UNIT 3

MAP SCALE

Structure

3.1 INTRODUCTION

You have already studied the introduction to cartography in Unit 1. If you have remembered correctly then cartography is nothing but 'an art and science of map making'. When we say it is science which means it follows certain scientific procedure which are universally accepted while constructing a map. Scale is to be specific and is one of the essential parts involved in the construction of map. Therefore, we can say that scale is very essential element of a map as it provides the true measurements of area or length of any feature on the ground. Without scale, a graphic representation will not be called a map and remains a figure or sketch. And, therefore, it is the most important element of a map. Try to find out what are the other essential elements of a map apart from the scale.

In this unit, we will describe the concept of map scale in Section 3.2 followed by representation of scale in Section 3.3. In the Section 3.4, we will explain conversion of scale by solving one example each for the conversion of

statement of scale to representative fraction (R. F), and vice versa. In the last section i.e. Section 3.5, we will discuss about four major types of scale i.e. plain scale, comparative scale, diagonal scale and vernier scale and also solve one example each.

In the next Block, you will read in detail about Map Projections where three dimensional image of the earth has been transformed to a two dimensional surface for which map scale is also an essential element.

Expected Learning Outcomes

After studying this unit, you should be able to:

- explain the concept of map scale;
- describe the three methods of representing map scale;
- perform scale conversion;
- describe various types of map scale and methods of construction; and
- interpret the reading of map scale.

3.2 CONCEPT OF MAP SCALE

You might know that without a scale, a map is incomplete and cannot be technically named as Map. Without scale a map is called a sketch. Why it is so? This is because we cannot precisely identify the exact measurement of distances between two places depicted on the map. Now, can you define a map scale? In simpler terms, map scale can be defined as:

"the ratio between the distance on map and the actual distance on the ground."

This can be expressed as:

$$\text{Scale} = \frac{\text{Map distanace between two points}}{\text{Ground distance between the same points}}$$

The representation of earth or even a piece of area cannot be done on a piece of paper practically without fixing a proportional geometric shape or symbols representing the features on the earth as paper cannot always be of the same size of the area under representation. For this reason, the maps are drawn on small piece of papers of varying sizes using some representative proportions where certain distance or size of representing features on the paper is true to the fixed proportionate size on the ground. For example, one centimetre line on paper may represent one kilometre distance on the actual ground.

The above discussion raised a broad question in our mind. The question is what are the factors responsible for deciding the appropriate scale? There are broadly three factors which are as follows:

- The magnitude or size of an area to be represented on a map;
- The extent of details to be represented on the map; and

- The size of the paper in which the map is drawn.

These three questions brought two concepts i.e. small scale and large scale maps. Let us now briefly discuss about these concepts.

- **Small scale maps** are those maps which depicts large area covered on a small size of paper. In this type of map, the scope for detailing about the area is not possible. Therefore, it depicts only important features and details about the area which are not available. Atlas map is the best example of small scale maps.
- **Large scale maps** are just opposite to small scale maps which depicts small area covered on a relatively bigger size of paper. Therefore, this type of maps depicts the earth's surface features in detail. Topographical maps and cadastral maps are the best examples of large scale maps.

Now, you must have understood the concept of map scale. Let us pause for some time and perform the below given activity to recapitulate what we have learnt till now.

SAQ 1

a) What is scale?

b) Differentiate between small scale and large scale maps?

3.3 REPRESENTATIVE METHODS OF SCALE

After defining the scale, one of the obvious questions that come to our mind is about the methods of showing scale on a map. Do you know the different methods of representing the scale on a map? Yes, you are right, broadly, there are three ways of representing scale. These are as follows:

- Statement of Scale
- Linear or Graphic Scale
- Representative Fraction (R.F.)

Each methods of representation have its own merits and demerits. Let us discus them one by one.

3.3.1 Statement of Scale

As the name suggests, in this method, the measurement of the map scale is represented in the form of a statement. The example may be as follows:

1 Centimeter to 1 Kilometer

It means that 1 centimeter distance on map is equal to 1 kilometer distance on the actual ground.

Major advantage of this scale is its simplicity to understand, but it has some disadvantages also. The major disadvantage of this scale is its non-flexibility. Let us understand this. When we enlarge or reduce a map by way of reproduction especially through scanning or photocopying, the scale changes.

