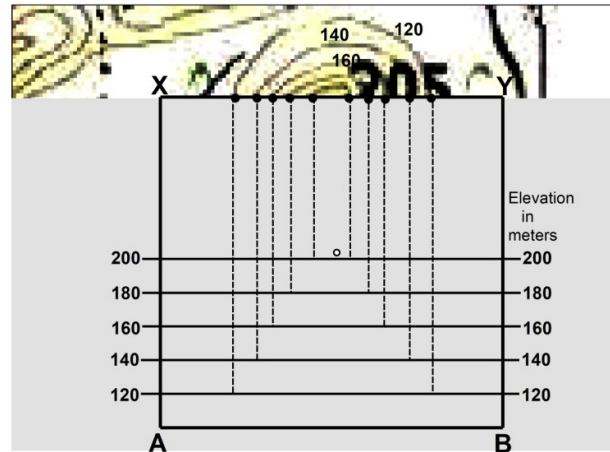


**Step 3:** Draw two vertical lines from X and Y separately, and connect these lines parallel to XY to form a line as AB. Now, mark any suitable vertical scale on AX and BY lines. Here, the chosen scale is 0.5 cm which is equal to 20 meters or otherwise you can also take it as 1 cm = 20 m as per your convenience.

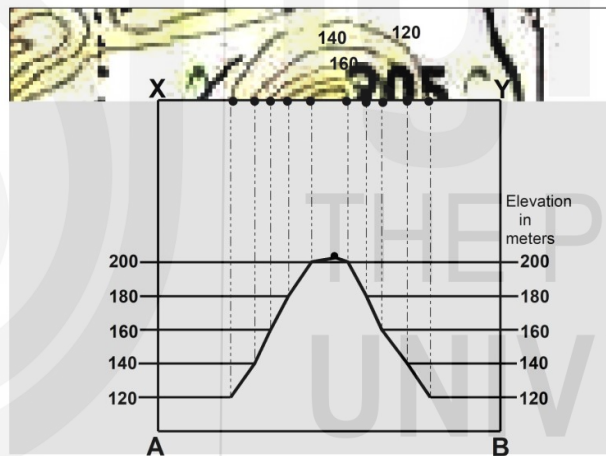


**Step 4:** Draw horizontal lines by connecting through each of these markings. These are shown elevations as 120 m, 140 m, 160 m, 180 m and 200 m.

Next, draw vertical lines connecting each contour for the corresponding elevation on the sheet.

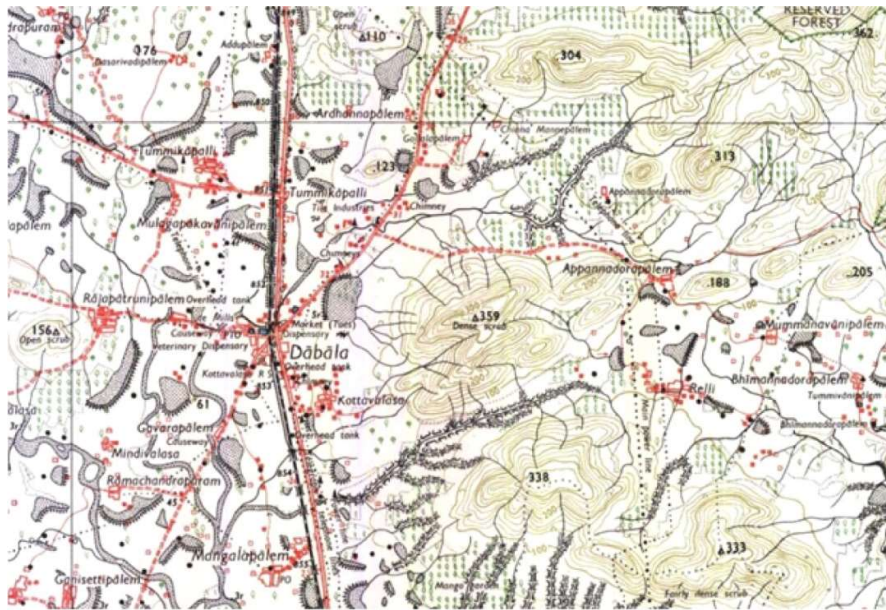


**Step 5:** Finally, you now have to connect the end points of vertical line starting from the base elevation point (120 m) to form a smooth curve. Peak of the hill which is a pointed top i.e. 205 m elevation should also be noted. This smooth curve will represent the cross-section of the contours.



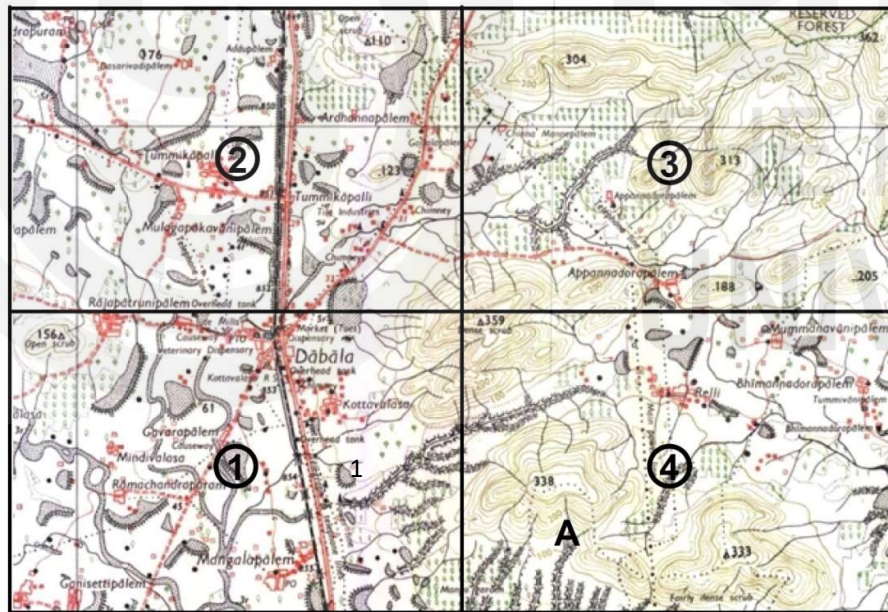
Based on the above explained procedure, you will now be able to draw and identify different relief features from the topographical map. Let us now perform the exercise as given below.

**PROBLEM 1:** Identify and note down different relief features from the given toposheet. The scale of the toposheet is 1:50,000.



**SOLUTION:** Take a printout of the given toposheet. Otherwise, you can also trace out the elevation information i.e. contours, spot heights and other elevation points.

**Step 1:** Let us first draw a grid conveniently with 4 or 6 parts for identification of the features. Note down the contour interval of toposheet.

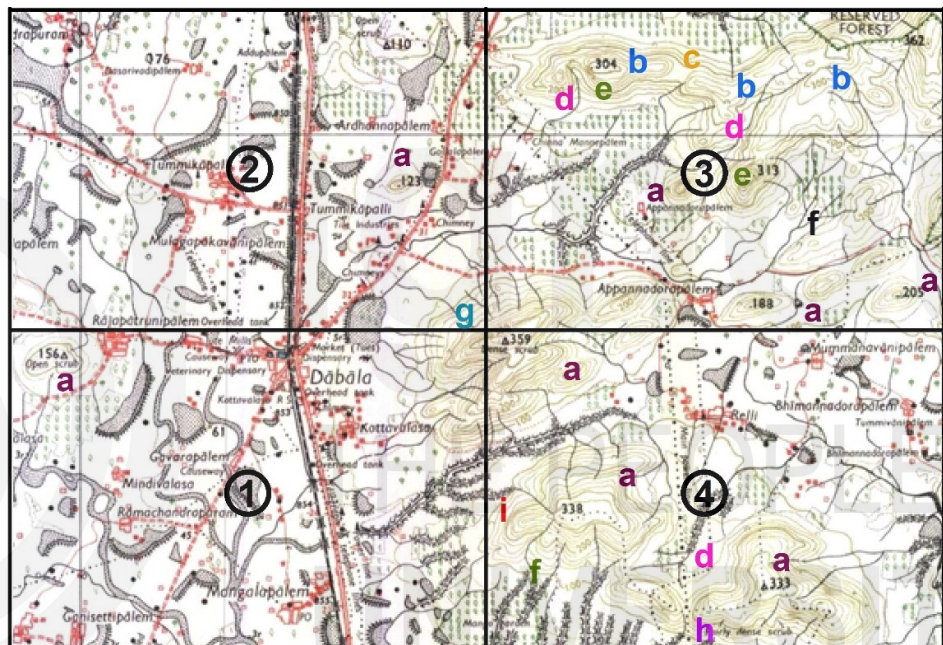


To identify the contour interval, for example, see bottom left corner of **Grid 4** marked as **A** where you will find the thick contour lines with numbers 100 and 200. These dark lines are called index contours. If you count contours between those numbers you will find a total of 4 lines which means that the contour interval is 20 m. The four contours are 120 m, 140 m, 160 m, and 180 m.

**Step 2:** Identify the spot heights and other elevation points. You must remember that the elevation shown on toposheet is in meters.

Grid No.	Elevation (in meters)
1	15, 661
2	76, 110, 123
3	304, 313, 188, 362, 205
4	359, 338, 333

**Step 3:** Now, identify different relief features with the help of the procedure as explained above Sub.Section 7.3.1. You can see the relief features represented with the help of alphabet letters on the sheet (given below) and their corresponding information is also provided in the table for better understanding.




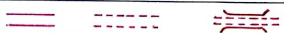












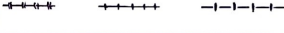




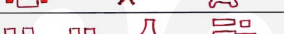
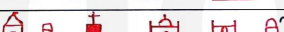
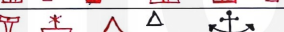

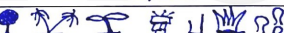
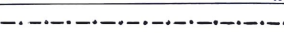




Grid No.	Letter indicated on the map	Name of the relief feature	Description	Observation
1.	a	Conical hill	Concentric contours are closed towards upper parts of the hill.	Height of the hill -123 m.
2.	a	Conical hill	-	Height of the hill -156 m.
3.	a	Conical hill	-	Bottom right corner and Center
	b	Ridge	Top of the hill. Contours are decreasing outwards.	Height of the hill – 304 m.
	c	Saddle	Low elevation between the ridges	
	d	Valley	Narrow gap between the	

			contours. Inner contours have small gap and outward contours are wide.	
	e	Steep slope	Closely spaced contours	
	f	Gentle slope	Widely spaced contours	
4.	a	Conical hill	-	All major hills
	d	Valley	Broad valley	Ravines
	g	Concave Slope	Closely spaced contours towards top of the hill than the bottom.	Spread in Grids 1 and 4
	h	Convex Slope	Closely spaced contours near the bottom of the hill than top.	Bottom of the sheet
	i	Cliff	Very closed contours and merge with one and other	

## 7.4 INTERPRETATION OF TOPOGRAPHICAL MAP

Toposheet reading and interpretation is not a difficult task, but at the same time, it is also not so simple. Studying a toposheet including study of marginal information, conventional signs and symbols requires knowledge of a toposheet. One should get well familiar with the details that are provided in the sheet.

You may refer to Fig.7.1, which shows the conventional signs and symbols for understanding the information of toposheet. As an interpreter, you must get acquainted with these signs, symbols, colours, letters, and the legend before starting the reading of a topographical map.

Roads, metalled: according to importance	
Roads, unmetalled: according to importance	
Unmetalled road: Cart-track, pack-track and pass, foot path with bridge	
Roads, double carriageway; according to importance	
Express highway: with toll; with bridge; with distance stone	
Stream: with track in bed; undefined, Canal	
Dams: masonry or rock-filled; earthwork, Weir	
River: dry with water channel; with islands and rocks. Tidal river	
Submerged rocks, Shoal, Swamp, Reeds	
Wells: lined; unlined, Tube-well, Spring, Tanks: perennial; dry	
Railway, broad gauge: double; single with station; under construction	
Embankments: road or rail, tank, Broken ground	
Railway other gauges: double; single with distance stone; under construction	
Light Railway or tramway, Telegraph line, Cutting with tunnel	
Contours with sub features, Rocky slopes, Cliffs	
Sand features (1) flat (2) sand hills (permanent) (3) dunes (shifting)	
Towns or Villages: inhabited; deserted, Fort	
Huts: permanent; temporary. Tower, Antiquities	
Temple, chhatri, Church, Mosque, Idgah, Tomb, Graves	
Lighthouse, Lightship, Buoys: lighted; unlighted, Anchorage	
Mine, Vine on trellis, Grass, Scrub	
Palms: Palmyra; other Plantation, Conifer, Bamboo, Other trees	
Boundary: international	
Boundary: state: demarcated; undemarcated	
Boundary: district: subdivision, tahsil or taluk; forest	
Boundary, pillars: surveyed; Unlocked; village trijunction	
Heights, Triangulated: station; point; approximate	
Bench- mark: geodetic; tertiary; canal	
Post office, Telegraph office, Overhead tank	

**Fig. 7.1: Conventional signs and symbols depicted on toposheet.**  
(Source: Survey of India, Govt. of India, New Delhi)

You may follow the below given steps while interpreting an toposheet:

**Step 1:** First, record the **Marginal information**.

It comprises toposheet name regarding location of the area, administrative division(s), number, longitude and latitudinal extent, scale, contour interval, index to sheets, information about administrative boundaries, year of survey, date of publication, date of revision and credit note, etc.

**Step 2:** Note down the information regarding **Physical features** under different heads namely **Relief, Drainage** and **Vegetation**.

**Step 3:** Relief includes interpretation of general topography, for example, hilly terrain, plateau, plain region, etc. First, note the elevation information viz. spot heights, bench marks, etc. and calculate the relative relief of the area with the help of following formula.

*Relative relief ( $R_r$ ) = Highest altitude ( $H_{max}$ ) – Lowest altitude ( $H_{min}$ )*

You also need to identify features such as ridge, peak, spur, col, escarpment, cirques, knolls, mounds, rapids, waterfall and valleys, etc.

**Step 4:** Discuss about the drainage which covers major rivers and their tributaries, source of water whether perennial or non-perennial, drainage patterns (dendritic, trellis, rectangular and parallel, etc.), waterbodies (reservoir, tanks, ponds, lakes and canals, etc.), springs, high tide and low tide lines, gullies, flood plains, swamps, mudflats and islands etc.

**Step 5:** Vegetation including natural vegetation, forest (reserve, protected, etc.), forest type, scrub, plantations (Teak, Pine, Devdar, Mango, Cashew, Casuarina, Coconut, etc.), grasslands, orchards, groves, and so on.

**Step 6:** Note down the information regarding **Cultural features** under different heads namely **Settlements, Transport and Communication, Landuse**.

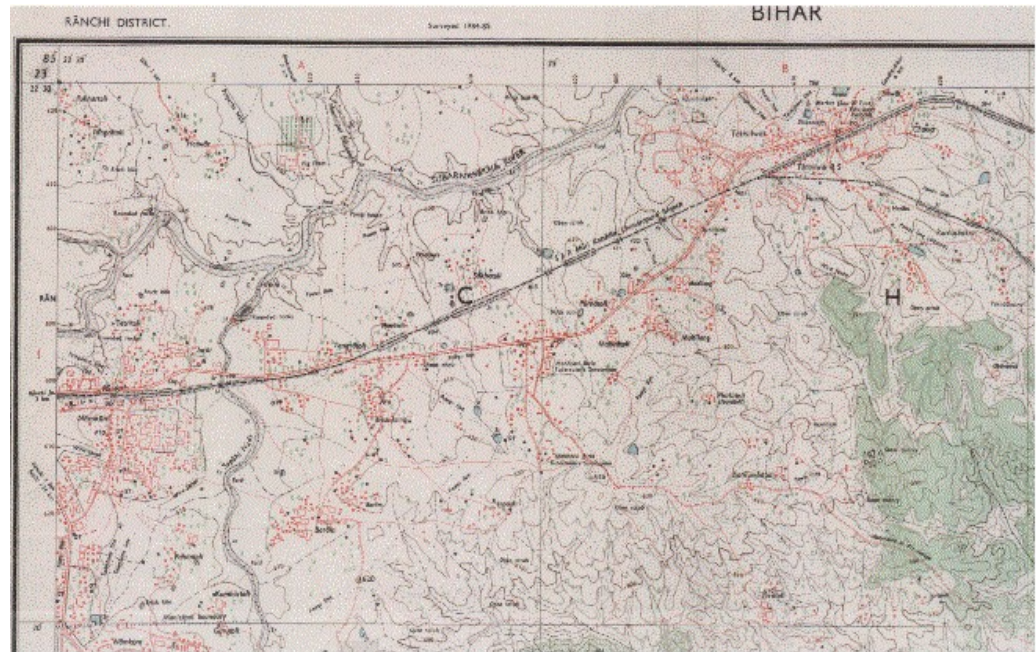
**Step 7:** Settlements including the coverage area of settlement, urban centers, village inhabited or deserted, settlement pattern (clustered, uniform, dispersed and isolated), size and shape (linear, square, rectangle, etc.), site of settlements, religious places, tombs, grave, post, telegraphic, police stations, port, fort, mines, hill stations, etc.

**Step 8:** Transport and Communication comprises types of roads (metalled and unmetalled), national and state highways, types of railways (broad gauge, meter gauge, tramway, metroline, etc.) tunnels, airport, transmission and power lines, etc.

**Step 9:** Interpret the landuse by considering afforestation (social forestry), arable and wastelands, land used for industry, agricultural and orchard, etc.

You have now understood the method of studying a toposheet. Let us interpret the Survey of India toposheet for understanding the marginal information and various physical and cultural features.

**PROBLEM 1:** Identify and interpret different features from the toposheet No. 73/E/7.



## TOPOSHEET INTERPRETATION

### MARGINAL INFORMATION

The toposheet number 73E/7, first edition, shows Ranchi District, Bihar covering the area between  $23^{\circ}15'$  to  $23^{\circ}30'N$  latitudes and  $85^{\circ}15'$  to  $85^{\circ}30' E$  longitudes. It was surveyed during 1978-80 and published under the direction of Major General Chandra Agarwal, Surveyor General of India in 1982. The scale of the sheet is 1:50,000 and contour interval is 20 m. The sheet is equally gridded into 9 parts as A1 to A3, B1 to B3, C1 to C3 with 5' interval each. Magnetic variation from True North is about  $3/4^{\circ}$  or  $45'$  West in 1975. The adjoining sheets are numbered as 73 E/2, E/3, E/4, E/6, E/8, E/10, E/11, and E/12.

### PHYSICAL FEATURES

#### *Relief*

The area of toposheet is typically representing the upland plateau terrain. Thick contours in south-eastern part are demonstrating high absolute altitude compared to other parts of the sheet. The highest and lowest altitudes are 791 m and 581 m, respectively. The relative relief of the area is 210 m. West, South and South-Eastern parts show predominantly rugged terrain. Conical hills (Grids-B2& C3) can also be found.

#### *Drainage*

Several streams are flowing through this region. The river Subarnarekha is flowing from SW part and is merging into the Gulasud reservoir. Another river named Jumar Nadi drains from NW part and is intermingling with the waters of river Potpota Nadi before merging into the reservoir. The main tributaries of Subarnarekha are Sapahi Nadi and Harmu Nadi. Drainage in the area is mainly non-perennial in nature where the streams become dry during summer and flow of water is common during the rainy season. Overall, drainage pattern of the region is dendritic. Major water bodies identified are Getalsud

Reservoir (C1), a reservoir across Pandra Nadi (A2), and a reservoir across the Subarnarekha river (A3).

### ***Vegetation***

Vegetation is mainly present in the SE corner where the presence of green colour explains that the area is covered with scattered trees and other vegetation. Horhap Reserved Forest and Silwai Protected Forests are extended with the Sal trees. Isolated patches of scrub are also found in the region.

## **CULTURAL FEATURES**

### ***Settlements***

Overall, the total area of toposheet becomes visible with good settlements covering approximately more than 25 percent area. The main important town of the area is Ranchi spreading between the rivers Subarnarekha and Jumar Nadi situated on the West, NW, and central parts. Villages are scattered evenly all over the plateau region except small portion (C3 and C2) where the topography is covered by the reserved and protected forests. Major villages for example Hatiya and Harser (A3); Pundag and Jaipur (A2); Sukurhutu, Nagri, Gogi (A1); Murum, Hochar, Boreya (B1); Baragain, Jorar, Baram (B2); Chandaghasi and Kharsidag (B1); Ulatu (C1); Tatisilwai and Gondlipokhar (C2); Karma and Anand (C3); etc. can be found. The settlement pattern is broadly uniform and compact linear. Linear pattern is common along the transport lines.

Mines, stone queries, and brick kilns are prominent in the area. Plantations like tea garden, eucalyptus, and sal are recorded (C1). High court (A2), Ranchi University (A2), Mental Hospital (A1), Agriculture University (A1), Birla Institute of Technology (C2) are situated. Relatively small in size, perennial water tanks are observed in the area for example near Silwai, Purnachatra, Purnatoli villages etc. Settlements also found along the transport lines are Satranji, Hatiya, Kalyanpur, Dhurva, Hinoo, Siromtoli, Kamre, Kanke, Sukurhutu, Bukru, Patratu, Gari, Edalatu, Dhipatoli, Durmartoli, Ormanjhi, Namkom, Puranatoil, Haratu and Tungritoli, etc. Settlements are mainly rural in nature based on the local agriculture base and are characterised by dispersed pattern.

