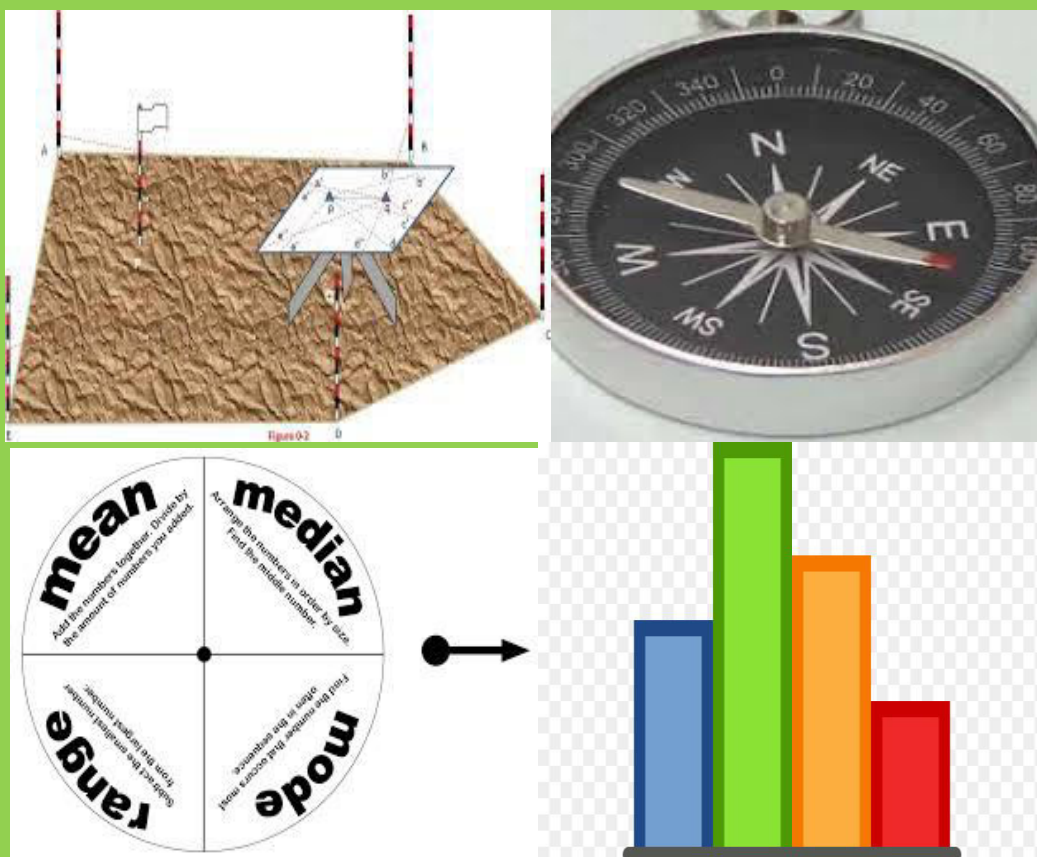




**B.A./B.Sc.GE-203**

# **PRACTICAL**

## **B.A./B.Sc. II YEAR**



**DEPARTMENT OF GEOGRAPHY AND  
NATURAL RESOURCE MANAGEMENT  
SCHOOL OF EARTH AND ENVIRONMENT SCIENCE  
UTTARAKHAND OPEN UNIVERSITY**

**BA/BSc GE-203**  
**PRACTICAL**



**DEPARTMENT OF GEOGRAPHY  
AND NATURAL RESOURCE MANAGEMENT  
SCHOOL OF EARTH AND ENVIRONMENT SCIENCE  
UTTARAKHAND OPEN UNIVERSITY**

**Phone No. 05946-261122, 261123**

**Toll free No. 18001804025**

**Fax No. 05946-264232, E. mail [info@uou.ac.in](mailto:info@uou.ac.in)**

**Website: <https://uou.ac.in>**

**B.A./B.Sc. GE-203**

**PRACTICAL**

---

**Board of Studies**

<b>Chairman</b> Vice Chancellor Uttarakhand Open University, Haldwani	<b>Convener</b> Professor P.D. Pant School of Earth and Environment Science Uttarakhand Open University, Haldwani
Prof. R.K. Pandey Head, Department of Geography DSB Campus, Nainital	Dr. B.R. Pant Head, Department of Geography MBPG College, Haldwani
Dr. D.S. Rawat Senior Scientist, GB Pant Institute of Himalayan Environment and Development Kosi-Katarmal, Almora	Prof. Anita Pande Department of Geography DSB Campus, Nainital
Dr. H.C. Joshi Department of Environmental Science School of Earth and Environment Science Uttarakhand Open University, Haldwani	Dr. Ranju J. Pandey Department of Geography & Nat.Res.Mgmt School of Earth and Environment Science Uttarakhand Open University, Haldwani

---

**Programme Coordinator**

---

Dr. Ranju J. Pandey  
Department of Geography and Natural Resource Management  
School of Earth and Environment Science  
Uttarakhand Open University, Haldwani



S.No.	Units Written By	Unit No.
1.	Dr. Geeta Rawat Department of Geography, SGR RPG College Pathribag, Dehradun	1 & 2
2.	Dr.S.K.Bandooni Associate Professor, Department of Geography, Shaheed Bhagat Singh Evening College, University of Delhi, Sheikh sarai, PhaseII, New Delhi-17	3
3.	Dr. Nawal Prasad Singh Assistant Professor, Department of Geography, Shaheed Bhagat Singh Evening College, University of Delhi, Sheikh sarai, PhaseII, New Delhi-17	4, 5& 6
4.	Dr. Ranju Joshi Pandey Department of Geography, Uttarakhand Open University, Haldwani	7&8
5.	Dr. Nirmala Lohani Assistant Professor, Department of Geography, Govt. Girls Degree College, Haldwani	9&10

---

**Course Editor:**


---

Dr. Ranju J. Pandey  
Department of Geography and Natural Resource Management  
School of Earth and Environment Science  
Uttarakhand Open University, Haldwani

Title	:	Practical
ISBN No.	:	978-93-90845-32-3
Copyright	:	Uttarakhand Open University
Edition	:	2020(First), 2021(Second)

Published By : Uttarakhand Open University, Haldwani, Nainital-263139

Printed By : Diamond Press, Jaipur

---

<b>CONTENTS</b>	<b>PAGE NO.</b>
<hr/>	
<b>BLOCK-1 REPRESENTING STATISTICAL DATA</b>	
UNIT: 1 Diagram and Graphs	1- 15
UNIT: 2 Distribution maps	16-27
UNIT: 3 Quantative Methods	28-47
 <b>BLOCK-2 STATISTICAL METHODS</b>	
UNIT: 4 Measurement of Central Tendency	48-65
UNIT: 5 Measures of Dispersion	66-78
UNIT: 6 Regression & Correlation	79-96
 <b>BLOCK-3 SURVEYING</b>	
UNIT: 7 Principals of Surveying	97-103
UNIT: 8 Plane Table Surveying	104-120
UNIT: 9 Prismatic Compass Survey	121-129
UNIT: 10 Indian Pattern Clinometer	130-135

# **BLOCK- 1 REPRESENTING STATISTICAL DATA**

---

## **UNIT 1 - DIAGRAMS AND GRAPHS**

---

***1.1 OBJECTIVES***

***1.2 INTRODUCTION***

***1.3 GENERAL RULES FOR CONSTRUCTING DIAGRAMS & GRAPHS***

***1.4 LINE DIAGRAM, BAR DIAGRAM, PYRAMID DIAGRAM, SQUARE DIAGRAM, BLOCK DIAGRAM, WHEEL DIAGRAM***

***1.5 CONCLUSION***

***1.6 SUMMARY***

***1.7 GLOSSARY***

***1.8 ANSWER TO CHECK YOUR PROGRESS***

***1.9 REFERENCES***

***1.10 SUGGESTED READINGS***

***1.11 TERMINAL QUESTIONS***

---

## 1.1 OBJECTIVES

---

After reading this unit, you will be able to:

- To know about general rules for constructing diagrams & graphs
- To know about Line diagram, bar diagram, Pyramid diagram, Square diagram, Block diagram, Wheel diagram.

---

## 1.2 INTRODUCTION

---

Diagrams and graphs are the most important elements in practical geography. In Geography, data are represented in several ways. Sometimes the same data are shown in several ways, and also several data are shown in the other way. Of these there are two methods to show statistical data as diagram and graph. If some geographical fact, instead of being written, is shown by pictures even a common man can understand it.

A Geographer is required to represent various kinds of statistical data on a map. He makes use of various types of statistical diagrams to represent the statistical information. Like diagrams, statistical data may also be represented by graphs. Graphs involve the drawing of regular lines – smooth or curved, each point on them being determined by two co-ordinates. For convenience squared papers are used, which are popularly called graph papers. The graphs are, however, notable for their accuracy and exactness. Whereas there are also few usefulness of diagrams the discussion on it in detail are as-

### USEFULNESS OF DIAGRAMS

The following are the advantages of these diagrams-

1. Any man without reading the data tables, can find out from these diagrams what has been shown there.
2. These diagrams look beautiful. So even that man who is not interested in reading can enjoy and get information to related topic by looking at them.
3. Relative comparison can be easily made with the study of these diagrams.
4. Any fact can be explained easily.
5. Less time is taken in getting them prepared.
6. The entire data which when expressed in numerical form may be unwieldy and require a number of pages to write down, are made visible at a glance.
7. Lastly, The diagrams help in deriving the required information in less time and without any mental strain.

### ***1.3 GENERAL RULES FOR CONSTRUCTING DIAGRAMS & GRAPHS***

The following general rules should be observed while constructing diagrams:

1. **Title:** Every diagram must be given a suitable title. The title should convey in as few words as possible the main idea that the diagrams intent to portray. The title may be given either at the top of the diagram or below it.
2. **Proportion between width and length:** A proper proportion between the height or length and width of the diagram should be maintained. If, the height and width is too short or too long in proportion, the diagram would give an ugly look. While there are no fixed rules about the dimensions, a convenient standard as suggested by Lutz in the book entitled “Graphic Presentation” may be adopted for general use.
3. **Selection of scale:** The scale showing the values may be in even numbers or in multiples of five or ten, e. g. 25, 50, 75, or 20, 40, 60. Odd values like 1,3,5,7 may be avoided.
4. **Footnotes:** In order to clarify certain points about the diagram, footnote may be given at the bottom of the diagram.
5. **Index:** An index illustrating different types of lines or different shades, colours should be given so that the reader can easily make out the meaning of the diagram.
6. **Neatness and cleanliness:** Diagrams should be absolutely neat and clean.
7. **Simplicity:** Diagrams should be as simple as possible so that the reader can understand their meaning clearly and easily. For the sake of simplicity, it is important that too much material should not be loaded in a single material should not be loaded in a single diagram otherwise it may become too confusing and prove worthless.

Now you know the role of diagrams in geography and general rules for construction of diagrams. So we will discuss further, the next objective of the unit as the representation of the geographical or statistical data through different type of diagrams, the chief of which are shown in graphically. The detail descriptions are given below.

### ***1.4 LINE DIAGRAM, BAR DIAGRAM, PYRAMID DIAGRAM, SQUARE DIAGRAM, BLOCK DIAGRAM, WHEEL DIAGRAM***

#### **DIFFERENT FORMS OF DIAGRAM**

Geographical or statistical data may be represented in forms of diagrams in several ways. Classification of statistical diagrams is generally made on the basis of facts shown in them. Diagrammatic representation can be made in any one of the following methods:

- a) **One Dimensional Diagrams-** Sometimes only one fact is shown, they are called One Dimensional Diagrams. They are simple diagram and the distribution of only one fact is shown in them such as rain, temperature, air pressure or the production of some particular thing. Their

construction does not include made thinking consideration and complicity of scale. The example of one dimensional diagram is Bar Diagram and Line Diagram.

**b) Two Dimensional Diagrams-** It can be included in the second class; they require more calculation than One Dimensional Diagrams. They can be placed in the class of quantitative maps. Two Dimensional Diagrams are Rectangular Diagrams, Circle Diagrams, and Wheel Diagrams etc.

**c) Three dimensional diagram-** In the third class can be included Three Dimensional Diagrams. Their constructive needs much calculation and care. Volume shapes are used in Three Dimensional Diagrams. In these diagrams the amount of area and cube shapes is according to scale. In their construction care has to be taken of the scale too along with statistical calculation. Whose volumes are made proportional to the given figure viz., cubes, cylinders, blocks, and spherical diagrams etc.

**d) Pictorial diagrams-** such as pictures and statically maps.

As you know the above mention diagrams are the part of different dimensional diagrams so the detail description and method of construction of different types of diagrams are as:

### **LINE DIAGRAM**

Line diagram mostly used when there is vast range of values in a table. In this diagram a straight line is draw on pre decided scale for each value of the table. These lines are drawn on horizontal or vertical axis with equal distance. To recognize the particular line there is need to write the name or year on it. Thus the diagram is good to compare between the production in different year or states but because of no thickness in the line diagram they are not looks attractive. The diagram can be exhibited on the graph paper.

Q.1 Construct the line diagram to represent the per capita income in different states of India.

**Table 1.1.Per Capita Income in Different States of India, 1980**

S.NO	Name of the State	Per capita income in Rupees
1.	West Bengal	1,130
2.	Uttar Pradesh	981
3.	Assam	960
4.	Rajasthan	913
5.	Orissa	843
6.	Madhya Pradesh	826
7.	Manipur	822
8.	Punjab	2,278
9.	Maharashtra	1,903
10.	Gujarat	1,623
11.	Tamil Nadu	1,350
12.	Himachal Pradesh	1,317
13.	Karnataka	1,267
14.	Andhra Pradesh	1,176

First arrange the table in descending order as-

**Table 1.2. Per Capita Income in Different States of India, 1980**

S.NO	Name of the State	Per capita income in Rupees
1.	Punjab	2,278
2.	Tamil Nadu	1,350
3.	Himachal Pradesh	1,317
4.	Karnataka	1,267
5.	Andhra Pradesh	1,176
6.	West Bengal	1,130
7.	Uttar Pradesh	981
8.	Assam	960
9.	Uttar Pradesh	981
10.	Assam	960
11.	Rajasthan	913
12.	Orissa	843
13.	Madhya Pradesh	826
14.	Manipur	822

### **CONSTRUCTION METHOD**

It is point out before that arrange the data in descending order, so according to table 1.2, draw a perpendicular on the one side of diagram and mention the scale of per capita income. Now find out the length of line according to per capita income in different states and draw them on base line with equal distance. Now write the name of concerning state on each line. You can write the horizontal and vertical scale with diagram (Fig. 1.1).

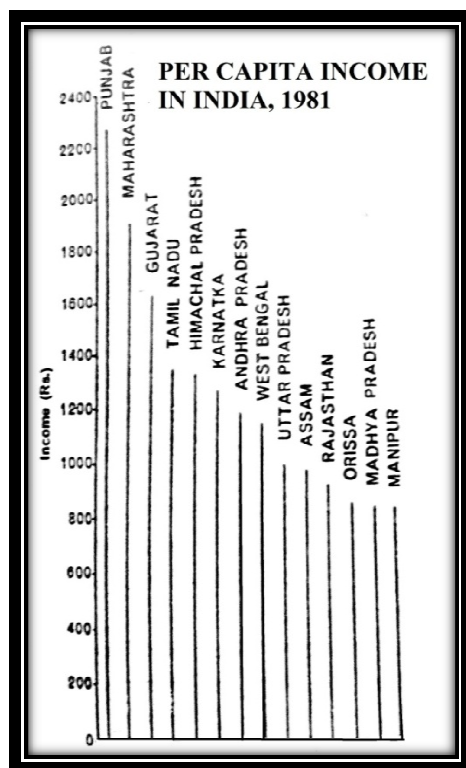


Fig. 1.1

## **BAR DIAGRAM**

Representation of quantities by bars is the easiest and simple type of diagram. Bars may be shown by a straight line or like a pillar with some uniform width. The lengths of bars vary in proportion to the quantity to be represented on a selected scale. They may be vertical or horizontal simple or compound. Horizontal base is used for the simple reason that comparison of one bar with another can better be made in terms of height. In a single study all bars must be of the same uniform width, separated by equal intervening spaces. If a horizontal arrangement is chosen as in fig. 1.2, the date order should always be in sequence from top bar to bottom bar, again because the eye reads horizontal lines starting at the top and working down the page. The horizontal arrangement makes the setting out of names and numbers fairly easy, as there is plenty of space at the beginning or end of bars, whereas there is very limited amount of horizontal space beneath vertical bars as shown in (fig. 1.2). These are also called staircase bar diagrams.

Q.2 Construct a simple bar diagram to represent the following data:

**Table 1.3. Sex Ratio in India, 1901 – 1981**

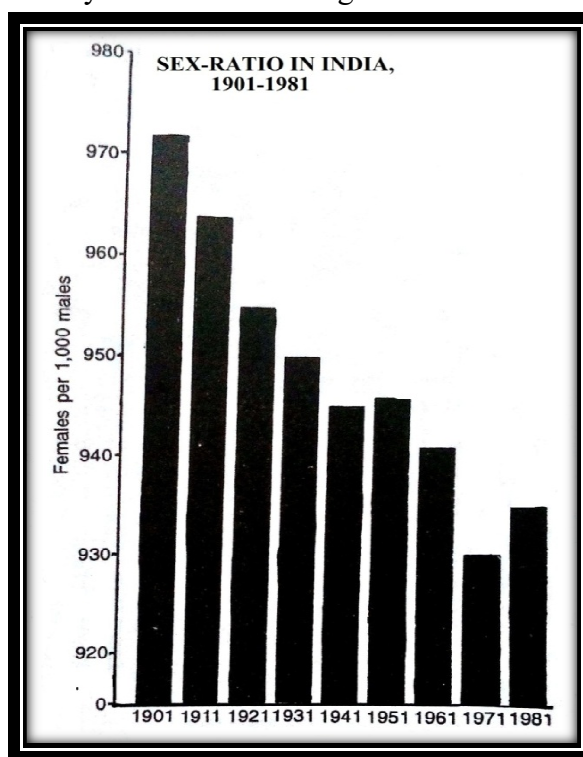
Year	No. of Females after 1000 Males
1901	972
1911	964
1921	955
1931	950
1941	945



1951	946
1961	941
1971	930
1981	935

### **CONSTRUCTION METHOD**

First draw a vertical and horizontal base line. Let it be one division on vertical line with the interval of 10. The highest figure is less than 980, so do not mark more than 7 divisions on the line. Marked this line with proposed scale such as one division = 920 females. Now make those divisions with proper scale such as 920, 930, 940 etc. as shown in fig. 1.2. Then divide the horizontal line from zero point with a suitable scale by comparing the figures for the various years. Draw vertical bars of equal-width, equal-distance and equal-spaced to show number of females per 1,000 males in various years as shown in fig. 1.2.



**Fig. 1.2**

### **PYRAMID DIAGRAM**

The Pyramid diagram is virtually a variant of a bar graph, where columns, constructed to represent specific qualitative population data and are arranged in a tier structure. There are generally two types of pyramid e.g. simple and compound. Simple pyramid diagram is used to show the growth of total population of a country, on the other hand a compound pyramid diagram is used to show the rural and urban composition etc.

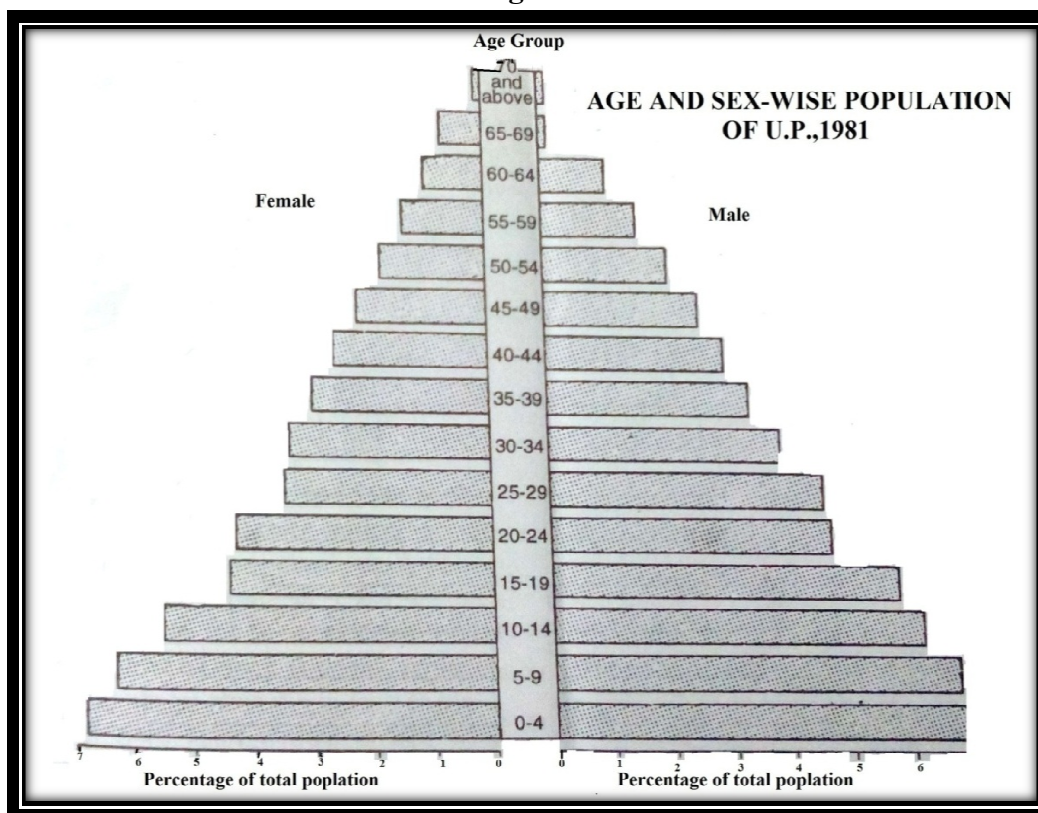
Q.1 Construct an age and sex pyramid from the following data-

**Table 1.4. Age and Sex –Wise Population of U.P, 1981**

Age Group	% of Male	% of Female	Age Group	% of Male	% of Female
0-4	7.0	6.8	40-44	3.0	2.6
5-9	6.8	6.3	45-49	2.6	2.2
10-14	6.2	5.5	50-54	2.1	1.8
15-19	5.8	4.4	55-59	1.6	1.4
20-24	4.7	4.3	60-64	1.1	1.0
25-29	4.6	3.5	65-69	0.1	0.7
30-34	3.9	3.4	More then 70	0.1	0.1
35-39	3.4	3.0			

### **CONSTRUCTION METHOD**

For the scale of convenience convert the population into percentage on the horizontal plane. Simultaneously mark the age group on the vertical plane in such a way that the base representing the youngest group, the apex the oldest (Fig. 1.3).

**Fig. 1.3**

### **SQUARES DIAGRAM**

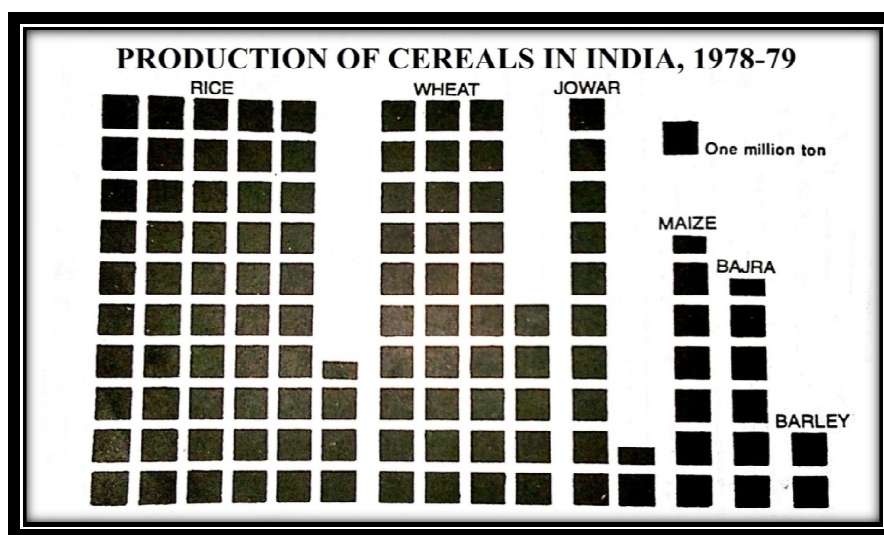
It is an important two- dimensional diagram and use to show the production in rupees and quintals etc. It is point out that for construction of diagram, firstly you have to select the

appropriate scale. So for the squares diagrams 1 square = 1000 quintals or 1,00,000 rupees etc. unit will select to calculate the number of squares for each value. After it, you will find out the number of squares. The important characteristic of square diagram is its easiness. you can prepare another table after calculation to calculate the numbers of squares. In order to avoid errors to the greatest extent, the same facts may be represented by grouping together a number of even-sized small squares. Each unit square may represent some conveniently selected quantity. Such a method is advantageous in comparison with the block method in two ways: (i) It is comparatively much more accurate; (ii) It may be easily commensurable by counting the number of unit square.

Q. 1. Make squares diagram on the data given below-

**Table -1.5 Production of Food Grains in India, 1978-79**

Grains	Production (Million Tons)	Grains	Production (Million Tons)
Rice	53.5	Maize	6.5
Wheat	35.0	Bajra	5.5
Jowar	11.5	Barley	2.0



**Fig. 1.4**

### **CONSTRUCTION METHOD**

If we take one square equal to one million ton production of grain then numbers of squares of rice, wheat, jowar, maize, bajra, and barley are 53.5, 35.0, 11.5, 6.5, 5.5, and 2.0 respectively and 114 for the total production (fig.1.4). Now draw the squares close to each other with equal distance with neatness.

## **BLOCK DIAGRAM**

A block diagram is a technique which may be utilized to show effectively different types of landforms and their evolution. This technique was introduced by G.K. Gilbert and was used by W.M. Davis in the late 19<sup>th</sup> century. Blocks Diagram may be either simple, giving two dimensional effects like rectangles and squares, or they may be complex, producing three dimensional effects like cubical blocks- cylinders, spheres, etc. In the former case the area of the block proportionate to the quantity shown by it; in the latter the volume of the block is made to proportionate to the quantity represented. The former case the area of the block proportionate to the quantity represented.

In square diagram we select the scale to determine the no. of squares and a bunch of squares shows one item from the table. Whereas in block diagram only one block is made for one item and the side of square will find according to pre decided scale. The blocks are constructed with same distance, one block for one item. It should be constructed in descending order. This diagram is more useful when there is high range of interval among the data in table. The demerit of the diagram is that it is unable to present the correct picture in reference to proportion at a glance.

Q. 1. Draw block diagram to represent the data given in Table 1.6.

**Table 1.6. Production of Food grains in India, 1970-71**

Grains	Million Tons	Size of the Block	Size of one side of block
Rice	53.5	$\frac{53.5}{2} = 26.75$	$\sqrt{26.75} = 5.17$ unit
Wheat	35.0	$\frac{35.0}{2} = 17.5$	$\sqrt{17.5} = 4.18$ unit
Jowar	11.5	$\frac{11.5}{2} = 5.75$	$\sqrt{5.75} = 2.39$ unit
Maize	6.5	$\frac{6.5}{2} = 3.25$	$\sqrt{3.25} = 1.80$ unit
Bajra	5.5	$\frac{5.5}{2} = 2.75$	$\sqrt{2.75} = 1.65$ unit
Barley	2.0	$\frac{2.0}{2} = 1.00$	$\sqrt{1} = 1.00$ unit

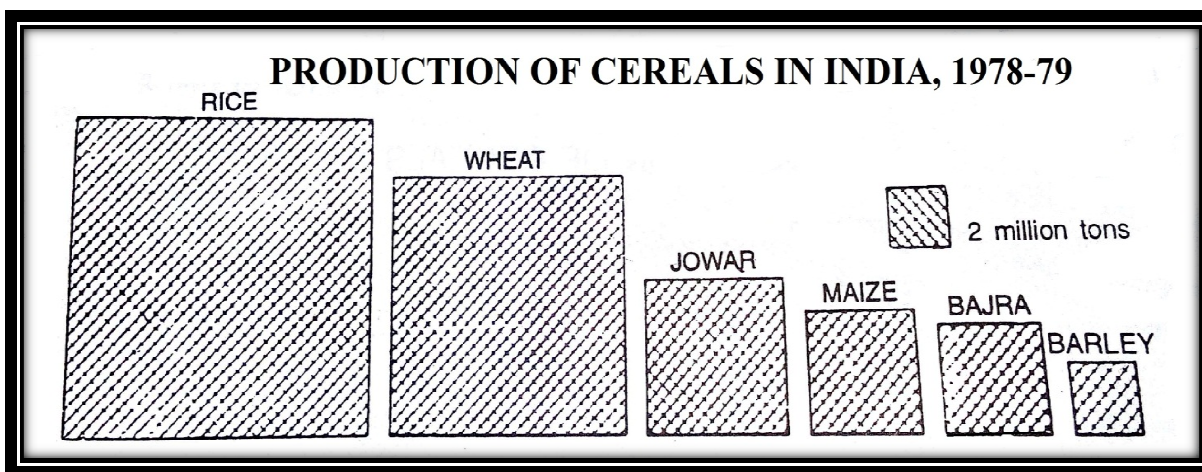


Fig.1.5

### CONSTRUCTION METHOD

After calculation according to the size of the paper draw the blocks one by one according to assume size of the block, as 1 cm. square = 2 million tons. Now draw the bigger block of rice first than wheat, jowar, maize, bajra and barley respectively (fig. 1.5). Errors below 5 percent may be ignored.

### WHEEL DIAGRAMS

These are called circular or wheel or pie diagrams and also known as areal diagrams. This type of diagram shows the distribution by a circle whose area is proportionate to the quantity represented. Just as bars and squares may be divided in order to represent component parts, similarly may be sub-divided into various sectors. It gives a good visual idea of the fact it represents and also looks pleasant; but it is not easily commensurable as the bar and the block. It has advantage over them in that it occupies less space than these, a fact which makes it more suitable for distribution maps.

Q.1 Construct a Wheel diagram to represent the data given in Table 1.7:

**Table 1.7, Land Use in India, 1976-77**

Classification of land	Area (crore hectare)	Classification of land	Area (crore hectare)
Forest	6.68	Fallow lands	2.40
Not available for cultivation	3.95	Cultivated land	14.02
Other uncultivated excluding fallow lands	3.36	Total	30.41

Now write the values of table in ascending order and, find out the angles in degrees:



Table 1.8, Land Use in India, 1976-77

Classification of land	Area (crore hectare)	Angle (degree)	Cumulative frequency (degree)
Cultivated land	14.02	$\frac{14.02 \times 360}{30.41}$	166 <sup>0</sup>
Forest	6.68	$\frac{6.68 \times 360}{30.41}$	245 <sup>0</sup>
Not available for cultivation	3.95	$\frac{3.95 \times 360}{30.41}$	291.8 <sup>0</sup>
Other uncultivated excluding fallow lands	3.36	$\frac{3.36 \times 360}{30.41}$	331.6 <sup>0</sup>
Fallow lands	2.40	$\frac{2.40 \times 360}{30.41}$	360 <sup>0</sup>
Total	30.41	360 <sup>0</sup>	360 <sup>0</sup>

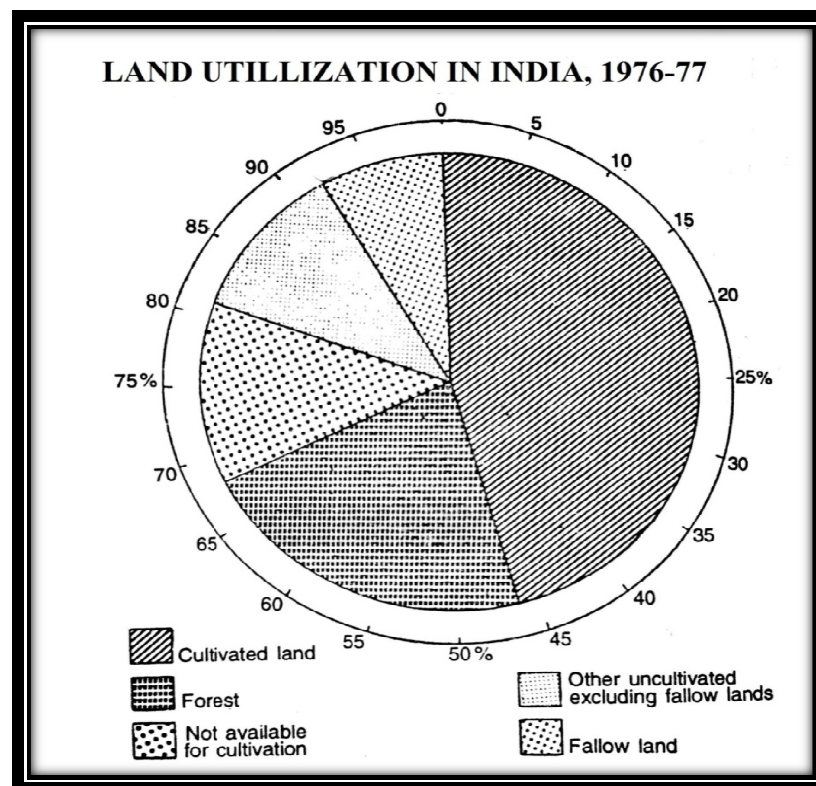


Fig.1.6

## **CONSTRUCTION METHOD**

To represent this data in the form of a pie diagram, you have to first draw a circle with any radius. Sometimes circles are drawn to the proportion of the area or any other figures. To divide these circles into various sectors, the principle to note is that the areas of the sectors should be proportional to the areas of different states. Now, the areas of the sectors are proportional to the angles at the center. Therefore,  $360^\circ$ , the total number of degrees contained in a circle, are to be divided into proportional parts to get sectors of the required areas. It should be draw clockwise as firstly fallow lands  $166^\circ$ , forest  $79^\circ$ , not available for cultivation  $46.8^\circ$ , other uncultivated excluding fallow lands  $39.8^\circ$ , fallow lands  $28.4^\circ$  or through cumulative frequency  $166^\circ$ ,  $245^\circ$ ,  $291.8^\circ$ ,  $331.6^\circ$ ,  $360^\circ$  respectively (fig.1.6).