But in this form of representation, the scale remains fixed in the form of a statement despite changes in the size of a map. The second major disadvantage is that one has to take stated measurement from somewhere else to calculate it on the map. The person not having the idea of unit of measurement of distance will have difficulty to relate the distances on map and the ground.

3.3.2 Graphic Scale

Graphic scales are those scales, which are depicted through graphs mixed with lines and/or empty or black blocks showing primary and secondary divisions. A line or a linear rectangle is divided into equal primary divisions representing a definite distance on the map corresponding to the ground. Again, the first primary division is sub-divided into secondary sub-divisions. You will learn about the geometrical construction of primary and secondary division of a graphic scale in the Practical Manual. The divisions and sub-divisions are then marked by statement to indicate the distance on the ground.

The graphical scales are constructed from the statement and ratio scales. The other property of the graphic scale is that it also represents comparative measurements and scales of cube roots and square roots. In the Section 3.5, you will read in detail about various types of graphical scale namely plain scale, comparative scale, diagonal scale etc. along with examples.

3.3.3 Representative Fraction (R.F)

It shows the relationship between the map distance and the corresponding ground distance in units of length. This can be expressed as:

$$\text{Representative Fraction (R.F)} = \frac{\text{Map distance}}{\text{Ground distance}}$$

This method of representing the scale is completely independent of unit of measurement. In other words, it is a universal unit. What does this mean? This means that it can be converted into any unit of measurement. That is why it is the most versatile method.

Let us understand the above mentioned statements in detail. This type of scale is expressed as numeric ratio, like 1:1,000,000 meaning thereby 1 unit of distance on the map is equal to 1,000,000 units on the ground. The numerator is always expressed as unity or 1 and remains constant which represents the map distance or unit. On the other hand, denominator is the ground distance, which varies according to the area covered in the map. That is why it is called ‘Representative Fraction’ or R.F.

One very important point to remember is that larger the value of a denominator, smaller will be the scale and vice versa. In the former case, the map would have large area coverage but fewer details in the map. Contrary to this, smaller the denominator, larger will be the scale with small area coverage but having more details. For example, ‘million map’ is an example of small scale map, and 1:25,000 map is that of a large scale map. The selection of scale depends on the purpose. The second point to remember is that both the units i.e. numerator 1 or map distance and denominator or ground distance

should be in the same unit of measurement like milimeter/centimetre/kilometer or inch/mile. Despite having so many advantages, this method of representation is also not free from disadvantages. The biggest disadvantage of this scale is that it is not as convenient as graphic scale both to measure and read.

After knowing different methods of representation of scale, let us perform the below given exercise which would help you in recapitulating what you have learnt in this section.

SAQ 2

Fill in the blanks with suitable words:

(a) Major disadvantage of statement of scale is that the person not having the idea of unit of _____will have difficulty to relate the distances on map and ground.

(b) In graphic scale, a linear rectangle is divided into equal _____ representing a definite distance on the map corresponding to the ground and the first primary division is sub-divided into _____.

(c) Representative Fraction is completely independent of _____and therefore it is a _____ unit.

3.4 METHODS OF SCALE CONVERSION

In the previous section, we have discussed three methods of representing scale. Do you know that these scales can be converted from one method to other? In this section, we will describe methods of conversion from statement of scale to Representative Fraction and vice versa with the help of one example each.

Let us understand the steps involved in both the conversion.

3.4.1 Statement of Scale to Representative Fraction

Let us now learn to convert a statement of scale to Representative Fraction with the help of following example.

Example 1: Convert the given Statement of Scale of 1 cm represents 5 km into R. F.

Solution: The below given are the steps to be followed while converting Statement of Scale into R. F.

1 cm represents 5 kms

Or, 1 cm represents 5 × 1,00,000 (1 km = 1,00,000 cms)

Or, 1 cm represents 5,00,000 cms

We can now replace the character “cms” into “units” and read it as:

1 unit represents 5,00,000 Units

Answer is R. F. 1: 5,00,000

3.4.2 Representative Fraction to Statement of Scale

After learning conversion from Statement to R.F., let us now learn to convert a Representative Fraction to statement of scale with the help of following example.