### ***Transport and Communication***

The region has well developed transport network consisting of national highway, metalled, unmetalled, and railway lines. However, transport network has not been uniformly developed. The town Ranchi is connected by roads all around that appears to be of radial pattern. The area mainly discernible with two major transport lines i.e. railway line passing from East to West and National Highway connecting West to East and North East and South East directions.

The broad gauge railway line SER Ranchi Lohar Daga Branch enters at Mattoli in the West and crosses through Subarnarekha river at Namkom running towards North East direction to meet the railway station Tatisilwai. From this place, the track has been divided into two parts as main SER Muri Kotshila Chandrapura Branch and Muri Kotshila Chandrapura Branch going

out both the lines to connect the railway junction of Muri. Other line Bonda Munda Hatiya Brach from Rurkela (160 kms) also enters into the area exactly in SW part and merges at Argora railway station. The prominent railway stations are Ranchi, Totisilwai, and Argora.

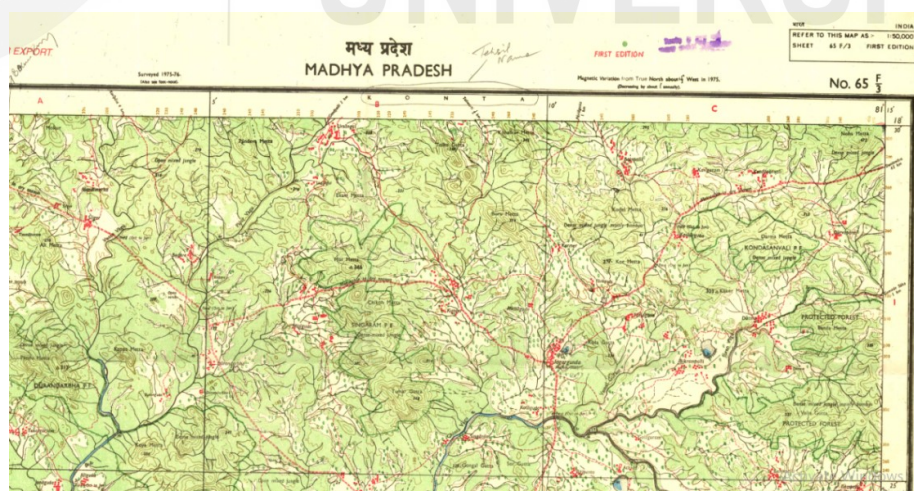
There are two national highways passing through this region namely NH-23 and NH-33. NH-23 enters in the East to meet Ranchi and from the Konka of Ranchi town, it is divided into two parts where one branch starts moving towards NE direction for connecting Hazaribagh (65 km) and the other one is connecting Bundu (22 km). Other prominent major roads are Ranchi-Pithouria-Khunt and Ranchi-Lohardoga-Gondlipokhar passing through this region.

There are several other branch lines of unmetalled, cart-track, and pack-track connected to the main metalled road. Overall, the area finds good means of transport communication. This region is manifested with several power and telephonic lines mainly constructed along the road and railways. We could find one main power line which enters near Tangtongtoli (Grid A1) and is crossing over railway and road lines and finally ends near Lodnapiri (C3). Telephonic and Telegraph lines are mostly following the roadways (B2 & B3). Power lines are criss-crossed everywhere and are constructed parallel to the roads at some places on this region. The transport and communication network is less developed in the forest region situated in the Eastern and Southern parts (Green colour patches). Overall, the transport development is in good condition except in some pockets having rugged terrain.

### **Landuse**

The region is predominantly practicing urban activities. Other significant occupation is agriculture. The region also has forestry and animal husbandry since forest cover is found in some patches.

**Exercise 1:** Identify and interpret physical and cultural features from any given toposheet?



## **7.5 SUGGESTED FURTHER READINGS**

- Misra, R.P. and Ramesh, A. (1986). *Fundamentals of Cartography*, New Delhi: McMillan.

- Sarkar, A. (2008): *Practical Geography: A Systematic Approach*, Kolkata: Orient BlackSwan
- Singh, G. (2004). *Map Work and Practical Geography*, Delhi: Vikas Publication House
- Singh, R.L. and Singh, R.P.B. (2003). *Elements of Practical Geography*, Delhi: Kalyani Publishers.
- [www.surveyofindia.org](http://www.surveyofindia.org)



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# EXERCISE 8

## Calculation of Slope Gradient by Wentworth's Method from a given Toposheet

### Structure

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8.1	Introduction Expected Learning Outcomes	8.3	Slope Determination by Wentworth's Method
8.2	Requirements	8.4	Suggested Further Readings

### 8.1 INTRODUCTION

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In the previous Exercise 7, you have learnt to draw various types of relief features along with interpretation of physical and cultural features from a toposheet. In this Exercise 8, you will learn how to calculate the slope by using Wentworth's method. Slope is recognized as an important aspect of surface form which is being used in surveying and mapping techniques.

### Expected Learning Outcomes

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After working through this exercise, you shall be able to:

- understand the slope determination method; and
- calculate slope gradient from a toposheet using Wentworth's method.

### 8.2 REQUIREMENTS

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To perform this exercise, you require the following materials.

- Ruler or Scale
- Pencil/Pen

- Sharpener and Eraser
- Scientific calculator
- Survey of India toposheet
- Drawing sheets or White sheets (A3 size or long sheets).

### 8.3 SLOPE DETERMINATION BY WENTWORTH'S METHOD

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As you know that slope determines the rate of rise or fall in a terrain feature. It can be measured with the help of contour lines from a toposheet. Generally, closer the contour lines, the steeper the slope; farther apart the contour lines, the gentler the slope. Totally flat ground has no contour lines. You must remember that gradient of slope is not uniform everywhere. To explain these irregularities generally, we calculate the average slope of the area. C.K. Wentworth introduced a simple field method in 1930 for determining average slope of an area from the contour map.

The method is explained as follows:

First, draw a grid in east-west and north-south directions on contour map of the area. Then, count all the contour crossings and determine the average number of contour crossings per kilometre or mile. Now, you calculate the average slope of the area using the equation as given below.

$$\tan \theta = \frac{N \times I}{3361}$$

or

$$\theta = \tan^{-1} \left( \frac{N \times I}{3361} \right) \text{ for the mile grid}$$

and

$$\theta = \tan^{-1} \left( \frac{N \times I}{636.6} \right) \text{ for the kilometer grid}$$

where

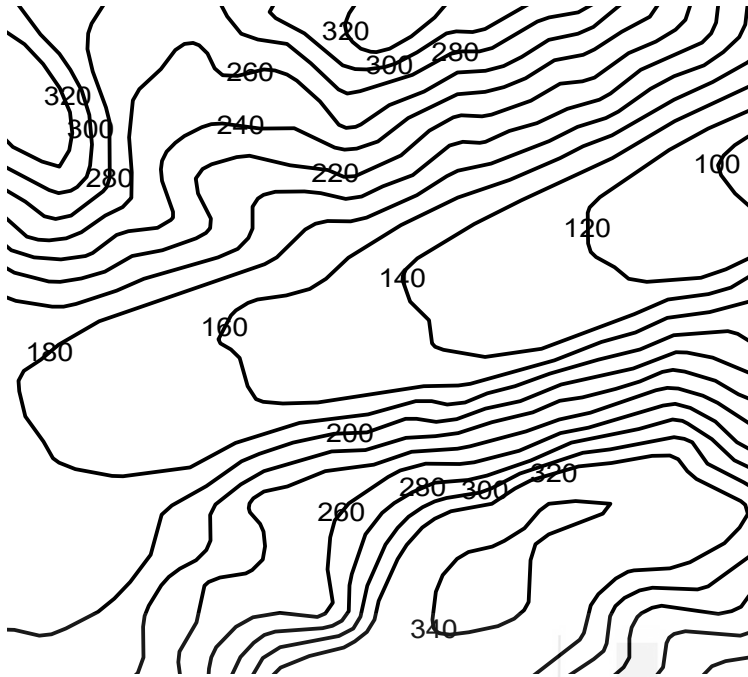
$N$  = Average number of contour crossings per mile or per kilometer;

$I$  = Contour interval;

$\theta$  = Average angle of slope

**PROBLEM 1:** Find out the slope from given contour map using Wentworth's method.

Note: Contour interval (I) = 20 m; Scale = 1:50,000.

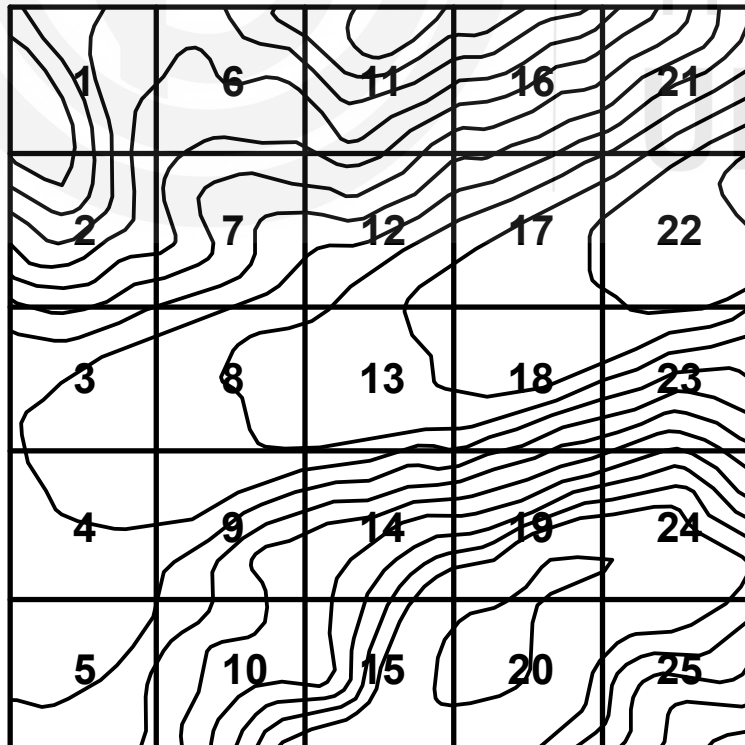


**Solution:**

**Step 1:** Let us note down the contour interval from the contour map. The difference value between any two contours is 20 m.

Hence, the contour interval (I) = 20.

**Step 2:** Draw one kilometre grid on contour map in east-west and north-south directions. Each block is drawn with a measurement of 2 cm by 2 cm which represents 1 square kilometer. The grid is numbered from 1 to 25.



**Step 3:** Count all the contour crossings in each grid. Prepare the table as given below.

Grid No.	No. of Contour Crossings (a)	No. of Grid lines (b)	Average No. of Contour Crossings $N = \left(\frac{a-b}{2}\right)$	$\frac{N \times I}{636.6}$	$\tan^{-1}\left(\frac{N \times I}{636.6}\right)$ ( $\theta$ )
1	8	4	2	0.06	3.43
2	14	4	5	0.16	9.09
3	6	4	1	0.03	1.71
4	2	2	0	0.00	0
5	4	4	0	0.00	0
6	8	4	2	0.06	3.43
7	8	4	2	0.06	3.43
8	4	4	0	0.00	0
9	8	4	2	0.06	3.43
10	13	4	4.5	0.14	7.96
11	14	4	5	0.16	9.09
12	12	4	4	0.13	7.40
13	8	4	2	0.06	3.43
14	17	4	6.5	0.20	11.30
15	10	4	3	0.09	5.14
16	15	4	5.5	0.17	9.64
17	10	4	3	0.09	5.14
18	10	4	3	0.09	5.14
19	18	4	7	0.22	12.40
20	8	4	2	0.06	3.43
21	16	4	6	0.19	10.75
22	12	4	4	0.13	7.40
23	14	4	5	0.16	9.09
24	17	4	6.5	0.20	11.30
25	10	4	3	0.09	5.14
<b>Total</b>	<b>266</b>	<b>98</b>	<b>84</b>	<b>2.64</b>	<b>69.25</b>

**Step 4:** You can also compute the average slope of the entire area by substituting all the values into the equation as given below.

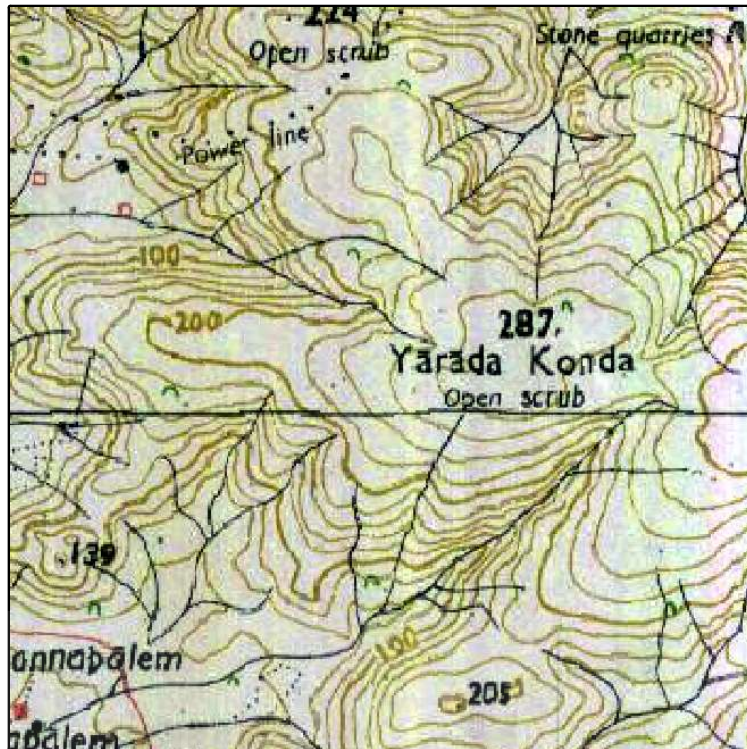
$$\theta = \tan^{-1}\left(\frac{N \times I}{636.6}\right) \text{ for the kilometer grid}$$

$$\theta = \tan^{-1}\left(\frac{84 \times 20}{636.6}\right) = \tan^{-1}\left(\frac{1680}{636.6}\right) = \tan^{-1}(2.639) = 69.25$$

Now, you got the average angle of slope for the given area i.e. **69.25 degrees**.

**PROBLEM 2:** Find out the average angle of slope from the given toposheet using Wentworth's method.

**Note:** Contour interval (I) = 20 m; Scale = 1:50,000



**Solution:**

**Step 1:** Let us calculate the units of scale of the toposheet.

$$\text{Here, RF} = 1:50,000 = \frac{1_{\text{map}}}{50,000_{\text{ground}}} = \frac{1 \text{ cm}_{\text{map}}}{50,000 \text{ cm}_{\text{ground}}}$$

$$\therefore 1 \text{ km on the ground} = \frac{1 \times 100,000 \text{ cm}}{50,000 \text{ cm}} = 2 \text{ cm on map}$$

where  $100,000 \text{ cm} = 1 \text{ km}$

Thus, 2 cm on the map is equal to 1 km on the ground or

1 cm on the map represents 0.5 km on the ground.

**Step 2:** Note down the contour interval (I). You can also observe it from the toposheet. The difference value between any two contours is 20.

Hence, the contour interval (I) = 20.

**Step 3:** Let us draw one kilometre grid on the toposheet in east-west and north-south directions. To do this, you can take printout of the given toposheet or overlay the toposheet and a drawing sheet one over the other on the tracing table. Trace out the boundary of the toposheet and the contour lines on drawing sheet.

**Step 4:** Mark the divisions with a measurement of 2 cm on the toposheet both vertically and horizontally. Now, connect each of these markings perpendicularly to prepare a grid. Each block is now drawn with a measurement of 2 cm by 2 cm which represents 1 square kilometer.



**Step 5:** Now, you have drawn one kilometre by one kilometre grid for the toposheet in east-west and north-south directions. Assign the numbers for the grid from 1 to 25.



**Step 6:** Count all the contour crossings in each grid. Prepare the table as given below.

Grid No.	No. of Contour Crossings (a)	No. of Grid lines (b)	Average No. of Contour Crossings $N = \left(\frac{a-b}{2}\right)$	$\frac{N \times I}{636.6}$	$\tan^{-1}\left(\frac{N \times I}{636.6}\right)$ ( $\theta$ )
1	23	4	9.5	0.298	16.59
2	22	4	9	0.283	15.80
3	17	4	6.5	0.204	11.53
4	20	4	8	0.251	14.09
5	6	4	1	0.031	1.77
6	18	4	7	0.220	12.40
7	19	4	7.5	0.236	13.27
8	14	4	5	0.157	8.92
9	18	4	7	0.220	12.40
10	7	4	1.5	0.047	2.69
11	15	4	5.5	0.173	9.81
12	17	4	6.5	0.204	11.53
13	12	4	4	0.126	7.18
14	17	4	6.5	0.204	11.53
15	20	4	8	0.251	14.09
16	20	4	8	0.251	14.09
17	19	4	7.5	0.236	13.27
18	9	4	2.5	0.079	4.51
19	22	4	9	0.283	15.80
20	20	4	8	0.251	14.09
21	12	4	4	0.126	7.18
22	25	4	10.5	0.330	18.26
23	17	4	6.5	0.204	11.53
24	14	4	5	0.157	8.92
25	14	4	5	0.157	8.92
<b>Total</b>	<b>417</b>	<b>100</b>	<b>158.5</b>	<b>4.980</b>	<b>78.64</b>

**Step 7:** You can compute the average slope of entire area by substituting all the values into the equation as given below.

$$\theta = \tan^{-1}\left(\frac{N \times I}{636.6}\right) \text{ for the kilometer grid}$$

$$\theta = \tan^{-1}\left(\frac{158.5 \times 20}{636.6}\right) = \tan^{-1}\left(\frac{3170}{636.6}\right) = \tan^{-1}(4.98) = 78.64$$

Now, you got the average angle of slope for the given area i.e. **78.64 degrees**.

**Lab Exercise 1:** Find out the average angle of slope from the given toposheet using Wentworth's method.

Note: Contour interval (I)= 100 m; Scale = 1:250,000



## 8.4 SUGGESTED FURTHER READINGS

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- Misra, R.P. & Ramesh, A. (1986). *Fundamentals of Cartography*, New Delhi: McMillan.
- Sarkar, A. (2008): *Practical Geography: A Systematic Approach*, Kolkata: Orient BlackSwan
- Singh, G. (2004). *Map Work and Practical Geography*, Delhi: VikasPublication House
- Singh, R.L. and Singh, R.P.B. (2003). *Elements of Practical Geography*, Delhi: Kalyani Publishers.

# EXERCISE 9

## PREPARATION OF CLIMOGRAPH AND HYTHERGRAPH

### Structure

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9.1	Introduction	9.5	Practical Exercises
	Expected Learning Outcomes	9.6	Summary
9.2	Requirements	9.7	References/Suggested Further
9.3	Fundamentals		Readings
9.4	Solved Exercises		

### 9.1 INTRODUCTION

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You have studied and learnt about the representation of climatic Data through different types of diagrams in Unit 12 of the theory course BGGCT 133 titled 'General Cartography'. This is an integrated laboratory component of the same course. You have also studied some exercises demonstrated through methods and steps in Unit 12 of the theory component. Besides learning the key as how to distinguish between weather and climate, you have also learned about the six basic elements of weather and climate with which you are already well versed. However, you have learnt these in terms of importance in day-to-day activities of life and use in geographical and non-geographical studies in a broader sense.

In this exercise 9, you will learn about the key techniques to prepare two kinds of climatic diagrams to highlight the general weather conditions as well as to exhibit the climatic condition of any area of interest (AOI) on the globe for which necessary data is available. The prerequisites to construct these diagrams will be discussed in Section 9.3. You have already learnt that climograph is a kind of short form of climatological diagram. This is also known as 'climogram'. Along

with this, we will also discuss one more type of diagram i.e. Hythergraph, another form of climatological diagram in Section 9.4. Like climograph, hythergraph also represents climatic condition of a place by showing more than two variables in three dimensions. We will not only highlight the key differences between climograph and hythergraph but also recapitulate the key techniques some of which you have already studied in Unit 12. You will further learn about the stepwise techniques to construct these climatic diagrams in Section 9.4. This will be followed by practical exercises which you have to solve and submit in practical record book given in the Section 9.5.

## **Expected Learning Outcomes**

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After completing exercise 9, you will learn the following skills:

- To chalk out the necessary set of apparatus and nature of freely available secondary data from different national and international sources.
- To prepare and construct the climograph and hythergraph for climatic data of area of interest (AOI) on the globe.
- To highlight the key points or give an idea about the general weather and climatic conditions of a geographical region as per the particular climatic diagrams.

## **9.2 REQUIREMENTS**

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You will agree with us that it is pertinent to have a clear and precise idea about the requisite sets of apparatus and varied sources of data as indispensable requirements before you start solving the given exercises.