---

## ***1.5 CONCLUSION***

Thus we can say that statistical data provide raw materials for drawing, diagrams. Method of representation of statistical data depend upon the nature of data i.e. agricultural, the distribution of population and other statics in different years or intervals of time may be best shown by diagrams. A diagram may be defined as the representation of statistical data or a geographic element in a highly abstract and conventionalized form by laying emphasis on one selected element. Broadly the statistical diagrams can be classified into three groups as One dimensional e.g. bars and line diagrams, Two dimensional e.g. square, rectangular, circular diagram etc. and Three dimensional e.g. cube and spherical diagrams etc. Few very important merits of diagrams are prepared in very short time, attractiveness, effective impression, good for comparison between different variables and easy method of construction. Whereas few general rules should keep in mind during construction of diagrams as selection of title, proportion between width and height, selection of scale, index, neatness and cleanliness, selection of diagram etc. For example line diagram should use when there is shortage of time otherwise bar diagram gives better impression so it should be select. Pyramid diagram can better option to show more than two variables at a time, square and block diagram are again easy but time consuming methods yet, fulfill the general rule of diagram as simplicity on the other side wheel diagram is best option to show landuse classification or any type of classification in a particular region.

---

## ***1.6 SUMMARY***

As you know, the objectives for the unit was general rules for constructing diagrams & graphs and the representation of few diagram as line diagram, bar diagram, pyramid diagram, square diagram, block diagram, wheel diagram. So the importance of diagrams and definition of it followed by introduction, usefulness of diagrams was the another subheading to the unit the advantages of diagrams are well explained as any men without reading them, can find out from these diagrams what has been shown there. The diagrams look beautiful, attractive and effective so the common man, who is not interested to read can enjoy and get information to related topic

by looking at them. Now he can get the information very easily at a glance without any mental strain, in less time. According to general rules for constructing diagrams & graphs attractiveness and effectiveness in communicating the required information is first rule whereas proper headings, proper size as diagram must suit the size of the paper, signs and colours may be used to indicate different nature and aspects of diagram. Less use of words or numerical, In case any feature of the diagram has not been adequately made clear footnote and Index should be given. Different types of lines or shades should be given so that the reader can easily understand the diagram.

Line diagram, bar diagram, Pyramid diagram, Square diagram, Block diagram, Wheel diagram are few diagrams explained very well in the unit as Line diagram mostly used when there is vast range of values in a table. In this diagram a straight line draw on pre decided scale for each value of the table, and the per capita income in different states of India show that Punjab was on first position in per capita income among the given states and Manipur with lowest income is on bottom in the list, fig. 1.1 represents the comparatively study at one glance. Other diagrams are also showing the clear picture of related aspect of data.

---

## 1.7 GLOSSARY

---

**Statistical data** – Statistic is the branch of mathematics that deals with the collection, organization, analysis and interpretation of numerical data.

**One Dimensional Diagram-** A diagram in which the size of only one dimension i.e. length is fixed in proportion to the value of the data is called one dimensional diagram. Such diagrams are also popularly called bar diagrams. These diagrams can be drawn in both vertical and horizontal manner.

**Two Dimensional Diagram** - In two dimensional diagram the length as well as the width of the bars is considered. The important types of such diagrams are rectangles, squares and circles diagram.

**Three dimensional Diagrams** - Having, or seeming the three dimensions, i.e. depth, width and height. Spherical diagram, Cube diagram and block pile diagrams are the example of type of diagrams.

**Square diagram** - It is an important two- dimensional diagram and use to show the production in rupees and quintals etc. through squares .

**Pyramid diagram** – The Pyramid diagram is virtually a variant of a bar graph, where columns, constructed to represent specific qualitative population data and are arranged in a tier structure.

**Wheel Diagram** - This type of diagram shows the distribution by a circle whose area is proportionate to the quantity represented. It is divided in order to represent component parts, than the areas of the sectors are proportional to the angles at the Centre. Therefore,  $360^{\circ}$  the total number of degrees contained in a circle and it is divided into different sectors according to table.



## 1.8 ANSWER TO CHECK YOUR PROGRESS

Q. 1. What are the general rules for constructing diagrams?

Q. 2. What are the chief advantages of diagrams?

Q. 3. Define two dimensional diagrams in Geography.

Q. 4. What is bar diagram? Draw a simple bar diagram to represent the following data

### **Per Capita Income in Rupees**

Year	1950-51	1955-56	1960-61
Per capita income	251	281	330

Q. 5. What do you mean by wheel diagram in Geography? Construct a wheel diagram to show the given data.

### **Area in Square Kilometers**

State	A	B	C
Area	14422	10321	8809

## 1.9 REFERENCES

1. Wikipedia, the Free Encyclopedia.
2. J.P Singh, Practical Geography, Rastogi Publication, Meerut.
3. Singh R.L and Rana Singh P.B, Elements of Practical Geography, Kalyani publication, New Delhi.
4. Negisingh Balbir, Practical Geography, Kedar Nath Ram Nath publication, Meerut.

## 1.10 SUGGESTED READINGS

1. Text Book Practical Geography by Md. Zulfequar Ahmad Khan, Concept Publishing Company, 1998.
2. Erwin Raisz, General cartography, McGraw-Hill Book Company.
3. George Richard Peter Lawrence, Cartographic method, Methuen.
4. Arthur Howard Robinson, Elements of cartography, Wiley.

## 1.11 TERMINAL QUESTIONS

- Q.1 What is statistical diagram? What is the basis of its classification?
- Q.2 Write the difference between diagram and graph.
- Q.3 What is Pyramid diagram?
- Q.4 Explain the Square diagram.

---

## UNIT 2 - DISTRIBUTION MAPS

---

**2.1 OBJECTIVES**

**2.2 INTRODUCTION**

**2.3 DOT METHOD**

**2.4 PROPORTIONAL CIRCLES**

**2.5 SPHERE METHODS**

**2.6 CONCLUSION**

**2.7 SUMMARY**

**2.8 GLOSSARY**

**2.9 ANSWER TO CHECK YOUR PROGRESS**

**2.10 REFERENCES**

**2.11 SUGGESTED READINGS**

**2.12 TERMINAL QUESTIONS**

## 2.1 OBJECTIVES

After reading this unit you will be able:

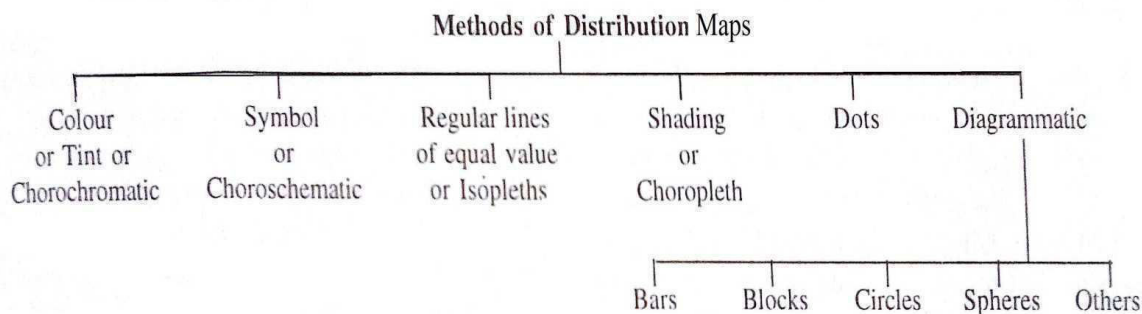
- To describe the Dot Maps.
- To explain the Proportional circles.
- To define and construction of Sphere methods.

## 2.2 INTRODUCTION

When the distribution of something is shown on a map, it is called a distribution map. For example, when we sketch on map, the distribution of some climate factor (temperature, air pressure), vegetation, soil, animal wealth, minerals, economic production, or population etc., that map will be called the distribution map of that particular thing. Such a map is called single factor map too. They are made with the purpose of showing the distribution of a particular thing too. So they are also called special purpose maps. The map showing the regional distribution of sources of energy will be called mineral map. Similarly the map showing the regional distribution of sources of energy will be called a map of sources of energy. So, the names of the various distribution maps will be related to the particular object the regional distribution of which distribution maps differ from topographical maps in that they show some one characteristics of the area. The questions of the exact location of any object or feature do not arise in such maps. It is the general appearance given by the surface distribution of something that is emphasized by these maps. In short the, distribution maps give the areal distribution of certain element.

### KINDS OF DISTRIBUTION MAPS

Distribution maps are made to show the regional distribution of some particular thing. But all distribution maps do not merely show the regional spread of thing, i.e., we do not merely learn from them how far the area of something spreads, but some distribution map also show in what area of something is available in small or large amount. So distribution maps can be divided into two broadkinds :qualitative distribution maps and quantitative distribution maps; colour, symbol, isopleth, dots and diagrammatic maps are the sub-division techniques of qualitative and quantitative distribution maps according to flow chart.



## **CLASSIFICATION OF QUALITATIVE MAPS**

The maps of qualitative areal distribution are of two general types:

1. **Maps of simple area distribution-** They show the area covered by a particular element. Thus, a map showing agricultural land uses, irrespective of the different types of agricultural uses found there is a map of simple areal distribution.
2. **Maps of Compounds areal distribution-** When a distribution maps shows the different types of the same element, it is a map of compound areal distribution. Thus, an agricultural land use map shows distinctly the distribution of various categories, such as land under crops, fallow lands, land under various types of forests, uncultivated lands, land under various types of forests, land not available for cultivation etc. belongs to this category.
3. **Qualitative Distribution maps-** Maps which show only the regional distribution of something or of its kinds and do not show their quantity amount are called qualitative distribution maps. So, from their maps one can learn in what regions of the country we can obtain something or its various kinds and species. From the distribution map soil we learn what kinds of soil is spread in what parts of the country. But these maps do not provide the quantitative knowledge of what quantity of soil is spread and in what regions. Quantitative distribution maps which show only regional spread can be divided into two kinds. Simple area distribution map and compound area distribution map.

## **METHOD OF CONSTRUCTION OF DISTRIBUTION MAP**

There are many methods of making distribution maps. Some methods can be used for making qualitative and quantitative maps both, while there are some methods which can be used for making distribution maps of one kind only. For example, the naming method is used for qualitative distribution only while the dot method is suitable only for quantitative distribution maps. The following facts are to be taken into consideration to decide which method should be used while making distribution map.

1. The outline map that is to be used for distribution maps should have all political boundaries marked in it.
2. We should have complete knowledge of the things or facts the distribution of which is to be shown in the map, e.g., if the distribution of wheat is to be shown in a map of India, we should have the data of its required quantity in every state or district. Then only its correct distribution can be shown.
3. The data for making distribution maps should have been taken from reliable sources and there should be a reference of their source, year of publication and place of publication.
4. We should have a correct knowledge of the surface shapes, climate, soil, vegetation and water and habitats etc. of the area in which distribution is being shown. If the cartographer is not acquainted with these, he will not be able to show the proper and correct distribution in the map.

## **QUANTITATIVE DISTRIBUTION OR THEMATIC MAPS**

Distribution maps of this kind, besides showing the area spread of some particular thing or of its kinds and species, also show in what quantity something or its various kinds are available in some area. Variable tendency of various materials is shown in these maps, e.g. the various tendencies of production can be shown in them.

### **Method of Making Quantitative Distribution Maps-**

The following methods are used for the preparations of distribution maps:

- (a) Dot Method
- (b) Isopleths Method
- (c) Shade or Choropleth Method
- (d) Diagrammatic Method

---

### **2.3 DOT METHOD**

---

When data are shown in distribution maps with dots, it is called dot method. In it all data are first converted into round figures. Then a scale is supposed, e.g., if one dot represents 500 hectares, we will divide every figure by 500 and the dots marked there will be as many as the figure thus obtained. To decide where the dots are to be placed we must consider the following points-

- (1) Special care is to be taken while making the dots on the map. The most important precaution is that production and other data should be shown only at the fixed places and within the limits.
- (2) While placing the dots special care should be taken that there are no dots in negative areas. Their distribution should be shown in positive areas only.
- (3) Dots should be placed in the map at those very places where that thing is produced e.g. if we have to show the distribution of some crop on the population, these dots will be placed in those very places where that crop grows or where the population resides. If the distribution of population is to be shown with the dot method, it should be noted with the help of the physical map of that area that there are no dots in the area of mountain, water map, swamp or desert or forest or other negative areas. If the data are related to production of crops, it should be noted that dots are placed in the map only at those places where the physical and climate conditions soil are suitable for production.
- (4) The size of dots should be the same in the map. The dots should not be smaller and larger on half dots.
- (5) The size of a dot should be such according to the scale of data and the sketch map of that region that while showing them in large numbers at a place of greater density the map should not grow black.
- (6) If the map of the region be small, the scale showing dot should be large, e.g., one dot equal to (ten lakh) one million. In the population in Report of 1951 the distribution of population was shown by the dot method for the first time in India. Urban population was shown with red dots.

- (7) The size of dots should be so fixed that there may be coalescence of dots in the areas of thickest density, i.e. dots may just one another. By doing like the variety of density of distribution in the map can be clearly seen at one sight.

The dot method has the following specialties-

- (a) It is very simple and successful representation of distribution map. It is therefore that this method is quite in use and acceptable.
- (b) This method does not give rise is any problem between political and geographical boundaries. It is equally useful for both.
- (c) The construction of maps by the dot method is based on correct data and true information. So there are no mistakes of average in it.
- (d) Generally only one thing is represented in one dot map, but the distribution of different things can be shown with different dots which can be smaller large in shape and the black, red, green colour may be use.
- (e) There are some practical problems in depicting dots on the map, these are:
  1. How much or how many shall each dot represent?
  1. How big shall each dot be?
  2. Exactly how shall each dot be placed within the area?
  3. The scale of dots for such a map needs to be carefully chosen if it is to be effective.

Q. 1. Show the given data of population distribution on the map of Uttar Pradesh:

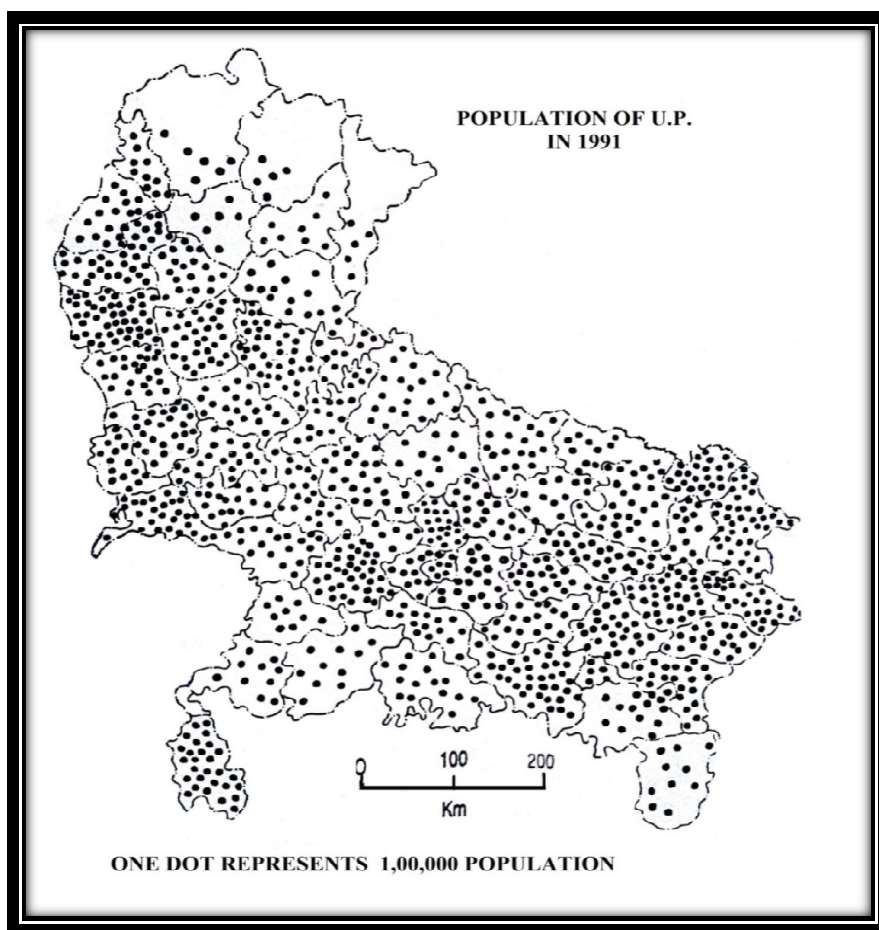
**Table- 2.1 Population of Uttar Pradesh, 1991**

District	Population	District	Population	District	Population
Garhwal	664,986	Bahraich	2757,862	Kanpur Nagar	2493,291
Pithoragarh	560,442	Gonda	3574,214	Jalaun	1217,021
Almora	820,810	Barabanki	2425,309	Jhansi	1426,984
Nainital	1585,325	Faizabad	2983,808	Lalitpur	745,632
Bijnor	2,444,042	Sultanpur	2558,698	Hamirpur	1465,707
Moradabad	4104,266	Siddarthnagar	1706,634	Banda	1,874,541
Rampur	1,498,344	Maharajganj	1678,131	Fatehpur	1893,400
Saharanpur	2301,886	Basti	2757,735	Pratapgarh	221,253
Hardwar	1121,392	Gorakhpur	3043,825	Deoria	435,122
Muzaffarnagar	2928,927	Bareilly	2821,239	Mau	1418,872
Meerut	34,30,398	Pilibhit	1279,873	Azamgarh	3148,830
Ghazibad	2755,494	Shahjahanpur	1981,950	Jaunpur	3,207,048
Bulandshar	2826,427	Kheri	2413,878	Ballia	2249,964
Aligarh	3286,681	Sitapur	2850,059	Ghazipur	2462,867
Mathura	1921,714	Hardoi	2741,486	Varanasi	4839,752

Agra	2753,070	Unnav	2198,174	Mirzapur	1661,622
Firzabad	1532,223	Lucknow	2733,619	Sonbhadra	1068,730
Etah	2240,296	RaiBarelli	2320,709	Allahabad	4927,123
Mainpuri	1305,605	Farrukhabad	2414,491	Kanpur Dehat	2136,534
Buddaun	2440,135	Etawah	2113,144		

## **CONSTRUCTION METHOD**

First take an outline map of Uttar Pradesh with boundaries of districts, the dots will mark in it. Now determine a scale for all data. Suppose one dot represents the population of one lakh. Then according to this scale there will be six dots for Garhwal. In the same way there will be 30 dots for Gorakhpur while placing dots you should have in your mind picture of the map of the district in which you are showing the population. Dots will be placed similarly in all states according to table 2.1 on the map. Negative areas should be left. Thus map of population distribution get prepared with dot method as shown in (fig. 2.1).



**Fig.2.1**



## **DIAGRAMMATIC METHOD**

This implies the use of diagram to represent statistical data over the map, such as bars, blocks, circles, spheres, etc. The method of drawing bars and blocks diagrams has already been discussed in the previous chapter. Now, the main problems lies with their placing on the map. They are made to correspond with the exact localities whose data they represent. Such as the centers of circles and spheres would correspond to the site of the towns or the centre of the region they represent. The base of the bars too would be placed at the exact centre of the region or at any point to be so selected that it may lie, as far as possible, within the limits of the area concerned. This method is employed for some specific purposes: (1) certain facts can exclusively be represented by diagrams on the maps; the maps showing the land use in the different regions necessarily adopt circular diagrams; the populations of big towns in a population map may be best shown by spheres. (2) Besides, it various graphs for different subjects as distribution of weather elements; temperature, rainfall etc.

Now, after analyzing the technique of different methods of drawing distribution maps, it is equally important to study some particular types of these maps prepared on different systems and their relative importance. The detail on proportional circles maps and sphere methods are here in detail, according to object of unit for your knowledge bank.

## ***2.4 PROPORTIONAL CIRCLES***

Proportional Circles Maps are used for displaying data in relation to the size of the circle. For the construction of this map first you must calculate the square root of your various data to get the radius. You might decide that 1mm is used to represent a radius of 1 million. So if you got radius for 5 lakh population =0.5 mm. You would then rule a radius of 5 mm. circles on the map.

Q.1 Show the population of principal cities of India with the help of data in given table.

**Table – 2.2: Population of Major Cities of India, 1961**

City	Population in Lakhs
Mumbai	42
Kolkata	30
Delhi	24
Hyderabad	12

Calculate the radii of various cities according to the formula given in the calculation of Table

2.2. Calculations in detail are as:

$$\text{Presumed radius } x = 3\sqrt{\frac{\text{any number}}{\text{Select number}}}$$



We, therefore, have the various radii for cities as:

Radius for the population of Delhi, its population was 24, 00, 000 = 1 cm.  $\times 3\sqrt{\frac{2400000}{1200000}} = 1.25$  cm.

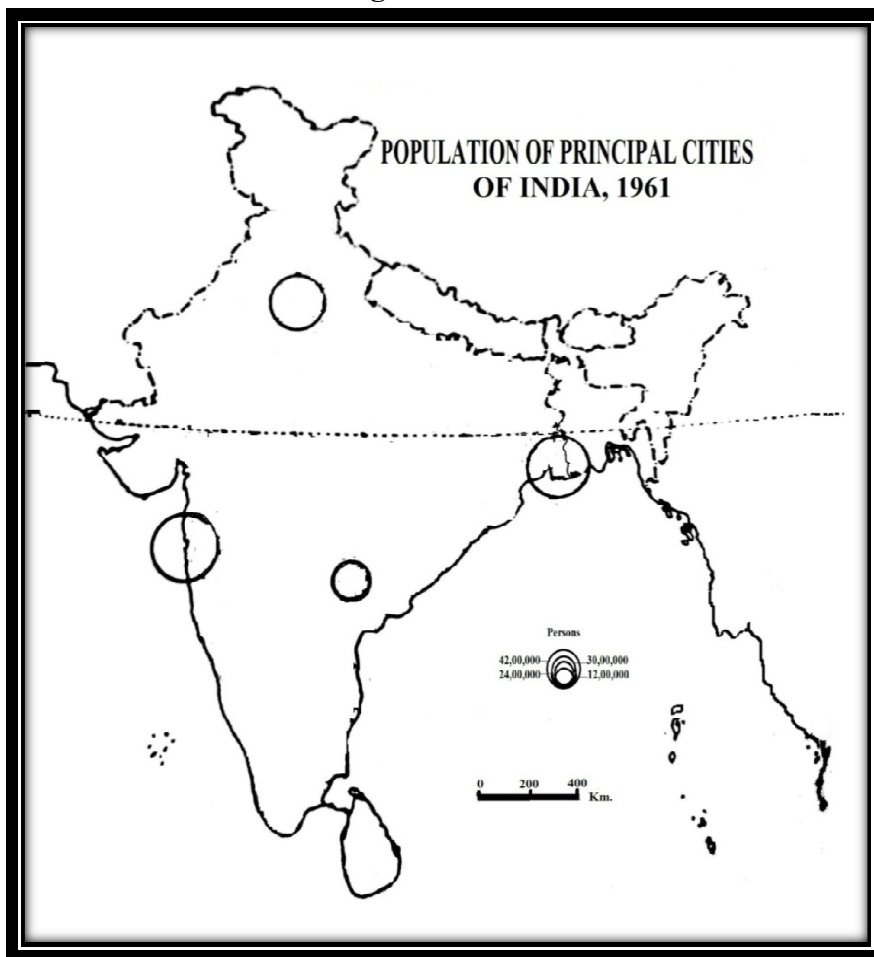
Radii for the population of Kolkata, its population was 30,00, 000 = 1 cm.  $\times 3\sqrt{\frac{3000000}{1200000}} = 1.35$  cm.

Radii for the population of Mumbai, its population was 42,00,000 = 1 cm.  $\times 3\sqrt{\frac{4200000}{1200000}} = 1.51$  cm.

### **Method of construction**

For the preparation of Proportional circle map to show the population of given cities in 1961. You have need of data, political map of India, calculator, colour pencils and, the drawing compass. Now you decide the size of the circle for it you have to calculate the square root for each values to get the radius of each circle for example the largest circle will draw for Mumbai, which had 42,00,000 population the square roots of Mumbai which comes 3.5 lakhs just like this we will calculate the data it will 1.51 cm. and 1.35 cm., 1.25 cm. and 1 cm respectively. Now draw the circle to find the center of Mumbai, Kolkata, Delhi and Hyderabad. Keep the title of the map on north side. It is the complete proportional circle map to show the population distribution in 4 major cities of India.

**Fig. 2.2**



## 2.5 SPHERE METHODS

In this method spheres represent the population of an area. The spheres are so drawn that their centers coincide with the exact location of cities. Table 2.3 gives the population of certain selected cities of India.

**Table –2.3: Population of major cities of India, 1961**

City	Population in Lakhs
Mumbai	42
Kolkata	30
Delhi	24
Hyderabad	12

Presumed radius of the smallest figure  $x = 3\sqrt{\frac{\text{any number}}{\text{the smallest selected No.}}}$

Suppose 12,00,000 population are shown by a sphere of a presumed radius 1 cm.

Therefore radius of sphere for the population of Delhi, its population was 24,00,000

$$\begin{aligned}
 &= 1 \text{ cm. } \times 3\sqrt{\frac{2400000}{1200000}} = 1.25 \text{ cm.} \\
 &= 1 \text{ cm. } \times 3\sqrt{2} \\
 &= 1 \text{ cm. } \times 1.25 = 1.25 \text{ cm.}
 \end{aligned}$$

The cube root of 2 is 1.25

Radius of sphere for the population of Kolkata, its population was 30,00,000

$$\begin{aligned}
 &= 1 \text{ cm. } \times 3 \\
 &= 1 \text{ cm. } \times 3 \\
 &= 1 \text{ cm. } \times 1.35 \text{ cm.}
 \end{aligned}$$

In Log table the cube root for 2.5 is 1.35, Now for 30,00,000 the scale is 1 cm.  $\times 1.35 = 1.35$  cm.

Radius of sphere for the population of Mumbai, its population was 42,00,000

$$\begin{aligned}
 &= 1 \text{ cm. } \times 3 \\
 &= 1 \text{ cm. } \times 3 \\
 &= 1 \text{ cm. } \times 1.51 \\
 &= 1.51 \text{ cm}
 \end{aligned}$$

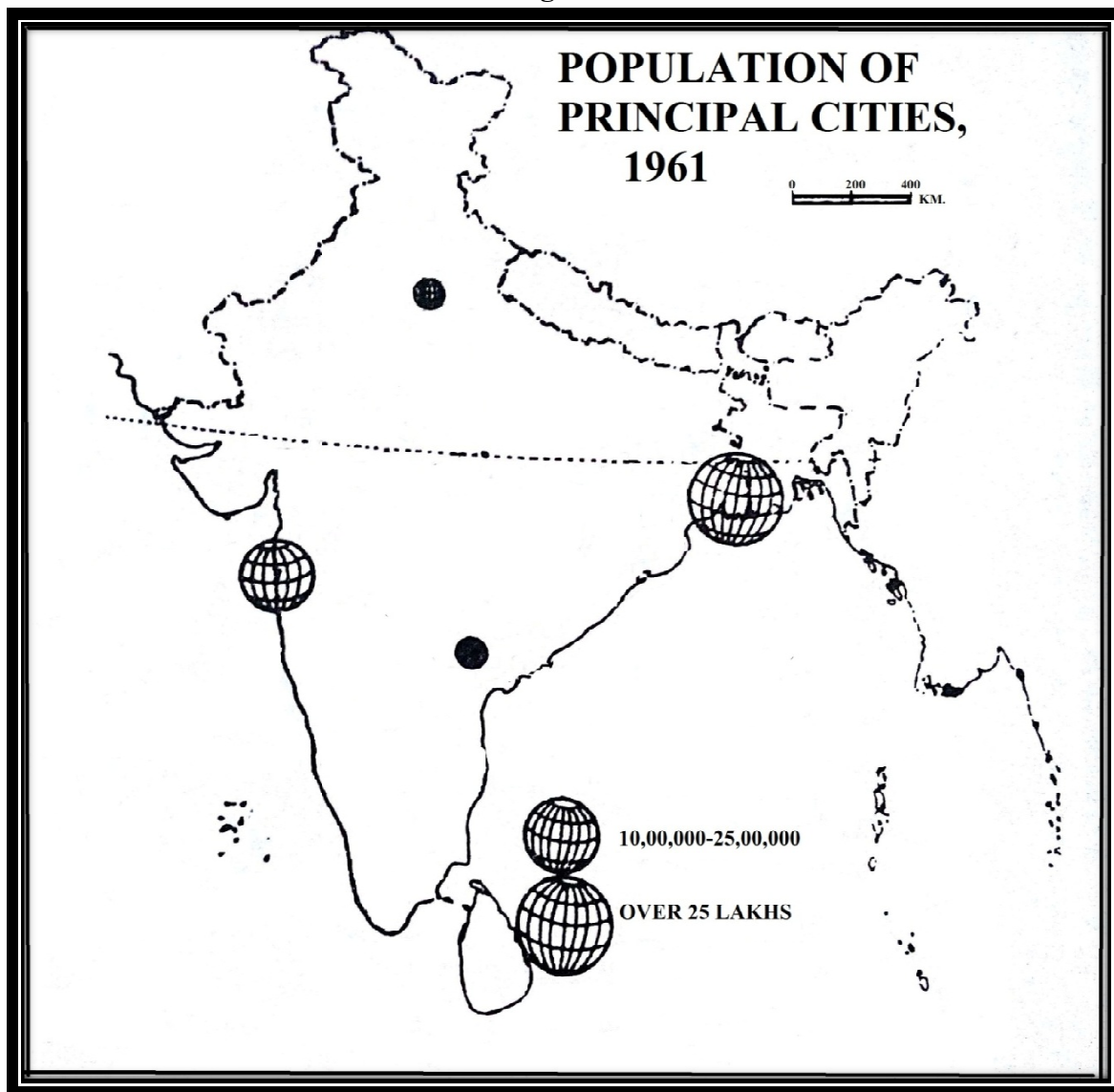
In Log table the cube root of 3.5 is 1.51 so that 42,00,000 the cube scale is 1 cm  $\times 1.51 = 1.51$  cm.

### METHOD OF CONSTRUCTION

First of all divides the each figure by 12 lakhs, the lowest figure in the table. Assuming that sphere of 1 cm. radius represents 12 lakhs population. Then the radius of other spheres will be calculated by the given formula. Now draw various spheres according to the radius scale for the preparation of sphere methods distribution map to show the population of four major cities in 1961. You have need of data, political map of India, calculator, colour pencils and, the drawing compass. According to calculation largest sphere will draw for Mumbai, which had 42, 00, 000 population the square roots of Mumbai which comes 3.5 lakhs and according to log table 1.51 is

the value of cube root. Like this draw another spheres of 1.35 cm., 1.25 cm. and 1 cm radius respectively. Concentration over the center of Mumbai, Kolkata, Delhi and Hyderabad should keep in mind.

Fig. 2.3



## 2.6 CONCLUSION

Thus we can say that distribution maps represent the pattern of distribution of any element based on some definite statistical data. It may be qualitative or quantitative. Distribution of continuous variables like temperature, pressure, rainfall, etc. may be shown by distribution maps. The dot method is the most important, useful and simple method of showing the distribution on the map. This method is particularly useful for showing absolute figures. Dots are put on the map to show the concerned distribution. Each dot is assigned a special value. The dots are put according to the actual distribution of the element to be shown. This method is used to show the

distribution of population, livestock's, agricultural production of a certain crop, production of minerals etc. The political map, relief map, drainage map, climatic map etc. are the basic maps for construction of dot map. This method is better than any other method of showing distribution because of its accuracy. More than one element can be shown on a single map by using multiple dot map method. Whereas it has also few demerits as the method requires a good deal of practice to draw it. This is useful for absolute figure only.

---

## 2.7 SUMMARY

As you know the unit is about role of distribution map in geography and dot method, proportional circles, sphere methods. So the development of unit is with the pre decided objectives. When the distribution of something is shown on a map, it is called a distribution map. For example, when we sketch on map, the distribution of some climate factor (temperature, air pressure), vegetation, soil, animal wealth, minerals, economic production, or population etc., that map will be called the distribution map of that particular thing. Distribution maps can be divided into two broad kinds : 1- Qualitative distribution maps and 2- Quantitative distribution maps.

Maps which show only the regional distribution of something or of its kinds and do not show their quantity amount are called qualitative distribution maps. Maps of simple area distribution and Maps of compounds areal distribution are two divisions of qualitative maps. Whereas, maps which show only the regional distribution and show their quantity amount are called quantitative distribution maps. Dot method and diagrammatic methods are the division of quantitative distribution maps. Dot method, circle method and spherical methods explain that these are the good technique to explain the distribution of population.

---

## 2.8 GLOSSARY

1. **Thematic map** – the maps used to display geographical concepts such as density, distribution, gradients etc. are called thematic map.
2. **Dot map** – It is a map type that uses a dot symbol to show the presence of a feature or phenomenon in an area.
3. **Proportional circle map** -Proportional Circles Maps are used for displaying data in relation to the size of the circle.

---

## 2.9 ANSWER TO CHECK YOUR PROGRESS

- Q.1 What is distribution map?
- Q.2 Give few examples of distribution map?
- Q.3 Explain the use and types of distributional maps.
- Q.4 What is dot method?
- Q.5 What are the advantages and disadvantages of dot method?

---

## 2.10 REFERENCES

---

1. R.L. Singh and Rana P.B. Singh, 'Elements of Practical Geography' Kalyani Publication New Delhi.
2. Dr. Balbir Singh Negi, 'Practical Geography', Kedar Nath Ram Nath, Publication, New Delhi.
3. Wikipedia, The Free Encyclopedia.
4. Dot distribution map – Wikipedia
5. NCERT Class XII : Geography Practical : PDF

---

## 2.11 SUGGESTED READINGS

---

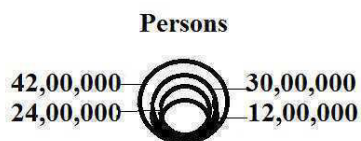
1. Text Book Practical Geography by Md. Zulfequar Ahmad Khan, Concept Publishing Company, 1998.
2. Erwin Raisz, General cartography, McGraw-Hill Book Company.
3. George Richard Peter Lawrence, Cartographic method, Methuen.
4. Arthur Howard Robinson, Elements of cartography, Wiley.

---

## 2.12 TERMINAL QUESTIONS

---

- Q.1 What are thematic maps?
- Q.2 What is dot method?
- Q.3 How do you define the Proportional Circles method?
- Q.4 How will you explain Sphere methods in geography?