Example 2: Convert the given R. F. 1:1,000,000 into Statement of Scale.

Solution: The following steps are involved in the conversion of Representative Fraction into statement of scale:

1:1,000,000 means that 1 unit on the map represents 1,000,000 units on the ground.

If it is to be expressed in metric system of measurement i.e., in Centimeter, Meter and Kilometer, then the steps are as follows:

1 cm represents 1,000,000/100,000 (1 km = 100,000 cm)

Or 1 cm represents 10 km

Answer: 1 cm represents 10 km.

If it is to be expressed in British system of measurement i.e., in inch and mile measurement, then the steps are as follows:

1 inch = 1,000,000/63,360 (1 Mile = 63,360 inches)

Or 1 inch = 15.78,283 Miles

Answer: 1 inch = 15.78,283 Miles

Till now, we have discussed the concept of scale, representation of scale and conversion of scale. In the following section, we will discuss various types of scale.

3.5 TYPES OF MAP SCALES: CONSTRUCTION AND READING

After defining the scale and describing various methods of representing scale, one of the obvious questions that comes to our mind is about the types of scale. Do you know how many types of scales are there? Yes, you are right, broadly, scale can be classified into five types. These are as follows:

1. Plain Scale
2. Comparative scale
3. Diagonal scale
4. Vernier scale
5. Special types scale.

In this section, we will discuss only one example each for plain scale, comparative scale and diagonal scale. Before discussing about various types of scale, we should know about the following points. These points should be kept in mind, at the time of construction of graphic or linear scale.

Steps Involved in the Construction of Graphic Scale

1. The scale should indicate the actual distance in round figure, such as 10, 20, 30, and so on. However, the length may not be in round or full digit always. It may be in decimal also.
2. Normally, the length of the graphic scale should be between 4 to 6 inch or 10 cm to 15 cm.
3. The division of graphic scale into primary and secondary divisions is made by geometrical methods about which we will discuss in Practical Manual. The value of each division should be mentioned on the upper side of the scale. The left side of the scale has the secondary division, showing the smallest measurement of the scale.
4. As discussed under section 3.3.2, this scale has two parallel lines. Conventionally, the lower line should be thick and each section of the scale may be shaded in alternate manner.

3.5.1 Plain Scale

Plain scales are those which measure up to two units or a single unit through its divisions and sub-divisions. Let us explain this with examples. Example of two units of measurement is 2 kilometer and 200 meter. Examples of divisions and sub-divisions are 5.4 cm and 3.8 meter, etc.

As mentioned above, plain scale represents up to two units, therefore, it consists of a line divided into number of equal main parts and the first main part is sub-divided into smaller parts. Zero (0), is marked at the end of the first main part. From zero mark numbers to the main parts or units towards right and give numbers to the sub-divisions or smaller parts towards left. Give the names of the units and sub-units below clearly. Indicate below the name of the scale and its R.F clearly.

Construction of plain scale is explained below with the help of an example. For your understanding, the process of construction is being explained in a step-wise manner.

Example 3: The R.F. of a map is 1:250,000. Construct a plain scale with primary and secondary divisions to read up to one km.

Solution: Before initiating the construction, we have to perform the following calculation to derive the length of the scale.

The given R. F. of the map is 1:250,000.

As we want to develop a scale in Kilometer, the given R. F. can be expressed as: one cm. represents 250,000 cm.

If we draw a line of 12 cm, it will represent the number of kms in following way:

1 cm. represents 250,000 cm

or If we express it in km. 1 cm = 2.5 km (1,00,000/250,000)

A line of 12 cm will represent 2.5 km x 12 = 30 km.

Steps involved in the Construction

1. Based on the above calculation, we have to read upto 1 km. in this linear scale for 30 km. Therefore, we will divide this scale into six primary divisions. Thus, each primary division will read 5 km.
2. As discussed earlier in this section, the extreme left primary division of the scale will be divided into five equal divisions. Each secondary division will represent a minimum distance of one km.
3. While numbering the scale, zero should be marked after one interval from the left, so that the left hand end of the line can be numbered 5 and the primary divisions to the right of zero can have numbers 5,10,15, 20 and 25. This method of numbering enables us to read off directly the whole numbers as well as the fraction from the scale (Fig. 3.1).