Such definite and important requirements are discussed sequentially. You have read that in earlier times, diagrams were used to be prepared manually with the help of map drawing equipments. However, with the passage of time, such manual mapping techniques were replaced with the computer enabled mapping techniques evolved through different periods of time and space corresponding to the advancements in science and technology which we know as 'information age'. However, as you learnt the manual technique to construct these in theory Unit 12, we will follow the manual techniques in this exercise as well. As you have studied that the purpose of both diagrams is to visually show the spatial distribution of elements of weather and climate of any geographical area on the surface of the earth in which you may be interested. Therefore, both types of diagrams have common set of requirements in order to prepare the graphical diagrams as highlighted below:

### **Data**

Secondary data pertaining to the required elements of weather and climate of a place or area of interest.

## **Apparatus**

- Ruled graph and tracing paper
- Drawing equipments
- Black ink
- Paper board
- Scale, HB Pencil, sharpener, and eraser

**(Note:** You are mandatorily required to complete the reading of Unit 12 to systematically apply the theoretical concepts learnt before embarking onto performing the exercises given in this exercise no. 9 for submission into your practical record book).

## **9.3 FUNDAMENTALS**

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It is of great importance to quickly recapitulate the theoretical components which you have studied and learnt in Unit 12 before solving and constructing the climatological diagrams according to the given exercises. Needless to say, that the clarity about fundamentals is not only of paramount value but also enables one to complete the related laboratory exercises accurately and lucidly and related ancillary tasks as well.

### **9.3.1 Representation of Climatic Data through Diagrams**

You may recall the diagrams which are exclusively used to represent the diverse types of climatic data. You learnt that such kinds of diagrams are meant to implicitly represent a range of climatological and meteorological data. Such diagrams may help us to even recreate the past weather conditions and provides a clue for the prediction of both short and long term weather forecasts for variety of applications. Some of the prominent sectors are agriculture and horticulture, aviation, navigation, fishing, tourism, highway forecast and many others which carry tremendous economic potentials to augment the economic output of a nation. You learnt to make some of such diagrams and their utilization meant to represent meteorological data as highlighted below:

1. Climograph
2. Hythergraph
3. Ergograph
4. Wind rose and Star diagram

In this exercise 9, we will discuss first two types with one each solved exercise for you to get further idea and acquire the practical skills.

### 9.3.2 Climograph

You came to know that climograph also known as climogram is a climatological diagram. It consists of a twelve-sided polygon corresponding to twelve months of a year. It is chiefly employed to show two climatic elements for a chosen meteorological station against one another in a graph paper. You learnt that these two climatic elements are wet bulb temperature and relative humidity to show the prevalent climatic condition of a chosen station or a geographical place. You read that a renowned scholar named Koeppen had also used Climograph in order to devise the classification of climatic regions to see the climatic variations. Climograph is first conceived by J. Ball in 1910 and subsequently improved by Leighly in 1926, USDA in 1941, and finally by Taylor in 1949. Besides, you also got acquainted that the same was also used to identify and locate the places based on scale of habitability for white settlers in the tropics during the time of exploration and conquests.

For doing so, you learnt that Griffith Taylor gave four special terminologies to represent four distinct climatic conditions. You also learnt that as a rule, one who is making a climograph must place these four distinct terms in the four directions typically representing four corners of a diagram. These are known as 1) 'Raw' representing the South-East side, 2) 'Muggy' representing the North-East side, 3) 'Scorching' representing the North-West side and 4) 'Keen' representing the South-West side of a climograph. You also learnt that how these four distinct terms are used to denote the climatic condition of a given station or place expressed in the context of wet bulb temperature and relative humidity on x-y axis of a diagram.

These are known as **Raw condition**, **Muggy condition**, **Scorching condition**, and **Keen condition** representing differing values in context of the two climatic variables as explained earlier.

You came to know that the location of twelve-sided polygon in a diagram provides hints to ascertain the climatic condition as well as type of geographical region of a given station or place. Apart from this, you further learnt that the shape of climograph gives a clue to identify the nature and type of climate. For example, 1) a spindle shaped climograph indicates dry continental type of climate, 2) the one with north-east to south-west diagonal orientation is indicative of monsoon type of climate, 3) Climograph with north- west to south-east diagonal orientation signifies Mediterranean type of climate; 4) Climograph with full spatial expanse in a diagram represents the British type of Climate.

Besides this, you also read that Griffith Taylor has also devised a scale of discomfort based on his logical inferences and personal experiences gained from the vast amount of similar work carried over at diverse places spanning across the World. You have also learnt about six scales of discomfort as explained by him having different range of temperature values.

### **9.3.3 Hythergraph**

You learnt that this is one more type among the many types of climatological diagrams. Like climograph, hythergraph was also first devised by the Griffith Taylor to signify the climatic condition of a station or place. You came to know that the necessity to develop Hythergraph arose as in a climograph more than two climatic variables cannot be shown and plotted. For this reason, numerous climatic diagrams got subsequently developed by using combination of two different climatic variables. You learnt that the main difference between climograph and hythergraph is in the depiction of two different types of climatic variables. You know that in case of a climograph, it is relative humidity (shown in X axis) whereas it is wet bulb temperature (shown in Y axis) whereas in case of a hythergraph, it is rainfall (shown in X axis) whereas it is temperature (shown in Y axis).

You have read that hythergraph is also like that of climograph having twelve-sided polygon to show the mean monthly temperature and rainfall of a station or a geographical place against one another. It is put into use to encapsulate a broad climatic variation with reference to spatial activities of human beings particularly concerned with the issue of inhabitation. You also learnt that in a hythergraph like that of a Climograph, there are also terminologies to represent the climatic conditions. These are designated as cold and dry in the South-West direction, cold and wet/moist in the South-East direction, hot/warm and dry in the North-west direction and finally hot/warm and moist/humid in the North-East direction. To conclude, you learnt that the steps of construction of a hythergraph are quite akin to that of climograph.

Let us discuss the stepwise methods of construction of climograph and hythergraph with the help of one exercise as an example given below. You must solve one exercise each for these two varieties of climatological diagrams for submission in your Practical Record Book.

## **9.4 SOLVED EXERCISES**

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In this Section, we are discussing two cases of Climograph and one case of Hythergraph with the solved exercises. After studying these, you will have a clear and precise idea and skill to perform the practical exercises as well as suggested exercises given in the ensuing sections.

Exercise 9.1 Draw a Climograph (after Griffith Taylor) of Churu to show the two climatic variables as per the below given data in the table.

**Table 9.1**

<b>Months</b>	<b>Ja</b>	<b>Fe</b>	<b>Ma</b>	<b>Ap</b>	<b>Ma</b>	<b>Jun</b>	<b>Jul</b>	<b>Au</b>	<b>Se</b>	<b>Oc</b>	<b>No</b>	<b>De</b>
	<b>n</b>	<b>b</b>	<b>r</b>	<b>r</b>	<b>y</b>	<b>e</b>	<b>y</b>	<b>g</b>	<b>p</b>	<b>t</b>	<b>v</b>	<b>c</b>

<b>Wet Bulb Temperature (in Degree Celsius)</b>	5.9	9.1	14	17.4	21.3	24.2	25.7	25.4	23.4	17.3	11.1	6.3
<b>Relative Humidity (in percent)</b>	80	72	58	38	38	50	68	74	68	58	65	75

Source: Normal Climatological Tables, India Meteorological Department, Pune, India.

### Steps to arrange and compute Data:

In this exercise, the required climatic data is already given in a desired format. Hence, no arrangement and computation are required as such.

### Steps-wise Techniques to Construct a Climograph:

First and foremost, you must examine the range of given data for the two climatic variables. Then, you must follow the steps one by one as mentioned below:

- (i) In the first step, you must select an appropriate scale on the ruled graph paper and draw an L shape figure accordingly. Then you have to mark the X-axis i.e. horizontal line (generally drawn and positioned at the bottom portion of a graph paper) known as abscissa and Y-axis (generally drawn and positioned at the left-hand side vertical portion of a graph paper) i.e. vertical line known as ordinate.
- (ii) In the second step, you must plot the data in case of relative humidity (RH) on the X-axis and in case of Wet-Bulb Temperature on the Y-axis as per the given values.
- (iii) In the third step, you must plot the values of climatic variable of Wet-Bulb Temperature in Y-axis. For doing this, you have to choose the graduated scale extending from -10 degree F to 90 degree F. Similarly, you must plot the values of climatic variable of relative humidity along the X-axis. As like earlier one, you will again choose the graduated scale for this climatic variable separately ranging between 20 to 100 per cent.
- (iv) Before proceeding to the fourth step, you should know the rationale behind as to why this fixed value is taken into consideration. You learnt in theory Unit 14 that mean monthly values of Wet-Bulb Temperature are plotted in relation to Relative Humidity as developed by Griffith Taylor. This diagram known as 'Climograph' is developed on a fixed frame in a graph paper to

highlight the physiological effects of climate on humans and their spatial avocations.

- (iii) In the fourth step, in order to show these two climatic variables in abscissa (X-axis) and ordinate (Y-axis), it is essential to choose an appropriate scale (you are familiar with scales and its types learnt in Unit 3 Block 1 of theory course). For solving this exercise, a scale of 1 CM = 10 degree F representing Wet Bulb Temperature and a scale of 1CM = 10% representing that of Relative Humidity has been chosen.
- (iv) In the fifth step, after choosing the appropriate scale, you must begin plotting the values in both the axis in a sequential manner as explained earlier. You will start by plotting the values for the first month of January and then gradually proceed towards the last month of December. This step will lead you to the completion of a diagram. You might be getting the question that how should we accomplish this skillfully orderly task?

(For illustration purpose, in order to obtain and plot the points for the month of January, you must draw perpendiculars from  $5.9/10 = 0.59$  cm and  $80/10 = 8$  cm to represent Wet-Bulb Temperature and Relative Humidity. The point where these two values of x and y axis will intersect perpendicularly with each other, you will obtain the required point for the month of January. Similarly, you will obtain and plot the points for rest of the eleven months from February to December. Once you have plotted the values of both the variables for all the twelve months, you must write the first letter of that month on the plotted points to represent all the twelve months of a year. Like J for January, F for February, M for March and so on till you reach D for December as a letter symbol denoting different months for the identification and easier visualization to the intended users or community of users.

- (v) In the sixth step, you will start linking these plotted points representing all the 12 months of a year consecutively starting with the month of January and ending at the month of December. You will perform this second last step with the help of a scale to maintain the symmetry and appearance. Once you will finish linking all the twelve points, it will lead to the development of a 12-sided polygonal figure known as 'Climograph' (after Griffith Taylor) as shown in fig 9.1.
- (vi) In the last step, you will write the names of four terms as learnt in theory Unit 12 in four different directions or corners in a Climograph to show the physiological effects of climate on human beings. These are known as 'Scorching' to be written in the North-west direction (upper left corner), 'Muggy' in North-east direction (upper right corner), 'Keen' in (lower left corner) and 'Raw' in (lower right corner) of the diagram.

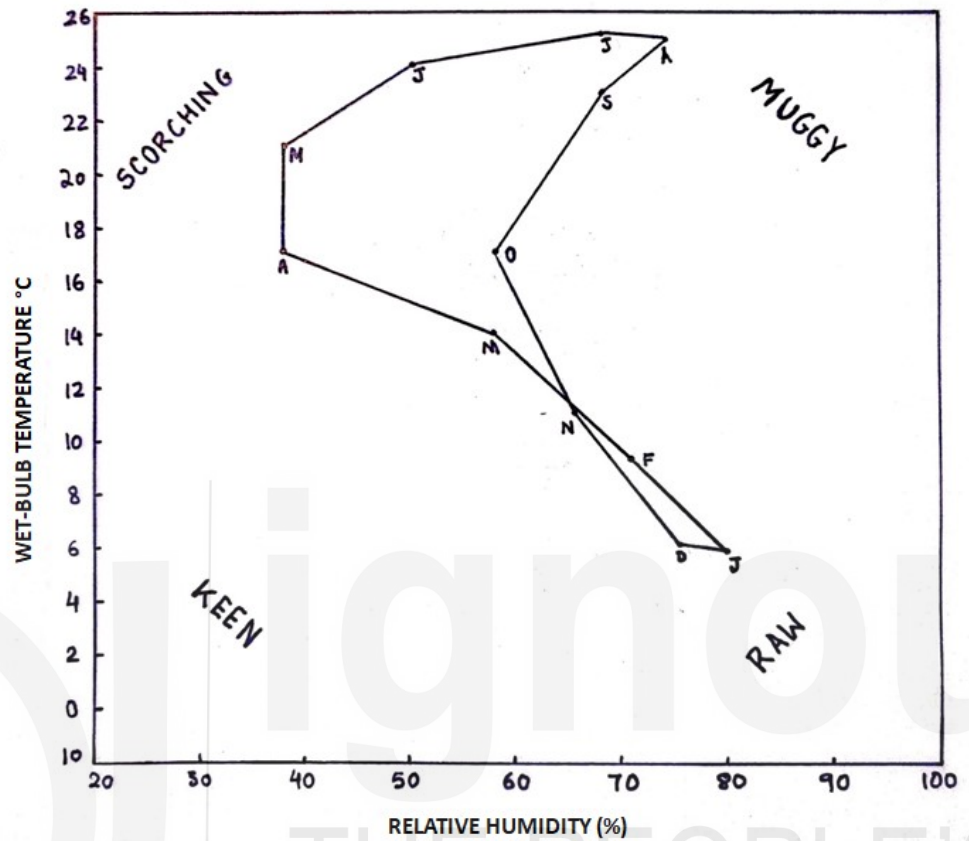


Fig. 9.1: Climograph of Churu, Rajasthan, India.

Exercise 9.2 Draw a Climograph (after E.E. Foster) of Cochin to show the two climatic variables as per the below given data in the table.

Table 9.2

Months	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Temperature (in Fahrenheit)	80.5	82	89	85.5	84	80	79	78.5	80	80	81.5	81
Rainfall (in inches)	0.9	0.8	2.0	4.9	11.7	28.5	23.3	13.9	7.7	13.9	6.7	1.6

Source: Normal Climatological Tables, India Meteorological Department, Pune, India.

**Steps to arrange and compute Data:**

As like previous exercise, the climatic data is already given in an arranged format. Therefore, you are not required to arrange and carry out the computation task.

### **Steps-wise Techniques to Construct a Climograph:**

In this case also, almost all the steps will remain same as like that of previous exercise 9.1 being followed in the construction process of a Climograph (after Griffith Taylor). It is devised to explain the system of climatic classification as propounded by a renowned scholar named Thornwaite.

Although, it is constructed on a set and fix frame as devised by E.E. Foster in 1944 as discussed below:

- In this diagram, the mean monthly temperature values in degree Fahrenheit are plotted against the mean monthly values of rainfall in inches.
- Temperature values are plotted in the abscissa on y-axis on a fixed graduated scale of -20 degree Fahrenheit to 100 degree Fahrenheit.
- Rainfall values are plotted in the ordinate on x-axis on a fixed graduated scale of 0 to 18 inches.
- The basic frame of a diagram has fixed six temperature zones to designate the temperature values as under:
  1. Frigid zone extending from - 20 to 0 degree Fahrenheit.
  2. Cold zone extending from 0 to 32 degree Fahrenheit.
  3. Cool zone extending from 32 to 50 degree Fahrenheit.
  4. Mild zone extending from 50 to 65 degree Fahrenheit.
  5. Warm zone extending from 65 to 80 degree Fahrenheit.
  6. Hot zone extending over 80 degree Fahrenheit.

Foster has further made a five sub-division in the last four temperature zones i.e. from cool zone (number 3) to hot zone (number 6). It is done to designate both the temperature and rainfall values as explained under:

1. Arid zone extends between 32.4 degree Fahrenheit, 0.32 inch and 83.2 degree Fahrenheit, 1.03 inch.
2. Semi-arid zone extends between 32.4 degree Fahrenheit, 0.59 inch and 83.2 degree Fahrenheit, 1.93 inch.
3. Sub-humid zone extends between 32.4 degree Fahrenheit, 1.10 inch and 83.2 degree Fahrenheit, 3.60 inch.

4. Humid zone extends between 32.4 degree Fahrenheit, 2.05 inch and 83.2 degree Fahrenheit, 6.73 inch.
5. Wet zone extends between 32.4 degree Fahrenheit, > 2.05 inch and 83.2 degree Fahrenheit, > 6.73 inch.

The final diagram known as climograph will appear as illustrated below in fig 9.2.

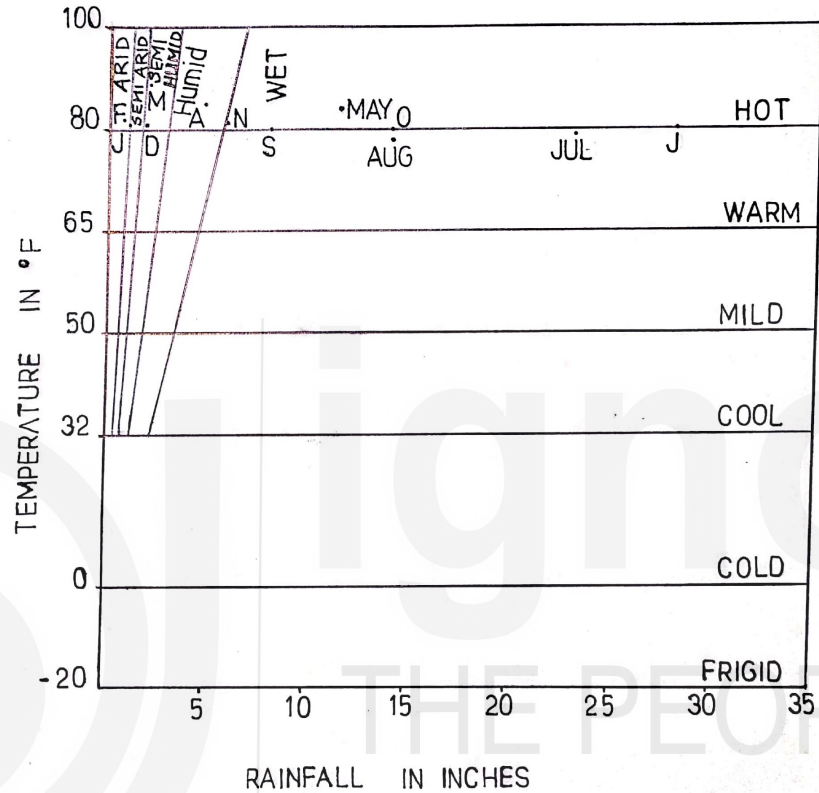


Fig. 9.2 Climograph of Chennai (After E.E. Foster), India.

Exercise 9.3: Draw a Hythergraph of Hisar located in Haryana to exhibit the two climatic variables as per the below given data in the table.

**Table 9.3**

Months	Ja n	Fe b	Ma r	Ap r	Ma y	Jun e	Jul y	Aug	Se pt	Oc t	No v	De c
Temperat ure (in Degree Celsius)	14. 7	18. 0	23. 4	29. 2	33. 2	34. 1	33.1	31.9	30. 4	23. 4	21. 3	16. 2
Rainfall (in centimetr	1.1 7	2.0 0	1.6 2	1.1 2	2.9 3	6.3 3	12.9 8	11.3 3	8.1 8	0.7 9	0.2 2	0.4 6



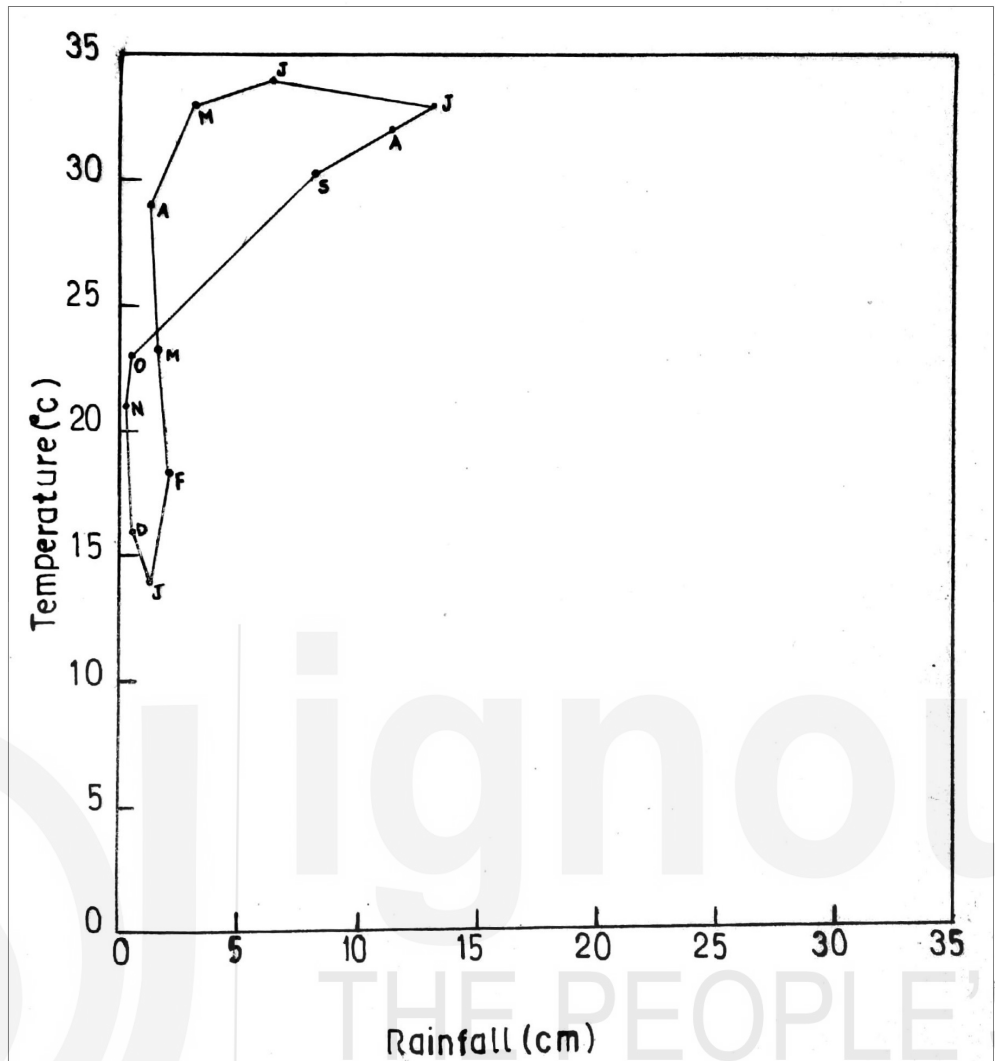


Fig. 9.3: Hythergraph of Hisar, Haryana, India.