---

## UNIT 3 - QUANTITATIVE METHODS

---

**3.1 OBJECTIVES**

**3.2 INTRODUCTION**

**3.3 THEMATIC MAPS**

**3.4 ISOPLETHS**

**3.5 CHOROPLETH**

**3.6 FLOW CHARTS**

**3.7 CONCLUSION**

**3.8 SUMMARY**

**3.9 GLOSSARY**

**3.10 ANSWER TO CHECK YOUR PROGRESS**

**3.11 REFERENCES**

**3.12 SUGGESTED READINGS**

**3.13 TERMINAL QUESTIONS**

---

### 3.1 OBJECTIVES

---

The objective of practical geography course is to train the students in the art of representing demographic, socio-economic and any database of an area through simple statistical and cartographic techniques. Block-1 of practical geography primarily deals with representing statistical data through various cartographic techniques such as diagrams, graphs, maps, quantitative methods etc. In Unit-1, you have learned about representing statistical data through various forms of diagrams and graphs such as line diagram, bar diagram, pyramid diagram and square diagram etc. Unit-2 dealt with various types of distribution maps. In this unit (3), we would take up other cartographic techniques such as Isopleths, Choropleth and Flow Charts.

---

### 3.2 INTRODUCTION

---

Statistics and mathematics became integral components of geographical studies under the Spatial Science paradigm, known as the Quantitative revolution. Statistical data can be represented in various ways such as diagrams and maps. A diagram represents statistical data in an abstract and conventional form. A distribution map shows the spatial distribution of a geographic element on a map. As geographers are primarily concerned with spatial relationships, distribution maps are far more important in geographical studies. Distribution maps indicate the distribution of any particular feature in an area. Distribution maps help us to understand the distribution of different elements of the physical and biological environment in an area. Distribution maps can be classified into two main categories:

**1. Non-quantitative Distribution Maps:** These maps represent the spatial distribution of data without taking into consideration the quantities such as representing vegetation or soil of a region. The areas where objects are located are either shaded with a particular shade, colour or tinted. But when the areal distribution of more than one thing is to be shown, different shades or tints are used. The maps showing non-qualitative areal distributions by shading or tinting the areas are called *chorochromatic maps*. Non-qualitative areal distributions are also shown by symbols such as dots, circles, triangles etc.; index letters such as T for tea and R for rice and drawing or pictures of the objects. Since, these symbols do not represent quantities; these maps are termed as non-quantitative distribution maps.

**2. Quantitative Distribution Maps:** Maps that show the variation in the distribution of a quantity by symbols such as dots, shades, isopleths, squares, circles and spheres are called quantitative distribution maps. These maps represent the spatial distribution of data including the quantities such as total population, density, literacy rate etc. For example, the distribution of population may be shown by dots where each dot may represent a given number of persons. Likewise, economic data like production of crops, minerals etc. may be shown by distribution maps. Distributions of continuous variables like temperature, pressure, rainfall etc. are represented by lines of equal value such as isotherms, isobars and isohyets respectively.

---

### 3.3 THEMATIC MAPS

---

All the maps can be broadly grouped into two categories i.e. general and thematic. Between them thematic maps are more systematic. The study of thematic maps develops an understanding between the regional and temporal changes in a region. A thematic map is a type of map specifically designed to show a particular theme connected with a specific geographic area like demographic atlas of Uttarakhand. A thematic map is a map that emphasizes a particular theme or special topic such as the average distribution of rainfall in an area. They are different from general reference maps because they do not just show natural features like rivers, cities, political sub-divisions and highways. Instead, if these items are on a thematic map, they are simply used as reference points to enhance one's understanding of the map's theme and purpose. Within thematic *univariate map* is a map dealing with only one type of data and therefore looks at the occurrence of one type of event. This process would be good for mapping a location's rainfall. *Bivariate data mapping* shows the distribution of two data sets and models their correlations such as rainfall amounts relative to elevation. *Multivariate data mapping* is mapping with two or more data sets. For example a multivariate map could look at rainfall, elevation and the amount of vegetation relative to both.

#### 3.3.1 TYPES OF THEMATIC MAPS

Although, cartographers can use these data-sets in many different ways to create thematic maps, there are five thematic mapping techniques that are used most often. The first and most commonly used of these is the *choropleth map*. This is a map that portrays quantitative data as a colour, shades or tint and can show density, percent, average value or quantity of an event within a geographic area. Sequential colours or shades on these maps represent increasing or decreasing positive or negative data values. Normally, each colour or shades also represents a range of values. We would learn more about the technique of choropleth mapping in section 3.5 of this unit. *Proportional or graduated symbols* are the next type of map and represent data associated with point locations such as cities. Data is displayed on these maps with proportionally sized symbols to show differences in occurrences. Circles are most often used with these maps but squares and other geometric shapes are suitable as well. The most common way to size these symbols is to make their areas proportional to the values to be depicted with mapping or drawing software. Another thematic map is the *isopleth or isarithmic map* and it uses isolines to depict continuous values like precipitation levels. These maps can also display three-dimensional values like elevation on topographic maps. Generally data for isarithmic maps is gathered via measurable points (e.g. weather stations) or is collected by area (e.g. tons of rice per acre by district). Isopleth maps also follow the basic rule that there is a high and low side in relation to the isoline. We would take up isopleth technique in detail in section 3.4 of this unit. A *dot map* is another type of thematic map and uses dots to show the presence of a theme and display a spatial pattern. On these maps, a dot can represent one unit or several, depending on what is being depicted with the map. Finally, *dasymetric mapping* is a complex variation of the choropleth map



and works by using statistics and extra information to combine areas with similar value instead of using the administrative boundaries common in a simple choropleth map. One more techniques would be taken up in section 3.6 of this unit namely flow charts.

### 3.4 ISOPLETHS

The term isopleth has been derived from Greek word *isos* meaning 'same' and *plethron* meaning 'measure'. Thus isopleths are lines joining places of equal value on a map. This value may be in the form of quantity, intensity or density. An isopleth map generalizes and simplifies data with a continuous distribution. It shows the data as a third dimension on a map, thus isopleth maps are more common for mapping surface elevations, amounts of precipitation, atmospheric pressure and numerous other measurements that can be viewed statistically as a third dimension. The third dimension is shown by a series of lines called isopleths which connect points of equal value. The isopleth interval is the difference in value between two adjacent isopleths. The values of the isopleths drawn on the map are always multiples of the intervals. Isopleths never cross or divide, starts from one corner of a map and end at another corner and sometimes form enclosed circles. Isopleth maps show a range of quantity. They show data as a third dimension on a map, making them good for weather data. Radar maps, temperature maps and rainfall maps are all isopleths maps. Isopleth maps usually have ranges of similar value filled with similar colors or patterns, showing changes over space. Some of the examples of isopleths are as follows:

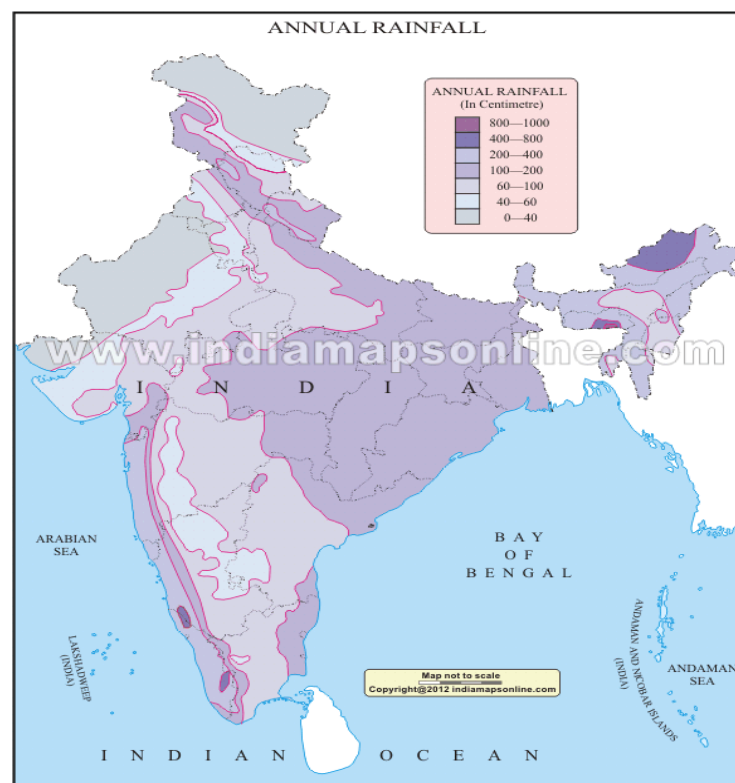
- **Isobar:** lines connecting points with equal atmospheric pressure at a given time or on average over a given period.
- **Isotherms:** lines connecting places with same temperature at a given time or on average over a given period.
- **Isohyets:** lines connecting areas of equal rainfall at any given time or on average over a given period.
- **Isohaline:** lines connecting areas of equal salinity at any given time or on average over a given period.
- **Isoseismic:** lines connecting areas of equal seismic intensity at any given area or an average over a given period.

#### 3.4.1 ISOPLETH MAPS

Maps on which quantities are represented by isopleths are called *isopleth maps*. Isopleth maps differ from choropleth maps in that the data is not grouped to a predefined region like a state or country. Temperature, for example, works better as an isopleth map than a choropleth map because temperature is continuous but does not change abruptly at any point. Isopleth maps also require a large amount of data for accurate drawing. These maps can take two forms:

- Lines of equal value are drawn such that all values on one side are higher than the "isoline" value and all values on the other side are lower, or
- Ranges of similar value are filled with similar colours or patterns.

This type of map is ideal for showing gradual change over space and avoids the abrupt changes which boundary lines produce on choropleth maps. Relief maps should always be in isopleth form for this reason. To draw isopleth maps, data of the stations are noted near the points showing the positions of the stations on the map. The intervals at which the isopleths are drawn are selected keeping in view the difference in quantity of the highest and the lowest value. The number of isopleths and their values are then fixed. Isopleths should neither be very closely packed nor very widely apart. Isopleths are drawn one by one keeping in mind that an isopleth runs through the stations representing quantities of the same value or is interpolated proportionately between them. Sometimes, as critical isopleth (showing the middle value) is drawn first to facilitate the drawing of the other contours. The spaces between the consecutive isopleths are many times shaded to show the varying values. For example, the shade becoming darker as the value increases and vice versa. This brings in more clarity of distribution. It may be noted that the shades here do not stand for density per unit area and, therefore, these shades should not be confused with choropleths. The isopleths when drawn close together indicate a sharp change in the values and when drawn wider apart they show a gentle change. The disadvantage of isopleths is that they are unsuitable for showing discontinuous or 'patchy' distributions and a large amount of data is required for accurate drawing. Figure-1 presents an example of isopleth map depicting areas with equal amount of annual rainfall in India.



**Figure 1: Isopleth Map Depicting Annual Rainfall in India**

Source: [www.indiamapsonline.com](http://www.indiamapsonline.com)

### **3.4.2 DRAWING ISOPLETHS AND INTERPOLATION**

To understand the patterns and distribution of various natural phenomena such as temperature, relief, rainfall, air pressure, population density etc., we need proper tools and mapping techniques for analyzing and displaying the spatial patterns. One way to display the data would be to simply plot the values on a map. However, it is very difficult to look at such a map and visualize spatial patterns. It would just look like a bunch of numbers scattered over an area. Isopleth is one of the common methods of displaying such data and the map produced using the method of Isopleth is called an Isopleth map. An isopleth map typically shows number of lines, often wavy or forming concentric irregular loops or other patterns. An isopleth connects places that all have the same value of whatever quantity is plotted. Each isopleth has a value associated with it and is usually labeled with that value. Isopleth maps show lines with values at regular intervals, including some standard reference value. The isopleth interval should be chosen so that the map shows enough isopleths to reveal the pattern clearly without being crowded with too many lines.

In order to draw isopleths, we employ a method known as interpolation. “Interpolation is a process that uses measurements that we have made about some phenomenon (e.g. precipitation, elevation or mineral content) at particular locations (i.e. a sample of all of the possible locations for which we have available measurements) to make predictions about that phenomenon at other locations where we don’t have measurements”. There are many reasons that we may often have a sample of data to work with. For example, there is limited numbers of weather stations that make the meteorological measurements. In such scenario, we have data for particular points but we would like to be able to see spatial patterns of the said phenomena for all locations within a region. Hence, we need to employ some method of interpolation in order to predict measures for all locations. The basic idea behind interpolation is that we should expect places that are near our sample locations to have values that are more similar to the sample values than places that are not near the sample locations.

Various types of interpolation that you may come across are: interpolation from points to other points, lines, areas and surfaces. Interpolation to points and lines often uses a simple method of interpolation called *linear interpolation*. This method was commonly used by cartographers for creating isoline maps before mapping become computerized and is used by cartographers to create isolines from data surfaces in secondary interpolation. The basic idea behind *linear interpolation* is based on the idea that we can use a sequence of values to predict the values at locations where we don’t have a value. Although linear interpolation methods were first developed for analyzing time series, we can apply the same principles in a spatial context by considering the distance between two points.

## **FACTORS AFFECTING INTERPOLATION OUTPUTS:**

Regardless of the type of interpolation method you may choose to use, there are numbers of factors that can affect the quality of the interpolated outputs:

- **Number of sample points:** Generally, the greater the number of sample points you have, the more accurate your interpolated surface will be, as the set of location is more likely to include locations whose values are important for defining the surface.
- **Location of sample points:** Similarly, the location of sample points can have an important impact on the end result of the interpolation. Often, samples are not evenly distributed over the region of interest, and may be biased to places where data collection is relatively easy. If there are no samples in a region of high variability, the interpolated surface may not be very accurate.
- **Edge effects:** Finally, edge effects can be quite important. Edge effects arise when there are no sample points to one side of a non-sampled region. The lack of samples may bias the estimate that the interpolation method makes of a non-sampled region, leading to large inaccuracies. In other words, the interpolation method is no longer (predicting missing values within a region), but is now extrapolating (predicting values in areas where there is no sample data).

## **STEPS IN DRAWING ISOPLETHS:**

When drawing an isopleth, you cannot expect it to pass directly through many surface weather stations because it is rare for an actual observation to match your isopleth value exactly. However, every place has a temperature, pressure, rainfall etc. When drawing isopleths, you usually have to interpolate values between observations. Here is a simple step by step instruction for interpolating isopleths-

1. Decide what isopleth values you will draw. That is, choose a standard reference value and an isopleth interval, which together define the set of possible contours that you may draw.
2. On the map, find the highest and lowest values overall from among those values plotted. These define the range of values that your isopleths will cover and also interval. The isopleth with the highest value that you can draw will not exceed the highest value plotted on the map and the lowest value will not be less than the minimum plotted value. For example, if the lowest temperature plotted on the map is 8.7°C, then the lowest possible isopleth can be 5°C. Similarly if the highest temperature plotted is 44.2°C, then the highest possible isopleth could be 45°C.
3. To start, draw either the isopleth with the highest value possible or the lowest value. Following these steps, you should find a value close to your desired isopleth value and then draw from one pair of observations to another until you reach the edge of the plotted values on the map. It may sometimes pass directly through an observation plotted on the map, but mostly would pass through the plotted observations. Isopleths should be drawn as smoothly as possible and each isopleth should be given a label on either end as well as somewhere in the middle. It is important to remember that isopleths can never cross or intersect each other. Near single highest value it makes circular form.

4. Repeat the above mentioned step for the next isopleth value. This time, you would be able to interpolate between observations and previously drawn isopleths. Continue until you have drawn all possible isopleths. It should be kept in mind that in some instances, you may need to draw more than one isopleth of the same value.
5. You can label the places with higher values as 'H' and lower values as 'L', so to distinguish locations with high and low value on the map.

### **3.4.3 IMPORTANT FEATURES OF ISOPLETH MAPS**

- Isopleth maps show gradual change and patterns over a large spatial area.
- Lines join places of equal values along their length.
- Uses fixed intervals so changes can be easily identified.
- Can add colour/density shading to enhance patterns/trends.
- Can be superimposed onto a base map.

### **3.4.4 ADVANTAGES OF ISOPLETH MAPS**

1. Isopleths are more scientific than other methods of showing distribution and effectively show the distribution and variations.
2. This is especially useful for climatic maps such as isobars, isotherms, isohyets etc. and is known as the main tool for the meteorologists.
3. It is very easy to determine the gradient (rate of change) with the help of isopleth maps. When isopleths are wide apart, they show low gradient but they are closer together they show high gradient.
4. Isopleth lines are independent of political boundaries and best suited to show the natural pattern of distribution of an element.
5. Isopleth is the most suited method for showing elements with transitional values. This is one of the reasons that isopleth maps are invariably used to show the distribution of temperature, pressure, other climatic elements and density.

### **3.4.5 DISADVANTAGES OF ISOPLETH MAPS**

1. The drawing of isopleths often needs interpolation which is a difficult process.
2. The method often suffers from lack of sufficient data.
3. There can be variations in the location of each isoline.
4. The shading implies equal values between the isolines which is misleading.
5. Requires data for a large number of locations but many times it is available for selected stations.

### 3.5 CHOROPLETH

The choropleth mapping technique, which uses “ranges” or “graduated colour”, is a type of thematic mapping that focuses usually on a single theme with data summarized by statistical or administrative areas. The name of this technique is derived from the Greek words *choros* – space and *pleth* – value. These are maps where areas are shaded according to a prearranged key and each shade or color type represents a range of values. Population density information, expressed as population per square km. is appropriately represented using a choropleth map. Choropleth maps are also appropriate for indicating differences in land use, like the amount of agricultural land, recreational land or type of forest cover and other production. Figure 2 and 3 presents some common examples of choropleth maps.

**Figure 2: Example of Choropleth map of Alaknanda Basin**

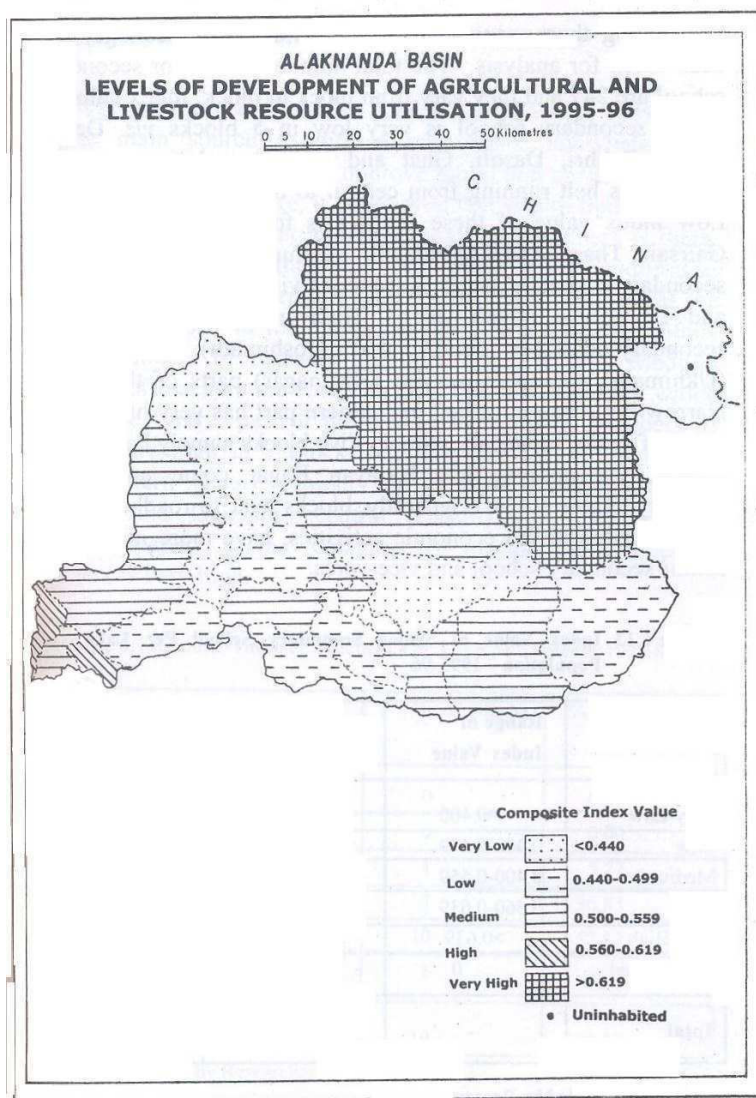
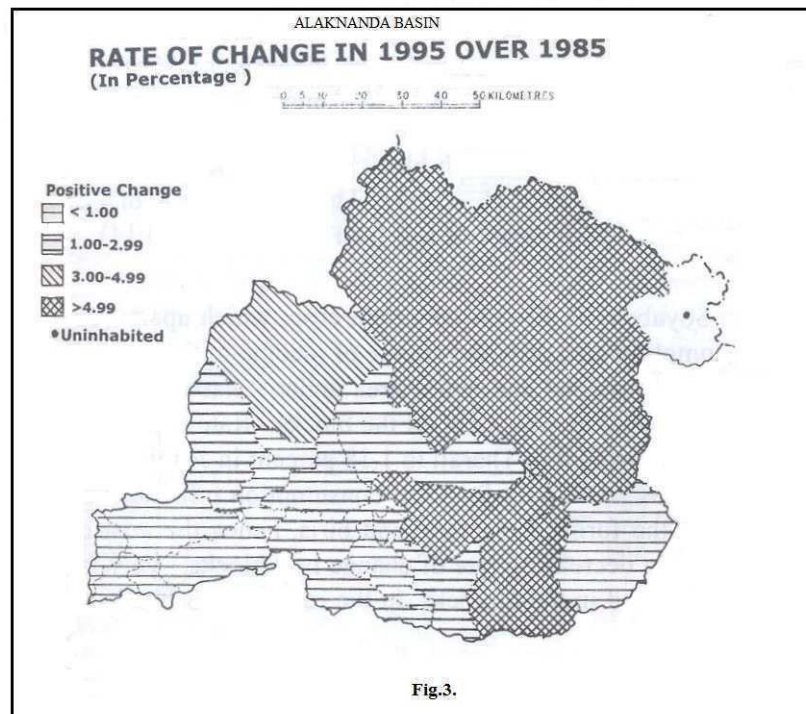


FIG. 2

Source: Author



**Figure 3: Choropleth map of Alaknanda Basin**

Source: Author

### **3.5.1 DATA USED IN THE CHOROPLETH TECHNIQUE**

The choropleth is a common technique for representing data for areas by variations in shading or pattern that represent classes of data. There are two types of data summarized by areas: totals (or absolute values) such as total population; or derived values (or ratios) such as density of population, or average value of dwelling. There is a general rule stating that unless areas have similar sizes, absolute values should not be used for the choropleth map. Using choropleth mapping for areas that vary in size, can lead to misleading maps. Ratios show the relationship between two quantities, and using them eliminates the influence of area, so that the map becomes meaningful by portraying accurately the distribution of features. The most commonly used ratios are averages, proportions (percentages) and densities. Some of the ratios are independent of area (spending on food as percent of total expenditure), others involves area in their calculation, for example population divided by area to obtain the density of population. Data used for choropleth maps are then standardized in one or another way to allow the comparison of distributions across areas.

The choropleth technique is only useful when the form of data is appropriate. Firstly, data should be discrete, with a single value representing each area. Continuous phenomena should not be mapped using a choropleth. Data must be derived values (rates and ratios) representing numerical (quantitative) differences on an interval or ratio scale of measurement. Mapping totals is inappropriate and leads to a meaningless map. Most choropleths have unequal areas. This very simple difference leads map readers to alter their impression of the pattern they see with

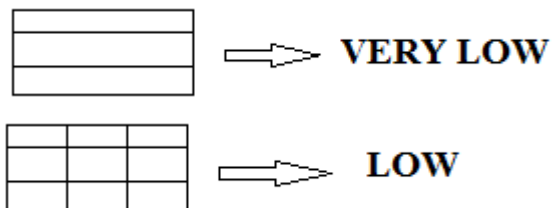
precedence given to large areas over small areas. This masks uniform distributions at a minimum and sorely distorts the relative high and low data densities in the map. Data needs to be normalized to account for unequal areas with typical measures being, for instance, per capita, percentage or per 100,000 people. For an un-classed choropleth, there is no need to categorize data. Each value can be assigned its own unique colour along the chosen symbol scheme.

**The Class-intervals :** The varying average values per unit-area are divided into some classes or groups such as 0-50, 50-100, 100-150, 150-200, 200-250 and so on. The difference between the two figures of a class, which is 50 in this case, is known as class-interval. It should also be noted here that every class has the same class-interval of 50 which is called *regular class-interval*. When the class intervals are different for each class, they are called *irregular class-intervals*. The class interval is chosen keeping in view the lowest and the highest values and with an aim to form realistic patterns. While selecting the class intervals, it should be kept in mind that the intervals are neither too small nor too big. If the class-interval is too small, it would result in too many classes which would further lead to a large number of shades, making the map unnecessarily confusing. Similarly, if the class interval is too large, it would lead to very few classes which will evidently mask many important details. In general, it is reasonable as well as convenient to have 4 to 6 classes for a choropleth map. Apart from above mentioned class interval method, other methods are as follows—

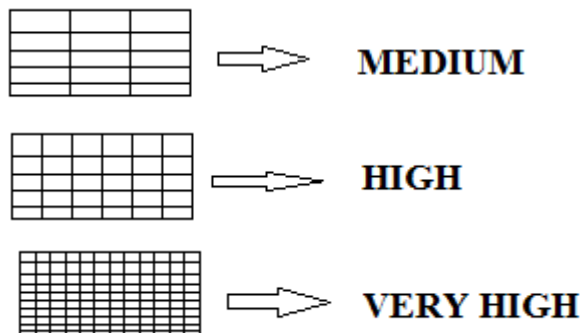
- (i) Less than 50, 50-100, 100-150, more than 150.
- (ii) 0.0- 49.99, 50.00 – 99.99, 100.00 -149.99, 150.00 – 199.99

**Symbols :** A shading scheme should be designed so that the upper and lower data values are symbolized at the extremities of a linear gradient through a suitable colour or shade space. Each value in the data array between the two extremities will then be assigned its own unique colour and the area shaded accordingly. This results in a map with many different colours or shades. Different magnitudes of data are represented through variation in the lightness (or value) of the symbols' colour scheme, lower data values are lighter and larger data values are darker. To put it simply, you can choose any colour/ shade scheme (which usually consists of shades of one colour) where the lightest and darkest shades represent the lowest and highest data values. It should also be kept in mind that generally, when one goes from light to dark shades, it depicts low to high values respectively. However, the this type of colour / Shades scheme can be reversed depending on the objective of the map, for example, one can use dark shades to depict areas with lowest sex ratios in order to attract more attention to the case.

#### Example of Shades:







**Map Use :** The Choropleth map is one of the most frequently used maps in geography. It uses a colouring/ shading scheme (different colours or a graduated colour scale) inside defined areas on a map in order to show value levels and indicate the average values of some property or quantity in those areas. When viewed, the map reader should be able to efficiently recognize the patterns of high and low and areas of relative similarity, while at the same time seeing which end of the spectrum they are viewing. At the very least, relative differences should be obvious and the reader should be able to determine often unique detailed patterns due to the lack of data classification. We visually interpret the symbols as lighter or darker (less or more) so we perceive darker symbols as meaning 'more'. For a bi-polar colour scheme we view data as tending to one end of the measured scale or another around a middle value. The multi-scale characteristic of a web map means we can design the map to reveal more contexts by adding labels at larger scales to aid interpretation.

### **3.5.2 ADVANTAGES OF CHOROPLETH MAPS**

- They can effectively be used to report area values at virtually any scale, from global to local- and the data can be thought about in many different ways at many different levels of analysis, from general overall patterns to the detection of details.
- It is helpful for finding intriguing hot spots, detecting relationships between the encoded variable and geographic location (and the many variables entangled with location).
- The levels of shading/colour can represent a range of values on a map.
- It has visually effective i.e. one can see a large amount of information and general patterns.
- This technique is significant for geographical analysis as it uses countries, states or regions as the base units.
- Groupings can be flexible to accommodate the spread of values.

### **3.5.3 DISADVANTAGES OF CHOROPLETH MAPS**

- Since the choropleth map uses an average number to represent defined areas, the viewer can not gain detailed information or perspective on any area's internal conditions.

- Interval/class sizes need to be carefully chosen.
- They give false impression of abrupt change at the boundaries of shaded areas.
- Choropleths are often not suitable for showing total values. Proportional symbols overlays (included on the choropleth map above) are one solution to this problem.
- Shadings are dependent on the size of the administrative areas selected. It can be difficult to distinguish between different shades.
- Variations within map units are hidden, and for this reason smaller units are better than large ones.
- We tend to pay more attention to the larger area on the map, despite the fact that it can have lower value. For example, we tend to equate the visual importance of each area with its geographic area rather than with the number of people living in there, giving sparsely populated areas great visual emphasis.
- Map assumes the whole region/area has the same value, but there could be variations.

---

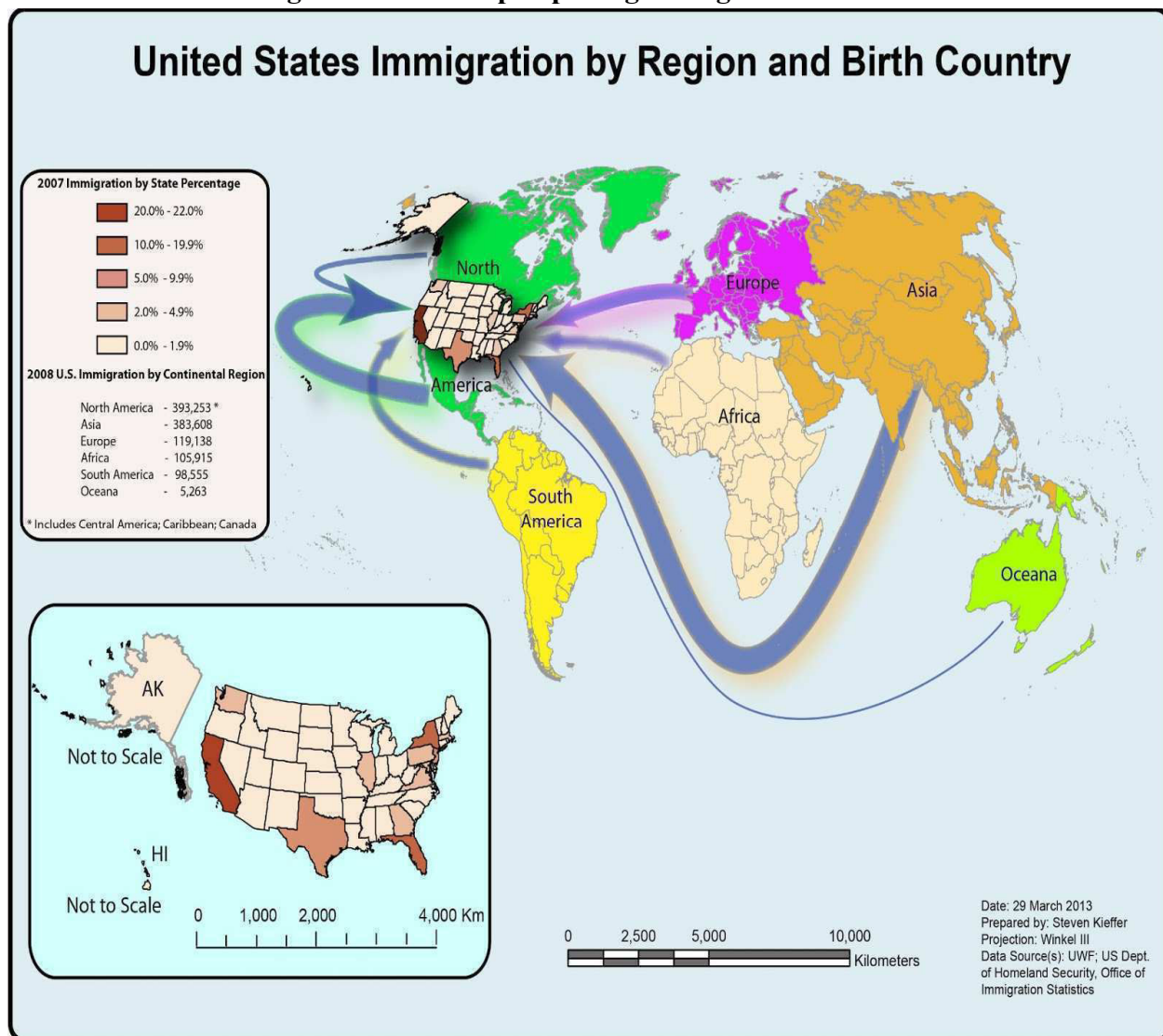
### 3.6 *FLOW CHARTS*

---

Cartographic flow maps are graphical representations for portraying the movement of objects, people, goods or traffic network from one location to another. Flow chart is a combination of graph and map. It is drawn to show the flow of commodities or people between the places of origin and destination. Transport flow map, which shows number of passengers, vehicles etc., is a common example of a flow chart. These charts are drawn using lines of proportional width. Flow maps can reduce visual clutter by merging single representations of movement. Flow maps are also fast to produce and simple to understand. Many government agencies prepare flow maps to show density of the means of transportation on different routes. Such flow maps/charts are generally drawn to represent two types of data: 1) the number and frequency of the vehicles as per the direction of their movement and 2) the number of the passengers and/or the quantity of goods transported. As it distorts the original shape, it is also known as cartogram.

Flow maps depict the movement of phenomena between geographic locations. Phenomena can represent the movement in geographical space of both tangible (e.g. people, bank notes, and goods) and intangible objects (e.g. energy, ideas, and reputation). The links in a flow map are called flow lines and describe the movement of objects from one location to another. To illustrate migrants flows, the network can be represented as a Flow Map Layout, where links sharing the same destination (i.e. flow lines) are aggregated and their thickness represents the sum of the moving migrants (i.e. flow magnitude).