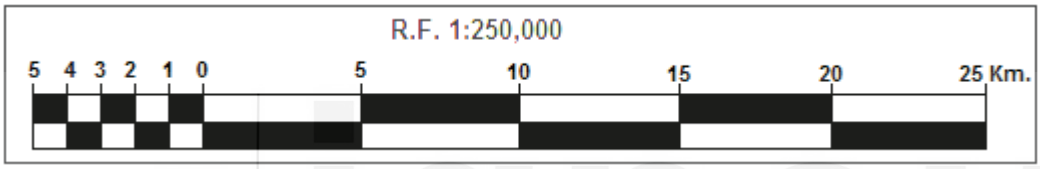

Fig. 3.1: Plain scale depicting primary and secondary divisions.

3.5.2 Comparative Scale

In simpler terms, a comparative scale may be expressed as a pair of scales having a common R.F. but graduated to read different units. Some of the examples of comparative scales are (i) different units; (ii) time scale; (iii) pace scale; and (iv) revolution scale. Let us discuss each of them and their construction with an example each.

i) **Different Units**: As the name suggests, this type of scale depicts reading in two different units. An example of a comparative scale of two different units may be showing distances in meters and yards having common zero point.

Let us solve the below given example for more clarity.

Example 4: A map is on the scale of R.F. 1:100,000. Draw a comparative scale to read the distances in Mile-Furlong and Kilometer-Hectometer.

Calculation

The given R.F. is 1:100,000.

As we want to develop a scale in miles, the given R. F. can be expressed as:

For mile

1 inch represents 100,000 inch

6" will represent $\frac{100000 \times 6}{63360}$ Miles $= \frac{625}{66}$ Miles = 9.46 miles

For our convenience, let us convert it into a round figure of 10 miles. In this case, we have to recalculate the length of the scale. Therefore, the length of

the scale will be as follows:

625 Miles are shown by a line of 6”
66

1 mile will be shown by a line of $\frac{6x66”}{625}$

10 miles will be shown by $\frac{6x66x10”}{625}$ = 6.3”

For km

1 cm. represents 100,000 cm or 1 km.

Then 15 cm. will represent 1 km. × 15 = 15 km.

Steps involved in the Construction

The following steps are followed while constructing comparative scale for depicting two different units. We have already calculated the length of the scale.

1. We will start the construction of comparative scale by drawing two straight lines. The length of the line representing mile is 6.3” whereas the second line representing kilometer is 15 cm.
2. Divide 6.3” line into 10 equal parts to show the primary division of one mile distance. Similarly, divide the line of 15 cm. into 15 equal parts to show the primary division of 1 km.
3. The first primary division in the extreme left will be divided into two equal parts. Thus, one secondary division will represent 4 furlongs. Similarly, to measure distance in hectometer, divide left primary division into two equal parts. Thus, one secondary division will measure the distance of 5 hectometer.
4. Now draw the comparative scale where the zero of both the scales should coincide with each other (Fig.3.2).

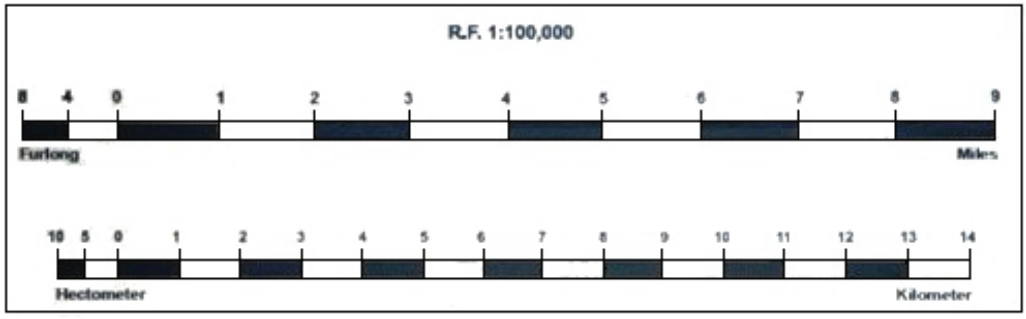

Fig. 3.2: Comparative scale depicting two different scales.