## 9.5 PRACTICAL EXERCISES

In the below given exercises, you must attempt both exercises for two different variety of climatological diagrams. You are compulsorily required to solve these with appropriate answers. Along with this, your answer must also incorporate the explanation of detailed steps of construction before you submit these in your Practical Record Book as already mentioned in previous exercises.

**(Note:** You are required to systematically adopt the steps as mentioned in detail in the related theory exercises in Unit 15 and the solved exercises of this exercise 9).

Exercise 1 (a): Draw a Climograph (as devised by a scholar named Griffith Taylor) of Sagar island located in the state of West Bengal, India to show the two climatic variables as per the below given data in the table.

**Table 9.4**

Months	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
<b>Wet -Bulb Temperature (in degree Celsius)</b>	17	20.1	24	26.4	27.6	27.7	27.3	27.2	27	25.4	21.8	18
<b>Relative Humidity (in percent)</b>	78	78	77	79	80	83	86	85	84	78	75	74

Source: Normal Climatological Tables, India Meteorological Department, Pune, India.

**Or**

Exercise 1 (b): Draw a Climograph (as devised by a scholar E.E. Foster) of Gaya located in Bihar to show the two climatic variables as per the below given data in the table 9.5.

**Table 9.5**

Months	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
<b>Wet -Bulb Temperature (in degree Celsius)</b>	11.6	14.2	17.5	21	24.3	26.2	26.6	26.7	26	22.7	17.4	13
<b>Relative Humidity (in percent)</b>	82	73	53	41	52	65	82	83	83	78	76	79

Source: Normal Climatological Tables, India Meteorological Department, Pune, India.

**Table 9.6**

Exercise 2: Draw a Hythergraph of Balasore located in Orissa to exhibit the two climatic variables as per the below given data in the table.

Months	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
<b>Temperature (in Degree Celsius)</b>	20.7	23.7	27.6	30.2	30.7	30.0	29.0	28.7	28.7	27.5	24.3	20.7
<b>Rainfall (in Millimetres)</b>	16.4	36.2	39.6	60.5	146.4	296.7	291.2	308.4	290	174.3	39.7	16.4

Source: Normal Climatological Tables, India Meteorological Department, Pune, India.

We are providing a hint for explaining the further suggested exercises rather than giving the full exercises as under:

- If interested, you may explore the freely available climatic and metrological data from different websites as mentioned in the preceding section of this exercise.
- After procuring the suitable data for the required variables as per the procedures, you may develop and construct these two diagrams to represent the climatic data for other stations or your state and professional place which may interest you.
- Besides, you may also make use of a hypothetical data after reading a related literature for your area of interest (AOI). Such voluntary and independently carried out activity may help you to develop as well as awaken your concept mapping ideas and skills as well.
- Such hands-on on experimental exercise on your own may help you to acquire more skills and expand your geographical knowledge as well as enable you to surmise the prevailing climatic circumstances over there.

Besides, it may likely to help you in many other ways depending upon the nature of involvement and activities, more prominently be benefitting in academic pursuits.

## **9.6 SUMMARY**

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Besides effectively learning to construct two climatological diagrams, you have also learnt the following skills in this exercise:

- You have learnt the practical skill to show the four major climatic components graphically and diagrammatically. These are temperature, pressure, humidity and precipitation etc.
- You have learnt about the two key methods to represent the climatic data viz., Climograph and Hythergraph for any geographical area of interest (AOI).
- You got the idea that Climograph or climogram is a twelve-sided polygon that represents the selected two climatic elements of a place against one another. This twelve-sided polygon or climograph was constructed by taking wet bulb temperature and relative humidity as indicators for representing the climatic condition of a place. The idea or rationale is to see the physiological effects of climate on humans and their spatial activities.
- Climograph was first conceived by J. Ball in 1910 and subsequently improved by Leighly in 1926, USDA in 1941, and finally by Taylor in 1949. You have studied about the world climatic regions of Koeppen and other

scholars in the first semester course titled 'Physical Geography'. Koeppen had also extensively used Climograph to sum up the climatic variations across the geographical regions of the world.

- Further, you have learnt about another method to represent the climatological data i.e. Hythergraph. A renowned scholar named Griffith Taylor was the first one to devise Hythergraph.
- You came to know that as like that of Climograph, Hythergraph is also employed to represent climatic condition of any place under investigation.
- You learnt that it has twelve-sided polygon to show the mean monthly temperature and rainfall of any meteorological station against one another.

## 9.7 REFERENCES/SUGGESTED FURTHER READINGS

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1. Khullar, D.R. (2003), *Essentials of Practical Geography*, Jalandhar: New Academic Publishing Co.
2. Mishra, R. P. and Ramesh, A. (1989) *Fundamentals of Cartography*, Concept Publishing Company, New Delhi.
3. Robinson, Arthur, H.J., Morrison, P., Muehrke, A., Kimmerling & Guptill, S. (eds.) (1995), *Elements of Cartography*, New York: Wiley
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5. Singh, L.R. & Singh, R. (1973), *Map Work and Practical Geography*, Allahabad: Central Book Depot.
6. Singh R. L. and Singh, R. P. B. (1991) *Elements of Practical Geography*, Kalyani Publishers, Ludhiana.

# EXERCISE 10

## PREPARATION OF WIND ROSE AND STAR DIAGRAM

### Structure

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10.1	Introduction	10.5	Summary
	Expected Learning Skills	10.6	Practical Exercises
10.2	Requirements	10.7	References/Suggested Further Readings
10.3	Fundamentals		
10.4	Solved Exercises		

### 10.1 INTRODUCTION

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You have already studied and learnt about the representation of climatic Data through various diagrams in Unit 14 of the course on 'General Cartography'. As explained in previous exercises, it is an integrated lab component of the same course demonstrated through solved exercises. Besides learning the key as how to distinguish between weather and climate, you also learned about the six basic elements of weather and climate with which you are already familiar with. You have also learnt about many statistical diagrams employed to represent the different variables pertaining to climatic data for a meteorological station or a place. You will further learn about some more cases of such diagrams with solved exercises.

In this exercise 10, you will learn about the key techniques to prepare two kinds of diagrams to highlight the general weather conditions as well as to exhibit the climatic condition of any geographical place. We will discuss the standard requirements to construct and complete the given practical exercises in Section 10.2. You have already learnt that wind rose is one of the most ordinary and simplest categories of star diagram which we will discuss in Section 10.3. Along

with this, we will also discuss the construction of a simple star diagram. We will not only highlight the key differences between these two but also make you learn the key techniques to construct along with importance in Section 10.4.

## Expected Learning Outcomes

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After completing exercise 10, you should be able to learn the following:

- To prepare and construct the wind rose for a given climatic data or your area of interest (AOI).
- To make simple star diagram for a given climatic data or your area of interest (AOI).
- To highlight the key points or give an idea about the general weather and climatic conditions which prevails in a geographical region.

## 10.2 REQUIREMENTS

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As already mentioned in earlier exercises, it is important to know about the necessarily required sets of apparatus and varied sources of data before you begin on the journey to solve the given exercises.

You are already familiar that in earlier times, maps and diagrams used to be prepared manually with the help of map drawing equipments which you have studied and learnt in Unit 2. Presently, both manual along with machine enabled techniques are employed for this purpose. The latter one is in tune with the advancements in the field of science and technology commonly known as 'information age'. Both of these climatological diagrams have common set of mandatory requirements as explained below:

### Data

- Secondary data of required elements of weather and climate of a place or an area of interest.

### Apparatus

- Ruled graph and tracing paper
- Black pen
- Drawing board
- Scale, HB Pencil, sharpener, and eraser

**(Note:** One compulsory prerequisite is to complete the reading of Unit 12 before you attempt to solve the given exercises to construct the diagrams under exercise no. 10 for submission into your practical record book).

## 10.3 FUNDAMENTALS

Let us take a quick glimpse of the theoretical components which you have learnt in Unit 12 before heading to solve the given practical exercises. You will agree that without properly learning the fundamentals, it is nearly impossible to take one step further to complete the related laboratory exercises accurately and lucidly.

### 10.3.1 Representation of Climatic Data Through Diagrams

You have studied some of the diagrams to represent the data of wind direction. These are known as wind rose and star diagram. Such diagrams are very useful for navigational purposes. You learnt that it is also known as star diagram or direction diagram. You came to know that this type of diagram is called star diagram as it looks like a star in which the rays radiate from the centre to all the directions in a centrifugal manner like that of an radial drainage pattern ( a water reservoir from which water streams or rivulets radiate into different directions usually from an elevated point) or a circular traffic chowk (for example, India Gate located in the Capital metro city of Delhi) from where roads radiate in different directions linking different places (inter-city and intra-city or linking different states and union territories of India). You are already familiar with the major and minor directions which include four cardinal and twelve sub-cardinal directions. You learnt that with the help of a wind rose, equal number of lines can be drawn radiating from the centre to show the given climatic data directly matching to these total sixteen sided directions as shown in Figure 10.1.

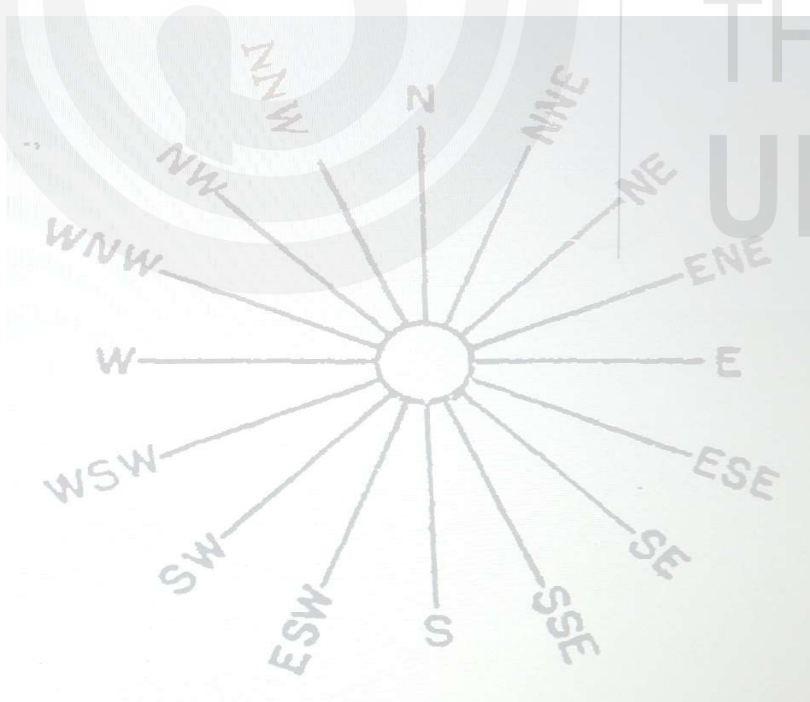


Fig. 10.1: Four Cardinal and Twelve Secondary Directions.

You further learnt that the length of each line radiating from the centre is directly proportional to the given quantity to be plotted and portrayed in a climatological diagram. Each line or ray of a star represents the number of hours or days in which the wind blew from a related direction for a given time period in a year. You have also observed that the wind may remain in a calm state for hours or days (as per the data in a given exercise). Such calm periods are denoted by its total numbers, which as a broad rule is written in the centre of the radiating lines by drawing a small circle (by choosing an appropriate scale, normally with a 1, 1.25, 1.5, 1.75 or 2.0 centimeter diameter) in the diagram. Once you finish drawing all the lines, then end points of these lines are joined one by one (starting from the first month of January and ending at last month of December) which is known as star diagram.

## 10.4 SOLVED EXERCISE

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Along with the exercises which you have read in the theory Unit 12, we will discuss some more cases pertaining to the star diagrams. We trust that it will immensely help you to get a fairly good idea as well as required skills to solve the practical exercises along with experimental exercises suggested in the succeeding section in the last part.

Here, we will talk about the detailed steps of construction demonstrated with one solved case each of different sub-kinds of star diagram as briefly discussed under (you have learnt some in theory Unit 12 and some you will learn here in this Exercise):

1. Wind rose diagram
2. Simple star diagram
3. Wind and visibility rose diagram
4. Compound wind rose diagrams

We will discuss one case each belonging to first two sub-types one by one illustrated with construction techniques in an apparent and systematic manner.

### **Wind Rose Diagram:**

As you learnt that it is one of the basic, commonest as well as easiest sub-types among the category of star diagrams. It is constructed to show the total number of days of a month in entire year on which the wind blew from a particular direction with reference to four cardinal and four sub-cardinal directions (you are already well familiar with it).

Let us attempt to solve an exercise for this sub-type to make you further learn the skills and techniques for trying hands-on yourself.

Exercise 10.1: Draw a Wind Rose diagram to show the data of wind direction for Panjim located in Goa, India as given in the below table.

**Table 10.1**

Direction of the Wind	N	NE	E	SE	S	W	SW	NW	Calm (no winds)
No. of Days	22	84	102	22	7	22	37	22	47

Source: Normal Climatological Tables, India Meteorological Department, Pune, India.

**Note:** N=North, NE=North East, E=East, SE=South East, S=South, W=West, SW=South West, NW=North West. First four of these are known as cardinal directions and last four are known as sub-cardinal directions with which you all are already well familiar.

### Steps to arrange and compute Data:

In this exercise, the required twin elements of weather and climatic data are already available in the arranged form. For this reason, you need not to carry out any arrangement and computation as such and can proceed directly to construct the two variants of star diagram.

### Steps-wise Technique to Construct a Wind Rose Diagram:

1. In the first step, you need to assume a small circle with a radius of 1, 1.25 or 1.50 centimeters. Fundamentally, this radius is generally assumed and drawn to write and represent the number of calm days i.e. lull condition, when wind didn't blow from any direction.
2. In the second step, you are required to draw a horizontal straight line almost in the middle section of a ruled graph paper or normal drawing paper. This line will represent the two major cardinal directions namely east and west corresponding to the eastern and western hemispheres on a globe.
3. In the third step, you are required to draw a vertical straight line which will intersect the horizontal line at the centre of a ruled graph paper or normal drawing paper. This line will represent the two major cardinal directions namely north and south corresponding to the northern and southern hemispheres on a globe.
4. Similarly, in the fourth step, you are required to figure out and draw the lines to depict the four secondary directions. These are north east, south east, north west and south west (NE, SE, NW, SW) respectively.
5. In the fifth step, you are required to intersect all the four cardinal directions. For example, to draw the lines representing the secondary direction of north

east, you have to intersect the part lying between that of north and east at 45 degree angle and then draw a straight line.

6. In the sixth step, you are required to repeat the same step in order to obtain and draw the lines to represent rest of the three secondary or sub-cardinal directions in a similar way.
7. Before attempting the next step, you must recall that we need to choose an appropriate scale to determine the length in order to draw the eight lines to delineate four main cardinal and four sub-cardinal directions.
8. In the seventh step, we have assumed that 1 centimeter long line drawn on a sheet of ruled graph paper will represent 10 numbers of days with reference to the blown wind for the time period under study.
9. In the eight step, you are required to follow this assumed scale and accordingly calculate the length of the lines as per the given data to represent the number of days when wind blew from these eight different directions.

For instance, the length of the line to be drawn in case of west direction is calculated as 2.2 centimeters. Now, you need to calculate the same for rest of the seven directions.

10. In the last step, according to the scale, when you have finished drawing all the eight lines, then join the outer tip of each of these points with a straight line. You can do so with the help of a scale in order to complete the construction process of this diagram. It will help to appear the final diagram more systematic as well as symmetrical.
11. After completion of the exercise, the resultant diagram will appear like the diagram as shown in Fig. 10.2 below.

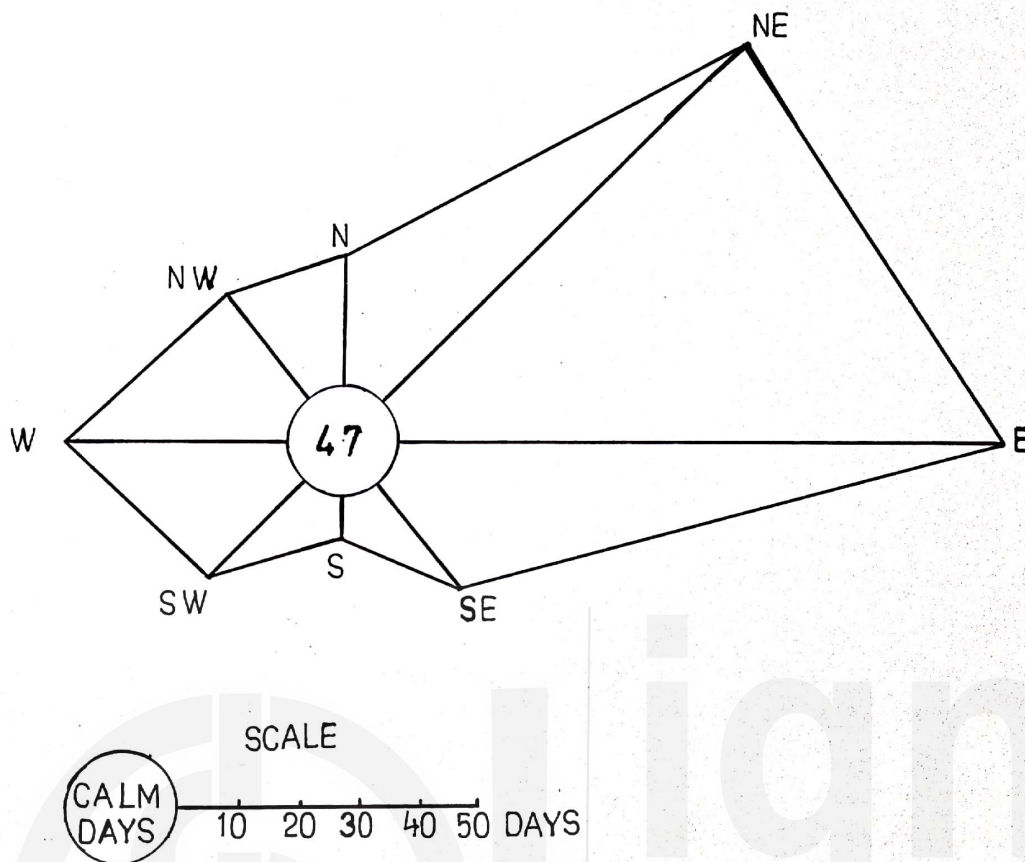


Fig. 10.2: Wind Rose Diagram of Panjim located in Goa, India.

**Simple star diagram:**

Apparently, you may yourself infer the meaning of this simple star diagram which is used to indicate the wind direction as like that of wind rose. We will demonstrate one case in this second sub-type of star diagram. Apparently, it is more or less like that of earlier sub-type except a slight variation in the construction technique and appearance.

Exercise 10.2: Draw a simple star diagram to show the data of wind direction for Ujjain located in Madhya Pradesh, India as given in the below table.

**Table 10.2**

Direction of the Wind	N	NE	E	SE	S	W	SW	NW	Calm (no winds)
No. of Days	4	15	40	22	4	11	98	58	113

Source: Normal Climatological Tables, India Meteorological Department, Pune, India.

**Steps to arrange and compute Data:**

You can carefully examine and discern that the required climatic data is already given in a desired format in the below given exercise. That's why you are not required to carry out any arrangement and computation. You may proceed to construct the simple star diagram.

### **Steps-wise Techniques to Construct a Simple Star Diagram:**

1. As like the steps followed in case of wind rose diagram, first six steps will remain the same in this case as well. However, there are further additional steps as discussed below.
2. In the seventh step, you have to suppose that 1 centimeter long line drawn on a sheet of ruled graph paper will represent 10 numbers of days with reference to the blown wind for the time period under study.
3. In the eight step, you have to follow this assumed scale and accordingly calculate the length of the lines as per the given data to represent the number of days when wind blew from these eight different directions.