Figure 4: Flow Map depicting Immigration to USA

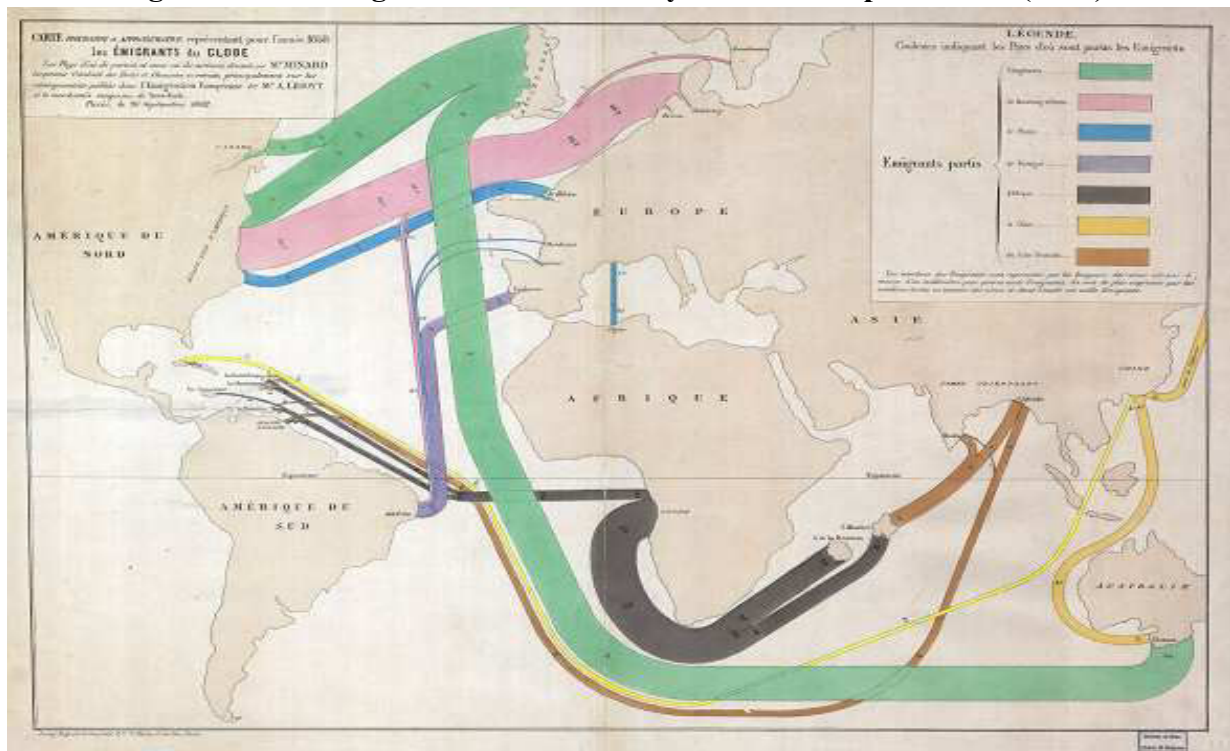


Source: Steven Kieffer (2013)

### 3.6.1 HISTORICAL BACKGROUND

The first flow map representation was created by Henry Harness in 1837 and then popularized by Charles Minard around 1850. The concept of creating flow maps by placing stroked lines on top of a geographic map dates back more than 150 years to the seminal visualizations of Charles Joseph Minard (Figure 5). It shows the emigrants of the World in 1858. The color of the flow lines identifies their origin.

**Figure 5: The Emigrants of the World by Charles Joseph Minard (1858).**



Source: Retrieved from <http://cartographia.wordpress.com/category/charles-joseph-minard/>; taken from Nikola Sander, Guy J. Abel, Ramon Bauer and Johannes Schmidt (2014) p.5.

Minard is considered a pioneer in the use of graphics in engineering and statistics, mainly due to his map on the subject of Napoleon's disastrous Russian campaign of 1812. The hand drawn map depicts the origins, destinations and volumes of migration flows in 1858, with one millimeter equaling 1,500 people. The coloured lines in this flow map represent information contained in a migration matrix on place, direction and volume. Minard's flow map is relatively effective and visually appealing because it shows only a small number of flows.

### **3.6.2 TYPES OF FLOW MAPS**

All the flow maps/ charts can be grouped into three categories namely radial, network and distributive. *Radial flow maps* show relationships between one source and many destinations and use separate lines radiating out from a starting point to show movement. *Network flow maps* depict the quantity of flow over an existing network. These types of flow maps are most frequently used to show transportation and communication networks. *Distributive flow maps* are maps that show relationships between a single source and many destinations like a radial flow map. However, in these maps normally a large single line is produced from one source and that split into many smaller lines as they reach their destination.

### 3.6.3 DRAWING FLOW MAPS

Flow charts or Flow-line maps are used to depict the quantity of goods or services moving between centres. They are ideal for representing various flows such as the volume of vehicle traffic between centres, the volume of airline traffic between cities, the amount of trade between commercial centres, or the number of telephone calls between two or more locations. The links between centres are depicted by quantitative linear symbols i.e. lines with varying widths which are scaled to the volume carried. For example, if 1 mm of line thickness corresponds to 10,000 passengers or to one million of metric tonnes of coal etc. then 3 mm of line thickness might correspond to 30,000 and 3 million of metric tonnes respectively. The scale used to set the thickness of the flow line depends on the range of values to be shown. An appropriate scale will show all values from maximum to minimum without cluttering the map. It is important to choose the scale carefully and often takes trial and error to reach satisfactory conclusion. In any case, flow-line maps should always include a key so that the user can relate the symbol to the actual volume. Flow lines may follow actual transportation routes such as roads or railroads or they may simply indicate the destination/origin of flows by straight or curved lines. Some may specify the direction of flow by arrow heads while in others direction of the flow is unimportant. In some other maps, flows in each direction may be shown by splitting the flow line into two sub-flow-lines.

#### **Example: Constructing Flow Map of Train movements in and around Delhi**

##### ***Requirements for the Preparation of a Flow Map***

- (a) A route map depicting the desired transport routes along with the connecting stations.
- (b) For construction of flow map of train movement in and around Delhi the data pertaining number. of trains of selected routes of Delhi and adjoining service areas is required. If we want to create a flow map depicting passenger flow, we would need data on no. of passengers travelling in trains along with the point of origin and destination of their movements. Similarly, we can create a flow map of goods transported by trains by extracting data on quantity of various goods along with the point of origin and destination of the movements.
- (c) The selection of a scale through which the data related to the quantity of passengers and/or goods or the number of trains is to be represented.

##### ***Steps of constructing the Flow Map***

- (a) Take an outline map of Delhi (or any centre) and adjoining areas in which railway line and the nodal stations are depicted.
- (b) Select a scale to represent the number of trains. For example, here we consider that the maximum number is 50 and the minimum no. is 5. We choose a scale where 10 mm = 50 trains. After this, we need to calculate the width of the flow arrows depicting other values through this calculation: (maximum symbol size) x (value/maximum value). In case of calculating the width for the value 5, the method would be -  $(10) \times (5/50) = 1\text{mm}$ . The maximum and minimum numbers will be represented by a strip of 10 mm and 1 mm thick lines respectively on the map. We would further employ the same method to calculate the width of flow arrows depicting other values.



- (c) Plot the thickness of each strip of route between the given rail route.
- (d) Draw a terraced or stair like scale as legend and choose distinct sign or symbol to show the nodal points (stations) within the strip.

### **3.6.4 ADVANTAGES OF FLOW MAPS**

Cartographic flow maps are graphical representations for portraying the movement of objects, such as people, goods or traffic network, from one location to another. On the one hand, flow maps can reduce visual clutter by merging single representations of movement. On the other hand, flow maps are also fast to produce and simple to understand. Some of the major advantages of flow maps are:

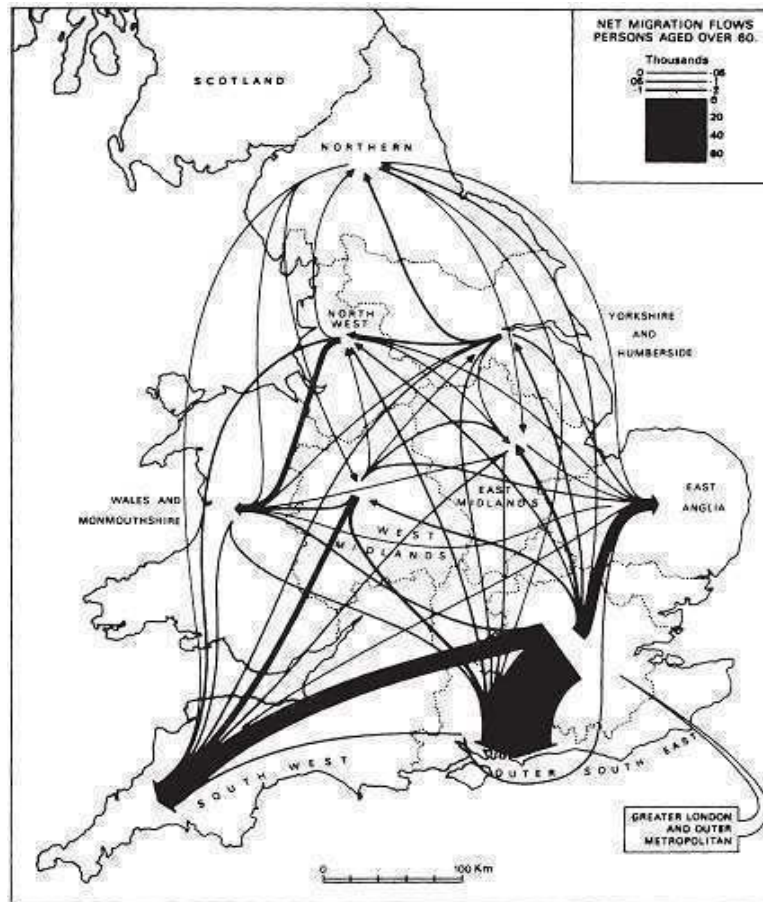
- Flow maps are good for showing directions (all) and size of movements (flow). It shows movement of people, goods, transport etc. and can also show volume and direction of movement.
- Flow maps are able to give a good visual impression of movement as they reduce visual clutter. This makes them very simple to understand.
- The scale/width of lines in flow maps is proportional to value.
- Flow maps can be superimposed onto a base.
- When properly designed, flow maps are beneficial because “they allow cartographers, GIS analysts and map users alike to easily see the differences in magnitude of a wide variety of items across space with very little map clutter” (Phan, et al). This in turn allows businesses to see where the majority of their products are going, commuters to see traffic patterns, and meteorologists to see wind patterns and so on.
- Another important thing to note about flow maps is that they can use and display both qualitative and quantitative data. For qualitative data the maps usually display symbols of uniform width that just show movement with arrows. This data is a connection of some sort and it is not based on magnitude. Quantitative flow mapping uses lines and symbols of different widths and sizes to show changes in magnitude between areas.

### **3.6.5 DISADVANTAGES OF FLOW MAPS**

1. One of the main drawbacks of flow maps is that they work well only for small datasets with limited complexity. If the database is too large and complex, it often leads to cluttering in the flow map which makes the map very difficult to understand. Figure 6 provides an example of a cluttered flow map with overlaying arrows indicating the size and direction of flows. In this map, London comes out to be the dominant centre as an origin of elderly migration in England. Despite recent improvements in geographic information systems, the graphical features of flow maps have changed little since the seminal works by Minard and Ravenstein (1885) in the 19th century. In the scenario of network infrastructure, nodes are usually located over a map or a globe. In this way, it is easy to detect redundant connections or to find badly placed connections. Such representation is also used in the context of climate networks, airport connections, mobility data, and social networks because in all the cases the geographic context is important.

2. Another disadvantage of flow maps is that in order to achieve a clear image, the real distance and direction may be distorted which may lead to misinterpretation. Flow maps also lack precise interpretation unless statistical data is added to the map.

**Figure 6: Net Inter-Regional Migration Flows of those aged 60 or more(1961-66).**



Source: Law & Warnes (1976, p. 464); taken from Nikola Sander, Guy J. Abel, Ramon Bauer and Johannes Schmidt (2014) p.6.

### 3.7 CONCLUSION

In this unit, we have learned some very important cartographic techniques such as Isopleths, Choropleth and Flow Charts/maps. Statistics and mathematics are integral components of geographical studies. Geographers employ many forms of statistical data in order to better understand and analyze spatial distribution and patterns of various phenomena. Such data can be represented in various ways such as diagrams and maps. Learning the proper ways to display or represent data is just as important as learning the proper statistical techniques to analyze data. As geographers are primarily concerned with spatial relationships, distribution maps are far more important in geographical studies. Distribution maps indicate the distribution of any particular feature in an area and help us to understand the distribution of different elements of the physical

and biological environment in an area. As discussed in this unit, isopleth, choropleth and flow maps are significant types of distribution maps used in geographical studies.

---

### 3.8 SUMMARY

---

Choropleth, Isopleth and Flow maps are crucial mapping techniques for representing spatial distributions and patterns. Isopleth maps are most suited for representing various natural phenomena such as temperature, rainfall, relief, salinity etc. Choropleth maps are one of the most common types of distribution maps that can effectively represent various socio-economic phenomena over regional as well as global level. Flow maps, on the other hand, are excellent in depicting movements (of people as well as goods and services) across space and can display both qualitative and quantitative spatial data. Hence, these mapping techniques are absolutely essential for geographers.

---

### 3.9 GLOSSARY

---

**Distribution maps:** Distribution maps indicate the distribution of any particular feature in an area and help us to understand the distribution of different elements of the physical and biological environment in an area. Distribution maps can be classified into two main categories- quantitative distribution maps and non-quantitative distribution maps.

**Isopleths:** Isopleths are lines joining places of equal value on a map which may be in the form of quantity, intensity or density. An isopleth map generalizes and simplifies data with a continuous distribution. Isopleth maps are more common for mapping surface elevations, amounts of precipitation, atmospheric pressure etc.

**Interpolation:** Interpolation is a method of constructing new data points within the range of a discrete set of known data points. In other words, interpolation is the method employed in which we use measures of a particular phenomenon at particular locations to make predictions about that phenomenon at other locations where we don't have measurements.

**Gradient:** The amount by which values may vary across each unit of distance in a direction perpendicular to isopleths is called the gradient.

**Class-interval:** Class interval is the size of each class into which range of a variable is divided, as represented by the divisions of a bar diagram or choropleth map etc. In other words, we group large amount of data into different classes to better understand the distribution; and the range of such class of data is called the class interval.

---

### 3.10 ANSWER TO CHECK YOUR PROGRESS

---

1. Define isopleths and provide examples of isopleth maps.
2. What is choropleth technique and what are the common uses of choropleth maps?
3. What are flow charts/maps and why we use these maps?
4. Why flow charts are known as cartogram?



---

### 3.11 REFERENCES

---

1. Singh, R. L. (1979), "Elements of Practical Geography", Kalyani Publishers.
2. Sander, Nikola; Guy J. Abel; Ramon Bauer and Johannes Schmidt (2014). "Visualizing Migration Flow Data with Circular Plots", Vienna Institute of Demography (Working Papers 02/2014), Austria.
3. Debiassi, Alberto (2016). "Study of Visual Clutter in Geographic Node-Link Diagrams", Doctoral Thesis, submitted in Department of Information Engineering and Computer Science, *Universita Degli Studi Di Trneto*.
4. Gruver, Adrienne (2017). "Cartography and Visualization", retrieved from [www.e-education.psu.edu](http://www.e-education.psu.edu)

---

### 3.12 SUGGESTED READINGS

---

1. Monkhouse, F. J. (1971). "Maps and Diagrams", Methuen: London.
2. Dury, G. H. (1972). "Map Interpretation", Pitman Publishing: London.
3. Istiaque, M. (1989). "Practical Geography", Heritage Publishers: New Delhi.
4. Platt, J. L. (1956). "Selected Exercises upon Geographical Maps- Part I", Unwin: London.
5. Singh, R. L. and R. P. B. Singh (1986). "Fundamentals of Cartography", Macmillan: New Delhi.

---

### 3.13 TERMINAL QUESTIONS

---

1. What do you understand by interpolation method in isopleth mapping technique? Provide a simple step by step example of isopleth interpolation.
2. How do we calculate class intervals for choropleth mapping technique?
3. How do we draw flow lines for flow maps? Elaborate with a simple example.
4. What are the advantages and disadvantages of isopleth, choropleth and flow maps?

## **BLOCK-2 STATISTICAL METHODS**

---

### **UNIT 4 - MEASUREMENT OF CENTRAL TENDENCY**

---

***4.1 OBJECTIVES***

***4.2 INTRODUCTION***

***4.3 MEASURES OF CENTRAL TENDENCY (MEAN, MEDIAN, MODE)***

***4.4 CONCLUSION***

***4.5 SUMMARY***

***4.6 GLOSSARY***

***4.7 ANSWER TO CHECK YOUR PROGRESS***

***4.8 REFERENCES***

***4.9 SUGGESTED READINGS***

***4.10 TERMINAL QUESTIONS***

## 4.1 OBJECTIVES

After reading this unit you will be able to:

- To determine the single value and describes the characteristic of the entire group.
- To reduce mass information or mass complex data into single value.
- To make useful for making decision in planning.
- To know the simple way to calculate complex information.

## 4.2 INTRODUCTION

One of the most popularly used set of summary figures is known as measures of location, which are often referred to as averages, measures of central tendency or central location (Lawrence J. Kaplan). An average is sometimes called a 'measure of central tendency' because individual values of the variable usually cluster around it (Crum and Smith). An average value is a single value within the range of data that is used to present all of the values in the series. Since the average is somewhere within the range of the data, it is sometimes called measure of central value (Croxtton Cowden). Average is an attempt to find one single figure to describe whole of figure (Clark). The single value is the point of location around which the individual items cluster.

Types of averages: There are following important types of averages;

1. Arithmetic Mean
2. Median and
3. Mode

## 4.3 MEASURES OF CENTRAL TENDENCY(Mean, Median, Mode)

### 4.3.1 MEAN

**Arithmetic Mean:** Arithmetic Mean is the number obtained by dividing the total value of different information by their numbers. This method is popular in daily life. There are two kinds of arithmetic mean;

- a. Simple arithmetic mean,
- b. Weighted arithmetic mean.

**Mean:** Calculation of simple arithmetic mean;

- a. Series of Individual observations
- b. Discrete Series;
- c. Continuous Series

*Series of Individual observations is easy to calculate. We divide the total values by numbers of observation.*

*For Example;*

$$\bar{X} = \frac{x_1 + x_2 + x_3 + \dots + x_n}{N}$$

$\bar{x} = \frac{\sum x}{N}$ ; where  $\bar{x}$  = Arithmetic mean,

$\sum x$  = sum of all values of the variables ( $x_1 + x_2 + x_3 + \dots + x_n$ ),

N = Numbers of observations.

### Direct Methods:

Q. No.01: Calculate the arithmetic mean of the daily income of the employees.

Employee: 1 2 3 4 5 6 7 8 9 10

Income: 25 20 35 55 30 50 40 60 45 65

Solution: Calculate the arithmetic mean.

Employees	Income
1	25
2	20
3	35
4	55
5	30
6	50
7	40
8	60
9	45
10	65
Total	$\sum X = 425$

Where;  $\bar{x} = \frac{\sum x}{N}$   $\sum x = 425$ ;  $N = 10$

$\bar{x} = \frac{425}{10} = 42.5$  Answer

Q. No. 02: Calculate the arithmetic mean of the marks in Geography.

Students	A	B	C	D	E	F	G	H	I	J	k
Marks	15	12	18	24	22	30	25	16	26	28	14

Solution:

Students	Marks
A	15
B	12
C	18
D	24
E	22

F	30
G	25
H	16
I	26
J	28
K	14
Total	$\sum x = 230$

Where;  $\bar{x} = \frac{\sum x}{N}$   $\sum x = 230$ ;  $N = 11$

$$\bar{x} = \frac{230}{11} = 20.90 \text{ Answer}$$

**Assumed mean method (short cut method):** Assumed methods can be applied when the items in series are less.

**Steps:**

1. Decide assumed mean (A).
2. Calculate the deviation from assumed mean ( $X - A = d$ )
3. Do total of deviation (d).
4. Apply formula;

$$\bar{x} = A + \frac{\sum d}{N}$$

Q. No. 01: Calculate the arithmetic mean of the marks in Statistics.

Students	A	B	C	D	E	F	G	H	I	J	k
Marks	15	12	18	24	22	30	25	16	26	28	14

Solution: Assumed mean (A)=20

Students	Marks(X)	$X - A = d$
A	15	-5
B	12	-8
C	18	-2
D	24	4
E	22	2
F	30	10
G	25	5
H	16	-4
I	26	6
J	28	8
K	14	-6
Total		$\sum d = 10$

Where;  $\bar{x} = A + \frac{\sum d}{N}$   $\sum x = 10$ ;  $N = 11$

$$\bar{x} = 20 + \frac{10}{11} = 20.90 \text{ Answer}$$

**B- Discrete series of data:** Multiply the variables by their respective frequencies to get sum of the product. Obtained total value is divided by the number of observations (total frequency).

**Steps:**

1. Multiply the frequency with variables (fx).
2. Find the sum of the products ( $\sum fx$ )
3. Divide the product by number of observations ( $\sum f = N$ )
4. Apply formula;

$$\bar{x} = \frac{\sum fx}{\sum f} = \frac{\sum fx}{N}$$

Q. No. 01: Calculate the arithmetic mean of the marks in Statistics.

Students	5	8	2	4	2	10	5	4	6	8	6
Marks	15	12	18	24	22	30	25	16	26	28	14

Solution:

Marks (x)	No. of Students (f)	fx
15	5	75
12	8	96
18	2	36
24	4	96
22	2	44
30	10	300
25	5	125
16	4	64
26	6	156
28	8	224
14	6	84
	$\sum f = 60$	$\sum fx = 1300$

Where;  $\bar{x} = \frac{\sum fx}{\sum f} = \frac{\sum fx}{N}$   $\sum fx = 1300$ ;  $\sum f = N = 60$

$$\bar{x} = \frac{\sum fx}{\sum f} = \frac{1300}{60} = 21.67 \text{ Answer}$$

**Step Deviation Method:** All deviations by assumed mean are divided by common factor.

Apply formula;

$$\bar{X} = A + \frac{\sum fd}{N} \times c$$

Where; A = Assumed mean

N = Numbers of observations

c = Common factor

f = frequency

$d = \frac{X-A}{c}$ ; step deviation

$\sum fd$  = Sum of product

Q. No. 01: Calculate the average marks of students in Statistics.

Students	5	8	2	4	2	10	5	4	6	8
Marks	10	15	20	25	30	35	40	45	50	55

Solution: Assumed mean= 25

Marks (X)	No. of Students (f)	X-A=d	$\frac{X-25}{5}$ (d)	fd
10	5	-15	-3	-15
15	8	-10	-2	-16
20	2	-5	-1	-2
25	4	0	0	0
30	2	5	1	2
35	10	10	2	20
40	5	15	3	15
45	4	20	4	16
50	6	25	5	30
55	8	30	6	48
	N=54			$\sum fd = 98$

Where;  $\bar{X} = A + \frac{\sum fd}{N} \times c$ , A = 25,  $\sum fd = 98$ , N=54 and C= 5

$$\bar{X} = 25 + \frac{98}{54} \times 5$$

$$\bar{X} = 25 + \frac{490}{54}$$

$$\bar{X} = 25 + 9.07 = 34.07$$

Answer: Average marks in statistics is 34.07.

**Continuous data series:**

Calculation method in continuous series is the same as discrete series. Mid-point of various class intervals is required in continuous series. The equation to find out the mid-points is:

Mid- Point =  $\frac{l_1 + l_2}{2}$ ; where ' $l_1$ ' is lower limit of class and ' $l_2$ ' is upper limit of class.

**Direct method:**

1. Calculate mid- point (m).
2. Multiply frequency with mid-point (fm).
3. Sum up the product ( $\sum fm$ ).
4. Divide product ( $\sum fm$ ) by total number of observations (N)
5. Use following formula:

$$\bar{X} = \frac{\sum fm}{N}$$

Q. No.01 :Find out the mean of the marks of students.

Marks	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90
Students	4	5	8	7	10	12	6	5	3

**Solution :**

Marks (x)	No. of students (f)	Mid-point (m)	f.m
0-10	3	5	15
10 -20	4	15	60
20-30	5	25	125
30-40	6	35	210
40-50	9	45	405
50-60	8	55	440
60-70	7	65	455
70-80	5	75	375
80-90	3	85	255
	N= 50		$\sum fm = 2340$

$$\bar{X} = \frac{\sum fm}{N} \text{ where; } \sum fm = 2340 \text{ and } N = 50.$$

$$\bar{X} = \frac{2340}{50} = 46.8$$

Answer: mean marks of the students are 46.8

**Short cut method:**

1. Calculate mid- point (m).
2. Decide assumed mean (A)



3. Find out the deviation from assumed mean ( $m-A=d$ )
4. Multiply deviation with frequency ( $fd$ ).
5. Sum up the product ( $fd$ ).
6. Divide product ( $\sum fd$ ) by total number of observations( $N$ )
7. Use following formula:

$$\bar{X} = A + \frac{\sum fd}{N}$$

Q. No.01 :Calculate arithmetic mean of the marks of students by short cut method.

Marks	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90
Students	4	5	8	7	10	12	6	5	3

**Solution:** Assumed mean ( $A$ ) = 40

Marks (x)	No. of students (f)	Mid-point (m)	m-A (d)	fd
0-10	3	5	-35	-105
10-20	4	15	-25	-100
20-30	5	25	-15	-75
30-40	6	35	-5	-30
40-50	9	45	5	45
50-60	8	55	15	120
60-70	7	65	25	175
70-80	5	75	35	175
80-90	3	85	45	135
	N= 50			$\sum fd = 340$

$$\bar{X} = A + \frac{\sum fd}{N} \text{ Where; } \sum fd = 340 \text{ and } N= 50.$$

$$\bar{X} = 40 + \frac{340}{50}$$

$$\bar{X} = 40 + 6.8 = 46.8$$

Answer: mean marks of the students are 46.8

**Step Deviation method:**

1. Calculate mid- point (m).
2. Decide assumed mean (A)
3. Find out the deviation from assumed mean ( $m-A=d$ )
4. Divide deviation by common factor  $\frac{m-A}{C}$

5. Multiply step deviation with frequency (fd).
6. Sum up the product (fd).
7. Divide product ( $\sum fd$ ) by total number of observations(N)
8. Use following formula:

$$\bar{X} = A + \frac{\sum fd}{N} \times C \text{ (where C= Common factor)}$$

Q. No.01 :Calculate arithmetic mean of the marks of students by step deviation method.

Marks	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90
Students	4	5	8	7	10	12	6	5	3

**Solution:** Assumed mean (A) = 40, Common factor = 10

Marks (x)	No. of students (f)	Mid-point (m)	m-A (d)	$\frac{m-A}{10} = d$	fd
0-10	3	5	-35	-3.5	-10.5
10-20	4	15	-25	-2.5	-10
20-30	5	25	-15	-1.5	-7.5
30-40	6	35	-5	-.5	-3
40-50	9	45	5	.5	4.5
50-60	8	55	15	1.5	12
60-70	7	65	25	2.5	17.5
70-80	5	75	35	3.5	17.5
80-90	3	85	45	4.5	13.5
	N= 50				$\sum fd = 34$

$$\bar{X} = A + \frac{\sum fd}{N} \times C \text{ Where; } \sum fd = 34 \text{ and } \sum f = N = 50, C = 10$$

$$\bar{X} = 40 + \frac{34}{50} \times 10$$

$$\bar{X} = 40 + 6.8 = 46.8$$

Answer: mean marks of the students are 46.8

**Charlier's Accuracy Check:** Charlier has given formula to check accurate calculation of arithmetic mean by the short cut method and the step deviation method in a frequency distribution.

$$\text{Formula ; } \sum f(d + 1) = \sum fd + \sum f$$

*Q. No.-01: Calculate the mean of given marks and apply Charlier's accuracy check to verify the calculation.*

Marks	0-10	10-20	20-30	30-40	40-50	50-60
Students	5	6	18	10	8	3

*Solution:*

Marks (X)	Students (f)	m	m-15	(m-15/10) d	fd	F(d+1)
0-10	5	5	-10	-1	-5	0
10-20	6	15	0	0	0	6
20-30	18	25	10	1	18	36
30-40	10	35	20	2	20	30
40-50	8	45	30	3	24	32
50-60	3	55	40	4	12	15
	N=50				$\Sigma fd$ = 69	$\Sigma f(d+1)=119$

*Apply Charlier's test;*

Formula ;  $\Sigma f(d+1) = \Sigma fd + \Sigma f$

$$119 = 69 + 50$$

*119=119 Hence, the calculation is correct*

$$\bar{X} = A + \frac{\Sigma fd}{N} \times C$$

$$\bar{X} = 15 + \frac{69}{50} \times 10$$

$$= 15 + 13.8 = 28.8$$

Hence Mean Marks 28.8=29 Answer

### Properties: Mean;

1. The calculation of arithmetic mean is simple.
2. It is easy to calculate and understand.
3. It is defined correctly without personal bias.
4. It is good for comparison.
5. It is not determined graphically.

### 4.3.2 MEDIAN

Median is the central positional average of a given data. Value of the arranged data which divides the whole data into two equal parts is called median. According to Connor," the median is that value of the variable which divides the group into two equal parts, one part comparing all values greater, and the other values less than the median."The middle item of the arranged data is called the median.

Rules;

1. Data should be arranged in an ascending or descending order.

2. Data may be divided into two parts, one less than the central value and the other more than the central value.
  3. The number of items (n) is odd; the median will be the value of  $(\frac{N+1}{2})$ th item.
  4. The number of items (n) is even, there will be two middle item  $(\frac{N}{2})$ th and  $(\frac{N}{2} + 1)$ th item.
1. Formula of Median is  $= L_1 + \frac{\frac{N}{2} - cf}{f} \times i$
  2. Compute cumulative frequencies (cf).
  3.  $L_1$  = Lower limit of median group.
  4.  $f$  = frequency of the median group.
  5.  $cf$  = cumulative frequency of the preceding class of the medium class.
  6.  $i$  = Class interval of the medium group.

A. Discrete series of data;

Q. No.01: Calculate median of the following distribution.

Marks(X)	10	20	30	40	50	60	70	80	90
Students(f)	2	4	5	8	11	9	6	3	1

Solution:

Marks	Students (f)	c.f.
10	2	2
20	4	6
30	5	11
40	8	19
50	11	30
60	9	39
70	6	45
80	3	48
90	1	49
	$\sum f = N = 49$	

Apply formula:

Med = Size of  $\frac{N+1}{2}$ th item

$$= \frac{49+1}{2} = \frac{50}{2} = 25^{\text{th}} \text{ item}$$

Answer: medium marks=25

**Continuous series of data:**

Q. No.01: Calculate median of the following distribution of marks.

Marks(X)	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90
Students(f)	2	4	5	8	11	9	6	3	2

Solution:

Marks	Students (f)	c.f.
0-10	2	2
10-20	4	6
20-30	5	11
30-40	8	19
40-50	11	30
50-60	9	39
60-70	6	45
70-80	3	48
80-90	2	50
	N=50	

Apply formula: Where  $\sum f = N$

Med = Size of  $\frac{N}{2}$ th item

$= \frac{50}{2} = 25$ th item

Medium size = 25 item

Formula of Median is  $= L_1 + \frac{\frac{N}{2} - cf}{f} \times i$

Median lies in the group 40-50.

$L_1 = 40$  (Lower limit of median group).

$f = 11$  (frequency of the median group).

$cf = 19$  (cumulative frequency of the preceding class of the medium class).

$i = 10$  (Class interval of the medium group).

$$\text{Median} = L_1 + \frac{\frac{N}{2} - cf}{f} \times i$$

$$\text{Med} = 40 + \frac{25 - 19}{11} \times 10$$

$$= 40 + \frac{6}{11} \times 10$$

$$= 40 + \frac{6 \times 10}{11}$$

$$= 40 + \frac{60}{11}$$

$$= 40 + 5.45 = 45.45$$

Answer: Median marks = 45.45

Q. No.02: Calculate median of the marks in geography. It is out of 50 marks.

Marks	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45
Students(f)	1	2	3	8	12	15	10	3	2

Solution:

Marks in Geography	Students (f)	c.f.
0-5	1	1
5-10	2	3
10-15	3	6
15-20	8	14
20-25	12	26
25-30	15	41
30-35	10	51
35-40	3	54
40-45	2	56
	N=56	

Apply formula:  $\sum f = N$

Med = Size of  $\frac{N}{2}$ th item

$$= \frac{56}{2} = 28\text{th item}$$

Medium size = 28 item

Formula of Median is  $= L_1 + \frac{\frac{N}{2} - cf}{f} \times i$

Median lies in the group 25-30.

$L_1 = 25$  (Lower limit of median group).

$f = 15$  (frequency of the median group).

$cf = 26$  (cumulative frequency of the preceding class of the medium class).

$i = 5$  (Class interval of the medium group).

$$\text{Median} = L_1 + \frac{\frac{N}{2} - cf}{f} \times i$$

$$\text{Med} = 25 + \frac{28 - 26}{15} \times 5$$

$$= 25 + \frac{2}{15} \times 5$$

$$= 25 + \frac{2 \times 5}{15}$$

$$= 25 + \frac{10}{15}$$

$$= 25 + 0.67 = 25.67$$

Answer: Median marks in Geography = 25.67

### Properties: Median;

1. Median is an average of position
2. It is simple to calculate and understand.
3. It can be determined graphically.
4. It is not affected by extreme value.
5. It is useful in a distribution of unequal class.

### Miscellaneous Questions of Mean and Median:

Q. NO. 01: Calculate the mean and median of the following distribution.

Area of House (m)	0-50	50-100	100-150	150-200	200-250	250-300
No. of Household	25	56	82	90	10	12

Solution: Calculation of Mean and Median, where assumed mean=125.

Area of House in meter	Mid Value (m)	Frequency (f)	$\frac{m-A}{50} = d$	fd	c.f.
0-50	25	25	-2	-50	25
50-100	75	56	-1	-56	81
100-150	125	82	0	0	163
150-200	175	90	1	90	253
200-250	225	10	2	20	263
250-300	275	12	3	36	275
		N = 275		$\sum fd = 40$	

$$\text{Mean} = A + \frac{\sum fd}{N} \times C$$

$$= 125 - \frac{40}{275} \times 50$$

$$= 125 - \frac{200}{275}$$

$$= 125 - 0.73$$

$$\text{Answer} = 124.27$$

**Median** = Apply formula:  $\sum f = N$

Med = Size of  $\frac{275}{2}$ th item

$$= \frac{275}{2} = 137.5 \text{ th item}$$

Medium size = 137.5 item

$$\text{Median} = L_1 + \frac{\frac{n}{2} - cf}{f} \times i$$

$$= 100 + \frac{137.5 - 81}{82} \times 50$$

$$= 100 + \frac{56.5}{82} \times 50$$

$$= 100 + 34.45$$

$$\text{Answer} = 134.45$$

### **4.3.3 MODE**

The word mode comes from French la mode which means fashion.