Let us now discuss other forms of comparative scale.

ii) **Time Scales**: As the name suggests, this scale depicts distance along with time like miles and minutes/hours. In this type of comparative scale, one line represents distance travelled whereas the other line represents the time taken

to cover the said distance. Like other comparative scale, zero, in both the scales should coincide to each other.

iii) **Pace Scales**: Can you decipher from the name which two parameters are compared in this scale? Yes, this form of comparative scale shows distance and coverage in terms of pace. In other words, this scales has two units i.e. distances covered in miles or kilometres and number of steps taken to cover the said distance. Now, you might be thinking that why do we use such type of scale? Generally, this type of scale is used while conducting a rapid reconnaissance where it may not be possible to use chain and tape due to shortage of time. In those circumstances, the distance can be measured with the help of paces. The length of a pace of the person employed for the purpose should be known and then the distance between two points can be measured by paces. The standard military pace is 30".

iv) **Revolution Scales**: This is another form of comparative scale that shows distance and revolution of wheels to cover the distance, where speedometer is an excellent example.

3.5.3 Diagonal Scale

Diagonal scales are drawn for greater precision or higher degree of accuracy. Can you imagine how is this precision achieved? Yes, you're right. We achieve this precision because this scale is specifically used to measure up to three units. For example, in a metric system you can measure kilometers (km), meters (m), and centimeters (cm). Similarly, in British system of measurement you can measure miles, furlongs and yards etc. If you observe closely the previous two scales, they are best suited for measuring up to two units. This scale is used when very small distances such as 0.1 mm are to be accurately measured or when measurements are required up to second decimal. The below given figure depicts micro-distance in a diagonal scale.

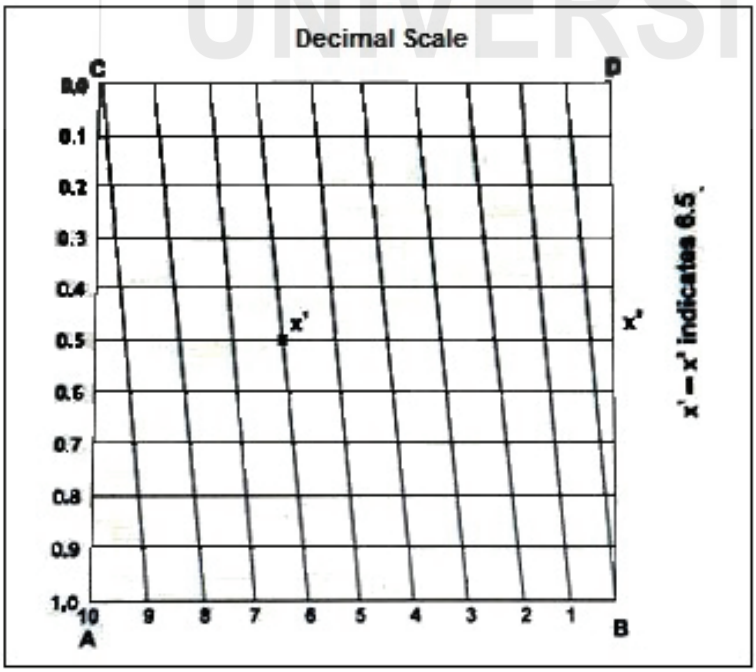

Fig. 3.3: Reading of micro-distance in a diagonal scale.

Example 5: To read the distance of one hundredth part of a mile, draw a diagonal scale on R.F. 1:63,360 and also show the distance of 1.56 mile on the scale.

Solution:

Steps involved in the Construction

1. As per the given exercise, 1" represents 1 mile, as 1 mile is equal to 63,360". Draw a line of 6", and divide it into 6 primary divisions. Thus, one primary division will represent one mile.
2. Divide the first primary division of the left side into ten secondary divisions. Thus, the one secondary division will represent 0.1 mile distance.
3. To read the distance of 0.01 mile draw 10 parallel lines to the main scale. On the left side of primary division mark 10 points of equal distances on the upper most line of the scale. Join these 10 small distances with the diagonals (Fig. 3.4).