For instance, the length of the line to be drawn in case of North-East direction is calculated as 1.5 centimeters. Now, you need to calculate the same for rest of the seven directions.

4. In the last step, according to the scale, when you have finished drawing all the eight lines, then join the outer tip of each of these plotted points with a straight line. You are required to take the help of a scale to let you finish the construction process of this climatological diagram. This step will make the final diagram look more symmetrical and orderly.
5. After completion of the exercise, the resultant diagram will appear like the diagram as shown in fig. 10.3 below.

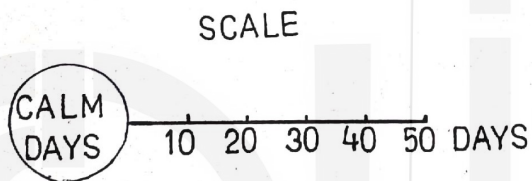
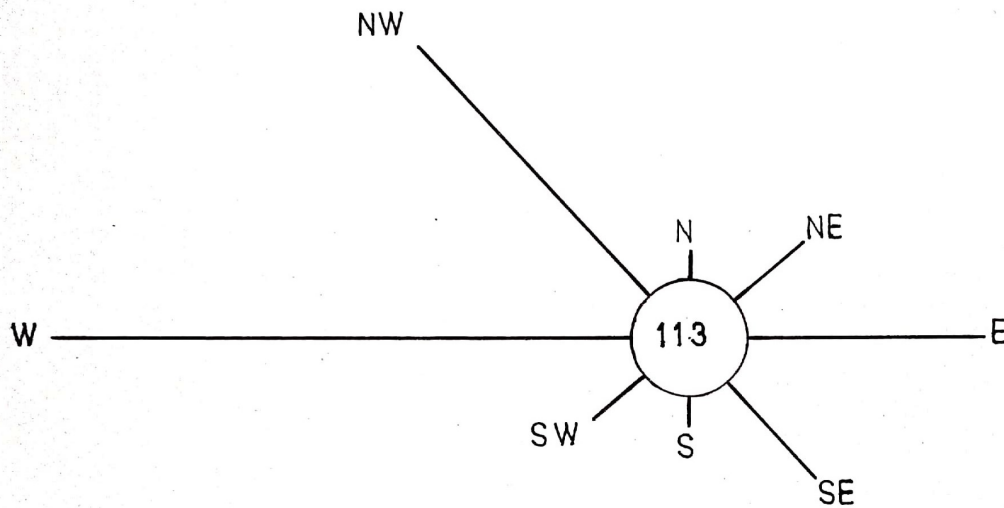


Fig. 10.3: Simple Star Diagram of Ujjain located in Madhya Pradesh, India.

## 10.5 PRACTICAL EXERCISES

You must compulsorily prepare one exercise each from the category of both the exercises as given below for two different types of star diagrams. You are required to write the pertinent answers. In addition, you must also include the analysis of the steps in detail before you submit these practical exercises in your practical record book. The same has already been mentioned in the introductory part of the laboratory booklet along with previous exercises.

**(Note:** You are required to systematically adopt the steps as mentioned in detail in the related theory exercises in Unit 12 and the solved exercises of this exercise 10 for fulfilling the requirement of submission of the same in your practical record book).

Exercise 10.3: Draw a wind rose diagram of Srinagar located in Jammu and Kashmir, India to represent the below given data in the table.

Table 10.5

Direction of the Wind	N	NE	E	SE	S	W	S W	NW	Calm (no winds)
No. of Days	2	8	5	18	6	9	4	7	41

Source: Normal Climatological Tables, India Meteorological Department, Pune, India.

Exercise 10.4: Draw a simple star diagram of Porbander located in Gujarat, India to represent the below given data in the table.

**Table 10.6**

Direction of the Wind	N	NE	E	SE	S	W	SW	NW	Calm (no winds)
No. of Days	9	7	4	1	2	15	17	17	28

Source: Normal Climatological Tables, India Meteorological Department, Pune, India.

As like previous exercise, we are emphasizing on a clue to try your hands-on to solve some suggested exercises independently as mentioned below:

- You may find out the freely available climatic and meteorological data from different websites as already mentioned in the previous exercise as well as in this one exercise.
- Obtain the required data in terms of climatic variables, and then try to construct different kinds of star diagrams in case of some other stations or your state and professional place as per your area of interest.
- As well, you may suppose a hypothetical data based on your existing knowledge supplemented with textbook readings for your area of interest (AOI).
- Thus, such voluntarily carried out experimental exercise may certainly help you to acquire more skills on the one hand and lead to gain more geographical knowledge in terms of climatic characteristics of another place on the other hand.
- Likewise, you may also be able to derive more benefits in general and particularly if you happen to take up higher studies in Geography.

## **10.6 SUMMARY**

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You have got the clear idea and successfully learnt the following skills in this exercise:

- You have learned the practical skills to show the wind direction and number of days graphically and diagrammatically through the construction of a climatological diagram.

- You have learnt about the two key methods to represent the climatic data viz., wind rose and simple star diagram to show the data of any geographical area of interest on a globe in the planet Earth.
- You got the idea that star diagram has sixteen radiating lines that represents the wind direction along with number of days when wind blew corresponding to these directions.
- You learnt that star diagram is made by taking the data of wind direction along with number of days to represent the climatic condition of a given station or geographical place.
- You learnt that wind rose is also known as star diagram or direction diagram due to star like appearance whereby the rays tend to radiate from the centre towards all the directions.
- You further learnt that each ray which you may visualize like the spoke of a bicycle represents the number of hours or days when the wind blows from the corresponding direction during a given time period.

## 10.7 REFERENCES/SUGGESTED FURTHER READINGS

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1. Khullar, D.R. (2003), *Essentials of Practical Geography*, Jalandhar: New Academic Publishing Co.
2. Mishra, R. P. and Ramesh, A. (1989) *Fundamentals of Cartography*, Concept Publishing Company, New Delhi.
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# EXERCISE 11

## INTERPRETATION OF INDIAN DAILY WEATHER MAP

### Structure

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- |      |                          |      |                      |
|------|--------------------------|------|----------------------|
| 11.1 | Introduction             | 11.5 | Practical Exercises  |
|      | Expected Learning Skills | 11.6 | Summary              |
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| 11.3 | Fundamentals             |      | Further Readings     |
| 11.4 | Solved Exercises         |      |                      |

### 11.1 INTRODUCTION

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You have already studied and learnt about the essential elements of weather maps in Unit 13 of the theory course on 'General Cartography' (BGGCT 133). Now, you are well familiar with weather maps and its kinds and learnt about some of its theoretical aspects. This exercise is a part of the lab component related to this Unit demonstrated through the interpretation techniques of weather maps as an integrated part in the same course. In addition, you have also learnt about weather forecasting and its importance particularly in few crucial sectors like aviation, sea navigation, precision farming and weather induced disaster alerts to minimize the losses of property and life.

In this exercise 11, you will learn about the key steps to read the weather code systems used to portray different elements of climate and weather in synoptic charts or weather maps which you have already studied in Unit 13. These code systems are devised and got subsequently improvised over a period of time and mutually agreed upon by all the signatory nations of World Meteorological Organization (WMO) located in Geneva, Switzerland. Such technically devised code systems to denote the different weather phenomena like wind speed and direction, atmospheric pressure, precipitation and cyclonic surge etc. got a thrust

directly as a result of spectacular technological developments. It took place in the twin fields spanning remote sensing, GPS and GIS (you will learn the details of these in your Skill Enhancement Courses of fourth and fifth semesters) coupled with ever powerful computational abilities. Nowadays, the data acquired from dedicated weather satellites like Meteosat of India, are providing the myriad of weather and climate related services. Some of the prominent beneficiary sectors are agriculture and its allied activities, aviation, forecasts related to impending natural disasters like cyclone, tsunami and floods etc. This exercise will equip you to portray the theoretical concepts and related climatological phenomenon for a particular geographical region, district, state or a nation for the given data on a map. Before this, we will briefly make you learn about the requisite apparatus along with nature and types of climatological data in Section 11.2. You have learnt that the interpretation of weather maps is very essential to know about two important aspects like the past climatic conditions and state of weather and impending weather induced disasters which we will briefly highlight for you to recapitulate the same in section 11.3. By now, we trust that you are well aware about the aptly done interpretation of such crucial climatic elements which plays a vital role concerning the safety of human beings as well as their spatial economic activities. Such activities may span from very mundane household level tasks to planning a travel for vacations to foreign (unknown) places/lands, setting up of an entrepreneurship unit to that of cultivation of crops, vegetables and flowers along with medicinal herbs in a highly sophisticated and scientifically carried out precision farming techniques. There may be multiple dozens of such spatial activities which are performed directly keeping in mind the prevailing weather conditions of a place. You may try to write down some of such activities in the margins of the page, which you may have observed in your surroundings, district, state, nation and different places of the world. Besides, it also provides a visual appeal to its diverse categories of intended users or clientele or group of community.

You know it well that maps, graphs and diagrams are also known as short hand script of a geographer. These visual techniques employed to portray multitude of data having geographical nature immensely helps a cartographer or a geographer to express hundreds and thousands of words with the help of one single or more than one corresponding methods of representation. These are also used by other earth scientists as well as social scientists.

## **Expected Learning Outcomes**

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After completing exercise 11, you should be able to learn the following:

- To explain about the secondary sources of weather and climatic data;
- To aptly interpret a given weather map for any areal unit as per the learnt procedures and techniques; and

- To visually highlight the key points in terms of both tangible as well as intangible phenomenon as portrayed in the given weather maps for various spatial economic activities and academic purposes.

## 11.2 REQUIREMENTS

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Before proceeding further, it is of utmost significance to know about the required requisite sets of apparatus and secondary sources of data.

### Data

- A published or schematic synoptic chart also known as weather map showing main parameters of weather and climate as explained.

### Apparatus

- Weather code systems with which you are familiar as learnt in theory Unit 13, you are required to refer the same.

(**Note:** You are required to complete the reading of Unit 13 before proceeding to perform the given exercises under this exercise).

## 11.3 FUNDAMENTALS

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As mentioned earlier, you have already studied and learnt in Unit 13 about the interpretation procedures of different elements on a given weather map. You may agree that the quick recapitulation of such fundamentals will immensely benefit you to solve the given exercises in succeeding Section.

### 11.3.1 Representation of Weather Components in a Map

You have studied that weather components are dealt with lot of scientific and technological inputs. You also came to know that 'Meteorology' is a scientific subject to study all the weather parameters in detail in its entirety which is a very promisingly upcoming vocational field. You learnt that there are several components of weather which are either individually or collectively displayed on a map through internationally standardised coded symbols. First component is **Atmospheric Pressure** which refers to the total weight of a unit column of air at any given place. An instrument called 'barometer' is employed to measure this column of air. Second one is **Wind Systems** in which Planet earth experiences a horizontal motion of air known as 'wind'. Wind is characterized by two main properties of direction and velocity. The instrument which measures the direction is called 'wind wane' whereas 'anemometer' is used to measure the velocity of wind. **Third one is Cloud Cover** which denotes the amount of sky partially or completely enclosed by various kinds of clouds at a particular time and place. The fourth component is **Precipitation** constituting a part of entire water or hydrological cycle. An instrument named 'rain gauge' is used to record the rainfall

in metric units i.e. either in millimetres, centimetres or inches. It is recorded for the entire length of day and night i.e. 24 hours. Rainfall occurs from the overcast sky into the atmosphere whenever substantial rain giving cloud cover develops e.g., nimbus clouds which literally means rain yielding mass of clouds. Besides these, other elements are known as **Atmospheric Attributes**, important ones are haze, mist, fog, dew, frost, drizzle, hailstones, snow, dust storm and cyclonic depressions etc. And also, the **Conditions of the Sea or Sea surface conditions** that are determined by the constantly prevailing wind systems.

### **11.3.2 Seasonal Characteristics of Indian Weather**

You have learned about the Indian weather system which is primarily characterized by four major seasons. Each season is characterized by variety and diversity of weather conditions year after year. The agricultural calendar across the geographical regions of India coincides and revolves around these major seasons. For example, the sowing and harvesting of major cereal crop of wheat in Northwest India takes place during the commencement of cold and hot weather seasons respectively. You came to know that these seasons are **1. Season of Cold Weather – December to February 2. Season of Hot Weather 3. Season of Southwest Monsoon (rainy) and 4. Season of Retreating Monsoon** as defined by the **India Meteorological Department (IMD), Govt. of India.**

### **11.3.3 Weather Symbols**

Before interpreting the weather maps of India, it is of utmost importance to first learn about the most commonly used specific weather symbols corresponding with different weather phenomena. Because, it is these two which will enable you to read and comprehend the various climatological parameters pertaining to the different weather seasons in details. In this exercise, we will take up the weather pertaining to any one weather season to practically demonstrate the techniques of interpretation of major elements.

Basically, it is a combination of symbols and abbreviation of letters. These are used to denote various weather elements. It is devised by Admiral Beaufort initially in 1806 and was subsequently modified in 1830. You learnt that the same plan is still in use at present, albeit, with some additions into it over a long period of time which became possible coinciding with two events. These two could led to academic paradigm shift (when one working model is supposed to be improvised or replaced by another better model) on one hand and constantly improving and empowering technological prowess at a nano scale on the other hand.

This meticulous plan of symbols was designed and approved by the International Meteorological organization located in Warsaw, Poland in 1935 (Singh, R.L. and Singh, R.P.B, 2003). It shows the versatility of weather symbols along with its praxis for various applications ranging from mundane tasks of daily commuting to that of highly specialized fields of scientific endeavours like precision farming and

sophisticated navigation systems etc. to indicate few important and prominent fields. If you are curious to know more about such crucial fields, try to list out the same by yourself after reading the related literature in the given page margins. This activity will surely help to further invoke your divergent thinking and cognitive thought processes. You will be amazed to notice that such small activities may do wonders to enhance your concept mapping skills and dexterity greatly with the passage of time. Besides, it may also raise the interplay between that of concepts and percepts to enable you to visualize the range of spatial things and objects in real world (including both physical and cultural features) with better acumens. One who possesses such distinctive skills has been recognized as a good geographer, who is able to differentiate and categorize the vast array of irrelevant things and objects into relevant ones to decipher subtle inferences for academic and non-academic purposes. In this line, the role being played by that of a climatologist and meteorologist bears a great personal and economic importance for different purposes and indispensable requirements of people of any geographical area, state or nation as explained previously. Weather and climate are a natural phenomenon which is not confined/restricted within a political or administrative boundary (in terms of village, tehsil, district, state and nation etc.) as its sphere of influence extends beyond and across.

## **11.4 SOLVED EXERCISES**

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You may recall the weather and climatic elements which are interpreted by adopting a set of procedures as learnt in theory Unit 13 and also briefly highlighted in sub-section 11.3.2. On the basis of this, now, you will learn about the interpretation techniques of weather maps through one case example.

This example pertains to the weather map of a month pertaining to the four different characteristic seasons of India. This map is obtained from the India Meteorological Department (IMD), Pune and New Delhi, India. Significant climatic parameters along with their sub-parameters that need to be studied in order to interpret the weather maps are discussed as under:

Exercise 11.1: Interpret the below given synoptic chart of 09 Nov, 1971 related to the winter season showing Indian daily weather conditions as given in fig 11.1 a and b.

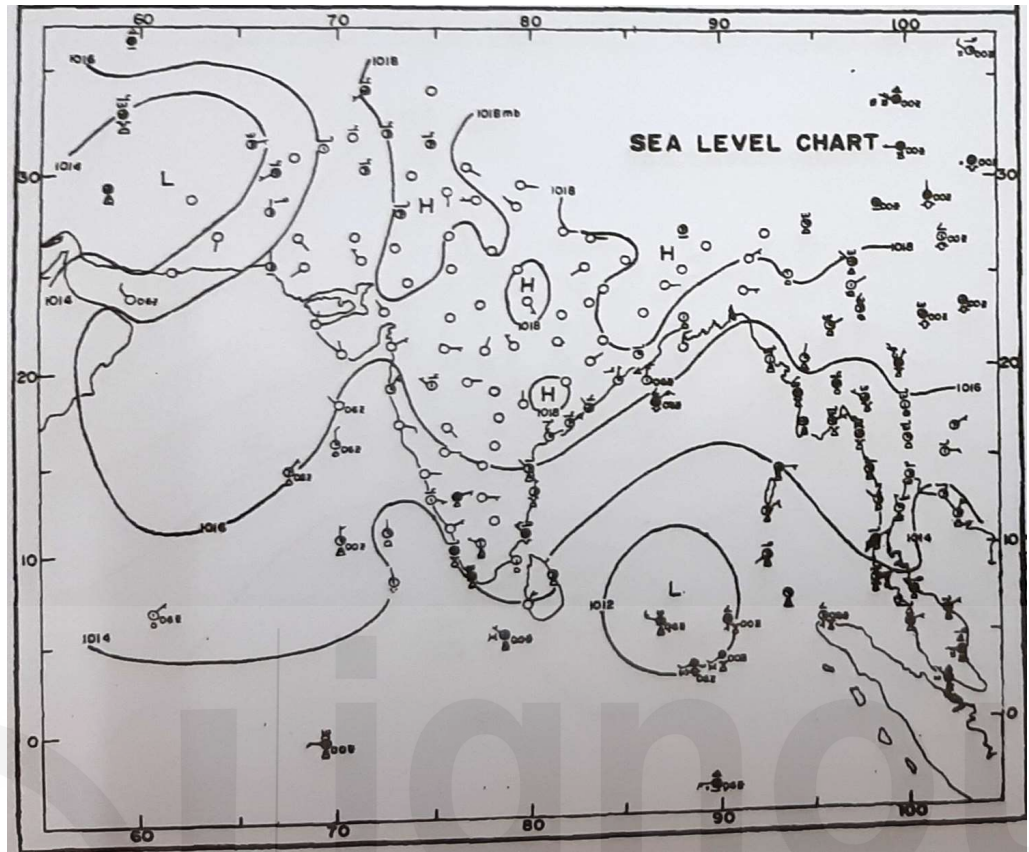


Fig. 11.2: (a) Synoptic Chart.

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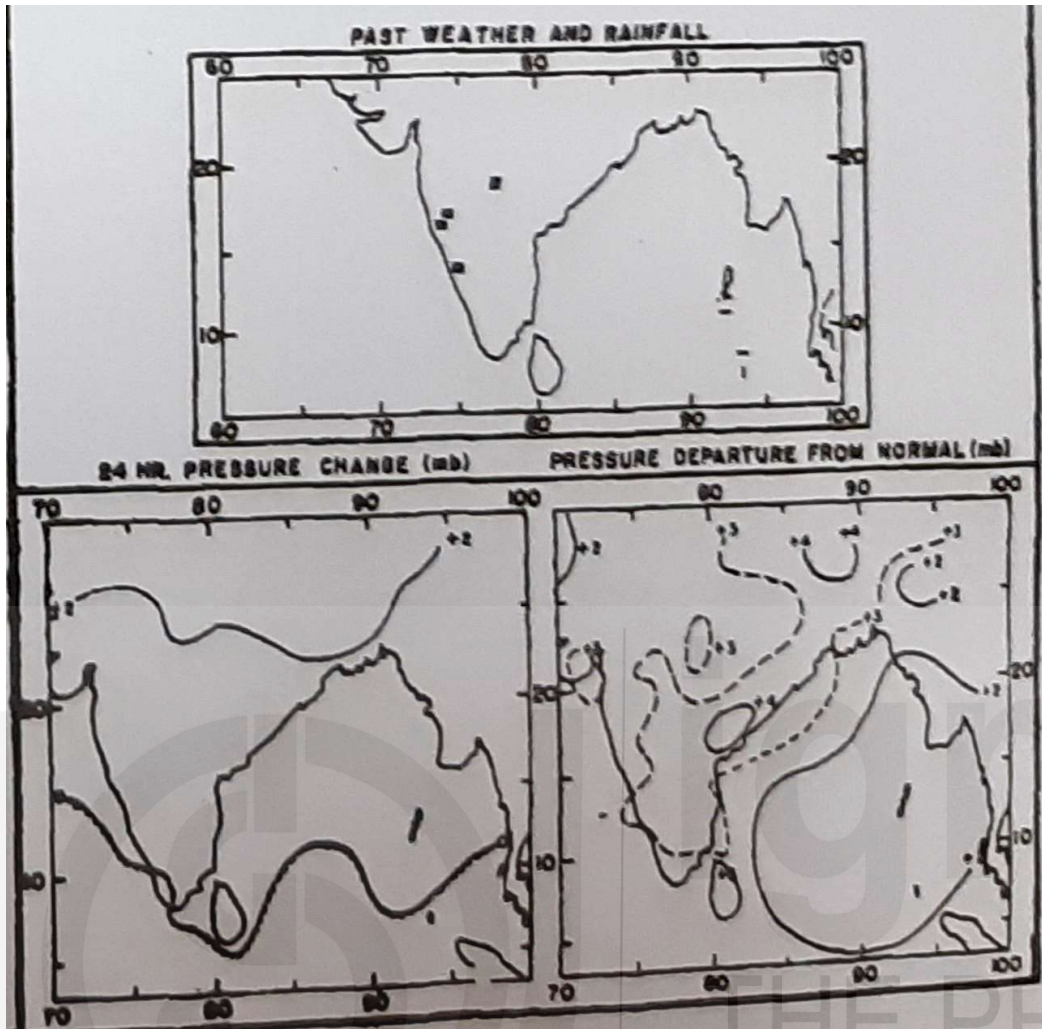


Fig. 11.2: (b) Rainfall and Pressure

**Source:** India Meteorological Department, Govt. of India, Pune, India.

(Note: Before starting the interpretation, it is advisable to recapitulate once again the weather codes very carefully to read the coded symbols as printed in the synoptic charts or weather maps. This will help you to interpret these scientifically and systematically in a smooth and apt manner as visualized in the given map).