Definitions:

A.L. Bowley - "Mode is that value of the graded quantity at which the instances are most numerous."

Zizek - "The value occurring most frequently in a series of items and around which the other items are distributed most densely."

Coxton and Cowden - "The mode of a distribution is the value at the point around which, the items tend to be most heavily concentrated. It may be regarded as the most typical of a series of values."



**Continuous data;**

Formula;

$$M_0 = L_1 + \frac{f_1 - f_0}{2f_1 - f_0 - f_2} \times i$$

Where,  $M_0$  = Mode $L_1$  = lower limit of modal class $f_1$  = frequency of the modal class $f_0$  = frequency of the class preceding the modal class $f_2$  = frequency of the class succeeding the modal class $i$  = class interval of the modal class

Q. No.01: Calculate Mode of the marks in Geography.

Marks	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45
Students(f)	1	2	3	8	12	15	10	3	2

Solution:

Marks in Geography	Students (f)
0-5	1
5-10	2
10-15	3
15-20	8
20-25	12
25-30	15
30-35	10
35-40	3
40-45	2
	N=56

$$M_0 = L_1 + \frac{f_1 - f_0}{2f_1 - f_0 - f_2} \times i$$

Where,  $M_0$  = Mode $L_1 = 25$  , lower limit of modal class $f_1 = 15$ , frequency of the modal class $f_0 = 12$ , frequency of the class preceding the modal class $f_2 = 10$ , frequency of the class succeeding the modal class $i = 5$ , class interval of the modal class

$$M_0 = 25 + \frac{15 - 12}{2 \times 15 - 12 - 10} \times 5$$

$$M_0 = 25 + \frac{3}{30 - 12 - 10} \times 5$$

$$M_0 = 25 + \frac{3 \times 5}{30 - 22}$$

$$M_0 = 25 + \frac{15}{8}$$

$$M_0 = 25 + 1.875 = 26.875 \text{ Answer}$$

## 4.5 SUMMARY

Q. No.01: Calculate Median and Mode marks in Geography.

Marks	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45
Students(f)	1	2	4	12	15	10	7	3	2

Solution:

Marks in Geography	Students (f)	c.f.
0-5	1	1
5-10	2	3
10-15	4	7
15-20	12	19
20-25	15	34
25-30	10	44
30-35	7	51
35-40	3	54
40-45	2	56
	N=56	

Apply formula:  $\sum f = N$

Med = Size of  $\frac{56}{2}$ th item

$$= \frac{56}{2} = 28\text{th item}$$

Medium size = 28 item

$$\text{Median} = L_1 + \frac{\frac{n}{2} - cf}{f} \times i$$

$$\text{Median} = 20 + \frac{28 - 19}{15} \times 5$$

$$= 20 + \frac{9 \times 5}{15} = 20 + \frac{45}{15} = 20 + 3 = 23 \text{ Answer}$$

$$\text{Mode} = L_1 + \frac{f_1 - f_0}{2f_1 - f_0 - f_2} \times i$$

$$M_0 = 20 + \frac{15 - 12}{2 \times 15 - 12 - 10} \times 5$$

$$M_0 = 20 + \frac{15}{30 - 22}$$

$$M_0 = 20 + \frac{15}{8} = 20 + 1.87 = 21.87 \text{ Answer.}$$

## 4.6 GLOSSARY

**Mean** - Mean refers to the average that is used to derive the central tendency of the data in question.

**Median** - To find the median, we arrange the observations in order from smallest to largest value. If there are an odd number of observations, the median is the middle value. If there is an even number of observations, the median is the average of the two middle values.

**Mode** - The mode is a statistical term that refers to the most frequently occurring number found in a set of numbers.

## 4.7 ANSWER TO CHECK YOUR PROGRESS

**Q. No.01:** Calculate the mean, median and mode of the attendance of students.

Attendance	58-60	60-62	62-64	64-66	66-68	68-70	70-72	72-74
Frequency	1	2	9	48	131	102	40	17

**Solution :** Assumed mean = 65

Attendance (X)	Mid value (m)	Frequency (f)	$\frac{m - 65}{2}$ (d)	fd	cf
58-60	59	1	-3	-3	1
60-62	61	2	-2	-4	3
62-64	63	9	-1	-9	12
64-66	65	48	0	0	60
66-68	67	131	1	131	191
68-70	69	102	2	204	293
70-72	71	40	3	120	333
72-74	73	17	4	68	350
		N=350		$\sum fd=507$	

Mean:

$$\bar{X} = A + \frac{\sum fd}{N} \times C$$

$$= 65 + \frac{507}{350} \times 2$$

$$= 65 + 2.89$$

$$= 67.89 \text{ Answer}$$

Median:

$$\text{Median} = \frac{N_{th} \text{ item}}{2} = \frac{350}{2} = 175$$

$$175^{th} \text{ item} = 67$$

Median class is 66-68

$$\text{Median} = L_1 + \frac{\frac{N}{2} - cf}{f} \times i$$

$$= 66 + \frac{175-60}{131} \times 2$$

$$= 66 + 1.76$$

$$= 67.76 \text{ Answer}$$

**Mode:**

Mode lies in the class 66-68

$$M_0 = L_1 + \frac{f_1 - f_0}{2f_1 - f_0 - f_2} \times i$$

$$M_0 = 66 + \frac{131-48}{262-48-102} \times 2$$

$$M_0 = 66 + 1.48$$

$$M_0 = 67.48 \text{ Answer}$$

---

## 4.8 REFERENCES

1. Gupta S. P. (2004) Statistical Methods, Sultan Chand and Sons Educational Publishers, New Delhi.

---

## 4.9 SUGGESTED READINGS

1. Sarkar Ashis (2013) Quantitative Geography. Techniques and Presentation, Orient Black Swan, New Delhi.
2. Bloor, M and F. Wood (2006) Keywords in Qualitative Methods: A Vocabulary of Research, Concepts Publication; New Delhi.
3. Gregory, S (1963) Statistical Methods and Geographers. Longman, London

---

## 4.10 TERMINAL QUESTIONS

1. Why arithmetic mean is commonly used measure of central tendency?
2. What is statistical average?
3. What is meant by central tendency?
4. What is mean of frequency distribution?
5. What is median?
6. What is mode?
7. Calculate the average marks of students in Statistics.

Students	4	7	3	4	3	19	5	4	6	8
Marks	15	20	24	25	30	36	42	44	51	56

8. Calculate the mean, median and mode of the attendance of students.

Attendance	55-60	60-65	65-70	70-75	75-80	80-85	85-90	90-95
Frequency	5	4	10	45	126	100	43	16

---

## UNIT 5 - MEASURES OF DISPERSION

---

**5.1 OBJECTIVES**

**5.2 INTRODUCTION**

**5.3 STANDARD DEVIATION, MEASURES OF VARIABILITY**

**5.4 CONCLUSION**

**5.5 SUMMARY**

**5.6 GLOSSARY**

**5.7 ANSWER TO CHECK YOUR PROGRESS**

**5.8 REFERENCES**

**5.9 SUGGESTED READINGS**

**5.10 TERMINAL QUESTIONS**

---

## 5.1 OBJECTIVES

---

Objective of measuring Dispersion;

- To determine the data is homogeneous and consequently the reliability of the average.
- Dispersion helps analysis why large dispersion happens and this may help to control the dispersion itself.
- To comparing the two or more series with regards to disparities or differences. The greater degree of dispersion would mean lack of uniformity while a low degree of dispersion would indicate high uniformity.
- A measure of dispersion is useful in the correlation and regression etc.

---

## 5.2 INTRODUCTION

---

It is the square root of the means of squared deviations from the arithmetic mean. Therefore, it is known as root mean square deviation. Standard deviation is the square root of the arithmetic average of the deviations measured from the mean. It is denoted by small Greek letter (sigma).

### DEFINITIONS

1. Dispersion is the degree the degree of the variation of variables about the central value. -D. C. Brooks and W. F. L. Dick.
2. Dispersion is a measure of the extent to which the individual items vary.- Prof. L. R. Connor.
3. The degree to which numerical data tend to spread about an average value is called the variation or dispersion.-Spiegel.
4. Dispersion is the measure of the variation of the items.-A. L. Bowley.
5. The Measurement of the scatterness of the mass of figures in a series about an average is called measure of variation or dispersion.-Simpson & Kafka.

### SIGNIFICANCE OF MEASURE VARIATION

1. Determine the reliability of an average.
2. The control of the variability.
3. Compare two or more series with their variability.

### USES OF RANGE

1. Quality control
2. Fluctuation in the rainfall and temperature.
3. Weather forecast.
4. Day to day life

### 5.3 STANDARD DEVIATION, MEASURES OF VARIABILITY

Methods of measuring Variation;

1. **Range:** Range is the difference between largest and the smallest value in the distribution;

Range = L-S, Where L= Largest item and Smallest item.

Coefficient of range =  $\frac{L-S}{L+S}$ .

Q. No. :01- Calculate Range and coefficient of Range of the Marks.

Marks: 8, 10, 12, 16, 20, 25, 30, 36.

Solution: Range = L-S = 36-8 = 28 Answer.

Coefficient of Range =  $\frac{L-S}{L+S} = \frac{36-8}{36+8} = \frac{28}{44} = 0.64$  Answer

2. **Quartile Deviation:**

Quartile deviation is measures of range of parts. Quartile deviation is based on the fifty (middle) percent of the distribution. It is divided into four equal parts by  $Q_1$ ,  $Q_2$  and  $Q_3$ . Further it is calculated the range between  $Q_3$  and  $Q_1$ , which is middle fifty percent of the distribution. It is necessary to arrange data in ascending order.

**Deciles** :Deciles divide a series into ten equal parts.

**Percentiles** : Percentiles divide series into one hundred parts.

Formula;

Quartile Range =  $Q_3 - Q_1$

Where  $Q_3$  =Third Quartile

$Q_1$  = First Quartile

Quartile Deviation (Q.D.):=  $\frac{Q_3 - Q_1}{2}$

Coefficient of Quartile Deviation =  $\frac{Q_3 - Q_1}{Q_3 + Q_1}$

Where; First Quartile ( $Q_1$ ) is  $\left(\frac{N+1}{4}\right)$  and Third Quartile ( $Q_3$ ) is  $3\left(\frac{N+1}{4}\right)$ .

**Steps to follow;**

1. Arrange frequencies in ascending order.
2. Calculate cumulative frequencies.
3. Calculate first quartile and third quartile.
4. Apply formula: Q.D.: =  $\frac{Q_3 - Q_1}{2}$

Q. N0. 1: Calculate coefficient of quartile deviation from following data;

X:- 51, 52, 53, 54, 55, 56, 57, 58, 59, 60.

f:- 2, 4, 6, 12, 10, 15, 4, 3, 2, 5.



Solution:

X	f	c.f.
51	2	2
52	4	6
53	6	12
54	12	24
55	10	34
56	15	49
57	4	53
58	3	56
59	2	58
60	5	63

$$Q_1 = \text{size of } \left(\frac{N+1}{4}\right) = \left(\frac{63+1}{4}\right) = 16.$$

Where 16<sup>th</sup> item is 54.

$$Q_3 = \text{Size of } 3\left(\frac{N+1}{4}\right) = 3\left(\frac{63+1}{4}\right) = \frac{3 \times 64}{4} = 48$$

Where 48 item is 56.

$$\text{Quartile Deviation (Q.D.)} = \frac{Q_3 - Q_1}{2}$$

$$= \frac{56 - 54}{2} = 1 \text{ Answer}$$

$$\text{Coefficient of Quartile Deviation} = \frac{Q_3 - Q_1}{Q_3 + Q_1}$$

$$= \frac{56 - 54}{56 + 54} = .018 \text{ Answer}$$

Q. No.2- Calculate lower and upper quartile, 5<sup>th</sup>decile and 16<sup>th</sup> percentile of the following information.

S. No. – 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11.

Marks: - 40, 50, 60, 65, 70, 75, 78, 80, 85, 90, 95.

Solution:

**Lower Quartile;**

$$Q_1 = \text{size of } \left(\frac{N+1}{4}\right) = \left(\frac{11+1}{4}\right) = 3$$

Size of 3<sup>rd</sup> items = 60

Lower Quartile is 60 Answer

**Upper Quartile;**

$$Q_3 = \text{Size of } 3\left(\frac{N+1}{4}\right) = 3\left(\frac{11+1}{4}\right) = \frac{3 \times 12}{4} = \frac{36}{4} = 9$$

Size of 9<sup>th</sup> items = 85

Upper Quartile is 85 Answer.

**5<sup>th</sup>Decile**

$$D_5 = \text{Size of } {}^5\left(\frac{N+1}{10}\right) = {}^5\left(\frac{11+1}{10}\right)$$

$$= \frac{5 \times 12}{10} = 6$$

Size of 6<sup>th</sup> item = 75

5<sup>th</sup>decile is 75 Answer

**16<sup>th</sup> Percentile**

$$P_{16} = \text{Size of } {}^{16}\left(\frac{N+1}{100}\right) \text{ item}$$

$$= {}^{16}\left(\frac{11+1}{100}\right)$$

$$= \frac{16 \times 12}{100} = 1.92$$

=Size of 1.92<sup>th</sup> item

= Size of 1<sup>st</sup> item + 0.92 (Size of 2<sup>nd</sup> item)

= 40 + 0.92 (50-40)

$$= 40 + 9.2 = 49.2$$

16<sup>th</sup> percentile is 49.2 Answer

**Mean Deviation (Average deviation);**

Mean deviation of a series is the arithmetic average of the deviation of the various items from measure of mean, median or mode.

Q. N. 03- Calculate mean deviation and its coefficient.

Marks: 10, 60, 50, 30, 75, 55, 45, 65, 30, 80.

Solution: Calculation of Mean Deviation

Deviation from mean ignoring sign (+, -), $\bar{X} = 50$	
Marks	$ D $
10	40
60	10
50	0
30	20
75	25
55	5
45	5
65	15
30	20

80	30
$\sum x$ = 500	$\sum  D  = 170$

$$\text{Mean } (\bar{X}) = \frac{\sum x}{N} = \frac{500}{10} = 50$$

$$\text{Mean Deviation from mean (M. D.)} = \frac{\sum |D|}{N} = \frac{170}{10} = 17$$

$$\text{Coefficient of M. D.} = \frac{M.D.}{\text{Mean}} = \frac{17}{50} = 0.34 \text{ Answer}$$

## Standard Deviation

### A: Discrete Series/data:

#### Actual Mean methods:

Q. N0.01: Calculate Standard deviation of the following data;

8, 10, 12, 15, 16, 20, 22, 25, 30, 32

Solution: Steps to calculation of Standard deviation;

Value-x	$(X-\bar{X})=x$	$x^2$
8	-11	121
10	-9	81
12	-7	49
15	-4	16
16	-3	9
20	1	1
22	3	9
25	6	36
30	11	121
32	13	169
$\sum x=190$		$\sum x^2=612$

Steps:

- 1- Calculate the actual mean of frequencies.
- 2- Find deviation of the value from mean  $(X-\bar{X})=x$
- 3- Square the deviation  $x^2$  and total it  $\sum x^2$ .
- 4- Divide total by numbers of observations
- 5- Apply formula;

$$\sigma = \sqrt{\frac{\sum x^2}{N}} \text{ where } \sum x^2 = 612, N=10$$

$$\sigma = \sqrt{\frac{\sum x^2}{N}}$$

$$\sigma = \sqrt{\frac{612}{10}}$$

$$\sigma = \sqrt{61.2} = 7.82 \text{ Answer}$$

Q. N0.02: Marks of two subject Geography and Statistics in ten regular evaluations are given. Find out which out of two subjects is consistent in scoring.

Geography(X): 26, 28, 30, 35, 44, 50, 55, 60, 64, 68.

Statistics(Y): 20, 34, 44, 56, 64, 70, 30, 72, 50, 60.

*Solution:* Compare the coefficient of variation to find out which of the subject is more consistent.

Geograp hy X	(X- $\bar{X}$ ) $x$	$x^2$	Statistics Y	(Y- $\bar{Y}$ ) $Y$	$Y^2$
26	-20	400	20	-30	900
28	-18	324	34	-16	256
30	-16	256	44	-6	36
35	-11	121	56	6	36
44	-2	4	64	14	196
50	4	16	70	20	400
55	9	81	30	-20	400
60	14	196	72	22	484
64	18	324	50	0	0
68	22	484	60	10	100
$\sum x = 460$		$\sum x^2 = 2206$	$\sum y = 500$		$\sum y^2 = 2808$

Calculate mean;

$$\bar{X} = \frac{\sum x}{N} = \frac{460}{10} = 46$$

$$\bar{Y} = \frac{\sum y}{N} = \frac{500}{10} = 50$$

$$\text{Geography: } \sigma = \sqrt{\frac{\sum x^2}{N}} \text{ where } \sum x^2 = 2206, N=10$$

$$\sigma = \sqrt{\frac{2206}{10}} = 14.852$$

$$C.V. = \frac{\sigma}{\bar{X}} \times 100 = \frac{14.852}{46} \times 100 = 32.288 \text{ Answer}$$

Statistics:  $\sigma = \sqrt{\frac{\sum y^2}{N}}$  where  $\sum y^2 = 2808$ ,  $N=10$

$$\sigma = \sqrt{\frac{2808}{10}} = 16.757$$

$$C.V. = \frac{\sigma}{\bar{Y}} \times 100 = \frac{16.757}{50} \times 100 = 33.514 \text{ Answer}$$

Since coefficient of variation (C.V.) is less in the case of Geography (X) hence marks in Geography is more consistence.

**b. Assumed mean method:**

Q. N0.03: Calculate Standard deviation of the following data;

8, 10, 12, 15, 16, 20, 22, 25, 30, 32

Solution: Steps to calculation of Standard deviation;

Assumed mean = 20

Value-x	$(X-\bar{X})=d$	$d^2$
8	-12	144
10	-10	100
12	-8	64
15	-5	25
16	-4	16
20	0	0
22	2	4
25	5	25
30	10	100
32	12	144
$N = 10$	$\sum x = -10$	$\sum d^2 = 622$

Where;  $\sum d^2 = 622$ ,  $\sum x = -10$ ,  $N=10$

$$\sigma = \sqrt{\frac{\sum d^2}{N} - \left(\frac{\sum d}{N}\right)^2}$$

$$\sigma = \sqrt{\frac{622}{10} - \left(\frac{-10}{10}\right)^2}$$

$$\sigma = \sqrt{62.2 - (-1)^2}$$

$$\sigma = \sqrt{61.2} = 7.82 \text{ Answer}$$

Q. N0.04: The instrument of Geography lab is 180 arranged according to the size of instrument as under. Calculate Standard deviation and its coefficient.

Measurement(X): 0-10, 10-20, 20-30, 30-40, 40-50, 50-60, 60-70, 70-80, 80-90

No. of Instruments (f): 8, 10, 12, 30, 40, 30, 25, 15, 10.

Solution:

Measurement(X)	f	Mid point(m)	(m-45)/10 =d	fd	$fd^2$
0-10	8	5	-4	-32	128
10-20	10	15	-3	-30	90
20-30	12	25	-2	-24	48
30-40	30	35	-1	-30	30
40-50	40	45	0	0	0
50-60	30	55	1	30	30
60-70	25	65	2	50	100
70-80	15	75	3	45	135
80-90	10	85	4	40	160
	N=180			$\sum fd = 49$	$\sum fd^2 = 721$

$$\text{Formula } \sigma = \sqrt{\frac{\sum d^2}{N} - \left(\frac{\sum d}{N}\right)^2} \times i$$

$$\sigma = \sqrt{\frac{721}{180} - \left(\frac{49}{180}\right)^2} \times 10$$

$$\sigma = \sqrt{4.005 - 0.074} \times 10$$

$$\sigma = \sqrt{3.931} \times 10$$

$$\sigma = 1.9826 \times 10 = 19.826 \text{ Answer}$$

Coefficient of Standard can be obtained by dividing standard deviation by mean.

$$\bar{X} = A + \frac{\sum d}{N} \times i$$

$$\bar{X} = 45 + \frac{49}{180} \times 10 = 45 + 2.722 = 47.722$$

$$\text{Coefficient of Standard Deviation } = \frac{\sigma}{\bar{X}} = \frac{19.826}{47.722} = 0.4154 \text{ Answer}$$

### C: Continuous Series (data):

Steps:

1. Calculate the actual mean of frequencies ( $\bar{X}$ ).
2. Find deviation of the mid-point from mean ( $m - \bar{X}$ ) =  $x$
3. Multiply deviation with respective frequencies.
4. Square the deviation ( $x$ )<sup>2</sup> and total it  $\sum fx^2$ .
5. Divide total by numbers (total) of observations.
6. ' $x$ ' is also used as 'd'.

$$7. \text{ Apply formula; } \sigma = \sqrt{\frac{\sum fx^2}{N}}$$

Q. N0.05: Calculate Standard deviation of the following data;

Marks (X): 12-16, 16-20, 20-24, 24-28, 28-32, 32-36, 36-40, 40-44, 44-48.

Students (f): 2, 3, 4, 5, 4, 3, 2, 2, 1.

x	f	m	fm	x	$x^2$	fx	$fx^2$
12-16	2	14	28	-14	196	-28	392
16-20	3	18	54	-10	100	-30	300
20-24	4	22	88	-6	36	-24	144
24-28	5	26	130	-2	4	-10	20
28-32	4	30	120	2	4	8	16
32-36	3	34	102	6	36	18	108
36-40	2	38	76	10	100	20	200
40-44	2	42	84	14	196	28	392
44-48	1	46	46	18	324	18	324
	26		$\Sigma fm = 728$				$\Sigma fx^2 = 1896$

Solution: where m = mid-point,  $(m - \bar{X}) = x = (m - 28)$

$$\bar{X} = \frac{\Sigma fm}{N} = \frac{728}{26} = 28, \text{ where, } \Sigma fm = 728, N = 26$$

Standard Deviation:

$$\sigma = \sqrt{\frac{\Sigma fx^2}{N}}$$

$$\sigma = \sqrt{\frac{1896}{26}}$$

$$\sigma = \sqrt{72.92} = 8.54 \text{ Answer}$$

Q. N0.04: Calculate Standard deviation of the following data;

Marks (X): 12-16, 16-20, 20-24, 24-28, 28-32, 32-36, 36-40, 40-44, 44-48.

Students (f): 2, 3, 4, 5, 4, 3, 2, 2, 1.

Solution: Assumed mean = 30

where, m = mid-point,  $(m - \bar{X}) = d = (m - 30)$

x	f	m	fm	d	$d^2$	fd	$fd^2$
12-16	2	14	28	-16	256	-32	512
16-20	3	18	54	-12	144	-36	432
20-24	4	22	88	-8	64	-32	256
24-28	5	26	130	-4	16	-20	80



28-32	4	30	120	0	0	0	0
32-36	3	34	102	4	16	12	48
36-40	2	38	76	8	64	16	128
40-44	2	42	84	12	144	24	288
44-48	1	46	46	16	256	16	256
	26		$\sum fm = 728$			$\sum fd = -52$	$\sum fd^2 = 2000$

$\bar{X} = 30$  (Assumed mean), where,  $\sum fm = 728$ ,  $N = 26$ ,

$\sum fd = -52$ ,  $\sum fd^2 = 2000$ .

Standard Deviation:

$$\sigma = \sqrt{\frac{\sum fd^2}{N} - \left(\frac{\sum fd}{N}\right)^2}$$

$$\sigma = \sqrt{\frac{2000}{26} - \left(\frac{-52}{26}\right)^2}$$

$$\sigma = \sqrt{76.92 - (-2)^2}$$

$$\sigma = \sqrt{76.92 - 4}$$

$$\sigma = \sqrt{72.92}$$

$$\sigma = 8.54 \text{ Answer}$$

## 5.4 CONCLUSION

The relationship between Quartile deviation, Mean Deviation and Standard Deviation is fixed in normal distribution. Arithmetic Mean +/- Quartile Deviation covers 50 percent of the items. Arithmetic Mean +/- Mean Deviation covers 57.51 percent of the items. Arithmetic Mean +/- Standard Deviation covers 68.27 percent of the items. These relationships are applicable to only normal distribution.

## 5.5 SUMMARY

Standard deviation is based on every item of the series. Sampling does not affect very much to Standard deviation. Sometimes understanding Standard Deviation becomes difficult because of complex calculations. It showed more weight to extreme values than less value.

## 5.6 GLOSSARY

**Standard Deviation-** The standard deviation is a statistic that measures the dispersion of a dataset relative to its mean and is calculate as the square root of the variance.

**Dispersion-** It tells how spread out numbers is from the mean.

---

## 5.7 ANSWER TO CHECK YOUR PROGRESS

---

1. What is Quartile deviation?
2. What is Standard deviation?
3. What do you understand by variability?

---

## 5.8 REFERENCES

---

1. Gupta S. P. (2004) Statistical Methods, Sultan Chand and Sons Educational Publishers, New Delhi.

---

## 5.9 SUGGESTED READING

---

1. Sarkar Ashis (2013) Quantitative Geography. Techniques and Presentation, Orient Black Swan, New Delhi.
2. Bloor, M and F. Wood (2006) Keywords in Qualitative Methods: A Vocabulary of Research, Concepts Publication, New Delhi.
3. Gregory, S (1963) Statistical Methods and Geographers. Longman, London.
4. Shah N M. (1995) Statistics : Theory and Practice, Arya Book Depot, Delhi, India.

---

## 5.10 TERMINAL QUESTIONS

---

1. Calculate Standard deviation from the following students (X) and Marks (Y).  
X:- 1, 2, 3, 4, 5, 6, 7, 8, 9, 10.  
Y:- 54, 62, 63, 65, 68, 71, 73, 78, 82, 84.
2. Calculate arithmetic mean and standard deviation from the following frequency.  
X:- 0-10, 10-20, 20-30, 30-40, 40-50, 50-60, 60-70  
Y:- 8, 12, 14, 16, 10, 6, 5.
3. Calculate standard deviation from the following frequency.  
Size: 4, 5, 6, 7, 8, 9, 10.  
Frequency: 6, 12, 15, 28, 20, 14, 5.  
(Ans: 1.541).
4. Calculate arithmetic mean and standard deviation from the following frequency by assumed mean method.  
Size: 4, 5, 6, 7, 8, 9, 10.  
Frequency: 6, 12, 15, 28, 20, 14, 5.  
(Ans: 1.541)
5. Calculate arithmetic mean and standard deviation from the following frequency by step deviation method.  
Value: 140, 145, 150, 155, 160, 165, 170, 175.  
Frequency: 1, 4, 15, 30, 36, 24, 8, 2.

(Ans:6.59).

6. Calculate coefficient of Standard deviation, variance, and coefficient of variation of the following data. Compare the variability of performance in geography of two semester exam from their average performance.

Ist Semester: 17, 19, 19, 21, 19, 23, 30, 28, 26, 28, 25, 21.

IInd Semester: 112, 110, 120, 117, 113, 108, 104, 102, 105, 105, 109, 115.

(Answer: Standard Deviation: 4.123, Coefficient of Standard deviation: 0.1793)

7. Calculate the median, third quartile, 7<sup>th</sup>decile and 70 percentile of the following marks of the students.

Marks: 0-10, 10-20, 20-30, 30-40, 40-50, 50-60, 60-70, 70-80.

No. of students: 3, 10, 17, 7, 6, 4, 2, 1.

(Answer: median: 27.05, Third quartile: 40.83, 7<sup>th</sup> decile: 37.14, 70<sup>th</sup> percentile: 37.14)

---

## UNIT 6 - CORRELATION AND REGRESSION

---

**6.1 OBJECTIVES**

**6.2 INTRODUCTION**

**6.3 (A) KARL PEARSON RANK DIFFERENCE METHOD**

**6.3 (B) SPEARMAN RANK CORRELATION**

**6.4 CORRELATION CONCURRENT DEVIATION METHOD**

**6.5 REGRESSION LINES AND LINES OF THE BEST FITS**

**6.6 CONCLUSION**

**6.7 SUMMARY**

**6.8 GLOSSARY**

**6.9 ANSWER TO CHECK YOUR PROGRESS**

**6.10 REFERENCES**

**6.11 SUGGESTED READINGS**

**6.12 TERMINAL QUESTIONS**

## 6.1 OBJECTIVES

After reading this unit, you will be able to:

- Establish degree of relationship between two variables. Example; humidity and rainfall. Crop production and rainfall.
- Discuss the types and range of correlation.
- Calculate correlation among the variables.
- To represents data in pairs  $(x, y)$ .

## 6.2 INTRODUCTION

Correlation is defined by different scholars. According to Simpson & Kafka, Correlation analysis deals with the association between two or more variables. YaLun Chou defined Correlation analysis attempts to determine the degree of relationship between variables. When the relationship is of the quantitative nature, the appropriate statistical tools for discovering and measuring the relationship and expressing it in brief formula is known as correlation by Croxten and Cowden. It is used to measure the degree of relationship between two variables.

## 6.3 (A) KARL PEARSONS RANK DIFFERENCE METHOD

### Karl Pearsons Coefficient of Correlation:

The Value of the coefficient of correlation is always fall between +1 and -1.

Kinds of correlation: Positive and Negative correlation

**Positive correlation:** When changes in two variables increase or decrease in one direction in relationship is called positive correlation.

**Negative Correlation:** When changes in two variables increase or decrease in opposite direction in relationship is called negative correlation. The value of one variable increases and another decreases.

1. If  $r = +1$ , It is perfect positive correlation between variables.
2. When  $r = -1$ , It is perfect negative correlation between variables.
3. If  $r = 0$ , It means there is no relationship between the variables.
4. When value of  $r$  between  $+ .75$  to  $1$  is high positive correlation

Positive correlation	Value	Negative correlation	Value
High	$+.75$ to $1$	High	$-.75$ to $1$
Moderate	$+.25$ to $.75$	Moderate	$-.25$ to $.75$
Low	$+0$ to $.25$	Low	$-.0$ to $.25$

The method is used to calculate coefficient of correlation is known as Pearson's coefficient. It is used to measure the degree of relationship between two or more variables. It is denoted by  $r$ .

**Steps to do:**

1. Calculate arithmetic mean of X and Y values.
2. Find out the deviation of X and Y and denote by small  $x$  and small  $y$ .
3. Square the small  $x$  and small  $y$  and total it separately ( $\sum x^2$  and  $\sum y^2$ ).
4. Multiply these calculated deviation of small  $x$  and small  $y$  and find out the total ( $\sum xy$ ).
5. Apply the following formula;

$$r = \frac{\sum xy}{\sqrt{\sum x^2 \cdot \sum y^2}}$$

Where  $x = (X - \bar{X})$  and  $y = (Y - \bar{Y})$ ,  $\bar{X} = \frac{\sum X}{N}$ ,  $\bar{Y} = \frac{\sum Y}{N}$

$r$  = the Correlation coefficient

$\sum xy$  = Multiplication of deviation of  $x$  and  $y$  series and calculation of the total.

$\sum x^2$  = Square the deviation of  $x$  and calculate the total.

$\sum y^2$  = Square the deviation of  $y$  and calculate the total.

Q. No.-01: Calculate coefficient of correlation from the following data.

S. No.	1	2	3	4	5	6	7	8	9	10
X	10	15	20	22	28	30	35	35	40	45
Y	15	15	20	20	25	35	35	40	45	50

Solution:

S. No.	X	Y	$x = (X - \bar{X})$	$x^2$	$y = (Y - \bar{Y})$	$y^2$	$xy$
1	10	15	-18	324	-15	225	270
2	15	15	-13	169	-15	225	195
3	20	20	-8	64	-10	100	80
4	22	20	-6	36	-10	100	60
5	28	25	0	0	-5	25	0
6	30	35	2	4	5	25	10
7	35	35	7	49	5	25	35
8	35	40	7	49	10	100	70
9	40	45	12	144	15	225	180
10	45	50	17	289	20	400	340
	$\sum X = 280$	$\sum Y = 300$		$\sum x^2 = 1128$		$\sum y^2 = 1450$	$\sum xy = 1240$

Solution:

$$r = \frac{\sum xy}{\sqrt{\sum x^2 \cdot \sum y^2}}$$

Where  $x = (X - \bar{X})$  and  $y = (Y - \bar{Y})$ ,

$$\bar{X} = \frac{\sum X}{N} = \frac{280}{10} = 28,$$

$$\bar{Y} = \frac{\sum Y}{N} = \frac{300}{10} = 30$$

$$r = \frac{\sum xy}{\sqrt{\sum x^2 \cdot \sum y^2}}$$

$$r = \frac{1240}{\sqrt{1128 \times 1450}}$$

$$r = \frac{1240}{\sqrt{1635600}}$$

$$r = \frac{1240}{1278.905} = 0.9695$$

Answer: It is high positive correlation.