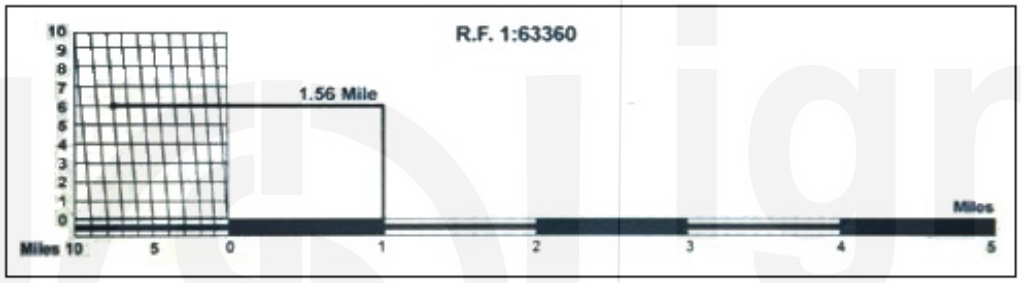

Fig. 3.4: Diagonal scale showing the distance of 1.56 mile.

3.5.4 Vernier Scale

Do you know why this scale is named so? This scale is named after it's inventor Pierre Vernier, a French Mathematician in 1631. Vernier scales are drawn to achieve greater accuracy in the form of fraction of a division in both linear and angular measurements. This scale consists of a small moving scale. This small moving scale has the graduated edge which slides along the graduated edge of a larger sale. The larger scale is known as primary scale and as mentioned above the small graduated scale is known as Vernier scale (Fig. 3.5).

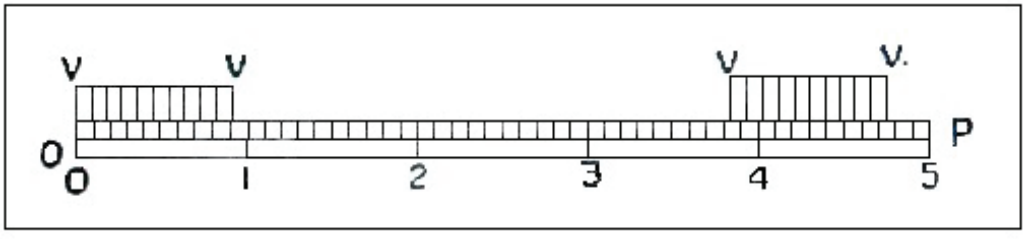

Fig. 3.5: Vernier Scale.

3.5.5 Special Type Scales

Special type scales are drawn to represent two types of distances – horizontal and vertical together. Various types of these scales are a) square root scales (showing proportionate circles with certain radius for representing some

quantitative values), b) cube root scales (showing spheres to represent quantities using cube root for volume), c) scales of verticals (showing height depending on focal length of the lens and altitude of the camera taken in areal photography), and d) perspective scales (showing block diagrams or field).

SAQ 3

Match the two columns.

Types of Scale	Example
A) Graphic Scale	i) Measures up to three units
B) Comparative Scale	ii) Square Root Scale
C) Diagonal Scale	iii) Time Scale
D) Vernier Scale	iv) Linear Scale
E) Special Types Scale	v) Slide Calipers

3.6 SUMMARY

In this unit, you have studied so far:

- Scale is an essential element of map and without a scale, a map is incomplete and cannot be technically be named as map. Without scale, a map is called a sketch. In simpler terms, map scale can be defined as the ratio between the distance on map and the actual distance on the ground.
- There are three ways of representing scale. These are (i) statement of scale, (ii) linear or graphic scale, and (iii) representative fraction.
- As the name suggests, in this method, the measurement of the map scale is represented in the form of statement. Graphic scales are those scales, which are depicted through graphs mixed with lines and/or empty or black blocks showing primary and secondary divisions.
- The scales can be converted from one form to another form. In this unit, we discussed methods of conversion from statement of scale to representative fraction and vice versa.
- There are five broad types of scales namely plain scale, comparative scale, diagonal scale, vernier scale, and special type scale.

3.7 TERMINAL QUESTIONS

1. State the three factors on which the scale depends.
2. Explain the three representation methods of map scales.
3. What points should be taken into consideration while constructing graphic scale.
4. Describe various types of map scales highlighting its advantages and disadvantages.