In this exercise, there are no definite steps as such as like that of other thematic maps and statistical diagrams which you have learnt in rest of the exercises. However, you are required to follow the procedures of interpretation one by one to aptly decipher the printed coded symbols corresponding to diverse types of weather and climatic elements. Let us proceed and interpret these weather elements in a sequential manner as described in the procedures of interpretation in theory Unit 13.

### Conditions of Atmospheric Pressure

Normally, you can observe that pressure starts rising from south to north except some regional variations. Many of you might have noticed such phenomenon which happens during the months of winter season as well as shown in Fig. 11.2 (a).

### **Location of High Bars**

This indicates the areas having successive bars of high atmospheric pressure. First one was placed almost covering few regions of central parts of the Indian subcontinent. It was marked by the isobar of 1018 milibar. The second consecutive high pressure areas are situated to the south-east of first one. It covered the regions near the central portions of eastern coastal areas toward inland locations. It was marked by the isobar of 1018 milibar as like first one. The third one covered the parts of western and northern India indicated by the 1018 milibar isobar. This part covered the regions of Thar Desert and parts of Himalayan region further extending towards north.

### **Location of Low Bars**

The fig. 11.2 (a) indicates the prevalence of two low pressure areas over the Indian Sub-continent. The well developed first one covered the areas of the open sea to the west of Andaman and Nicobar Islands. It was marked by an isobar of 1012 milibar. The second low pressure area is situated in the western portions outside India. It was marked by the encircling isobar of 1014 milibar.

### **Isobar Trends**

The broadly spaced isobars indicate towards the seasonal retreating trends of the pressure distribution. This may occur on account of the retreating monsoonal winds characterized by pressure differences with marked regional variations therein.

### **Pressure Gradients**

Very broadly spaced isobars indicate the prevalence of very moderate pressure gradients. It covered the entire Indian sub-continent barring some regions around the portions of mid-southern and central India and some portions of eastern India with regional variations. None of the regions seem to be covered by closely spaced isobars as such with which many of you are familiar.

### **Wind Conditions**

(a) Wind direction (b) Wind velocity

#### **Wind Direction**

You have learnt that the weather element of wind direction is directly influenced by the high and low pressure area based on the prevalent season of a year. The

wind blew from regions of low pressure to regions of high pressure with regional variations on account of geographical and topographical factors. Wind direction was from west to east and vice-versa with some variations therein being influenced by the low pressure area situated at the outer edge of western India towards West Asia. It appears to be blowing from the north-east towards the south-east direction and vice-versa in the eastern coastal areas.

### **Wind Velocity**

You know that wind velocity is largely determined by the gradient of pressure. It can be seen from the Fig. 11.1 (a) that wind flow started from the south-west direction lying between isobars of 1014 and 1016 mb with 5 knot wind speed moved towards north-east direction. The winds touched upon the western coastal portions of the Indian sub-continent and moved towards eastern direction. The high pressure belts can be observed in the central portion of India mainly with 5 knot wind speed towards south-east direction (with isobar of 1018 mb). Due to the two successive high pressure belts in northern portion, the winds are recorded more or less stagnant discernible with capital letter 'H' (with encircling isobars). The winds seem to be originating from the Arabian sea between 10 to 20 degree latitudes, moving towards the north-east direction after encountering the western coastal land of India with varying wind speed. It can also be observed that north-west (isobar of 1014 mb) of land area and south-eastern parts (isobar of 1012 mb) of the sea recorded low pressure evident from the capital letter 'L' indicating calm winds. Overall, it is observed that western belt of the India during this month recorded high pressure with nearly stagnant winds.

### **13.4.3 Sky Conditions**

#### **Cloud Cover**

You can observe from the Fig. 11.2 (a) that atmosphere covering the entire Indian sub-continent is largely cloudless barring North-eastern regions. However, there are exceptions also. Few isolated geographical regions especially covering some parts of Northern and western along with scattered parts of western and eastern coastal India registered cloud cover in varying proportions. However, the sky remained almost cloudy in portions encircling the eastern India at few places in north-eastern parts of India.

#### **Cloud Character**

Almost the entire India seems to be relatively free from clouds. However, low or medium level clouds were noticed in few places along the eastern coastal regions along with the areas which receive maximum amounts of precipitation.

#### **Precipitation**

Parts of western India experienced some amount of rainfall. It can be observed from the fig. 11.2 (b) that most parts of the Indian sub-continent experienced almost dry conditions.

### **Other Atmospheric Attributes**

Generally, the sky condition was observed to be clear. However, some spells of atmospheric disturbances were noticed in some places in eastern coastal areas.

### **Departure of Pressure from Normal**

Entire parts of southern India experienced positive pressure departures. The same condition can also be seen prevailing in the geographical regions of western, eastern and to some extent in central India. However, the values of pressure departure vary between + 2 to + 4 milibars in these parts. Some areas spanning the coastal belts of Orissa, Andhra Pradesh and Tamil Nadu experienced a positive trend by recording more than + 4 milibar pressure departure from the normal.

### **Departure of Temperature from Normal**

The coded symbols or symbolic data for this element is not given and shown on these synoptic charts.

### **Conditions of the Sea**

The prevalence of moderate to strong winds extended over the coastal parts barring few portions on both east and west coast. The sea conditions were noticed to be calm with few exceptions. Some regions experienced stationary weather conditions extending towards the north in the western coast along the Malabar and Konkan coastal regions etc.

## **11.5 PRACTICAL EXERCISES**

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Now, we are giving below four exercises, you have to attempt any two and solve as given under:

Exercise 1: On the basis of below given weather map of India, interpret the areas of low and high pressure along with other weather elements with the help of weather codes neatly.

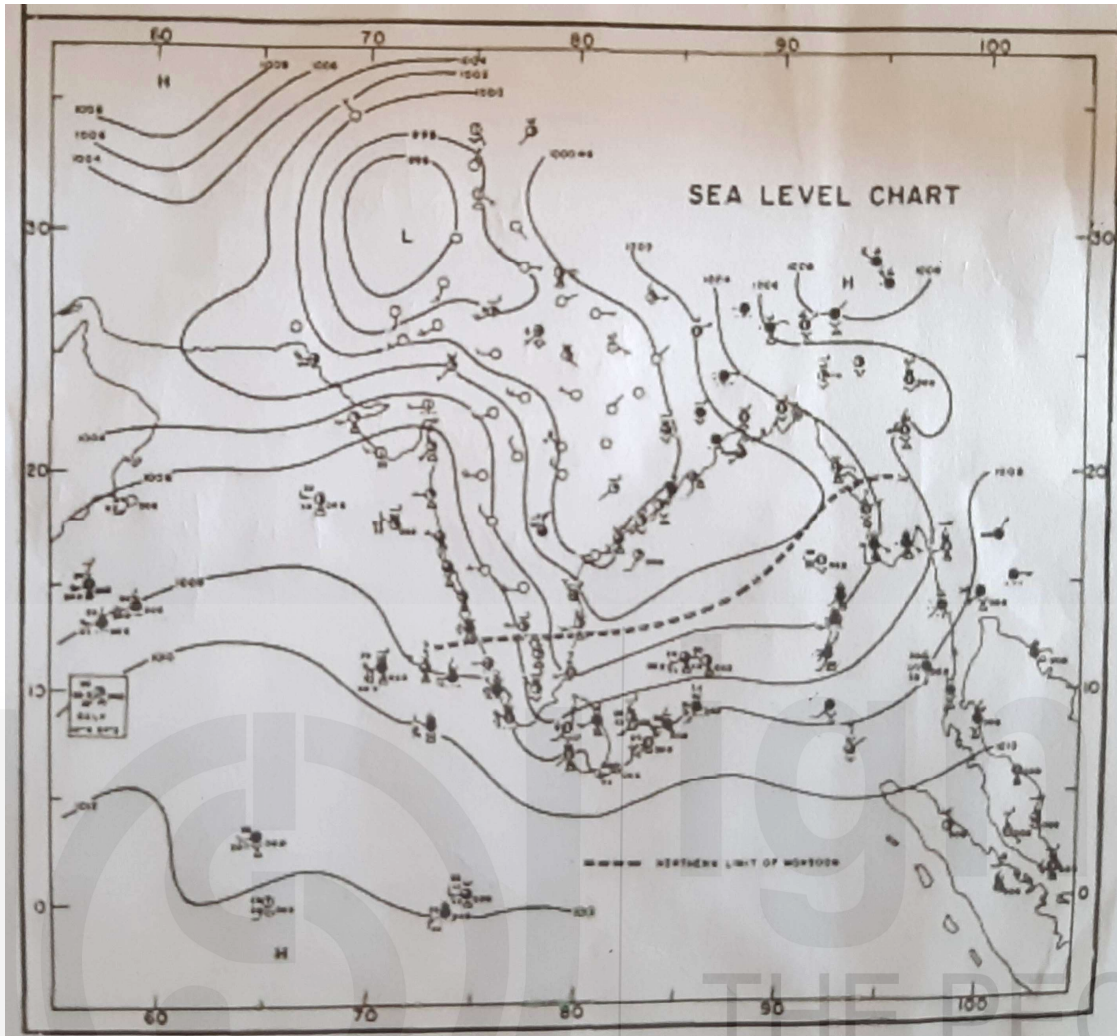


Fig. 11.3: Indian Daily Weather Map (Synoptic Chart 0300 GMT 28 May, 1969).

**Source:** India Meteorological Department, Govt. of India, Pune, India.

Exercise 2: Draw a schematic weather codes in the given outline map of India for any month to show the elements of wind velocity and direction prevalent during the northeast monsoon season. Suitably interpret and highlight the key points.

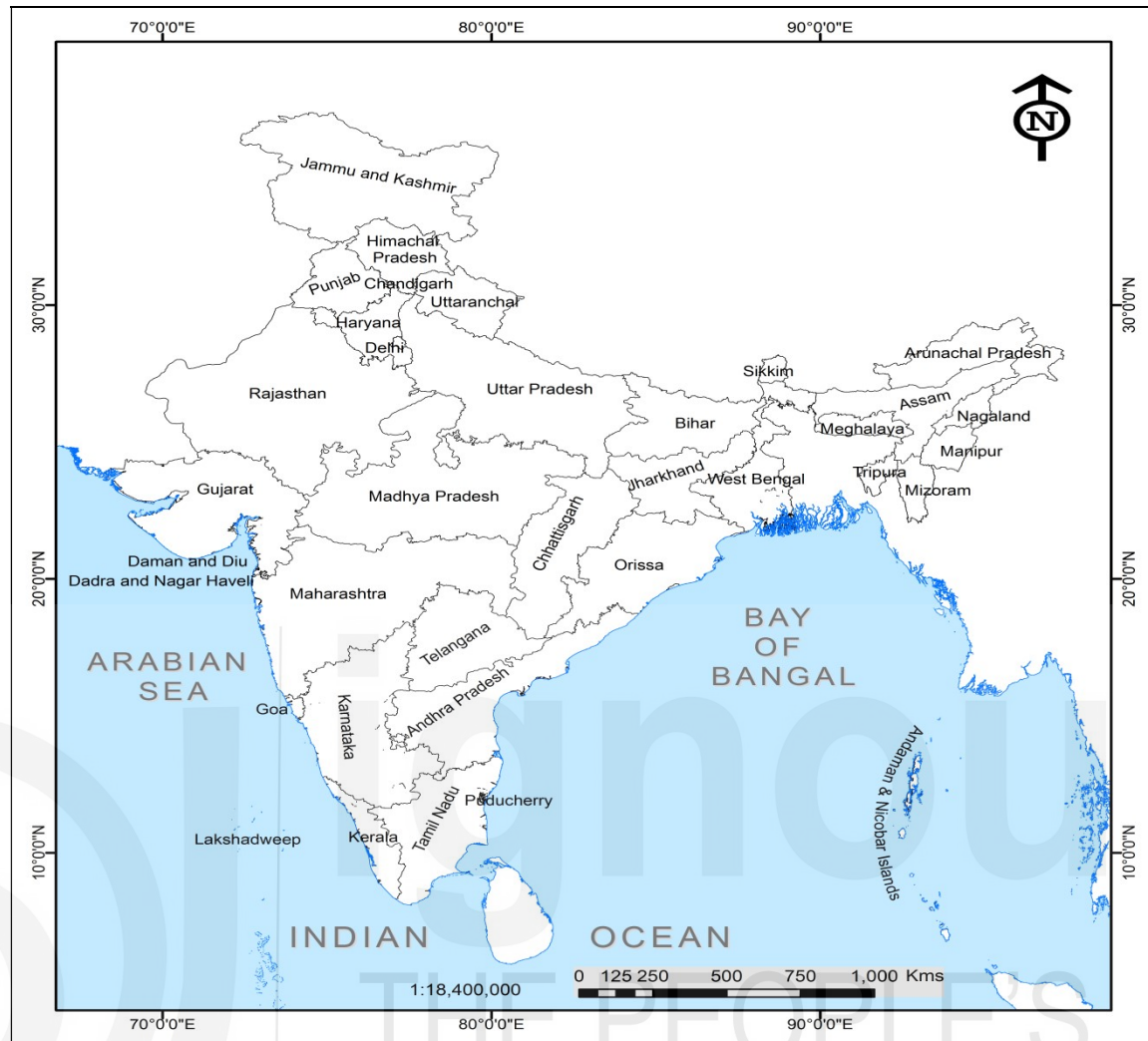


Fig. 11.4: Outline Map of India.

Exercise 3: Interpret the departure of temperature and pressure conditions on the basis of below given weather maps of India.

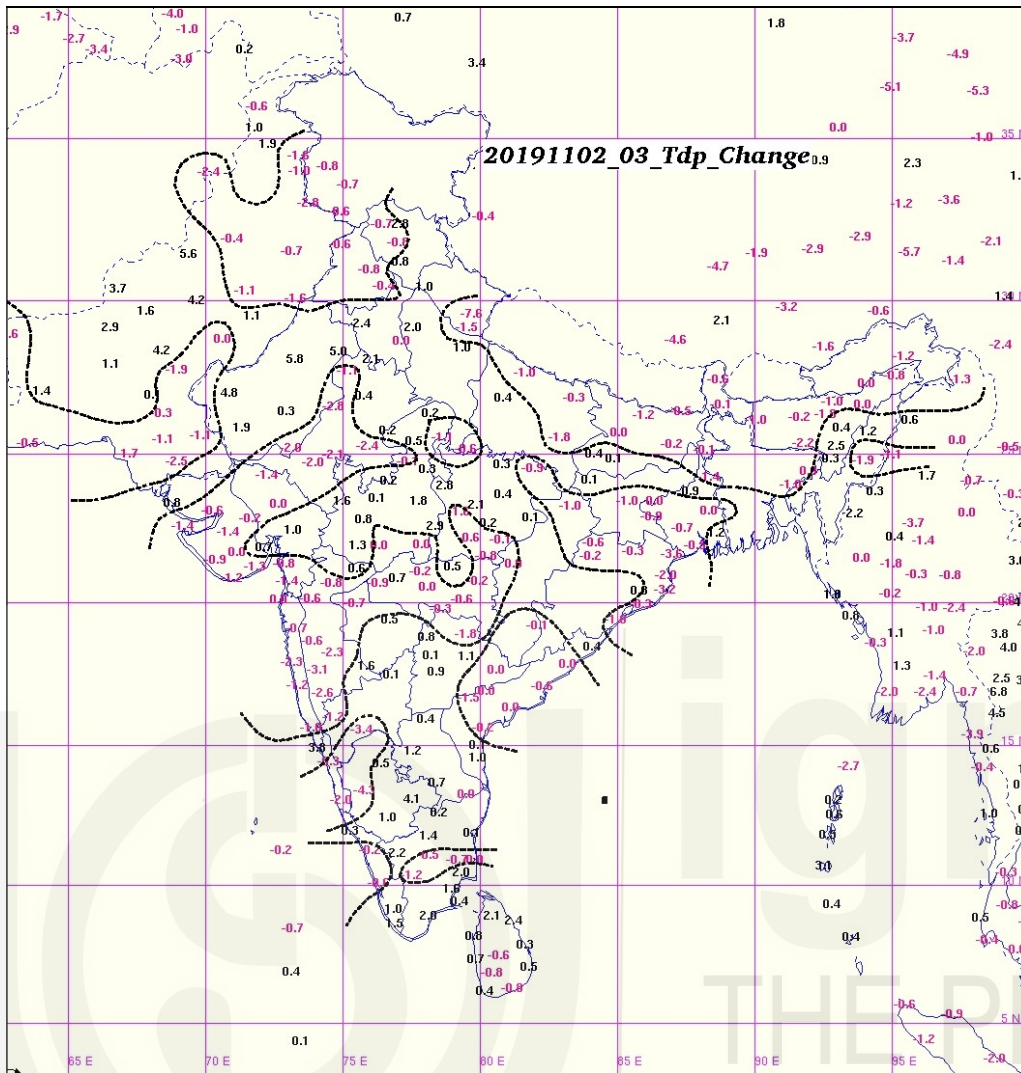


Fig. 11.5: Isopleth Map of India depicting the Departure of Temperature from Normal for the Month of November, 2019.

**Source:** India Meteorological Department, Govt. of India, Pune, India.

Exercise 4: As per the rainfall data shown in the weather map of India in Fig. 11.9, interpret the geographical distribution appropriately.

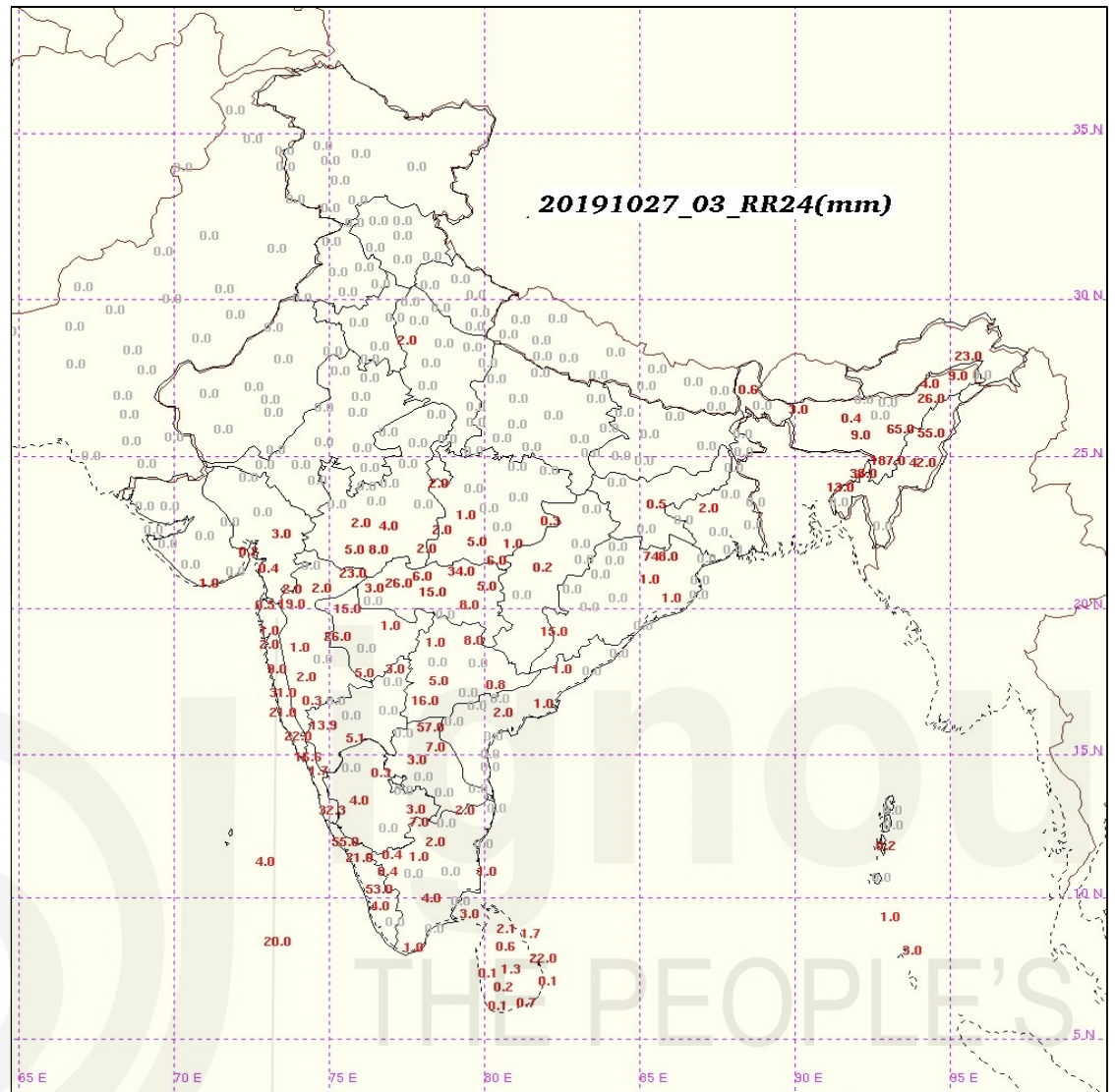


Fig. 11.6: Rainfall Map of India for the Month of October, 2019.