Q. No.-02: Calculate coefficient of correlation from the following data.

S. No.	1	2	3	4	5	6	7	8	9	10
X	10	10	15	20	25	30	35	40	45	50
Y	10	8	12	18	22	25	25	30	35	45

Solution:

S. No.	X	Y	$x = (X - \bar{X})$	$x^2$	$y = (Y - \bar{Y})$	$y^2$	$xy$
1	10	10	-18	324	-13	169	234
2	10	8	-18	324	-15	225	270
3	15	12	-13	169	-11	121	143
4	20	18	-8	64	-5	25	40
5	25	22	-3	9	-1	1	3
6	30	25	2	4	2	4	4
7	35	25	7	49	2	4	14
8	40	30	12	144	7	49	84
9	45	35	17	289	12	144	204
10	50	45	22	484	22	484	484
	$\sum X = 280$	$\sum Y = 230$		$\sum x^2 = 1860$		$\sum y^2 = 1226$	$\sum xy = 1480$

Solution:

$$r = \frac{\sum xy}{\sqrt{\sum x^2 \cdot \sum y^2}}$$

Where  $x = (X - \bar{X})$  and  $y = (Y - \bar{Y})$ ,

$$\bar{X} = \frac{\sum X}{N} = \frac{280}{10} = 28$$

$$\bar{Y} = \frac{\sum Y}{N} = \frac{230}{10} = 23$$

$$r = \frac{\sum xy}{\sqrt{\sum x^2 \cdot \sum y^2}}$$

$$r = \frac{1480}{\sqrt{1860 \times 1226}}$$

$$r = \frac{1480}{\sqrt{2280360}}$$

$$r = \frac{1480}{1510.086} = 0.980$$

Answer: It is high positive correlation

Q. No.-03: Calculate coefficient of correlation from the following data.

S. No.	1	2	3	4	5	6	7	8	9	10
X	10	15	20	22	28	30	35	35	40	45
Y	50	45	40	35	35	25	20	20	15	15

Solution:

S. No.	X	Y	$x = (X - \bar{X})$	$x^2$	$y = (Y - \bar{Y})$	$y^2$	$xy$
1	10	50	-18	324	20	400	-360
2	15	45	-13	169	15	225	-195
3	20	40	-8	64	10	100	-80
4	22	35	-6	36	5	25	-30
5	28	35	0	0	5	25	0
6	30	25	2	4	-5	25	-10
7	35	20	7	49	-10	100	-70
8	35	20	7	49	-10	100	-70
9	40	15	12	144	-15	225	-180
10	45	15	17	289	-15	225	-255
	$\sum X = 280$	$\sum Y = 300$		$\sum x^2 = 1128$		$\sum y^2 = 1450$	$\sum xy = -1250$

Solution:

$$r = \frac{\sum xy}{\sqrt{\sum x^2 \cdot \sum y^2}}$$

Where  $x = (X - \bar{X})$  and  $y = (Y - \bar{Y})$ ,

$$\bar{X} = \frac{\sum X}{N} = \frac{280}{10} = 28$$

$$\bar{Y} = \frac{\sum Y}{N} = \frac{300}{10} = 30$$

$$r = \frac{\sum xy}{\sqrt{\sum x^2 \cdot \sum y^2}}$$

$$r = \frac{-1250}{\sqrt{1128 \times 1450}}$$

$$r = \frac{-1250}{\sqrt{1635600}}$$

$$r = \frac{-1250}{1278.905} = -0.977$$



Answer; It is high negative correlation.

Q. No.04: Calculate coefficient of correlation from the following data

X	12	18	23	27	30	35	35	40	43	47
Y	45	40	38	35	32	30	27	23	18	12

Solution:

S. No.	X	Y	$x = (X - \bar{X})$	$x^2$	$y = (Y - \bar{Y})$	$y^2$	$xy$
1	12	45	-19	361	15	225	-285
2	18	40	-13	169	10	100	-130
3	23	38	-8	64	8	64	-64
4	27	35	-4	16	5	25	-20
5	30	32	-1	1	2	4	-2
6	35	30	4	16	0	0	0
7	35	27	4	16	-3	9	-12
8	40	23	9	81	-7	49	-63
9	43	18	14	196	-12	144	-168
10	47	12	16	256	-18	324	-288
	$\sum X = 310$	$\sum Y = 300$		$\sum x^2 = 1176$		$\sum y^2 = 944$	$\sum xy = -1032$

Solution:

$$r = \frac{\sum xy}{\sqrt{\sum x^2 \cdot \sum y^2}}$$

Where  $x = (X - \bar{X})$  and  $y = (Y - \bar{Y})$ ,

$$\bar{X} = \frac{\sum X}{N} = \frac{310}{10} = 31$$

$$\bar{Y} = \frac{\sum Y}{N} = \frac{300}{10} = 30$$

$$r = \frac{\sum xy}{\sqrt{\sum x^2 \cdot \sum y^2}}$$

$$r = \frac{-1032}{\sqrt{1176 \times 944}}$$

$$r = \frac{-1032}{\sqrt{1110144}}$$

$$r = \frac{-1032}{1053.633} = -0.97946$$

Answer: It is high negative correlation.

### Calculation of Correlation Coefficient by Direct Methods

One of the methods to calculate Correlation Coefficient is without taking deviations variables either from actual mean or assumed mean. It can be calculated with actual X and Y Value. The formula in such a case is;

$$r = \frac{N \sum XY - (\sum X)(\sum Y)}{\sqrt{N \sum X^2 - (\sum X)^2} \sqrt{N \sum Y^2 - (\sum Y)^2}}$$

Q. No. 01: Calculate the coefficient of correlation by direct method.

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

Solution:

X	$X^2$	Y	$Y^2$	XY
1	1	10	100	10
2	4	11	121	22
3	9	12	144	36
4	16	13	169	52
5	25	14	196	70
6	36	15	225	90
7	49	16	256	112
8	64	17	289	136
9	81	18	324	162
10	100	19	361	190
$\Sigma X=55$	$\Sigma X^2=385$	$\Sigma Y=145$	$\Sigma Y^2=2185$	$\Sigma XY=880$

$$r = \frac{N \sum XY - (\sum X)(\sum Y)}{\sqrt{N \sum X^2 - (\sum X)^2} \sqrt{N \sum Y^2 - (\sum Y)^2}}$$

Where  $\Sigma X=55, \Sigma X^2=385, \Sigma Y=145, \Sigma Y^2=2185, \Sigma XY=880$

$$r = \frac{10 \times 880 - 55 \times 145}{\sqrt{10 \times 385 - (55)^2} \sqrt{10 \times 2185 - (145)^2}} = \frac{8800 - 7975}{\sqrt{3850 - 3025} \sqrt{21850 - 21025}}$$

$$r = \frac{825}{\sqrt{825 \times 825}} = \frac{825}{825} = 1$$

Ans: It is perfect positive correlation

Q. No. 02: Calculate the coefficient of correlation by direct method.

X	11	12	13	14	15	16	17	18	19	20
Y	16	15	14	13	12	11	10	9	8	5

Solution:

X	$X^2$	Y	$Y^2$	XY
11	121	16	256	176
12	144	15	225	180
13	169	14	196	182
14	196	13	169	182
15	225	12	144	180
16	256	11	121	176
17	289	10	100	170
18	324	9	81	162
19	361	8	64	152
20	400	5	25	100
$\Sigma X=155$	$\Sigma x^2=2485$	$\Sigma Y=113$	$\Sigma Y^2=1381$	$\Sigma XY=1660$

$$r = \frac{N \Sigma XY - (\Sigma X)(\Sigma Y)}{\sqrt{N \Sigma X^2 - (\Sigma X)^2} \sqrt{N \Sigma Y^2 - (\Sigma Y)^2}}$$

Where;  $\Sigma X=155$ ,  $\Sigma x^2=2485$ ,  $\Sigma Y=113$ ,  $\Sigma Y^2=1381$ ,  $\Sigma XY =1660$

$$r = \frac{10 \times 1660 - 155 \times 113}{\sqrt{10 \times 2485 - (155)^2} \sqrt{10 \times 1381 - (113)^2}}$$

$$r = \frac{16600 - 17515}{\sqrt{24850 - 24025} \sqrt{13810 - 12769}}$$

$$r = \frac{-915}{\sqrt{825 \times 1041}} = \frac{-915}{\sqrt{858825}} = \frac{-915}{926.728} \quad r = -0.987$$

Answer: It is high negative correlation.

### 6.3 (B) SPEARMAN RANK CORRELATION

Rank correlation is also known as Spearman's Rank correlation. British Psychologist Prof. Charles Spearman has given this difference method. When certain factors can not measure precisely in qualitative terms, this method is useful. For example quality, honesty, intelligence etc.

$$\text{Formula } rk = 1 - \frac{6 \Sigma D^2}{N^3 - N}$$

Where; rk=coefficient of rank correlation,

$\Sigma D^2$ =the total of the squares of the differences of corresponding ranks,

N=Numbers of pairs of observations

**Steps:**

1. Calculate the difference of two ranks ( $R_1 - R_2$ ) and denote by D.
2. Square the differences (D) and find out the total ( $\Sigma D^2$ )
3. Apply the formula;  $rk = 1 - \frac{6 \Sigma D^2}{N^3 - N}$

There are two types of calculation;

- (a) Rank are Given
- (b) Rank are not given

**Case-I: When Ranks are given**

Q. No.01 : In a map making competition two judges rank the 10 students. Calculate the rank correlation coefficient.

Judge-I	1	2	3	4	5	6	7	8	9	10
Judge-II	10	9	8	7	6	5	4	3	2	1

Solution: Calculate the rank correlation coefficient.

Rank by Judge-I ( $R_1$ )	Rank by Judge-II ( $R_2$ )	$(R_1 - R_2)$ $D$	$D^2$
1	10	-9	81
2	9	-7	49
3	8	-5	25
4	7	-3	9
5	6	-1	1
6	5	1	1
7	4	3	9
8	3	5	25
9	2	7	49
10	1	9	81
N=10			$\sum D^2 = 330$

$$rk = 1 - \frac{6\sum D^2}{N^3 - N} \text{ Where; } \sum D^2 = 330, N = 10$$

$$rk = 1 - \frac{6\sum D^2}{N^3 - N}$$

$$rk = 1 - \frac{6 \times 330}{1000 - 10}$$

$$rk = 1 - \frac{1980}{990}$$

$$= 1 - 2 = -1$$

Answer: Hence, there is perfect negative correlation.

**Case-II: When Ranks are not given;**

Q. No.02: In a map quiz competition, two judges rank the 10 students. Calculate the rank correlation coefficient.

X	12	14	16	10	11	15	8	20	9	18
---	----	----	----	----	----	----	---	----	---	----

Y	24	16	20	15	12	28	10	14	15	30
---	----	----	----	----	----	----	----	----	----	----

**Steps:**

1. Assign ranks to given data
2. Arrange data (X and Y) in ascending order.
3. Lowest rank is one in ascending order and follows.
4. Calculate the difference of two ranks ( $R_1-R_2$ ) and denote by D.
5. Square the differences (D) and find out the total ( $\sum D^2$ )
6. Apply the formula;  $rk = 1 - \frac{6\sum D^2}{N^3 - N}$

Solution: Calculate the rank correlation coefficient.

X	Rank by Judge-I ( $R_1$ )	Y	Rank by Judge-II ( $R_2$ )	( $R_1-R_2$ ) D	$D^2$
12	5	24	8	-3	9
14	6	16	5	1	1
16	8	20	7	1	1
10	3	18	6	-3	9
11	4	12	2	2	4
15	7	28	9	-2	4
8	1	10	1	0	0
20	10	14	3	7	49
9	2	15	4	-2	4
18	9	30	10	-1	1
N=10					$\sum D^2=82$

$$rk = 1 - \frac{6\sum D^2}{N^3 - N} \quad \text{Where; } \sum D^2=82, N=10$$

$$rk = 1 - \frac{6\sum D^2}{N^3 - N}$$

$$rk = 1 - \frac{6 \times 82}{1000 - 10}$$

$$rk = 1 - \frac{492}{990}$$

$$rk = 1 - 0.496 = +0.504$$

Answer: It is moderate correlation

**Merits of Rank Method;**

1. It is easy to calculate in compared to Karl Pearson's method.
2. Rank method is only method for finding the degree of correlation.
3. Rank method is useful for qualitative nature of data (intelligence, beauty, honesty, dignity etc.)
4. The answer of Karl Pearson's and Spearman's Rank will be same if values are not repeated.

**Demerits of Rank Method;**

1. This method is only useful for individual observation rather than frequency distribution.
2. It is not good for find out correlation in a grouped frequency distribution.
3. It is based on rank only.
4. It is not suitable for more than 30 item values.

**6.4 CORRELATION: CONCURRENT DEVIATION METHOD**

Concurrent Deviation Method of correlation is the simplest of all the methods. Directions of change of X variable and Y variables have to find out in this method. The formula of the concurrent method;

$$r_c = \pm \sqrt{\pm \left( \frac{2C - n}{n} \right)}$$

Where  $r_c$  coefficients of Correlation, C is number of positive sign and multiply  $D_x$  and  $D_y$  and add it to get C.

n = Number of pairs of observations compared.

**Steps to follow;**

1. Find out the direction of change of X and Y variables.
2. If second value is increasing in compare to first value put sign + (positive).
3. If second value is decreasing in compare to first value put sign – (negative).
4. If second value is constant or same in compare to first value put sign 0 (zero).
5. Follow the same process for other value.
6. Denote  $D_x$  for X and  $D_y$  for Y value.
7. Add the only positive (+) sign to determine the value of C.
8. n will be one less than to total observation. If total observation is 11 then n will be 10.
9. The significant of  $\pm$  sign inside the under root and outside the under root.
10. It is not considered the –(negative) sign under the root because value multiplied with the minus (-) sign inside would make it positive.

Q. No. 01: Calculate the correlation coefficient of concurrent deviation from following.

X	50	45	40	44	42	48	52	56	56
Y	55	50	45	48	46	58	25	25	36

Solution: Calculation of correlation by concurrent deviation method where n will be 8.

X	$D_x$	Y	$D_y$	$D_x D_y$
50		55		
45	-	50	-	+
40	-	45	-	+
44	+	48	+	+
42	-	46	-	+
48	+	58	+	+
52	+	25	-	+
56	+	25	0	0
56	0	36	+	0
				C= 6

Apply formula;  $r_c = \pm \sqrt{\pm \left( \frac{2C-n}{n} \right)}$

$$r_c = \pm \sqrt{\pm \left( \frac{2 \times 6 - 8}{8} \right)} r_c = \pm \sqrt{\left( \frac{4}{8} \right)} = 0.707 \text{ Answer}$$

Significance:

1. It is the simplest method.
2. If the number of variable is very large apply this method to get quick idea of degree of relationship.
3. Limitation of the method does not differentiate between small and big changes.

---

## 6.5 REGRESSION

---

**Objectives :** To estimate the unknown value from known value.

### Introduction:

Regression is the measure of the average relationship between two or more variables in the original units of the data. A measure of the relation between the mean value of one and corresponding values of other variables.

Regression analysis is a method for estimating the unknown values of one variable from known values of another (Fransis Galton). Regression describes the functional relationship between dependent and independent variables. It is useful to estimates one variables from another. Correlation of two variable scan be determined by Regression lines and coefficient of regression. Linear regression is used for predictive analysis. Regression estimates are used to describe data to explain the relationship between dependent variable and independent variables.

The simplest form with one dependent and one independent variable is defined by the formula  $y = c + bx$ ,

Where  $y$  = estimated dependent,  $c$  = constant,  $b$  = regression coefficients, and  $x$  = independent variable.

There are two regression lines. These two regression lines consists two regression equations and two regression coefficients. Regression equations are algebraic expressions. These equations are:

X on Y regression equation:  $X_c = a + bY$

Y on X regression equation:  $Y_c = a + bX$

The value of 'a' and 'b' in the equations can be obtained by solving the following two equations.

These two equations are called normal equations. They are:

X on Y regression equation ( $X_c = a + bY$ )------(I)

$$\sum X = Na + b \sum Y$$

$$\sum XY = a \sum Y + b \sum Y^2$$

Y on X regression equation ( $Y_c = a + bX$ )------(II)

$$\sum Y = Na + b \sum X$$

$$\sum XY = a \sum X + b \sum X^2$$

Q. N0. 01: Calculate regression equations of the following data.

X	1	2	3	4	5	6	7	8	9	10
Y	10	9	8	11	12	13	12	14	15	16

Solution: Calculation of equations: X on Y and Y on X.

X	Y	$X^2$	$Y^2$	XY
1	10	1	100	10
2	9	4	81	18
3	8	9	64	24
4	11	16	121	44
5	12	25	144	60
6	13	36	169	78
7	12	49	144	84
8	14	64	196	112
9	15	81	225	135
10	16	100	256	160
$\sum X$ = 55	$\sum Y$ = 120	$\sum X^2 = 385$	$\sum Y^2 = 1500$	$\sum XY = 725$

### 1. Regression equation of X on Y

$$X_c = a + bY$$

Two normal equations are:

$$\sum X = Na + b \sum Y \dots\dots\dots(i)$$

$$\sum XY = a \sum Y + b \sum Y^2 \dots\dots\dots(ii)$$

Substitute the values:

$$55 = 10a + b120 \dots\dots\dots(i)$$



$$725 = 120a + b1500 \text{-----(ii)}$$

Multiply the equation (i) by 12

$$660 = 120a + b1440 \text{-----(iii)}$$

$$725 = 120a + b1500 \text{-----(iv)}$$

Subtract equation (iv) from (iii)

$$-65 = -60b$$

$$b = \frac{-65}{-60} = 1.08$$

Substitute the value of b in equation (i)

$$55 = 10a + b120$$

$$55 = 10a + 1.08 \times 120$$

$$55 = 10a + 129.6$$

$$10a = 55 - 129.6$$

$$10a = -74.6$$

$$a = \frac{-74.6}{10}$$

$$a = -7.46$$

Therefore the regression equation X on Y is:

$$\text{Answer: } X_c = -7.46 + 1.08Y$$

### 1. Regression equation of Y on X

$$Y_c = a + bX$$

Two equations are:

$$\sum Y = Na + b \sum X \text{ ..... (i)}$$

$$\sum XY = a \sum X + b \sum X^2 \text{ ..... (ii)}$$

Substitute the values:

$$120 = 10a + b55 \text{ ..... (i)}$$

$$725 = 55a + b385 \text{ ..... (ii)}$$

Multiply the equation (i) by 7

$$840 = 70a + b385 \text{ ..... (iii)}$$

$$725 = 55a + b385 \text{ ..... (iv)}$$

Subtract equation (iv) from (iii);

$$115 = 15a$$

$$a = \frac{115}{15} = 7.67$$

Substitute the value of 'a' in equation (i);

$$120 = 10a + b55 \text{ ..... (i)}$$

$$120 = 10 \times 7.67 + b55$$

$$120 = 76.7 + b55$$

$$120 - 76.7 = b55$$

$$43.3 = b55$$

$$b = \frac{43.3}{55} = 0.787$$

Therefore the regression equation Y on X is:

Answer:  $Y_c = 7.67 + 0.787X$ .

Q. No. 02: Marks obtained by students of Geography and Statistics in B.A (H). Find out the regression coefficient of students.

Marks in Geography(X)	46	42	44	40	43	41	45
Marks in Statistics(Y)	40	38	36	35	39	37	41

Solution: Calculation of equations: X on Y and Y on X.

X	Y	$X^2$	$Y^2$	XY
46	40	2116	1600	1840
42	38	1764	1444	1596
44	36	1936	1296	1584
40	35	1600	1225	1400
43	39	1849	1521	1677
41	37	1681	1369	1517
45	41	2025	1681	1845
$\sum X$ = 301	$\sum Y$ = 266	$\sum X^2 = 385$	$\sum Y^2 = 10136$	$\sum XY = 11459$

### 1. Regression equation of X on Y

$X_c = a + bY$

Two normal equations are:

$$\sum X = Na + b \sum Y \dots\dots\dots(i)$$

$$\sum XY = a \sum Y + b \sum Y^2 \dots\dots\dots(ii)$$

Substitute the values:

$$301 = 7a + b266 \dots\dots\dots(i)$$

$$11459 = 266a + 10136 \dots\dots\dots(ii)$$

Multiply the equation (i) by 38;

$$11438 = 266a + b10108 \dots\dots\dots(iii)$$

$$11459 = 266a + b10136 \dots\dots\dots(iv)$$

Subtract equation (iv) from (iii)

$$-21 = -28b$$

$$b = \frac{-21}{-28} = 0.75$$

Substitute the value of 'b' in equation (i);  $\sum X = Na + b \sum Y$

$$301 = 7a + 0.75 \times 266$$

$$301 = 7a + 199.5$$

$$7a = 301 - 199.5$$

$$7a = 101.5$$

$$a = \frac{101.5}{7}$$

$$a = 14.5$$

Therefore the regression equation X on Y is:  $X_c = a + bY$

$$\text{Answer: } X_c = 14.5 + 0.75Y$$

### 1. Regression equation of Y on X

$$Y_c = a + bX$$

Two equations are:

$$\sum Y = Na + b \sum X \dots\dots\dots(i)$$

$$\sum XY = a \sum X + b \sum X^2 \dots\dots\dots(ii)$$

Substitute the values:

$$266 = 7a + b301 \dots\dots\dots(i)$$

$$11459 = 301a + b12971 \dots\dots\dots(ii)$$

Multiply the equation (i) by 43

$$11438 = 301a + b12943 \dots\dots\dots(iii)$$

$$11459 = 301a + b12971 \dots\dots\dots(iv)$$

Subtract equation (iv) from (iii);

$$-21 = -28b$$

$$b = \frac{-21}{-28} = 0.75$$

Substitute the value of 'a' in equation (i);  $\sum Y = Na + b \sum X$

$$266 = 7a + 0.75 \times 301$$

$$266 = 7a + 225.75$$

$$266 - 225.75 = 7a$$

$$40.25 = 7a$$

$$a = \frac{40.25}{7} = 5.75$$

Therefore the regression equation Y on X is:  $Y_c = a + bX$

$$\text{Answer: } Y_c = 5.75 + 0.75 X.$$

## 6.6 CONCLUSION

Both correlation and simple linear regression can be used to examine the presence of a linear relationship between two variables providing certain assumptions about the data are satisfied.

The results of the analysis, however, need to be interpreted with care, particularly when looking for a causal relationship or when using the regression equation for prediction. Multiple and logistic regression will be the subject of future reviews.

---

## 6.7 SUMMARY

Correlation and regression analysis are related in the sense that both deal with relationships among variables. The correlation coefficient is a measure of linear association between two variables. Values of the correlation coefficient are always between -1 and +1. A correlation coefficient of +1 indicates that two variables are perfectly related in a positive linear sense, a correlation coefficient of -1 indicates that two variables are perfectly related in a negative linear sense, and a correlation coefficient of 0 indicates that there is no linear relationship between the two variables. For simple linear regression, the sample correlation coefficient is the square root of the coefficient of determination, with the sign of the correlation coefficient being the same as the sign of  $b_1$ , the coefficient of  $x_1$  in the estimated regression equation.

Neither regression nor correlation analyses can be interpreted as establishing cause-and-effect relationships. They can indicate only how or to what extent variables are associated with each other. The correlation coefficient measures only the degree of linear association between two variables. Any conclusions about a cause-and-effect relationship must be based on the judgment of the analyst.

---

## 6.8 GLOSSARY

**Regression Line** - Regression analysis is a set of statistical process for estimating the relationships among variables

**Rank Difference** - The relationship between ranking of different ordinal variables or different rankings of the same variable, where a ranking is the assignment of the ordering labels, first, second, third etc.

---

## 6.9 ANSWER TO CHECK YOUR PROGRESS

1. What do you mean by correlation?
2. What do you mean by Rank correlation?
3. Discuss Karl Pearson methods of correlation.
4. What do you mean by Regression?

---

## 6.10 REFERENCE

1. Gupta S. P. (2004) Statistical Methods, Sultan Chand and Sons, Educational Publishers, New Delhi .

---

## 6.11 SUGGESTED READINGS

---

1. Sarkar Ashis (2013) Quantitative Geography. Techniques and Presentation, orient BlackSwan, New Delhi.
2. Bloor, M and F. Wood(2006) Keywords in Qualitative Methods: A Vocabulary of Research, Concepts Publication; New Delhi.
3. Gregory, S (1963) Statistical Methods and Geographers, Longman, London.

---

## 6.12 TERMINAL QUESTIONS

---

1. Calculate Karl Pearson's coefficient of correlation and the regression equation from following data.

X: 15,18,21,24,27,30,36,39,42,68

Y: 25,25,27,27,31,33,35,41,41,45

2. Calculate the coefficient of concurrent deviation from the following.

X: 60, 55, 50, 56, 30, 70, 40, 35, 80, 80, 75.

Y: 65, 40, 35, 75, 63, 80, 35, 20, 80, 60, 60.

3. The data relate to age of students of statistics and the number of days they reported sick in a month.

Age (X): 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28

Sick Days (Y): 1, 0, 2, 5, 2, 4, 6, 5, 7, 8, 7.

4. Calculate regression equation of X on Y and Y on X of following data.

X: 1,2, 3, 4,5,6, 7, 8, 9.

Y : 9, 8, 10, 12, 11, 13, 14, 16,15.

5. Calculate the coefficient of rank correlation between X and Y.

X: 36, 56, 20 , 65, 42, 33, 44, 53, 15, 60.

Y: 50, 35, 70, 25, 58, 75, 60, 45, 89. 38.

## **BLOCK-3 SURVEYING**

---

### **UNIT 7 - PRINCIPALS OF SURVEYING**

---

**7.1 OBJECTIVES**

**7.2 INTRODUCTION**

**7.3 FUNDAMENTAL OF SURVEYING**

**7.4 TYPES OF SURVEYING**

**7.5 CONCLUSION**

**7.6 SUMMARY**

**7.7 GLOSSARY**

**7.8 ANSWER TO CHECK YOUR PROGRESS**

**7.9 REFERENCES**

**7.10 SUGGESTED READINGS**

**7.11 TERMINAL QUESTIONS**

---

## **7.1 OBJECTIVES**

---

After reading this unit, you will be able to:

- Know about fundamentals of Surveying
- Explain about the types of surveying

---

## **7.2 INTRODUCTION**

---

Survey is an art in which the horizontal distances, angle and heights measured on the surface with the help of survey instruments. After this it is showed as a map as per conventional method. Thus, the survey consists of three functions. (i) Field work, in which with the help of survey equipment horizontal distances between the fixed points in the area are written in the field book by measuring angle, directions and height. (ii) Mapping, in which measurement are written in field book, according to the rules of map art, the given area map is made and (iii) Computation, in which the necessary calculation work is done to determine positions, area and volume.

From the above description, it is clear that the survey is a mixture of science and art. The surveyor is required to survey the principles of survey, the technical knowledge of the design of the equipment and their right use. Surveyors must also have full knowledge of the general rules of map art. A good surveyor should have high observation capability. A good surveyor should have the ability to make quick decisions. In the previous unit we read about the regression and correlation. In this unit we will tell you the principals of the survey and also we will explain the types of survey.

---

## **7.3 FUNDAMENTAL OF SURVEYING**

---

Different methods of survey are based on two basic rules. (i) Working from the whole to the numerator and (ii) use of more than one independent process in determining the position of new centers. According to the first rule, in the surveys, a sequence of controlling points is first established with high precision. For horizontal control, these points are decided by triangulation or absolute traverse. To perform this task by triangulation, divide the given area into large triangles and conduct surveys with maximum accuracy of these triangles. After this, these triangles are divided into sub departments. The purpose of this work system is to prevent accumulation of error and to control minor errors. According to the second law, the conditions of the new centers are determined by the pre- decided centers on the basis of linear measurement, angle measurement or both types of measurement in the survey. For example, in chain surveys, the main lines and the measurement of the center are examined and it is checked by the check or tie line.

Two types of measurement are used in plane surveys. (i) Linear measurement and (ii) Angular measurement. Linear measurement can be again divided into two departments. (i) Horizontal distance, (ii) Vertical distance. Similarly, angular measurement has two different

subdivision. (i) Vertical angle and (ii) Horizontal angle. It should be remembered that in the survey, always H.E. is measured between the points given on the ground.

---

## 7.4 TYPES OF SURVEYING

---

The survey can be classified according to various different bases as follows:

- 1- Primary classification of survey
  - (i) Geodetic Surveying
  - (ii) Plane Surveying
- 2- According to the method of surveying
  - (i) Triangulation Surveying
  - (ii) Traverse Surveying
- 3- Classification according to the survey instrument/equipment used
  - (i) Chain and Tape Surveying
  - (ii) Plane table surveying
  - (iii) Compass surveying
  - (iv) Sextant surveying
  - (v) Theodolite surveying
  - (vi) Dumpy level
  - (vii) Indian pattern clinometers
  - (viii) Air surveying
- 4- Classification according to the object of the survey
  - (i) Topographical survey
  - (ii) Archaeological surveying
  - (iii) Geological surveying
  - (iv) Military survey
  - (v) Cadastral survey
  - (vi) City survey
  - (vii) Engineering survey
  - (viii) Other surveys
- 5- Classification according to the nature of the survey area
  - (i) Land survey
  - (ii) Marine or navigation survey
  - (iii) Astronomical survey



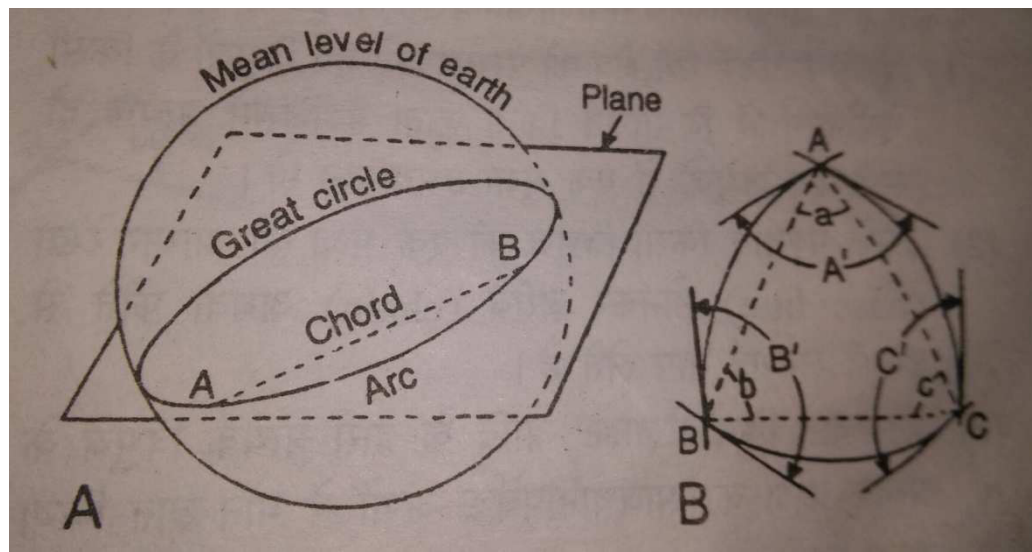
## 1- Geodetic survey

In the view of spheroidal shape of the earth, the survey carried out is called trigonometrical survey. Trigonometrical survey is done to find the precise conditions on the earth given to the points given in a large area. The methods of the equipment used in this survey are very refined. These types of surveys are only done by the Government. For example- Survey of India in India, US Geological survey in the United States and US Cost & Geodic survey department conducted trigonometrical surveys.

If the shape of the earth is assumed like a full sphere, it is obvious that the line joining any two points, A and B, will be curved on the surface. In the similar fashion if any three points are joined with one another, the resulting figure will be a spherical triangle. In figure 7.1 B, ABC is a spherical triangle and  $A'$   $B'$   $C'$  are the spherical angles. If the curvature of the earth is not brought into consideration meaning, the earth's surface is considered as a plane then the lines joining these points will be the simple lines and the resultant triangle will be the plane triangle ABC, the angles  $a, b, c$ , of the triangle will be the plane angles. Hence in Geodetic survey the use of spherical trigonometry is made.

## 2- Plane surveying

Fig. 7.1



Source: J P Sharma Practical Geography

In the plane survey the surface of the earth is considered as flat that is no consideration is made on the impact of the curved shape of the earth while doing surveys. Students of Geography conduct surveys from different instruments through this method. To conduct this type of survey, it is necessary to have knowledge of both line arithmetic and tignometry. Although flat surveys

are not as accurate as Geological survey but this method is appropriate for survey of relatively small areas, because there is no effect of curvature of the earth on distances distilled in a small area. This is the reason that the use of flat surveys in the construction of the boundaries of the cities and villages and construction of roads, railways and canals etc.

### 3- Triangulation surveying

In the triangulation survey, an area is divided into triangle. Find the value of one side of the triangle and all the angles. With the help of trigonometry on the basis of these values, the length of the remaining arms is fixed and from this, the process of making maps is called triangulation survey.

This survey is done in the following steps:

- (i) The first given area is divided into one of the corresponding triangles in an order, in which two adjacent triangles have one side in common.
- (ii) After this, one side of a triangle, regarding the base as a baseline, measures its length by using Chain & Tape.
- (iii) After this, the degree of the values of each angle of each triangle is determined by theodolite.
- (iv) By placing the above values in the following trigonometric formula, the length of the remaining two sides of the triangle with the first baseline is fixed.

$$\frac{\sin A}{a} = \frac{\sin B}{b} = \frac{\sin C}{c}$$

In the above formula has an angle of A, B and C triangle and a b c are respectively sides facing these angles. When the length of the three sides of the baseline triangle is known, the sides of the proximal triangles can be determined by using the above formula.

From the above description it is clear that in the triangulation survey, every distance of the field is not measured by the chain and it is done according to the baseline.

### 4- Traverse surveying

The sequence of simple lines connecting the sequence of pre determined points in a survey path is called traverse. The point at which the traverse line changes its direction is called a traverse point. Thus in the traverse survey, all the lines that make up the traverse line are measured. The angle between two simple lines is found out at each traverse point. To measure distances on the surface, the chain and tape method is used. Angular measurements are found out by prismatic compass or theodolite. This method is often used in flat areas because there is lack of surface obstacles; it is easy to measure distances. There are two types of traverse. (1) Close traverse, (2) Open traverse. The surveyor in the close traverse comes back to the same point as the traverse

point start. For example, survey of any field or ground. In the open traverse the surveyor continues to grow continuously and does not reach the starting point. For example survey of any road or canal.

---

## 7.5 CONCLUSION

Survey is very important for making a map of an area. It can be easily made to map of an area with the help of scale. This is a very important study. It is a record of surface. Basic need for survey is preparing for construction, ensuring accurate boundaries, understanding topography etc.

---

## 7.6 SUMMARY

Information about different types of surveys was given in this unit. What is geodetic, plane, triangulation and traverse survey? What are the uses of these surveys? What are the principals of the surveys? Which rules are based on the surveys? What are the measurements used in the survey? Like the linear measurement, angular measurement, horizontal distances, vertical distances, horizontal angle, vertical angle.