5. List the importance of diagonal scale.

3.8 ANSWERS

Self Assessment Questions

1. Scale is the ratio between the map distance to the actual corresponding ground distance.
2. a) Measurement of distance
   b) Primary divisions, secondary divisions
   c) Unit of measurement, universal
3. A-iv; B-iii, C-i; D-v; E-ii

Terminal Questions

1. You have to broadly highlight the factors on which scale depends. Refer to the Section 3.2.
2. Refer to the Section 3.3.
3. Refer to the Section 3.5.
4. Refer to the Section 3.5.
5. Briefly highlight the importance of diagonal scale to answer this question. Refer to the sub-section 3.5.3.

3.9 REFERENCES/SUGGESTED FURTHER READING

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GLOSSARY

Atlas: Very small scale and highly generalized maps of the world or different regions of the world showing major physical features, settlements, transport networks and important landmarks.

Azimuth: Horizontal angular measurements of coordinate systems from zero degree.

Cadastral Map: Maps showing parcel or property boundaries.

Cartography: It is the art and science of map making.

Comparative Scale: It may be expressed as a pair of scales having a common R.F. but graduated to read different units.

Chorochromatic Maps: Maps showing non-quantitative properties of any feature or phenomena over the space like presence or absence.

Choropleth Maps: The maps showing physical or cultural features by various colours or grey scale shades or patterns.

Choro-schematic Map: The maps showing the location and distribution of something over the space through alphabets.

Cultural Map: Maps representing the cultural landscapes, especially the cultural or institutional properties like race, tribe, religion, literacy, etc. of the earth surface.

Diagonal Scale: Scales drawn for greater precision or higher degree of accuracy with secondary and tertiary scales for the accuracy up to two decimal digits involving diagonal lines of sub-divisions.

Dot Maps: The maps showing the distribution of various features like population, trees, animals, etc. by dots representing definite number or quantity are called dot maps.

Ellipsoid or **Spheroid:** It is a three-dimensional shape created from a two-dimensional ellipse with a property of polar flattening and equatorial bulge.

Geoid: It represents the earth's shape and is the reference surface taking mean sea level surface from which topographic heights and ocean depths are measured.

Great Circle: Equator and all longitudes.

Greenwich Mean Time (GMT): It is a time at the Royal Observatory located at Greenwich, London and is a reference time for entire globe.

Isopleth Maps: The maps using regular line showing a uniform value of weather elements like rainfall, temperature and pressure etc.

Linear or Graphic Scale: Graphic scales are those scales, which are depicted through graphs mixed with lines and/or empty or black blocks showing primary and secondary divisions.

Map: A map is a pictorial depiction of whole earth or its part into two dimensional surface involving geometric objects, colour, symbols and texts.

Neatline: Neatline is the line bordering the geographical data (outline), of the area of representation. It may be called the outer boundary of the map having various designs of lines.

Peutinger Table: Peutinger Table (*Tabula Peutingeriana*) is a historical Roman map showing Roman Empire with major roads and military posts.

Physical Map: The maps which represent the physical features are said to be physical maps.

Plain Scale: Plain scales are those which measure up to two units or a single unit through its divisions and sub-divisions.

Projection: Map projection is the mathematical transformation of graticules (latitudes and longitudes) of the spherical earth on a two dimensional plane surface.

Representative Fraction (RF): It is the expression of scale in terms of ratio between map distance and the actual corresponding ground distance, where the numerator is map distance always expressed as one and the denominator is the same corresponding distance on the ground.

Rhumb Line: A curve crossing at every meridian on the earth's surface at the same angle.

Scale: Scale is the ratio between the map distance to the actual corresponding ground distance.

Statement Scale: When the map scale is represented in the form of statement, it is called statement scale.

T-O Map: It is also called a T and O map. It is a type of medieval world map also called a Beatine map or a Beatus map having religious importance where Jerusalem was placed at the Centre of the World.

Topographical Map: The maps prepared to depict both kinds of surface features including natural and cultural features.

Vernier Scale: These scales are drawn to achieve greater accuracy in the form of fraction of a division in both linear and angular measurements consisting of a small moving scale.

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