**Source:** India Meteorological Department, Govt. of India, Pune, India.

As emphasized in previous exercises, a brief idea is spelled out for independently solving some suggested exercises as given under:

- You may find out the available unrestricted weather maps from different websites as already mentioned in the previous exercise as well as this one.
- Once you have gathered the requisite weather maps, you may try your hands-on to interpret different elements of weather and climate one by one in the given map.
- Besides, on the basis of weather maps and reports which are available and downloadable for daily, weekly, monthly and yearly basis on the IMD website, further supplemented with related more readings; you may also schematically draw some of the weather elements on an outline map for

your area of interest (AOI). Then, you can try hand-on to interpret the same following due techniques and procedures.

- We believe that such hands-on to solve the experimental exercises may not only increase your knowledge level, but also let you handle and relate it with spatial economic activities carried out by human beings in particular like agriculture and travel etc.

## 11.6 SUMMARY

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In this exercise, you have learnt the following skills as highlighted below:

- To identify the coded weather symbols on a given weather map.
- To interpret different elements of weather and climate succinctly and derive proper meanings of these symbols.
- To signify the past and present weather conditions with the help of interpreted weather maps in a given map.
- To relate and apply the meaning of these both for academic and spatial economic activities alike.

## 11.7 REFERENCES/SUGGESTED FURTHER READINGS

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1. Khullar, D.R. (2003), *Essentials of Practical Geography*, Jalandhar: New Academic Publishing Co.
2. Mishra, R. P. and Ramesh, A. (1989) *Fundamentals of Cartography*, Concept Publishing Company, New Delhi.
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# EXERCISE 12

## PREPARATION OF SIMPLE THEMATIC MAPS

### Structure

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12.1	Introduction	12.5	Practical Exercises
	Expected Learning Skills	12.6	Summary
12.2	Requirements	12.7	References/Suggested
12.3	Fundamentals		Further Readings
12.4	Solved Exercises		Glossary

### 12.1 INTRODUCTION

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By now, you must have learnt and got a good idea about the maps and its types which you have studied in Units 2 and 15 of the course on 'General Cartography' (BGGCT 133). You are having proper knowledge about the theoretical aspects, characteristics, importance, utilization and limitations of maps as far as representation of various geographical phenomenon are concerned. This last exercise is also a part of the lab component corresponding to these two Units particularly Unit 15. In this exercise, we will discuss and demonstrate the construction of two cases of simple thematic maps. It includes both qualitative and quantitative categories. In addition, you are also well aware that how maps play an important role in teaching and research along with professional as well as daily activities of human life.

In this exercise 12, you will learn about the key methods to prepare two of the simple kinds of thematic maps. First two cases are qualitative maps pertaining to the choroschematic techniques and third one is quantitative case pertaining to the category of diagrammatic method. These two mapping methods will equip you to portray the theoretical concepts and related geographical phenomenon which you have learnt in the above-mentioned Units concerning a geographical entity for your area of interest on the globe or planet Earth. Before you start learning these three techniques, it is very important to learn about the requisite set of apparatus along with the nature, types and sources of geographical data discussed in Section 12.2. You have already learnt that

choroschematic is a mapping technique that helps to represent the distribution of qualitative aspects of human and natural parameters etc. Along with this, you will also learn about the maps made with the help of diagrammatic method. This method is primarily used to give a visual illustration of the selected phenomena under investigation which we will discuss in section 12.3. You are also familiar that this method is known by four different names as it helps to visualise the distribution which is otherwise imperceptible in the data inside the selected administrative units. You all know that maps, graphs and diagrams serve as a short hand script of the geographer to enable the depiction of thousands of written words with the help of one single or more than one corresponding methods of representation.

## **Expected Learning Outcomes** \_\_\_\_\_

After completing this exercise, you should be able to learn the following:

- To highlight a list of requisite sets of apparatus along with particular sets of data with its sources.
- To construct the two different variants of choroschematic maps by using qualitative data for a given geographical data of interest.
- To construct the diagrammatic maps by using quantitative data for a given geographical data of interest.
- To visually grasp the major distributional pattern of the phenomenon with reference to spatial distribution and variations for these mapping methods.

## **12.2 REQUIREMENTS**

As pointed out in earlier exercises, knowledge about the requisite sets of apparatus and varied sources of data are very important prerequisites before attempting to solve the practical exercises given in the last part of this exercise.

We will discuss and highlight these appropriately. You have already read about the history of mapping. Nonetheless, keeping in tune with the technological advancements, we believe that the knowledge and manual hands-on technique on exercises will help you to gain the deeper understanding and appreciate the art and science of map-making. All of you are well versed with the definitive purpose of maps along with graphs and diagrams. It is used to show the spatial distribution and areal variation through visualization of portrayed phenomenon in a single piece of paper without reading the corresponding lengthy text. Therefore, we are giving you the exercises to construct manually. For the construction of such simple thematic map types, you are essentially required to have following materials as discussed under:

### **Data**

- Secondary data matching with that of a selected outline map (as already explained in preceding exercises).

- One of the first prerequisites is to obtain an outline map showing administrative boundaries for the chosen area of interest or study. It could be at three administrative levels: district, state and national levels.

### **Apparatus**

- Drawing equipments like scale, set squares, protractor,
- Tracing sheets and drawing sheet paper
- HB Pencils, black pen, eraser and sharpener
- Drawing board and stencil pens

(Note: As outlined in preceding exercises, you have to compulsorily complete the reading and thorough understanding of Units 2 and 15 before attempting to solve the practical exercises. This will help you to recall the theoretical aspects and apply and relate these here).

## **12.3 FUNDAMENTALS**

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You will agree that without recalling the theory components which you have learnt in Units 2 and 15 concerning the meaning and purpose of simple thematic map types, it will not be prudent to move further. One will definitely not be only able to solve and construct the maps as per the given exercises on one hand and will not be able to appreciate the whole process involved in the art and science of map-making i.e., popularly known as cartography. You have studied and learnt that there are various methods to represent the given data. All of the methods or techniques of representation are broadly clubbed under two methods namely qualitative and quantitative methods. We will briefly discuss these two types for you to recall the same which may help you to relate these to solve the given practical exercises.

### **12.3.1 Qualitative Maps: Choroscopic Method of Representation**

You have studied that there are many types of qualitative methods. Here, we are taking up choroscopic method for illustration purpose. You have studied and learnt that choroscopic method is a kind of mapping technique to represent variety of both the characteristics including physical and human characteristics. You came to know that this method is useful to demonstrate the spatial distribution of chosen or given geographical features. It is achieved through drawing of either geometrical, pictorial, letter symbols or naming methods etc. You learned that it is done in two steps. The first step involves the portrayal of chosen geographical elements meticulously with the help above-mentioned symbols and method as per the given case. The second step involves the careful drawing of the same with even size and boldness on an entire map. Besides, you learnt that scaling technique is also employed to make it appear systematic, symmetrical and more useful. This is done to highlight the symbols that represent a specific amount and the number of symbols also. You have also studied that choroscopic map has

major benefit as one can show more than one element simultaneously on a single map. You have studied that classic example is that of Minerals map of India being prepared by the 'Geological Survey of India'. This map is prepared with an aim to show the availability and spatial distribution of metallic and non-metallic minerals across the states and union territories of India.

On the basis of theoretical knowledge gained so far, now, you will study the two cases of solved exercises pertaining to the choroschematic mapping technique. The study of the same will enable you to take on the task of attempting and solving the practical exercises as a mandatory component which needs to be submitted for evaluation.

### **12.3.2 Quantitative Maps: Diagrammatic Method of Representation**

Like qualitative maps, quantitative maps also encompass many methods of representation. Two of such methods namely choropleth and isopleth have been discussed and demonstrated with one each solved exercises in exercise number 6 of this laboratory course titled 'Cartography: laboratory' (BGGCL-134). Here, we are taking up diagrammatic method as an example for demonstration purpose which you learnt in Unit 15 also. In this method, you learnt that diagrams are used to highlight the distribution of various geographic features in a marked area on any given outline map under investigation. The placed diagram on the given outline map becomes known as diagrammatic map whereas diagrams are known as located diagrams. For such purposes, some of the commonly employed diagrams include bar, blocks, circular, cubical, line graph, rectangular, square and spherical diagrams etc. You have already learnt in detail about such diagrams in Unit 9 of the same course. You explored that this method is specifically used to serve three distinct functions concerned with thematic or distribution maps. First one is the necessity of explicitly showing certain geographical facts in terms of absolute statistical figures with the help of diagrams on the maps. Common example is that of depiction of land use map of a given geographical region which may be best represented by employing the circular diagrams. Second one states that the population of a largest city may best be shown by adopting the spherical diagrams. Third one, when you may confront a situation of non-availability of sufficient statistical data.

The key principles and techniques which one should keep in mind before attempting to make such diagrammatic maps are summarized as under:

- As per the chosen method of graphs and diagrams, their centers should match with the exact location of a given place as far as possible.
- The base of a graph or a diagram must be plotted corresponding to the center of the given place. Otherwise, it should be placed in such a manner that the same should be located inside the administrative boundaries of that place.

- In some cases, where adjoining administrative boundaries are to be shown in a diagrammatic map, in such instances, there shall be a case of overlap.
- To counter and navigate such situation, the chosen method of representation is required to be drawn in a sequential manner in terms of ascending order.
- The graphs or diagrams having smaller sizes should appear clear and legible (representing lesser quantities) whereas in case of larger ones, there may be some overlaps which may make it look like somewhat hidden under each other, which is usually taken within acceptable limits.

## 12.4 SOLVED EXERCISES

Exercise 12.1: Draw a choroschematic map by adopting geometrical array of symbols to show the distribution of coal and lignite in a given outline map of India.

**Table 12.1**

S. No.	Mineral	Distribution
1	Coal	Jharkhand, Odisha, Chattisgarh, West Bengal, Madhya Pradesh, Telengana and Maharashtra
2	Lignite	Tamil Nadu, Rajasthan, Gujrat, West Bengal, Jammu & Kashmir and Puducherry

Source: India, A Reference Annual, Publication Division, Ministry of Information and Broadcasting, Govt. of India, 2020.

### Step-wise Solution to Arrange the Qualitative Data:

We will discuss the crucial steps one by one in detail and sequence to enable you to solve this exercise.

- As per the above given data, you are required to portray the qualitative data. You know that this case doesn't require any calculation and data arrangement as such. You may proceed directly.
- However, you are required to choose the appropriate symbols by closely examining the nature and range of given items i.e. number of major metallic minerals and their spatial distribution in this exercise.
- Usually in such cases, we may choose an array of available geometrical symbols.
- These may include a whole range of geometrical symbols like dot, circle, semi-circle, arc, square, rectangle, triangle, hexagon and many others.
- In this case, the so chosen geometrical symbols are shown in legend in the bottom right portion of the final map as shown in fig. 12.1.

### Details of Step-wise Construction:

- In the first step, after meticulously examining the data, you are required to place the chosen geometrical symbol on the map as per the nature of its distribution all across spanning the states and union territories on an outline map.
- In second step, you have to keep on repeating the first step until you complete plotting all the chosen symbols for the coal and lignite in this exercise.
- The finally constructed map will appear as exhibited in Fig. 12.1.

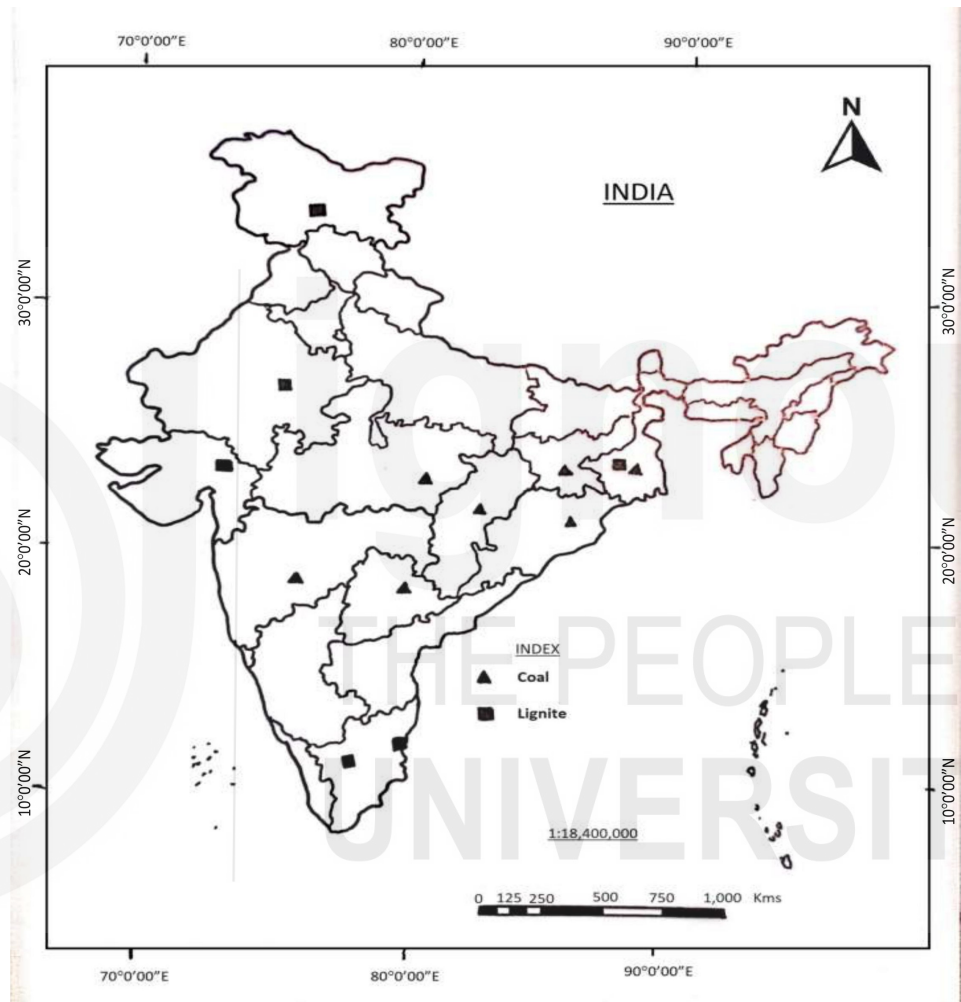


Fig. 12.1: Choroschematic Map showing the Distribution of Coal and Lignite in India.

Exercise 12.2: On the basis of given data below, draw a choroschematic map by following the naming method to show the distribution of major classical dance forms in a given outline map of India.

**Table 12.2**

S. No.	Name of the Major Classical Dance	States
1	Bharatanatyam	Tamil Nadu

2	Kathak	Uttar Pradesh
3	Odissi	Odisha
4	Kuchipudi	Andhra Pradesh
5	Kathakali and Mohiniyattam	Kerala
6	Manipuri	Manipur
7	Sattriya	Assam

### **Step-wise Solution to Arrange the Qualitative Data:**

As like previous exercise, the same steps will be followed one by one.

- In this case also, you are required to portray the qualitative data. You know that this case doesn't require any calculation and data arrangement as such.
- Hence, you are free to proceed further.
- You are required to write the name of a dance corresponding to its geographical distribution on a given map accordingly.

### **Details of Step-wise Construction:**

- In the first step, after meticulously examining the qualitative data, you are required to write the different types of dance on the map as per the nature of its distribution across the different states of the country.
- In the second step, you have to repeat this step until you complete writing the names of all the major types of classical dance on a map.
- The final map will appear as shown in Fig. 12.2.



Fig. 12.2: Choroschematic Map showing the Distribution of Major Classical Dance Forms of India.

Exercise 12.3: Draw a suitable diagrammatic map on an outline map of India to show the rainfall data in case of some select states as given in the below table.

Table 12.3

Monthly Rainfall (in Millimeters)												
Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cherrapunji	17.8	59.8	34.4	84.7	138.9	258.6	309.3	181.6	115.4	46.4	64.7	21.8
Dwarka	1.1	1.1	0.2	0	0	65.7	171.7	109.3	48.5	3.5	2.2	0.4
Madurai	8.5	11	18.3	60.1	80.6	34.3	56.9	93.9	121.5	18.5	14.7	51.3

Source: Normal Climatological Tables, India Meteorological Department (IMD), Pune.

**Step-wise Solution to Calculate and Arrange the Qualitative Data:**

- You may proceed directly to construct the diagrammatic map as required data is already given in a desired format.
- However, you are required to recall the diagrammatic methods which you have learnt in theory component in Unit 12 as well as Exercise 5 of the laboratory component.
- This will help you to choose the appropriate and correct method after carefully examining the nature and range of the given weather and climatic data.

### **Details of Step-wise Construction:**

- In the first step, you are required to precisely examine the nature and range of given data.
- In the second step, you have to locate the given stations or places on an outline map of India.
- In the third step, you may choose the line graph (considered as best to represent the given weather and climatic features) to show the distribution of monthly rainfall on an outline map of India as per the nature of its distribution for given number of meteorological stations all across the country.
- In the fourth step, you have to keep on repeating the third steps till you accomplish constructing the line graphs for all the given meteorological stations or places in an outline map of India.
- The resultant final map will look like as depicted in Fig. 12.3.

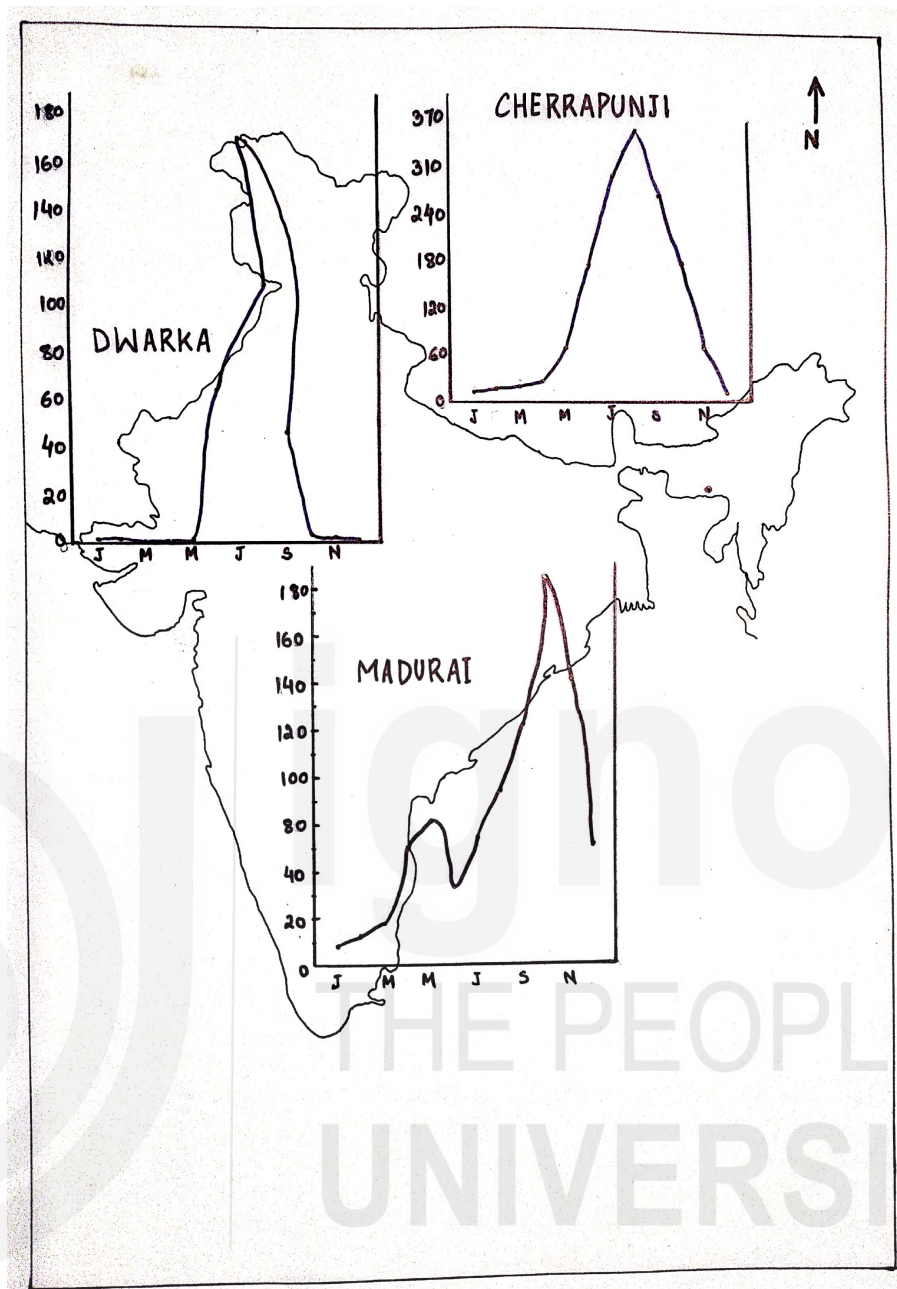


Fig. 12.3: Diagrammatic map showing the Distribution of Monthly Rainfall in Select Meteorological Station of India.