---

## 7.7 GLOSSARY

---

• <b>Survey</b>	-	The measuring and recording of the details of an area of land
• <b>Geodetic</b>	-	Relating to geodesy
• <b>Triangulation</b>	-	The tracing and measurement of a series or network of triangles in order to determine the distances and relative positions of points spread over an area.
• <b>Astronomical</b>	-	Relating to astronomy
• <b>Topographical</b>	-	Representation of the physical features of an area
• <b>Cadastral</b>	-	Showing the extent, value of land
• <b>Engineering</b>	-	The study of using scientific principles to design and build structures

---



---

## 7.8 ANSWER TO CHECK YOUR PROGRESS

1. What is Geodetic survey?
2. What is Plane survey?
3. What is Triangulation survey?
4. What is Traverse survey?

---

## **7.9 REFERENCES**

---

1. Sharma, J.P. (2014): Practical Geography Rastogi Publications, Meerut.

---

## **7.10 SUGGESTED READINGS**

---

1. Gaur, K.S. (1968), Manchitra Kala Ki Sameeksha, Agra Book Store, Agra.
2. Sharma, J.P. (2014), Practical Geography Rastogi Publications, Meerut.
3. Singh, R.B. (2003), Practical work in Geography Pt I NCERT, New Delhi.
4. Singh, R.L. & P.K. Dutt (1966), Elements of practical Geography, Students friends.

---

## **7.11 TERMINAL QUESTIONS**

---

- Q 1. Explain the difference between the types of Survey according to the different bases.
- Q 2. Explain the differences of Geodetic Survey and plane survey.
- Q 3. Explain the methods of Triangulation Survey and Traverse survey.

---

## UNIT 8 - PLANE TABLE SURVEYING

---

**8.1 OBJECTIVES**

**8.2 INTRODUCTION**

**8.3 PLANE TABLE SURVEYING**

**8.4 RADIATION, INTERSECTION AND TRAVERSING (OPEN & CLOSE)**

**8.5 RESECTION (TWO POINT & THREE POINT PROBLEM)**

**8.6 CONCLUSION**

**8.7 SUMMARY**

**8.8 GLOSSARY**

**8.9 ANSWER TO CHECK YOUR PROGRESS**

**8.10 REFERENCES**

**8.11 SUGGESTED READINGS**

**8.12 TERMINAL QUESTIONS**

---

## 8.1 OBJECTIVES

---

After reading this unit, you will be able to:

- Know about Plane Table Surveying
- Explain about the different methods of plane table survey
- Know about positioning techniques

---

## 8.2 INTRODUCTION

---

Plane Table Survey is an accurate easy to use graphical method. From the survey to the map, the entire work done in the field, while in other surveys the measurement work is done in the ground and mapping is done in the laboratory. This is the most suitable and popular survey technique for flat parts but in hilly terrains and extreme rugged states the survey is difficult. Errors are very less due to the completion of the entire survey done in the area.

---

## 8.3 PLANE TABLE SURVEYING

---

The invention of the plane table was in 1570. Today, it is considered the most popular tool to make plan by surveying the ground. The biggest feature of the plane table is that all the work is completed in the field, like surveying and mapping on paper. There are many benefits to the plan completion in the area.

- No need to make field book. As a result, the survey work becomes easy.
- If any details of the area in making the plan have been left then he gets instant knowledge.
- The survey work is completed quickly.

---

### **INSTRUMENT REQUIRED FOR PLANE TABLE SURVEYING**

The following tools are required in the Plane Table Survey :

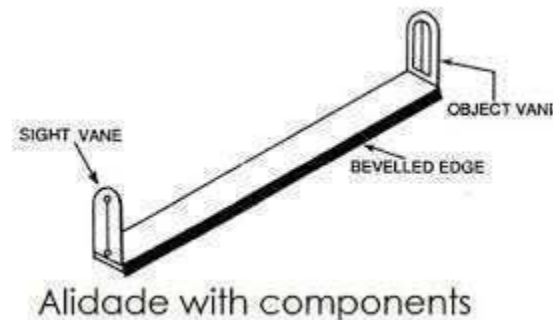
**Plane Table and Tripod Stand** - Plane table is the main tool of the survey, which has two parts- (i) Drawing board and (ii) Tripod stand. Drawing board is made of pine wood. These are of different sizes like 40x30 cm, 70x60 cm, 45x45 cm and 60x60 cm etc. For strengthening, on the lower surface of the drawing board the teak wood is wooded. In the middle of the board, there is aluminum round plate on the bottom, which is called pivot plate.

Drawing board is tightly used on a 1.5 meter long tripod stand. If the ground is rough then that drawing board can be leveled from the tripod stand. Tripod stand legs are made of teak wood. In the top of it is attached to a plate of aluminum by fly-nuts, which is called Tribrach plate. Drawing board and tripod stand joints to each other with clamping screw.



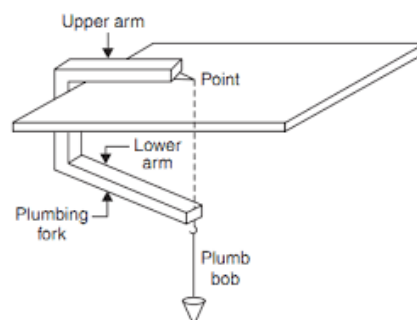
Source Google

**Alidade** - The alidade is a ruler with a sight line attached and is used on the plane table for intersect the object, drawing rays, direction lines, etc. It consists of a metal (brass or gunmetal) or boxwood straightedge or ruler of about 45 cm long. The alidade may be plain fitted with sight vanes at both the ends and it can be fitted with a telescope. One of the sight vanes is provided with a narrow rectangular slit. Whereas other is equip with a central vertical hair or wire.



Source Google

**Plumbing Fork and Plumb Bob** - Plumbing fork is a U-shaped metal frame with an upper horizontal arm and a lower inclined arm. The upper arm is provided with a pointer at the end while the lower arm is provided with a hook to suspend plumb bob.



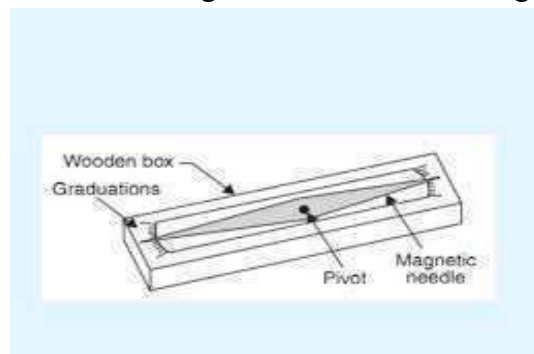
Source Google

**Spirit level** - If the spirit level which may be very sensitive is not fitted to the alidade, the table can be leveled by placing the spirit level in two positions at right angles to each other and setting the plane table such that the bubble is central in both positions.



Source Google

**Trough compass** - Trough Compass with two bubble tubes at right angles to each other mounted on a square brass plate is used for indicating the direction of the magnetic meridian on the paper.



Source Google

**Survey Operation** - After checking all the equipment of the survey, it is taken to the place of the survey.

### **1-Reconnaissance Sketch Map**

Before starting a survey of an area, make an estimated image of the area and target points should be marked on that estimated image. Where the place is not clearly visible, the ranging rod should be buried. To mark all the details, by selecting the station, the field should be selected so that the entire area can be made on paper.

### **2-Setting up the plane table**

The following procedure is adopted for establishing a plane table.



After reconnaissance sketch map drawing sheet is attached with the help of a board pin on the table. Drawing sheet is very important on which the map has to be made. Plane table is fixed in the first survey station at the height of the chest. At first station two actions are done to fix the plane table (i) leveling, (ii) centering. At the next station, do three works to establish the plane table. Leveling, centering & orientation.

**(a) Leveling the plane table**

Use spirit level to level the drawing board. The air bubble always escapes to the height in the spirit level. To adjust the plane table, spirit level is placed in middle and each corner of the drawing board. If the drawing board is not flat, then it's leveled by shaking one leg of the tripod stand. After adjusting the plane table should be tight.

**(b) Centering of the plane table**

Finding the position of the drawing board in the vertical direction of the survey station is called centering. The table should be centered by using plumbing fork. By using which we can arrange the plotted point exactly over the ground point.

After the work is done at first station, pick up the plane table and put it at another survey station. The position of which is already marked on drawing paper. In this process, drawing board can get a difference in vertical condition.

**(c) Orientation**

Draw lines on the drawing board, fable lines corresponding to the ground keeping parallel is called orientation. It is very important to make an orientation before drawing rays at all survey stations otherwise any details mentioned in the plane will be in a different situation than its actual position. There are two main methods of making orientation.

**(i) Orientation by trough compass**

It is very easy to orientation the plane table with the help of trough compass. At the survey station where the planning of the plane table is oriented, loose the drawing board and centering & leveling with that station. After this, in the drawing paper with the north- south line drawn on the first survey station, keeping the trough compass, the drawing board revolves around the magnetic north direction indicated by the needle. When the needle of the trough compass is located in the middle, then the drawing board is tighten to the tripod stand. With this method, to orient the plane table, the previously drawn north south line on the drawing paper is set according to the direction. After the orientation, the centering and leveling of the plane table is re- examined.

If an iron pitcher is located near a survey station, then the magnetic needle cannot tell the correct north direction. Therefore, this method cannot always be accurately oriented.

**(ii) Orientation by back sighting**

In this method, plane table is oriented by placing both ends of previously laid- baseline on the drawing paper in the direction of survey stations located on the ground. For example, suppose A and B are two surveying stations on the ground, in which the A B baseline appears on the drawing paper from a b line. (fig.8.1) Now, for the purpose of orienting the table on the B station, buried ranging rod at the A station and loose the drawing board on the tripod stand and adjust the centering and leveling of plane table at B station. Once the correct centering is done, B and b points will be in a vertical line. Now keep the alidade with b a line. Now rotate the drawing board so that the wire of object vane is straightened at A station where ranging rod is buried. After getting straightened, tighten the drawing board. While rotating the drawing board, the alidade should remain constant on the b a line. When rotating the drawing board, if there is a difference in its leveling or centering, then it should be removed and should re- look at the pre station A and check the precision of the orientation.

The method of orientation of the plane table by the back sighting is considered to be more reliable and authentic. Therefore, when using the orientation, often use this method.

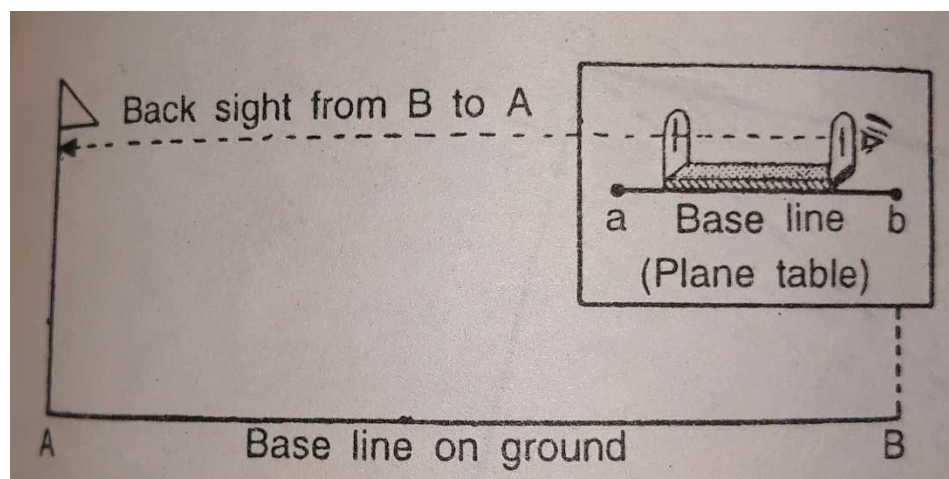


Fig. 8.1 Source Practical book J.P.Sharma

**COMPLETING THE PLAN**

After making all the necessary details and boundary line of the area, its scale should be marked below the plan. Writing the name of the relevant area on each plan and the name of the survey method below it is necessary.

**PRECAUTIONS USING THE PLANE TABLE SURVEY**

- Drawing board should be tightly kept in the time of surveying. If it is slightly disturbed then becomes difficult for its working.
- Alidade side should be straight and make the rays straight and fine.
- The scale should be like this, in which the map will not be too big or too small.

- Scale should be kept according to the details on the map.
- Magnetic north must be made on the diagram. Metallic items should not be nearest at the time of work. The clock tide on your hand also influences it.
- Plane table should be properly set up, because the accuracy of the survey depends on these works.
- The rays should be fine and the serial number should be marked on each ray. The rays should not be long.
- The drawing board should be exactly flat.
- When the survey is not completed on a one paper you should transfer all the stations of the first hole by holes on the second paper.
- While drawing rays the alidade should not be move.

---

## ***8.4 RADIATION, INTERSECTION AND TRAVERSING (OPEN & CLOSE)***

---

There are four methods of plane table survey.

- Radiation method
- Intersection method
- Traverse (open & close)
- Resection

### **RADIATION METHOD**

In this method of plane table surveying plane table is set up only one station and various points are located by radiating a ray from the instrument station to each of the points and plotting to scale along the ray and distance measured from the station to the point is sighted. Suppose ABCDEF is an open flat field. This field will be surveyed by radiation method as follows.

- First of all select a survey station (suppose P) in the middle of the field from where all the areas are clearly visible. This station can also be selected outside or the corner of any area, but sometimes doing so, any detail drawing cannot be inscribed within the bounds of the paper and all the work needs to be reworked. This problem is resolved by choosing the survey station in the middle station of the area and using the appropriate measures.
- Insert p point in the middle section of drawing paper and with the help of plumb bob or plumbing fork, correctly centering and balancing the plane table, keeping the p point right above the P station.
- Record the magnetic north direction by placing the trough compass in the upper corner of the drawing paper.
- Now put an alpin on the p point and by keeping alidade in support of this alpin , do rays on buried ranging rod A,B,C,D,E and F and other details within the area.
- Every buried ranging rod ABCDEF also measured distance from chain and tape from the P station. Cut these rays into the ray of drawing board according to the definite scale and

mark a b c d e f point in the drawing paper. Similarly, the details on the inside side of the area will be marked.

- After viewing the area, complete the boundary line in plan by joining a, b, c, d, e, and f points and write the name of the area and survey method on the plan and make the scale.

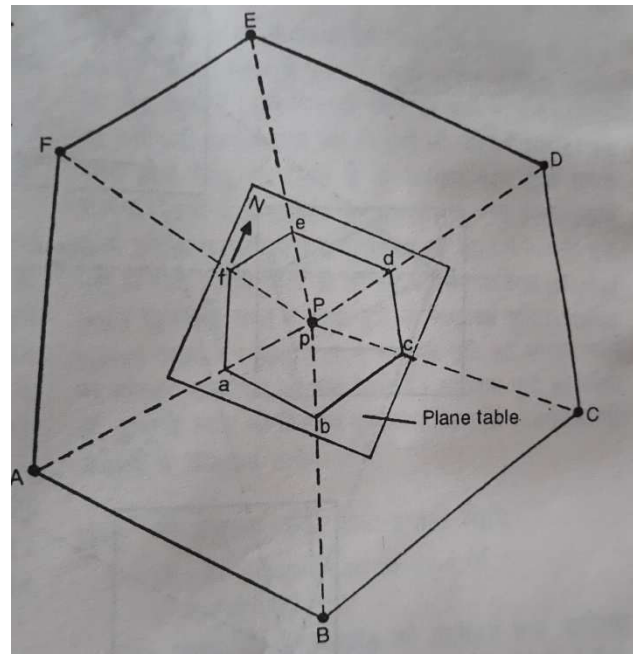


Fig. 8.1 Radiation Method Source Practical book J.P.Sharma

## **INTERSECTION METHOD**

In this method, doing survey from the first station and then second, third, fourth, fifth and the next and reach at the first station. Any field, houses and settlements survey is done by the closed traverse method. In this method we can locate the point by plotting two rays from two known stations. The simple line joining the two survey stations from which the rays are drawn is called baseline. There is no need to measure any distance other than the baseline in the intersection mode. Hence this method is also called the triangulation method of the plane table. This method is particularly useful for placing the inaccessible areas of open areas in the plan. The purity of the plan of an area created by the intersection method depends on the correct selection of the baseline and its measurement. While selecting the baseline, the following points should be kept in mind.

- Every detail of the field is clearly visible from both sides of the baseline.
- The angle between the baseline and ray should not be too large or too low.
- The baseline should be selected on the level of flat and obstructive grounds so that it can easily be measured accurately with the help of chain and tape.

## **Procedure**

According to the 8.2 figure, A B C D is an area. The process of survey and planning of this area through the intersection method will be completed in the following stages.

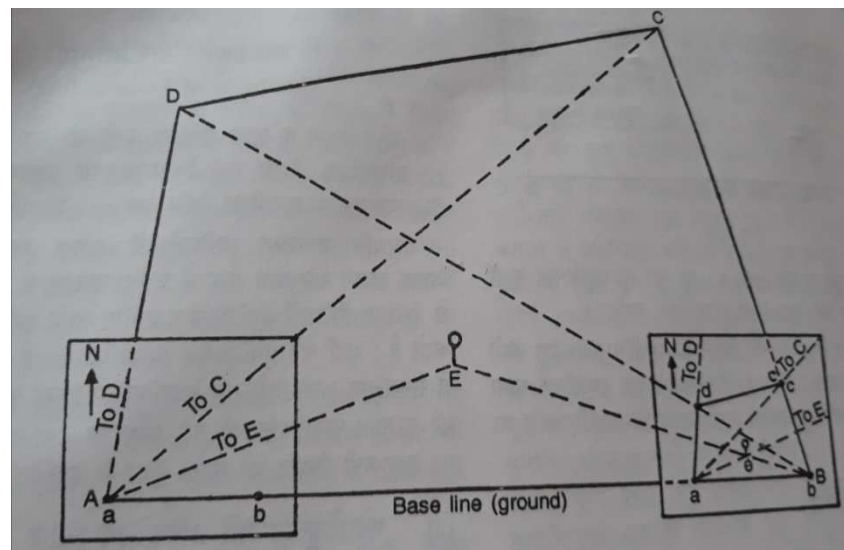


Fig. 8.2 Intersection Method Source Practical book J.P.Sharma

- Inspect the given area and choose the details to be displayed in the plan and buried ranging rod on border lines, so that they can be targeted with the alidade.
- Keeping in mind the above mentioned points, select a suitable baseline in the area and measure this line from chain or tape. A B line is considered to be the base line in the given example.
- Fix the plane table on the A station and display the magnetic north direction with the help of a trough compass in the upper corner of the drawing paper.
- Using a plumb bob and fork, find 'a' point on the drawing board just above the A station and make an alpin on this point.
- Keeping alidade with the support of alpin, draw a ray by targeting the B station. According to the pre-determined scale of this ray, cut a line a b equal to A B distance, which will reveal the base line in the plan.
- After this, by rotating the other points or details of the field, draw the rays from 'a' point towards them. For identification mark the related details on each ray such as, To C, To D, and To E etc.
- After done this work, transfer the plane table to the B station. According to the pre method, do the leveling, centering and orientation of the plane table. Located on the drawing board just above the b point at B station.
- Now, by buried the alpin on the point b, like the previous one, rotate the details of the area by rotating the alidade while drawing the ray.

- The intersection of rays drawn by targeting any details from both stations will reveal the status of related details in the plan. So identify the related rays and mark the c, d, and e intersection point in the plan.
- After making the details, write the name of respective area and the name of the survey method on the plan and make the scale and signs.

## **TRAVERSING METHOD**

This is the method used for locating plane table survey stations. In this method, ray is drawn to next station before shifting the table and distance between the stations measured. The distance is scaled down and next station is located. After setting the plane table at new station orientation is achieved by back sighting. To ensure additional checks, rays are taken to other stations also, whenever it is possible. Figure 8.3 shows a scheme of plane table survey of closed area. This method can be used for both traverses (Open & close).

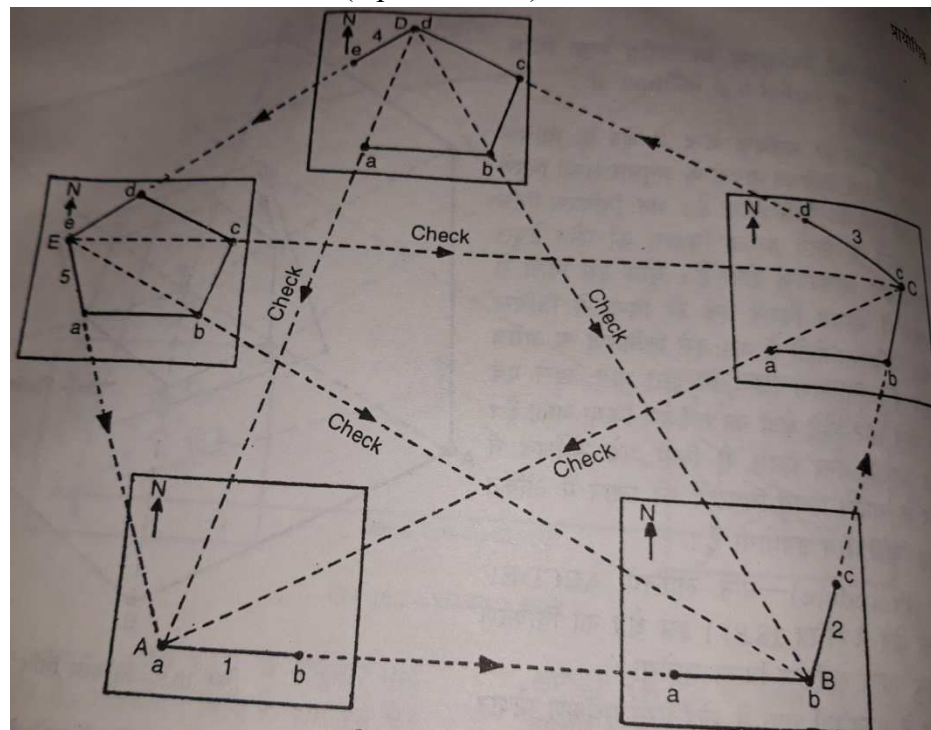


Fig. 8.3 Source Practical book J.P.Sharma

## **OPEN TRAVERSE METHOD**

In this method, doing the survey work by setting up the drawing board at the first station and then setting up the second, third, fourth and next station and do not come back to the first station. That means base line and stations are open. These types of surveys can be of any way, canal and river.



## 8.5 RESECTION (TWO POINT & THREE POINT PROBLEM)

Determining the position of the plane table on the pre surveyed map based on known points in the field is called positioning. Plane table are placed in any place in the area and by drawing two or three details in the map, pulling the ray back and find the intersect point. This intersect point is the actual position of the map, from where the survey work is carried out. The following three methods of resection are:

### 1- Resection after Orientation by compass

In this method, the drawing board is fixing with the help of trough compass and targeting any two points in the field, draws the rays on back, which are intersect. This intersection will reveal the actual position of the drawing board.

- Let's say A and B are two such stations in any area, those who have been exposed from a and b points on the plan. There is also a new station P which is to be displayed in the plan.
- Placing the given plan on the drawing board, place the plane table on the P station.
- Keep the trough compass with the magnetic north south line on the plan and rotate the drawing board in the direction indicated by the compass needle. When the right orientation is done, tighten the drawing board.
- Keep the alidade with the help of an alpin at a point and target the station A. Back the ray with the help of alidade.
- Now keep the alidade with the support of the alpin at the b point and target the station B. Draw a second ray on back, which first cut the ray at p point. The p point will reveal the position of P station in the plan. This method is used only in small scale measuring plans.

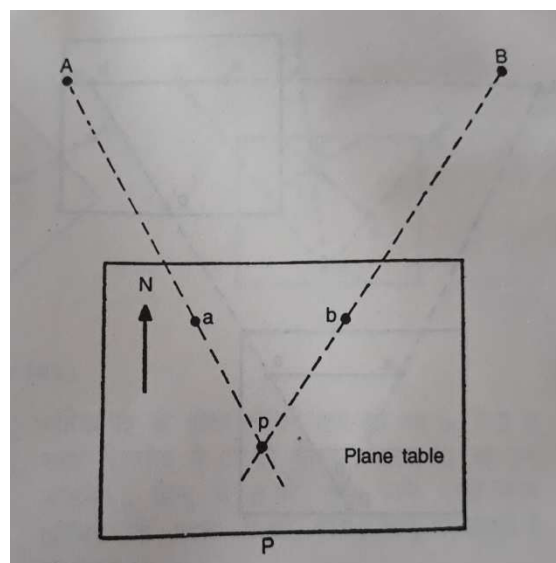


Fig. 8.4 Orientation by compass Source Practical book J.P.Sharma

## 2- RESECTION AFTER ORIENTATION BY BACK SLIGHTING

In this method, the orientation of the drawing board by the back sighting and know the status of plane table in the plan. It has the following process.

- Suppose A and B have two stations in the area. The distance between which is manifested by a b line in the plan. There is also a new station P which is to be marked on the plan.
- By placing the plan on the drawing board and place the plane table on the B station. After properly centering at the B station, keeping the alidade into b a line and turn the drawing board towards the station by back sighting. Tighten the drawing board on the right orientation.
- Take the plane table to the P station. Keep p' at the top of P station and flat the plane table.
- Keep the alidade with p' b line and move the drawing board and target the B station. When the right orientation is done, tighten the drawing board. Targeting the station A and draw ray towards own direction which cuts the b p' line at the P point. The p point will reveal the position of the P station in the plan.

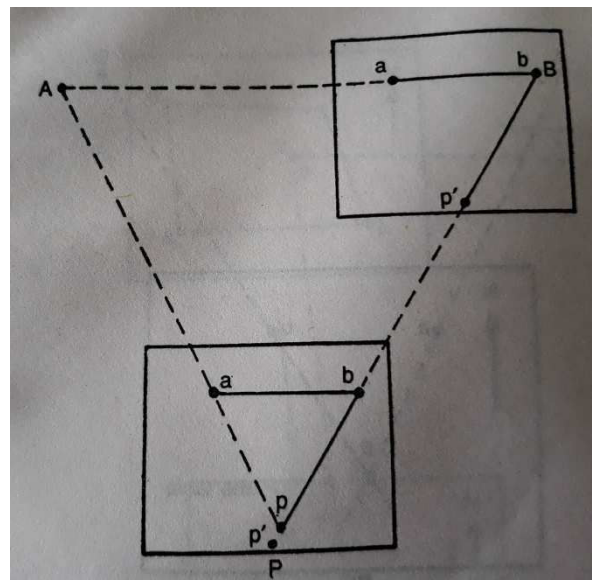


Fig. 8.5 Resection after orientation by back sighting (Source Practical book J.P.Sharma)

## 3- THREE POINT PROBLEM

There are three points in the plan, and with the help of these three points, the position of the plane table station to show in the plan is called three point problem. A B C is three such points that can be seen from plane table station P, in whose plan the positions are indicated by a, b and c. By selecting any one of the mechanical, graphical or other trial and error methods, the position of the p station can be mentioned in the plan. These methods are extensively written below.



### 1- MECHANICAL OR TRACING PAPER METHOD

This is a very simple method. In this method tracing paper are used.

#### PROCEDURE

Suppose the plane table has been fixed at any of the P station in the area from where the A B and C points in the area can be clearly seen. If A, B, and C points in the plan were written by a, b and c, respectively, according to the tracing paper method, the P station will be mentioned as follows.

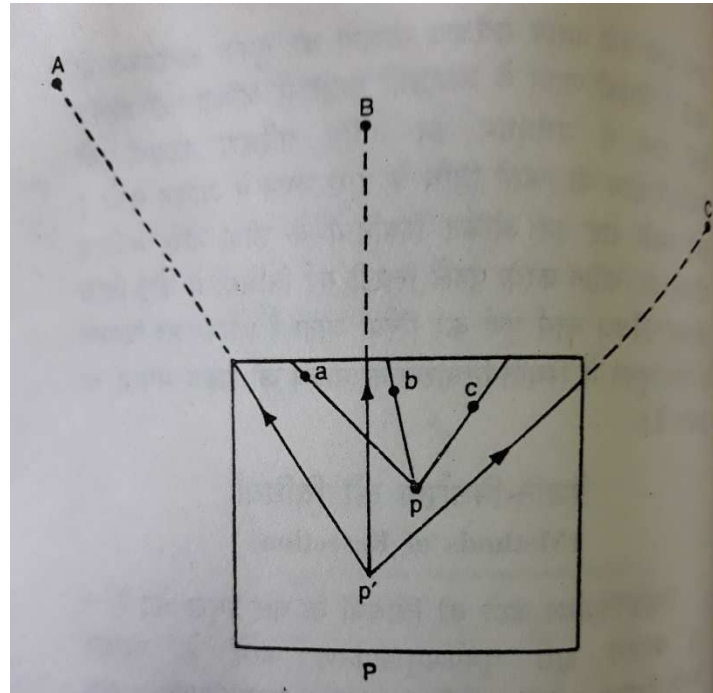


Fig. 8.6

- After placing the plane table on the P station, with the help of a trough compass make correct orientation of the plan.
- Placing a tracing paper with the help of pins on the drawing board. Use the plumb bob and plumbing fork to position (p') in the tracing paper on the P station.
- Draw the three rays targeting A, B and C points by placing the alidade to the p' point. For identification, write the names of the points related to these rays on the field.
- Now remove drawing pins from the drawing paper and move the drawing paper back and forth as needed and keep it on the plan that the rays drawn by targeting the A, B and C points on the drawing paper will be done right above the a b and c points in the plan.
- Now if every ray of drawing paper is located just above the corresponding point in the plan, mark the p' point in the plan by pinning the pin on the p point. p point will reveal the position of p station in the plan.

According to the above method, after placing the plane table station in the plan, check the accuracy of resection. For this purpose, keep alidade with the help of p a line and orient the plane

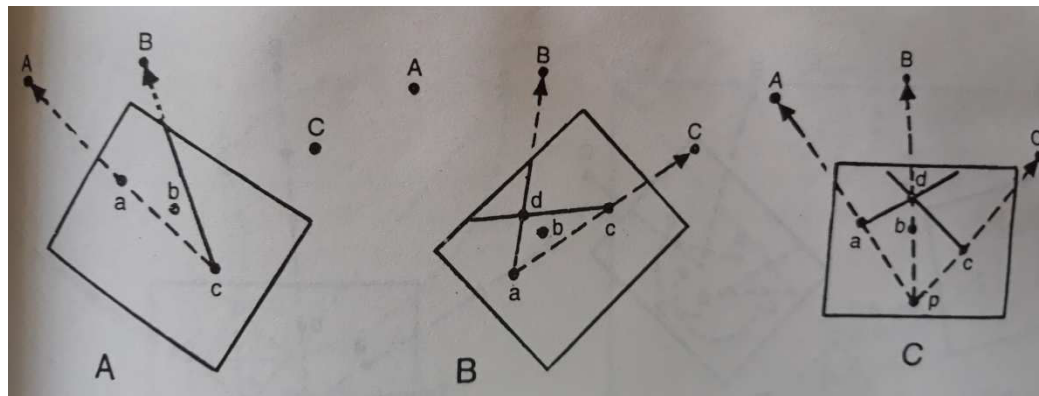
table directly in the A station by rotating the drawing board. If the resection is correct, then Bb and Cc will pass through every p point in the rays.

## 2- GRAPHICAL METHODS

There are many graphical methods to determine the position. Only one graphical method have been explained here.

### (a) BESSEL'S METHOD

If there are three such points of view in the area A, B and C, which has been disclosed by a, b and c in the plan, then according to the Bessel's method, plane table station (P) will be mentioned in the plan as follows.



- Fixed the plane table on the P station. Keep alidade with the help of Ca line and target the A point and tighten the drawing board. Now draw a ray by targeting the point B from the point c. (fig.8.1 A)
- Loose the drawing board. This time keeping the alidade of ac line and look at the C and tighten the drawing board. Now by targeting the point B from a point, draw a second ray, which cuts the first ray on the d point. ( fig.8.1B)
- Joint the point b and d and loosen the drawing board. Now according to fig. 8.1.C, keeping the alidade with the help of b d line and target the point B. Now tighten the drawing board. Now keeping the alidade with the help of alpin on the point, drawing the ray back on your side targeting at A point. this ray cuts on the d b line at p point. p point will reveal the position of P station in the plan.

Keep the alidade with the p c line to check the accuracy of resection. If you look in the alidade, if the sight line passes through C, The positioning will be considered as correct.

### (b) Llano's method

## 3- Trial and error method

## **MERITS AND DEMERITS OF PLANE TABLE SURVEY**

Plane table survey is better to other surveys in many forms. There are some flaws along with simplicity and accuracy.

### **Merits :**

- Plane table survey method is easy as well as accurate.
- There is no need to make field book in it.
- All work of survey and mapping is completed in the field therefore knowledge of errors also knows at the same time.
- It only has the baseline horizontal measurements so the surveys are completed soon.
- The prismatic compass survey is not possible in the magnetic field, so this method is best for that.
- Along with the survey, it is also examined; therefore there is also a correction of the errors.
- In plane table survey two people also complete the survey.
- This survey is most suitable in terms of quickness, accuracy and thrift.

### **DEMERITS :**

- Plane table survey cannot be in the wet climate because in this climate the paper becomes moist and there is difficulty in measuring.
- In this survey is not easy to carry all survey equipments from one place to another, so it is inappropriate for long scale areas.
- In the survey of huge terrain, the paper has to be changed repeatedly.
- This survey does not receive all the details of the area and the area is also not known.
- The selection of the base line in the mountainous parts is difficult and there are obstacles in determining the target points.

---

## **8.6 CONCLUSION**

Plane table survey is simple and accurate. The field book is not required in the plane table survey. All the work of survey and mapping is completed only in the field. This is the useful survey for magnetic fields. The survey work is completed only by fewer persons. Apart from this, there is unsuitable for areas with humid climate. Difficulty to move its equipment from one place to another. Plane table survey also has difficulty in mountainous part.

---

## **8.7 SUMMARY**

Plane table surveying is a popular survey technique, in which all the work is done in the field from survey to map. The surveyor examines all the equipment and creates an approximate image of the area. After this, the fixing of plane table in which laying the paper plating, determines the base line, determination of the north direction and the process of centralization is adopted. During the survey the board should be tightened. The rays should be straight and fine. Should

keep appropriate scale . North direction should be determined with accuracy. Base lines should be accurately measured. The leveling of plane table should be examined. All these precautions are necessary.

Plane table survey is done by three methods- Radiation, Intersection, and Traversing. The distances of all the target points are measured in the radiation method whereas in the intersection method only the length of the base line is measured and the target points determine from the intersection.

An open traverse method is adopted for survey of any way, canal, and river etc. survey conducted closed traverse for building, residential, settlements etc.

---

## 8.8 GLOSSARY

---

- **Fixing** - A plane table is set over a point and brought to precise horizontal level.
- **Mapping**- Make a map of the survey area with the appropriate scale.
- **Base line**- Line joining two stations.
- **Centralization**- To set the table vertically on the ground point.
- **Intersection**- Targeting a station by drawing the ray and intersect it from the other station draw a ray.
- **Traverse**- Series of survey stations and base line.