## 12.5 PRACTICAL EXERCISES

As like previous exercises, you have to compulsorily attempt one exercise each corresponding to two different variants of choroschematic technique. You have to write suitable answers and also interpret the detailed steps and procedures as followed while constructing these maps as given in the practical exercises. Then, you have to submit these final exercises as already explained in the earlier exercises and introductory part of the laboratory booklet in your Practical Record Book.

(**Note:** We suggest that you first carefully read and comprehend all the steps and procedures properly as explained above in detail before you proceed to solve these exercises).

From the below given two exercises, attempt and prepare both the exercises for submission into your Practical Record Book.

**Exercise 1:** Draw a choroschematic map to show the distribution of major wetlands across the states as declared under Ramsar Convention on the basis of below given data in the table on an outline map of India.

**Table 12.4**

Sl. No.	Name of the States	Number	Name of the Wetland
1	Andhra Pradesh	1	Kolleru
2	Assam	2	Deepar Beel
3	Gujarat	3	Nalsarovar Bird Sanctuary
4	Himachal Pradesh	4	Pongdam
		5	Renuka
		6	Chandratal
5	Jammu & Kashmir	7	Wullar
		8	Tso Morari
		9	Hokersar
		10	Mansar & Surinsar
6	Kerala	11	Ashtamudi
		12	Sasthamkotta
		13	Vembanadkol
7	Madhya Pradesh	14	Bhoj
8	Manipur	15	Loktak
9	Orissa	16	Chilika
		17	Bhtarkanika
10	Punjab	18	Harike
		19	Kanjli
		20	Ropar
11	Rajasthan	21	Sambhar
		22	Keoladeo NP
12	Tamil Nadu	23	Point Calimere
13	Tripura	24	Rudra Sagar
14	Uttar Pradesh	25	Uppar Ganga
15	West Bengal	26	East Kolkatta wetland

		27	Sundarban wetland
<b>Total</b>		<b>27 Wetland Sites</b>	

Source: Annual Report 2019-20, Ministry of Environment, Forest and Climate Change, New Delhi.

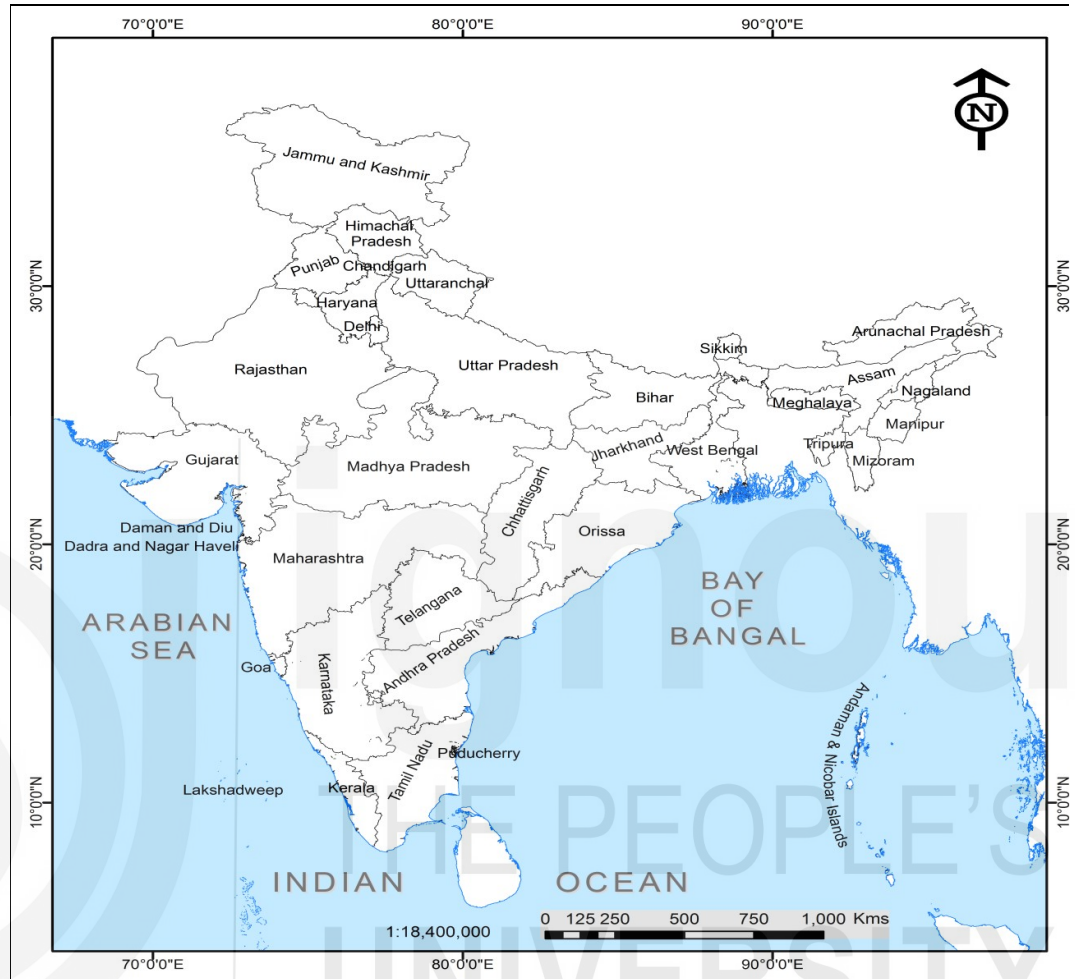


Fig. 12.4: Outline Map of India.

**Exercise 2:** Draw a diagrammatic map by choosing suitable method of representation to show the distribution of season-wise normal rainfall for the any three select meteorological sub-division wise stations on the basis of below given data for the year 2019 in an outline map of India.

**Table 12.6**

Sr. No.	Meteorological Stations	Seasons-wise Distribution of Normal Rainfall (in millimetres)			
		Winter	Pre-monsoon	Monsson	Post-monsoon
1	Assam and Meghalaya	46.7	587.8	1773.7	196.5
2	Haryana, Chandigarh	30.9	39.3	444.0	20.2

	and Delhi				
3	Gujarat Region	1.5	6.3	922.9	29.8
4	Tamil Nadu, Puducherry and Karaikal	27.9	126.4	342.0	447.4
5	Lakshadweep	25.2	203.3	1013.1	321.8

Source: Annual Climate Summary, 2019, India Meteorological Department (IMD), New Delhi.

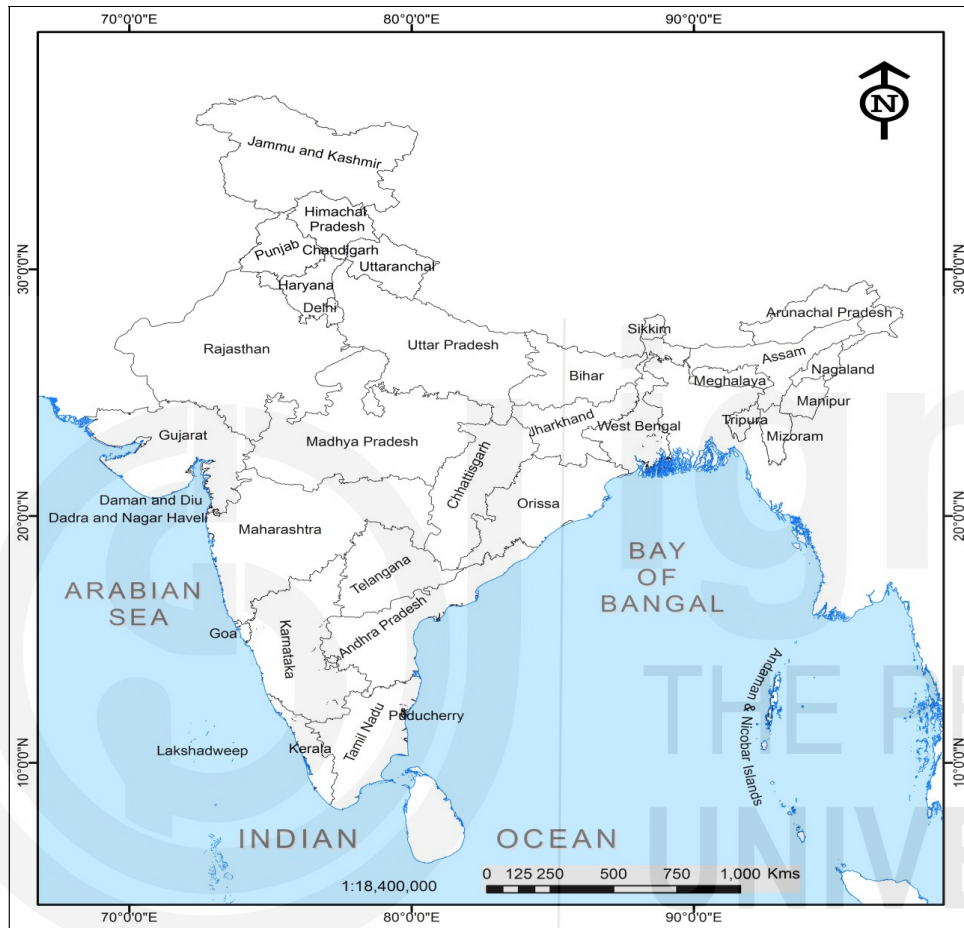


Fig. 12.5: Outline Map of India.

Following the hints pointed out in previous exercises from 6 to 11 except 7 & 8, some hints are also highlighted in this last exercise as well. You are free to explore further and try out your hands-on on experimental exercises voluntarily and independently as mentioned below:

- You are free to explore and find out the freely available secondary data of geographical nature from different govt. sources and websites as already explained in the previous exercises (the ones which you have studied in Units 8 to 10 of Block 3 in the theory course BGGCT 133).
- After collecting the required data for geographical variables of your area and interest, you may try to construct these two variants of

choroschematic maps and diagrammatic maps to show the spatial distribution and variations.

- Along with this, you are also free to generate hypothetical data in case of 'niche areas' (for which formal data is not available) based on your geographical knowledge for your theme of interest (TOI).
- You may definitely gain mapping and practical skills through such voluntarily and independently performed supplementary exercise on the one hand and the same may also help you to broaden your cognitive concepts and intellectual landscape which may help you to gain more and more geographical knowledge.
- As explained earlier, thus such well learned mapping skills may also help you to acquire cutting edge in your higher studies further and professional spheres as well to examine and take the things and issues with a critical bent of mind coupled with all-inclusive approach.

## 12.5 SUMMARY

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In this exercise, you have learnt the following skills as pointed out below:

- Besides secondary data and outline boundary maps, details of the basic requirements like drawing equipment's and stationary items before attempting to solve and prepare the maps based on given practical exercises.
- The techniques of making two variants of choroschematic maps in order to represent the geographical distribution as well as spatial variation of the chosen geographical phenomenon for a particular unit on the globe.
- You have also learnt the representation of climatic data with the help of a suitable diagrammatic method in a given outline map.
- You have appropriately learnt to represent the qualitative visualization of chosen phenomenon with the help of above-mentioned mapping techniques.
- You came to know that such mapping techniques helps not only a geographer, cartographer and economists but also serves as a definite tool and medium to other cognate disciplines to visualise the phenomenon as depicted on a given map.
- A thematic map also helps to explore and study the areal variation of a single geographic element to the user or an observer. The idea or rationale is to ascertain the geographical along with non-geographical factors which gives birth to spatial variations across the space and time.
- You have also explored and got acquainted that geographic phenomena could be both physical and human phenomenon as described in preceding Sections of this exercise and other exercises of this lab course as well.

- As a whole, thus, you learnt that such mapping techniques evolved through the space and time helps us to visualize and obtain knowledge without actually visiting and reading the lengthy text material through varied types of qualitative and quantitative thematic or distribution maps.

## 12.7 REFERENCES/SUGGESTED FURTHER READINGS

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1. Khullar, D.R. (2003), *Essentials of Practical Geography*, Jalandhar: New Academic Publishing Co.
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4. Sarkar, A. (2009) *Practical Geography A Systematic Approach*, Orient Blackswan Private Limited, Kolkata.
5. Singh, L.R. & Singh, R. (1973), *Map Work and Practical Geography*, Allahabad: Central Book Depot.
6. Singh R. L. and Singh, R. P. B. (1991) *Elements of Practical Geography*, Kalyani Publishers, Ludhiana.

## GLOSSARY

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<b>Appropriate design</b>	: It refers to the way we arrange the diagrams and their associated attributes during the construction. Appropriate design mainly consists of three features namely title, legend and scale.
<b>Atmosphere</b>	: It is composed of various major and minor gases surrounding the planet earth's surface.
<b>Atmospheric attributes</b>	: It includes small but significant weather phenomenon's like haze, mist, fog, dew, frost, drizzle, hailstones, snow, dust storm and cyclonic depressions etc.
<b>Atmospheric pressure</b>	: This refers to the total weight of a unit column of air at any given place.
<b>Cardinal direction</b>	: As well known to all of you, it refers to the four main cardinal directions namely North, South, East and West corresponding to Northern Hemisphere or North Pole, Southern Hemisphere or South Pole, Eastern and Western Hemispheres on a globe.
<b>Centrifugal</b>	: You have already studied about the term centrifugal in your first semester course on Physical Geography. You may recall that it refers to a force which originates in the centre and then radiates outward in all possible directions.
<b>Centrifugal drainage</b>	: It refers to a drainage system in which smaller rivulets or streams originate from the centre and then radiates outwards.
<b>Choropleth map</b>	: It shows the distribution of geographical phenomenon like population distribution, density, literacy and rural and urban population etc. through uniform colour shading or shading to show the intensity, density, distribution and variation in the given data visually.
<b>Choroschematic maps</b>	: It illustrates the spatial distribution of geographical features either through pictorial or letter symbols.
<b>Climate</b>	: Generally, it means the average weather conditions for more than 30 to 35 years.
<b>Climatic data</b>	: This refers to the statistics available for different parameters or elements of weather and climate like temperature, precipitation, pressure, sunshine, cloud, and wind etc.

<b>Climograph</b>	: It is a kind of diagram to represent two climatic variables in order to ascertain the four different climatic conditions known as raw, scorching, muggy and keen of a meteorological station. It is devised by Griffith Taylor and E.E. Foster.
<b>Cloud cover</b>	: It denotes the amount of sky partially or completely enclosed by various kinds of clouds at a particular time and place.
<b>Data Classification</b>	: To put the data into order into manageable class intervals for their graphical depiction and representation on a map with techniques and well laid down procedures.
<b>Data Tabulation</b>	: To arrange the data in a tabular form for further processing like analysis and interpretation, construction of diagrams and maps as per the need of the user.
<b>Depressions or cyclones</b>	: It means a particular geographic area characterized by low atmospheric pressure conditions. The atmospheric winds drive counter-clockwise in the northern Hemisphere and clockwise in the southern Hemisphere correspondingly. This term is also applied to denote the occurrence of catastrophic 'hurricane' in the Indian and Western Pacific Oceans.
<b>Diagram</b>	: It is a method to represent the vast array of statistical data graphically entailing innumerable geographical and non-geographical phenomenon's at local, regional, national and international scales.
<b>Diagrammatic Method</b>	: It is a kind of method to show the distribution of myriad types of geographical data by employing the different types of diagrams within the administrative boundaries for a given outline map as per the case.
<b>Hythergraph</b>	: Like climograph, it is also a kind of another diagram to represent two different climatic variables for exhibiting the weather and climatic conditions of a meteorological station or area of interest (AOI) under study.
<b>Index or legend</b>	: It refers to the key to read the portrayed phenomenon's through the use of standard symbols, data categories, schemes and labels in a geographical diagram or in a map precisely as well.
<b>Isarithm</b>	: A line on a map that links all points with the same value.
<b>Isobaric systems</b>	: Weather maps showing the isobars are commonly shown in a normal way. However, the shapes of isobars

	have numerous varieties corresponding with various categories of weather conditions.
<b>Isopleth map</b>	: It is a kind of quantitative areal map consisting of two words known as 'Iso' which means equal and 'Plethron' which means a multitude or crowd. This method is used to show the quantities with the help of lines drawn on the basis of equal values. Some prominent ones are isotherms (equal temperature), isobars (equal pressure), isonephs (equal clouds), isohyets (equal rainfall) and isorymes (equal frost) etc.
<b>Keen condition</b>	: It portrays the cold and dry condition when wet-bulb temperature remains below 40 degree Fahrenheit and relative humidity stays below 40 percent.
<b>Map Utility</b>	: It may cater to the needs of assorted range of users including academicians, researchers, administrators, planners and entrepreneurs etc.
<b>Muggy condition</b>	: This term signifies hot and humid condition when wet bulb temperature remains over 60 degrees Fahrenheit and that of relative humidity stays over 70 percent.
<b>One dimensional diagram</b>	: It is referred as a combination of several sub-methods to show only one dimensions related to a geographic entity or phenomenon graphically. The various diagrams are bar, line, pyramid etc. with their further sub-divisions.
<b>Outline map</b>	: It refers to a map having outline and inline boundaries which may be village, tehsil, and district, and state, national and international level on a given map.
<b>Precipitation</b>	: It refers to the part of entire water or hydrological cycle, when water falls on the earth's surface in its diverse forms like drizzle, rain, hailstorm, sleet and snow etc.
<b>Proportional or graduated symbols</b>	: Such kind of meticulously selected symbols are employed in a map in order to highlight the data values in relation to their point locations. You may amply and efficiently visualize the examples of a point locations which may consists of a village, town, city or million plus city or a metropolitan city etc. besides many others.
<b>Qualitative thematic maps</b>	: It is a kind of qualitative map in which generally one or more than one chosen theme is shown without using the numerical value or more popularly data to provide a good visual impression. Such maps are also known as thematic maps necessarily and hence not statistical maps.

<b>Qualitative maps</b>	: It refers to a kind of map in which qualitative aspects are visually represented. Few simple examples are choroschematic map and diagrammatic maps etc.
<b>Quantitative maps</b>	: It refers to a kind of map in which numerical quantities are visually represented. The common examples are dot map, choropleth map and chorochromatic maps etc.
<b>Quantitative thematic maps</b>	: In this type, the data is used to portray one or more than one chosen theme with the same purpose as like that of quantitative thematic maps.
<b>Raw condition</b>	: It represents cold and moist condition when wet-bulb temperature falls below 40 degree Fahrenheit and relative humidity remains over 70 percent.
<b>Scorching condition</b>	: This term indicates hot and dry condition when wet bulb temperature stays over 60 degree Fahrenheit and relative humidity remains below 40 percent.
<b>Secondary Data</b>	: It refers to the variety of data on human and natural resources being collected regularly and periodically by different government agencies to meet the requirements of multifarious purposes like planning, education and research etc.
<b>Star diagram</b>	: It looks like a star; therefore, it is known as star diagram. It refers to a kind of diagram in which like that of the rays of a star, eight radiating lines representing four cardinal and four sub-cardinal directions are drawn to quantify (no. of hours or days) the wind direction.
<b>Suitable Scale</b>	: The selection of an appropriate scale is very important and fundamental aspect keeping in close consideration the type and size of data to graphically exhibit the same by employing appropriate methods of representation.
<b>Synoptic charts</b>	: These are prepared by the IMD to depict the weather conditions at six times for different parts of hours everyday with the help of satellite data supplemented with data acquired from ships in the sea for various purposes and community of users.
<b>Three dimensional diagrams</b>	: It is referred as a combination of several sub-methods to show three dimensions of a geographic entity or phenomenon graphically. The various types include cube, sphere, and rectangle etc. with their further sub-divisions.

<b>Thematic maps</b>	: As the name itself reveals that it is a map solely based on one or other definite themes. Fundamentally, such maps made on the basis of a theme represents a variety of physical and anthropogenic themes to cater to the requirements of a specialists as well as general community of users.
<b>Two dimensional diagrams</b>	: It is referred as a combination of several sub-methods to show two dimensions concerning a geographic entity or phenomenon graphically. The various types include proportional circle, pie and block etc. with their further sub-divisions.
<b>Visualization</b>	: It means the representation of both qualitative and quantitative data through various types of maps and diagrams to represent the given data in order to show the spatial and temporal variation at a glance without reading the lengthy text in a document.
<b>Weather</b>	: It denotes the atmospheric condition at any given time or place over the earth's surface.
<b>Wind direction</b>	: It refers to the four cardinal and twelve secondary directions (in total 16 directions) from where the wind keeps blowing across the geographical realm or regions of globe, each with unique seasonal and local characteristics.
<b>Wind rose diagram</b>	: It is one of the commonest forms of star diagram having sixteen lines representing sixteen different directions from where wind blows with varying quantity varying from one season to another season.
<b>Wind velocity</b>	: You are familiar with it as a measure of the wind speed and also an indication about the above-mentioned directions.