---

## 8.9 ANSWER TO CHECK YOUR PROGRESS

---

Q.1-Why do we not need for field book in plane table survey?

Q.2-What to do before going to the field for a plane table survey?

Q.3-What is the base line?

Q.4-How to check the level of the plane table?

Q.5-To make centralization apart from plumb bob which equipment can use?

Q.6-What do you mean by three point problem?

Q.7-Why plane table survey is easy?

Q.8-Why plane table survey completes early?

Q.9-What obstacles do the hilly parts in the plane table survey?

---

## 8.10 REFERENCES

---

- <https://civilseek.com/plane-table-surveying/>
- <https://theconstructor.org/surveying/plane-table-surveying-methods-examples/12877/>
- [www.civilengineeringx.com/surveying/methods of plane tabling](http://www.civilengineeringx.com/surveying/methods%20of%20plane%20tabling)
- [vmou kota university ge-09 practical geography](http://vmoukotauniversityge09practicalgeography)
- <https://theconstructor.org/surveying/plane-table-survey-equipments/6474/>
- <https://civilseek.com/plane-table-surveying/>
- Sharma, J.P. (2014): Practical Geography Rastogi Publications, Meerut.

---

### ***8.11 SUGGESTED READINGS***

---

1. Gaur, K.S. (1968): Manchitra Kala Ki Sameeksha, Agra Book Store, Agra.
  2. Sharma, J.P. (2014): Practical Geography Rastogi Publications, Meerut.
  3. Singh, R.B. (2003): Practical work in Geography Pt I NCERT, New Delhi.
  4. Singh, R.L. & P.K. Dutt (1966): Elements of practical Geography, Students friends.
- 

### ***8.12 TERMINAL QUESTIONS***

---

- Q.1-What is the difference between radiation and intersection method?
- Q.2-Describe the merits and demerits of plane table survey.
- Q.3-How many methods of plane table survey?
- Q.4-What is traverse method?
- Q.5-What is the resection?
- Q.6-What is the two point problem?

---

## UNIT 9 - PRISMATIC COMPASS SURVEYS

---

**9.1 OBJECTIVES**

**9.2 INTRODUCTION**

**9.3 PRISMATIC COMPASS SURVEYING**

**9.4 RADIATION, INTERSECTION AND TRAVERSING (OPEN & CLOSE)**

**9.5 ELIMINATION OF CLOSING ERROR, USING BOWDITCH'S RULE**

**9.6 CONCLUSION**

**9.7 SUMMARY**

**9.8 GLOSSARY**

**9.9 ANSWER TO CHECK YOUR PROGRESS**

**9.10 REFERENCES**

**9.11 SUGGESTED READINGS**

**9.12 TERMINAL QUESTIONS**

---

## 9.1 OBJECTIVE

---

After studying this unit, you will be able to:

- To know about prismatic compass instrument.
- To know about bearing, types of bearings and representation of bearing.
- Conversion of whole circle bearing into quadratic bearing.
- Observed bearings of open and closed Travers by radiation and intersection method.
- Local attraction of bearing, correcting the bearings for local attraction.

---

## 9.2 INTRODUCTION

---

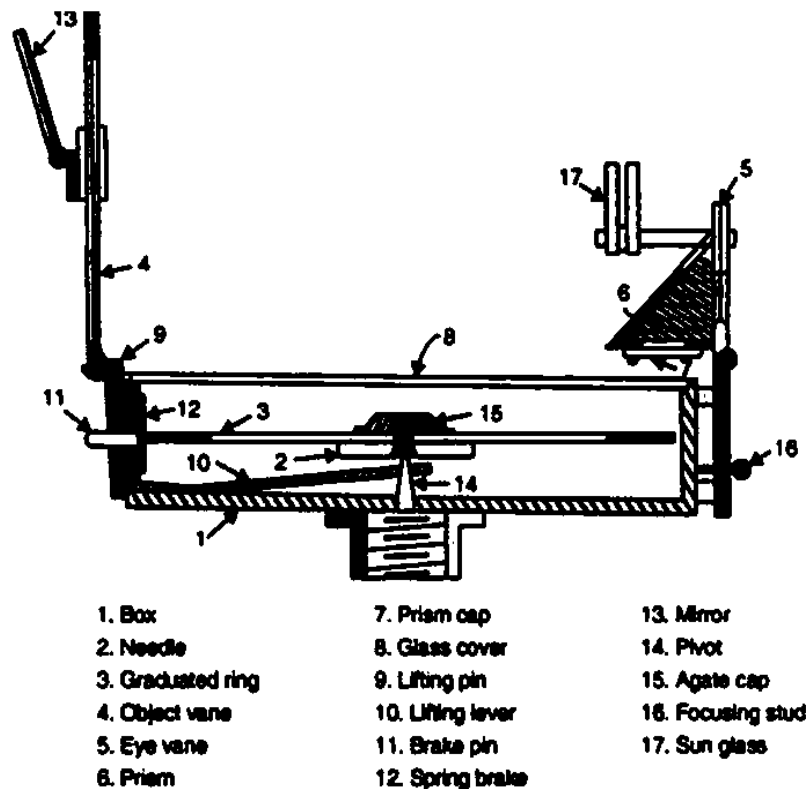
Prismatic compass is an instrument used to measure the bearing of a line. It consists of a magnetic needle pivoted at the center and is free to rotate. Magnetic needle is balanced on a sharp pointed steel pivot, with the help of an agate cap. The area below the magnetic needle is graduated between 0 to 360 degrees. The needle carries an aluminum ring with graduations in degrees and half degrees, which are written in an inverted style. The instrument cover consists of a sighting vane and vertical hair to align the compass along the instrument station and the staff station. The compass case and lid is solid brass with a black powder coating. The prism can be flipped up for use as a front sight, and at the same time view the compass heading. There are two colored filters that can be placed in the optical path of the measurement to reduce glare.

There is a small cover that can be swung into place to protect the prism. The degree markings on the compass rose are stamped mirror image so the heading reads properly when viewed through the prism. When taking a heading measurement, the magnetic heading appears clearly under the object being sighted. Two adjustment screws allow the height of the prism to be precisely set for proper focus. Pressing a small plunger button near the rear sight locks the compass card for easier reading. The compass has a needle lift mechanism to protect the agate compass jeweled bearing when being transported. The rear sight has a replaceable thread and a hinged mirror that can also be raised or lowered. The compass can be threaded onto the lightweight surveyor's tripod with a ball and socket head using standard 3/4 inch x 24 threads. The compass measures 11.1 cm in diameter, 3.8 cm thick, and weighs 539 grams. When mounted on its tripod, the height of the compass is adjustable from a minimum height of 31.7 cm tall to a maximum height of 53.3 cm tall. This compass is accurate with a resolution of about 1/2 a degree. Both the compass and tripod come with canvas cases. The other equipment and accessories used in this type of surveying are tripod stand, chain, tape, ranging rods, pegs, plumb bob, hammer, field-book, pencils, eraser.

## **PARTS OF PRISMATIC COMPASS**

- 1 Metal box :** metal box is having diameter of 8 to 12 cm. It protects the compass and forms Elements of prismatic compass entire casing or body of the compass. It protect compass from dust, rain etc. Under revision
- 2. Magnetic needle :** Magnetic needle is the heart of the instrument. This needle measures angle of a line from magnetic meridian as the needle always remains pointed towards north south pole at two ends of the needle when freely suspended on any support.
- 3. Graduated circle or ring :** This is an aluminum graduated ring marked with  $0^{\circ}$  to  $360^{\circ}$  to measures all possible bearings of lines, and attached with the magnetic needle. The ring is graduated to half a degree.
- 4. Object vane :** object vane is diametrically opposite to the prism and eye vane. The object vane is carrying a horse hair or black thin wire to sight object in line with eye sight.
- 5. Eye vane :** Eye vane is a fine slit provided with the eye hole at bottom to bisect the object from slit.
- 6. Prism :** prism is used to read graduations on ring and to take exact reading by compass. It is placed exactly opposite to object vane.
- 7. Prism cap :** The prism hole is protected by prism cap to protect it from dust and moisture.
- 8. Glass cover:** its covers the instrument box from the top such that needle and graduated ring is seen from the top.
- 9. Lifting pin :** a lifting pin is provided just below the sight vane. When the sight vane is folded, it presses the lifting pin.
- 10. Lifting lever :** The lifting pin with the help of lifting lever then lifts the magnetic needle out of pivot point to prevent damage to the pivot head.
- 11. Spring brake or brake pin :** to damp the oscillation of the needle before taking a reading and to bring it to rest quickly, the light spring brake attached to the box is brought in contact with the edge of the ring by gently pressing inward the brake pin
- 12. Reflecting mirror :** It is used to get image of an object located above or below the instrument level while bisection. It is placed on the object vane.
- 13. Pivot:** pivot is provided at the center of the compass and supports freely suspended magnetic needle over it.
- 14. Agate cap:**
- 15, Focusing stud :** The prism is moved up or down in its slide till the graduations on the aluminum ring is seen clear, sharp and perfect focus. The position of the prism will depend upon the vision of the observer
- 16. Sun glasses :** These are used when some luminous objects are to be bisected.
- 17. Eye vane:** Eye vane is a fine slit provided with the eye hole at bottom to bisect the object from slit.





**THE PRISMATIC COMPASS.**

Fig -9.1

### 9.3 PRISMATIC COMPASS SURVEY

1. Set up the prismatic compass over a station at your convenient height.
2. The instrument must be exactly overhead the ground station .To do this, a plumb bob is .suspended from the bottom center of the instrument to touch the head of the ground pin
3. Unfold the object vane and also the eye vane.
4. Level the instrument either by hand or by using a round pencil so that the compass ring moves freely.
- 5 .Rotate the instrument so that the line of sight ( i.e. ., the line joining the center of the eye vane and the object vane ) joins the station with the ranging rod held vertically over another station.
6. Look through the eye vane and take the reading in degrees and minutes at the intersection of the horse hair/ ranging rod with the compass ring.

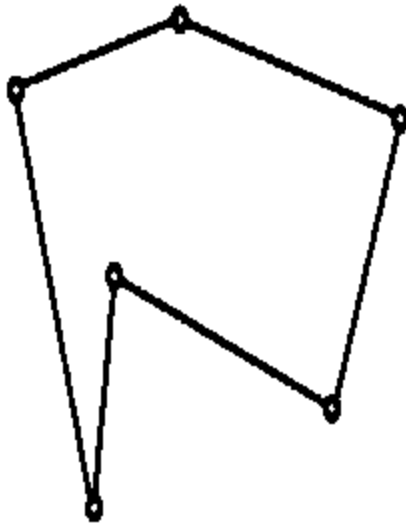
## 9.4 RADIATION, INTERSECTION AND TRAVERSING (OPEN AND CLOSE)

**Radiation method** : In this method, the approximate centre of the field is located and the compass is exactly centered over that stations, say 'O' by dropping a small pebble to fall from the centre of the compass and hit the peg. Then make the compass needle horizontal by adjusting the ball and socket joint. After centering and leveling of the compass, raise the sighting vane and prism of compass. The compass box is rotated until the ranging rod at first station 'A' hairline of object vane and slit of the sighting vane are in the same line. Then take the reading accurately and note down the bearing of line OA. In the similar way take bearing of lines OB, OC, OD and OE by rotating the compass box in the respective directions. The readings will indicate the angles with which the line, OA, OB, OC, OD and OE makes with the north line. Then with the help of chain, measure the distances OA, OB, OC, OD and OE on ground, after proper ranging.

**Inter section method** : Field Work This method poses a simple change from the previous method. In this method mark two points (P & Q) at a distance of 10 to 15 m in such a way that all the station points around the boundary of the plot can be seen clearly (either inside the area or outside). Set the compass over the station point 'P' and complete the temporary adjustments. Observe bearings to all the station points, (A, B, C, D & E) in clockwise direction. Take also the fore bearing of the line 'PQ'. Shift the compass to the other station 'Q' and complete the temporary adjustments and observed the back bearing of the line 'QP'. Rotate the compass box to all other station points, (A, B, C, D & E) and note down all the bearings clearly. Also measure the base line distance (PQ). In this method there is no necessity of measuring the internal distances. (b) Plotting With observed data, plot the observed bearings taken at P and project the corresponding rays. Set the distance PQ and get point 'Q' by taking a suitable scale. Then draw rays from station 'Q' to all the station points. The intersection of ray pa and qa will give the location of station 'A'. Similarly locate other stations B, C, D & E. For a check, measure the distance AB, of one side, and compare them with the plotted lengths. Then field can be divided into number of triangles and the area can be calculated, summing up all the areas we will get the total area of the field.

**Closed Traverse** : When a series of connected lines forms a closed circuit, i.e. when the finishing point coincides with the starting point of a survey, it is called as a 'closed traverse'; here ABCDEA represents a closed traverse. (Fig 2. (a))

**Open Traverse** : When a sequence of connected lines extends along a general direction and does not return to the starting point, it is known as 'open traverse' or (unclosed traverse). Here ABCDE represents an open traverse. (Fig 2. (b))

**CLOSED TRAVERSE****FIG -9.2(a)****OPEN TRAVERSE****FIG-9.2(b)**

We will setup the compass at point A, B, C and so on and note the Fore Bearing and back bearing of lines. The length of lines or legs are measured by chain twice and mean lengths are calculated. During taking measurements in the field the method used angular measurement and linear measurement should be of same standard of accuracy, i.e. either combination of Prismatic compass and Chain or combination of Theodolite and Metallic tape.

**Forward and Backward Bearings** In compass surveying, two bearings are observed for each line, one from each end of the line. The bearing of a line in the direction of the progress of survey is called the forward bearing or fore bearing while the bearing measured in the opposite direction is called as the backward bearing or back bearing.

**Local Attraction** A compass needle is affected by the presence of masses of iron and steel such as lamp posts electric cables, steel girders etc., they deflect the needle and the effect of this disturbance is called local attraction. Due to local attraction, the difference between the fore bearing and back bearing of a survey line will not be equal to  $180^\circ$ . The observed bearings of lines affected by local attraction are corrected by starting from the unaffected line and the correct bearings of the successive lines are calculated.

---

## **9.5 ELIMINATION OF CLOSING ERROR, USING BOWDITCH'S RULE**

---

Due to errors in observation and in plotting angles the plan may not close exactly. If the compass is in good order and there is no mistake in observation the backward and forward bearing of a line should differ by  $180^\circ$ . If the difference is not  $180^\circ$  there is probably local attraction at one or at both the stations.

The table 1 illustrates the method of elimination of local attraction in a closed traverse.

**TABLE -9.1**

LINE	F.B	B.B	Difference	Correction	Corrected bearing	
					F B	B B
AB	134° 30'	314° 30'	180°	—	134° 30'	314° 30'
BC	120° 0'	299°30'	179°30'	BB +0°30'	120° 0'	300° 0'
CD	174°30'	356° 30'	182°	FB +0°30' , BB -1°30'	175°0'	355°0'
DA	276°30'	95°0'	181°30'	FB -1°30'	275°0' '	95°0'

**Correct the bearings of the lines for local attraction:** from the above table 1 it is evident that the line there is no local attraction. The other lines shows attraction. The forward bearing of BC is 299°30' and backward bearing 179°30', CD forward bearing 174°30' and back ward bearing 356°30' and DA forward bearing 276°30' and back ward bearing 95°0'. This show that due to attraction the magnetic needle at BC line has been deflected by BB +0°30' , CD line by FB +0°30' , BB -1°30' and DA line by FB -1°30'. Thus the bearing BC, CD ,and DA line should be changed by corrected bearing.

**Bowditch' Rule:** For rough survey, such as a compass traverse, the Bowditch rule may be applied graphically without doing theoretical calculations. According to the graphical method, it is not necessary to calculate latitudes and departures etc. however before plotting the traverse directly from the field notes, the angles or bearings may be adjusted to satisfy the geometric conditions of the traverse.

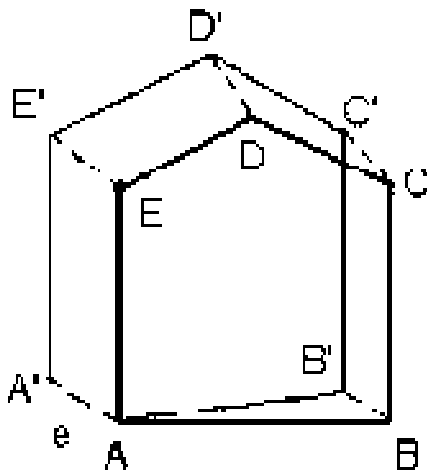


FIG -9.3(a)

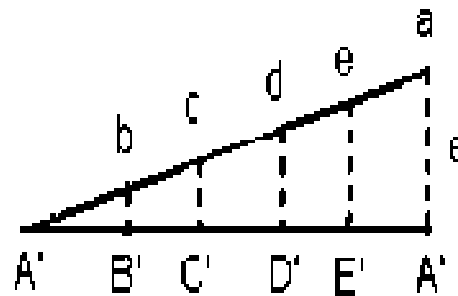


FIG-9.3(b)

### Closing error by Bowditch's rule

The polygon AB'C'D'E'A' represents an unbalanced traverse having a closing error equal to A'A since the first point A and the last point A' are not coinciding ( fig-3 (a)). The total

closing error  $AA'$  is distributed linearly to all the sides in proportion to their length by a graphical construction shown in figure.  $AB'$ ,  $B'C'$ ,  $C'D'$  etc are represent the length of the sides of the traverse either to the same scale or reduced scale. The ordinate  $aA'$  is made equal to the closing error  $A'A$ . by constructing similar triangles, the corresponding errors  $bB'$ ,  $cC'$ ,  $dD'$ ,  $eE'$  are found. The lines  $eE'$ ,  $dD'$ ,  $cC'$ ,  $bB'$  respectively( fig -3(b)). The polygon  $ABCDE$  so obtained represents the adjusted traverse. It should be remembered that the ordinates  $bB'$ ,  $cC'$ ,  $dD'$ ,  $eE'$ ,  $aA'$  represent the corresponding errors in magnitude only but not in direction.

---

## 9.6 CONCLUSION

---

In this unit we learnt to:

1. Describe a prismatic compass.
2. List the different parts of a compass and various accessories used along with compass.
3. Adjustment of a prismatic compass.
4. Describe how to observe bearing.
5. Radiation and Intersection method and traversing (Open and Closed) method of prismatic compass.
6. Explain closing errors observation of bearing.
7. Elimination the closing error using Bowditch's rule.

---

## 9.7 SUMMARY

---

1. Prismatic compass is an instrument used to measure the bearing of a line.
2. In the radiation method, the approximate centre of the field is located, in the intersection method mark two points' bearings clearly. Also measure the base line distance. In this method there is no necessity of measuring the internal distances.
3. Closed traverse is a traverse in which the sides of a traverse form a closed polygon. Open traverse is a traverse in which the sides of a traverse do not form a closed polygon.
4. Meridian is a standard direction from which, the bearings of the lines are measured.
5. Bearing is a horizontal angle made by the survey line with reference to the meridian.
6. Bearings of survey lines are represented in (i) Whole Circle Bearing System.  
(ii) Quadrantal Bearing System.
7. The difference between fore bearing and back bearing of a line should be  $180^\circ$ .
8. Local attraction: A compass needle is affected by the presence of masses of iron and steel such as lamp posts, electric cables, steel girders etc. They deflect the needle and gives the working value of bearing the effect of this disturbance is called local attraction.

---

## 9.8 GLOSSARY

---

**Compass** - An instrument for determining direction.

**Prism** - Right angled isosceles type.

**Eye vane** - Eye vane is a fine slit provided with the eye hole at bottom to bisect the object from slit.

**Bearing** - Angles

**Magnetic needle** - This needle measures angle.

---

## 9.9 ANSWER TO CHECK PROGRESS

---

Q.1 What is bearing?

Q.2 What the difference between fore bearing and back bearing of a line?

Q.3 Which things a compass needle is affected?

Q.4 The following fore bearing and back bearing were observed while traversing an area with a compass:

Line FB BB

AB 37°30' 217°30'

BC 43°15' 224°15'

CD 73°00' 252°15'

DE 12°45' 193°15'

EA 60°00' 239°15'

Q 8 Find the corrected bearing of the line?

---

## 9.10 REFERENCES

---

1. Bygott, J. (1948) : An introduction to map work and practical geography, London.
2. Misra, R.P. and A. Ramesh: (1969), Fundamentals of Cartography, Mysore.
3. Raisz, Erwin (1962) :Principles of cartography, Tokyo.
4. Robinson, A.H. (1966) :Elements of Cartography, New York.
5. Sharma, J.P. (2014) :Practical Geography Rastogi Publications, Meerut.

---

## 9. 11 SUGGESTED READINGS

---

1. Gaur, K.S. (1968): Manchitra Kala Ki Sameeksha, Agra Book Store, Agra.
2. Sharma, J.P. (2014): Practical Geography Rastogi Publications, Meerut.
3. Singh, R.B. (2003): Practical work in Geography Pt I NCERT, New Delhi.
4. Singh, R.L. & P.K. Dutt (1966): Elements of practical Geography, Students friends.

---

## 9.12 TERMINAL QUESTIONS

---

Q.1. What is the uses of prismatic compass?

Q.2. Write the parts of prismatic compass?

Q.3. How many method of prismatic compass survey ?

---

## UNIT 10 - INDIAN PATTERN CLINOMETER

---

***10.1 OBJECTIVES***

***10.2 INTRODUCTION***

***10.3 INDIAN PATTERN CLINOMETER***

***10.4 DETERMINATION OF HEIGHT BY INDIAN PATTERN  
CLINOMETER***

***10.5 CONCLUSION***

***10.6 SUMMARY***

***10.7 GLOSSARY***

***10.8 ANSWER TO CHECK YOUR PROGRESS***

***10.9 REFERENCES***

***10.10 SUGGESTED READINGS***

***10.11 TERMINAL QUESTIONS***

---

## **10.1 OBJECTIVES**

---

After studying this unit, you will be able to:

- Know about Indian Pattern clinometer instrument.
- Uses of clinometer.
- Determination of height.

---

## **10.2 INTRODUCTON**

---

Indian Pattern clinometer is developed by survey of India, so it is known as Indian clinometer. It is also known as tangent clinometer. It issued to find out the heights of various objects as well as for contouring.

---

## **10.3 INDIAN PATTERN CLINOMETER**

---

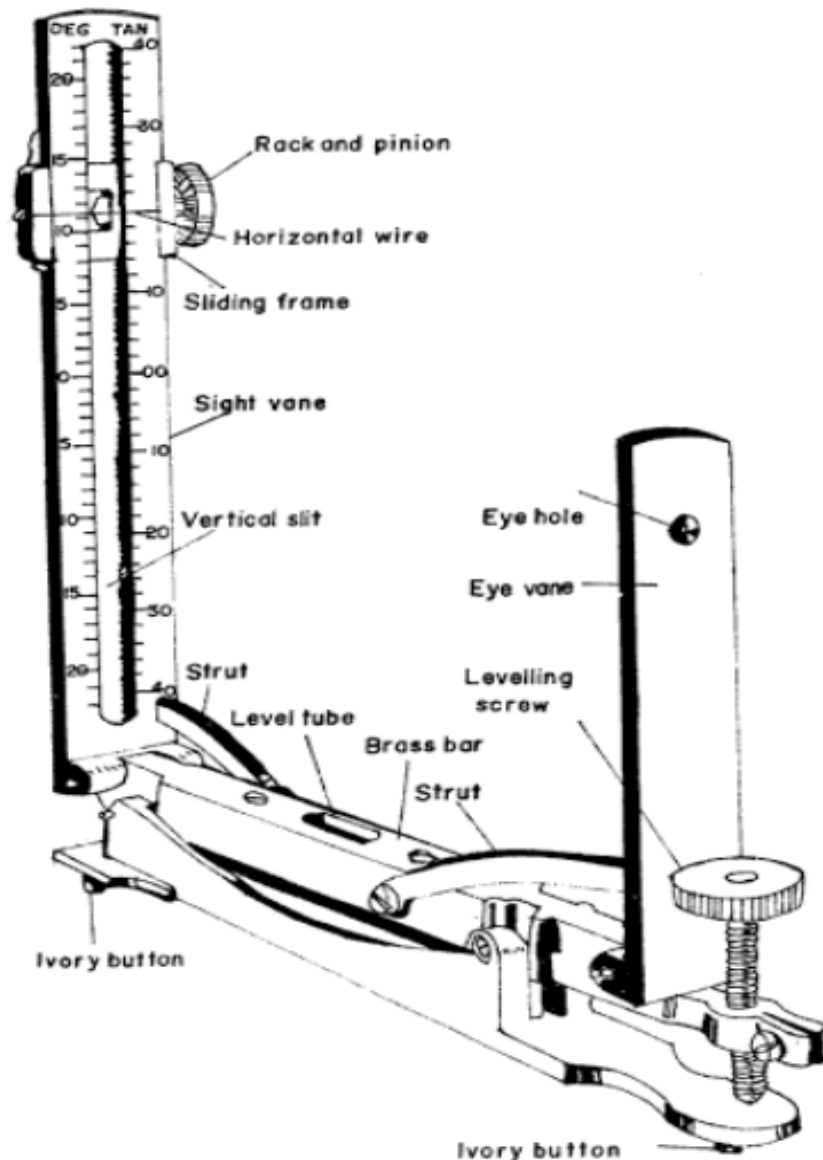
Indian pattern clinometer used for determining difference in elevation and depression between point and it specially adapted to plane tabling. The clinometer is placed on plane table.

Essentially it is a spirit level attached to brass plate at each end of which there is a flap which could be made to stand up vertically. The level of the instrument can be adjusted by a screw at one end. One of the folding leaves has a small sight-hole at the top. The other leaf has a vertical slit in the middle. Along one edge of the slit there is a scale is in level with the sight-hole.

To take an observation the instrument is levelled so that the bubble of the spirit level is in mid-run and object is sighted through the sight-hole. The point on the scale where the line of sight intersects is noted. If the distance between the observer and the object is known the rise or fall can be calculated from the reading on the tangent scale.

Suppose the reading on the tangent scale is 0.4. Since the graduation along the tangent scale shows the value of the ratios of the perpendicular it is obvious that the rise of the point from the level of the clinometer at O is 0.4 of the horizontal distance. If the height of the Clinometer above sea level is known the height of the observed point is obtained by adding the rise in level from O.





*Fig . No. – 10. 1 Indian Clinometer*

## **PARTS OF INDIAN CLINOMETERS**

The parts of an Indian Pattern Clinometers are showing you in Fig .No.-10.1.

- 1. Base Plate-**A base plate carrying a small bubble tube and leveling screw. Thus it can be accurately leveled.
- 2. Eye Vane-** The eye vane carrying a peep hole. It is hinged at its lower end to the base plate.
- 3. Object Vane-** The object vane having graduation in degrees at one side and tangent of the angles to the other side of the central opening.
- 4. Brass Bar-** The brass bar attach above the base plate. In the middle of brass plate level tube and level of the instrument can be adjusted by a screw at one end.

## 10.4 DETERMINATION OF HEIGHT BY INDIAN PATTERN CLINOMETER

The Survey of India clinometer is intended for determining differential heights. A small level is attached to the frame carrying the vanes and the instrument is so adjusted that, when made truly level, a line through the sight-vane to the zero of the object vane is horizontal. Above and below this zero, there is, on both sides of the object slit, a scale of natural tangents. The scale of natural tangents can be read by estimation to three places of decimals.

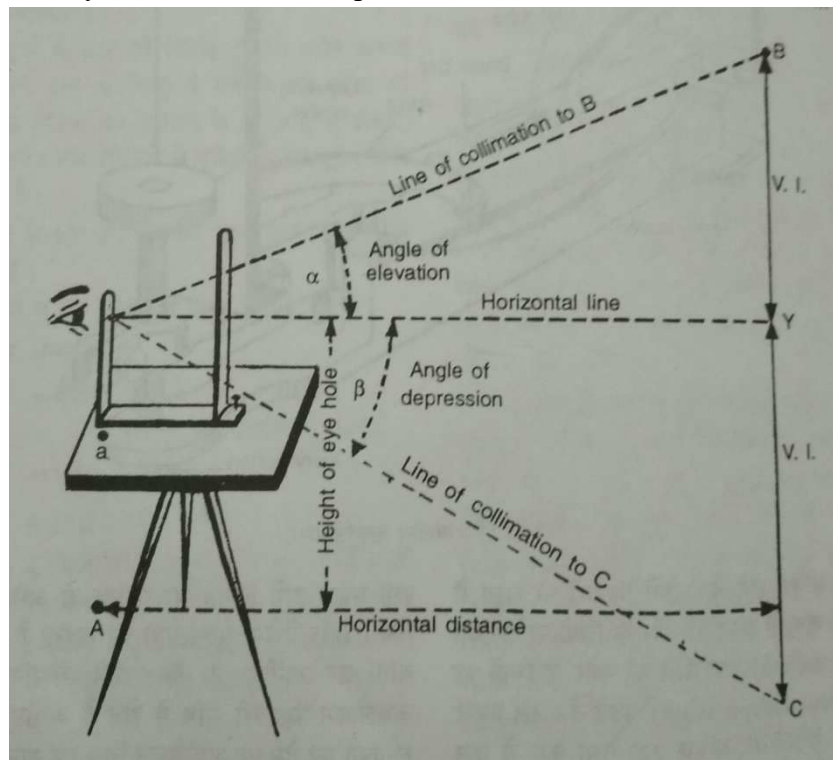


Fig. 10.2

In using the clinometer, care should be taken that the vanes are upright and parallel, and that they have not been bent. The clinometer should never be lifted on or off the plane-table by either of its vanes, to avoid bending them. The vanes are usually graduated for a horizontal distance, between vanes, of 20.32 cm; that is, the distance between the eye-hole and the zero of the graduations should be exactly 20.32 cm; also the distance from the eye-hole to the extreme graduation, + .40 above, or — .40 below the zero on the tangent scale, should be 21.88 cm. In observing, the eye should not be too close to the eye-hole, but about 5 to 10 cm away from it. To obtain the difference of height between his own position and any other object in view, the observer looks through the hole in the sight-vane, after leveling the clinometer by means of the level on the base-plate, and notes what figure on the tangent scale is cut by the ray to the object.

1. Set the plane table over the A and keep the clinometer on it.

2. Level the clinometer with the help of leveling screw.
3. Looking through the eye hole, move the slide of the object vane till it bisects the signal at the other point to be sighted.
4. Note the reading tangent of the angle against the wire. Thus the difference in elevation between eye and object. Distance  $\times$  tangent of vertical angle  $= \alpha \tan x$ .
5. Put the above value in the following formula-  

$$V.I. = H.I. \pm D \tan \theta$$

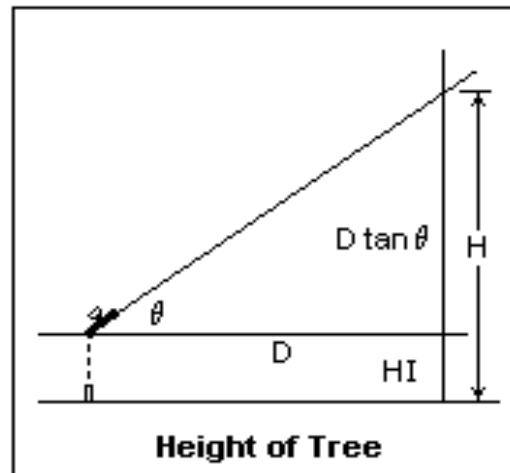


Fig. no -10.3 Determination of Height by Indian Clinometer

When a point is located very far from the instrument station or there is obstruction in the path. It is difficult to measure horizontal distance, then the height and depth of the point from the instrument station is found out on the basis of vertical angle formed by two collinear stations and horizontal distance between them.

For example- Suppose we have to find the height of point B from instrument station A but, because of a lake in way, it is difficult to measure horizontal between A and B.

## 10.5 CONCLUSION

In this unit we learnt to:

1. Describe a Indian Pattern Clinometer.
2. List the different parts of a Indian Clinometer.
3. Method of using the Indian Clinometer.
4. Describe how to determine the height of any object.

## 10.6 SUMMARY

Indian Pattern clinometer is developed by survey of India, so it is known as Indian clinometer. It is also known as tangent clinometer. Indian pattern clinometer used for determining difference

in elevation and depression between point and it specially adapted to plane tabling. The clinometer is placed on plane table.

---

## ***10.7 GLOSSARY***

---

**1. Clinometer-** Height determining instrument.

**1. Base Plate-**A base plate carrying a small bubble tube and leveling screw.

**2. Eye Vane-** The eye vane carrying a peep hole. It is hinged at its lower end to the base plate.

**3. Object Vane-** The object vane having graduation in degrees at one side and tangent of the angles to the other side of the central opening.

**4. Brass Bar-** The brass bar attach above the base plate. In the middle of brass plate level tube and level of the instrument can be adjusted by a screw at one end.

---

## ***10.8 ANSWER TO CHECK YOUR PROGRESS***

---

Q.1. What is the use of Indian Pattern Clinometer?

Q.2. Write the parts of Indian Pattern Clinometer?

---

## ***10.9 REFERENCES***

---

1. Bygott, J. (1948), An introduction to map work and practical geography, London.

2. Davis Clark, (1983) Plane and Geodetic Surveying, vol. 1, 6<sup>th</sup> Ed., revised C.B.S. Publishers, Delhi.

2. Misra, R.P. and A. Ramesh: (1969), Fundamentals of Cartography, Mysore.

3. Raisz, Erwin (1962): Principles of cartography, Tokyo

4. Robinson, A.H. (1966): Elements of Cartography, New York.

5. Sharma, J.P. (2014): Practical Geography Rastogi Publications, Meerut.

---

## ***10.10 SUGGESED READING***

---

1. Gaur, K.S. (1968), Manchitra Kala Ki Sameeksha, Agra Book Store, Agra.

2. Sharma, J.P. (2014), Practical Geography Rastogi Publications, Meerut.

3. Singh, R.B. (2003), Practical work in Geography Pt I NCERT, New Delhi.

4. Singh, R.L. & P.K. Dutt (1966), Elements of Practical Geography, Students friends.

---

## ***10.11 TERMINAL QUESTION***

---

Q.1 How we can determine the height by Indian Pattern Clinometer?

Q.2 Explain the function of an Indian clinometer with a sketch.