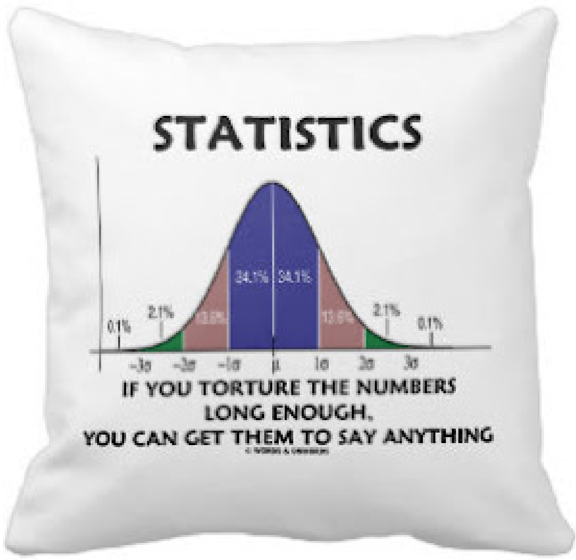
Chittagong University of Engineering and Technology,

Lecture Note



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Contents

1 Introduction to Statistics

1.1 History

Most people believe that the word **Statistics** derived from the word **state**, was referred to a collection of facts of interest to the state. Other believe that Statistics originated from the Italian word **Statista**, the French word **Statitique** and the German word **Statistik**.

It's root goes way back to Ancient Chinese, Romans, and Greeks. Probably happened at the time of **Ramses-II**. Initially, the term Statistics was related to **Political State** that's why it is also called **The Science of Statecraft** or **The Science of King**.

1.1.1 Meaning of Statistics?

The word Statistics is used in three different senses: Singular, Plural, Plural of Statistic.
Singular- Like Physics, Mathematics, etc.Statistics is considered singular as a separate scientific discipline.
Plural- When Statistics denotes some numerical data(statistical data). In other words, by Stat we mean a set of numerical data relating to any field of inquiry. In early stage of the word Statistics was used in this sense.
Stat as plural of Statistic- Any numerical value describing a characteristic of a sample is called a statistic.
Examples:

1. Sample mean $\bar{x}$
2. Sample variance s^2 and so on.

If only one such measure is obtained, it is called a statistic in a singular form.

1.1.2 Stat is Science or Arts

Stat is regarded as an art of applying the science of the scientific method.

The famous Bangladeshi statistician, Qazi Motahar Hossain, said " A knowledge of Statistics is like a knowledge of Algebra: it may prove of use at any time under any circumstances".

Statistics

Statistics is concerned with scientific methods for collecting, organizing, summarizing, presenting, and analyzing sample data from a specified population of interest, as well as drawing valid conclusions, making inferences about the population characteristics, and finally reaching a reasonable decision.

Nurul Islam

Statistics

Statistics is the science of basing inferences on observed data and encompassing the entire problem of making decisions in the face of uncertainty.

Freud and Walpole

Statistics

The field of statistics deals with the collection, presentation, analysis, and use of data to make decisions, solve problems, and design products and processes.

Davidian, M. and Louis T.A.

Statistics

Statistics, the branch of scientific knowledge, refers to the body of techniques and methodology developed for the collection, classification, organization, presentation, and analysis of statistical data and for the use of such data in decision-making in the face of uncertainty in any field of inquiry.Statistics

1.2 Characteristics

Statistics are characterized by:

- Aggregate of Facts
- Affected to a substantial extent by a variety of reasons
- Numerical expression
- Enumerated and Estimated as per reasonable standard of accuracy
- Data collection is carried out in a systematic manner
- Data must be placed in relation to one another

1. **Aggregate of Facts**: Single, nonconnected facts or figures are not statistics; rather, when facts are aggregates, they are said to be statistics because they can be compared.

2. **Affected to a substantial extent by a variety of reasons**: This means that statistics are influenced to a substantial extent by a number of factors that operate together. For example, rice production statistics are based on various factors such as a cultivation method, climatic conditions, seeds, fertilizers, manures, etc.

3. **Numerical expression**: Statistics are expressed in terms of numbers. Therefore, qualitative expressions such as happy, sad, right, wrong, good, or bad do not amount to statistics. For example: 'Production of ABC ltd. has risen' is not statistics, but 'Production of ABC ltd. has risen from 92000 units in 2020 to 110000 units in 2021' is statistics.

4. **Enumerated and Estimated as per reasonable standard of precision**: Reasonable accuracy must be present in the statistical data, as it acts as a basis for the field of statistical inquiry. This is because if the scope of the inquiry is narrow, then by using the method of actual counting, the data can be collected, whereas if the scope of inquiry is wide, then the data collection will be based on estimates and estimates can be inaccurate.

5. **Data collection is carried out in a systematic manner**: The collection of statistics should be performed in a systematic as well as planned manner because, in the absence of any system, the data collected can be unreliable and inaccurate, which may also lead to misleading conclusions. In addition, the purpose for its collection needs to be stated beforehand to keep its usefulness intact.

6. **Data must be placed in relation to one another**: Data collection is performed for comparison purposes and, therefore, the basis must be homogeneous. Because when the basis of two units is heterogeneous, the comparison is not possible.

1.3 Function of Statistics

The following are the important functions of statistics:

- Reduces complexities.
- Expresses facts in numbers.
- Presentation of data in condensed form.
- Increases individual knowledge and experience.
- Different phenomena are compared.
- Helpful in the formulation of policies.
- Helpful in prediction and forecasting.

1. **Reduces complexities**: Using statistical methods, voluminous data can be presented in a way that can be easily understood. Hence, it reduces the complexity to understand a vast amount of data, to simplify its meaning.

2. **Expresses facts in numbers**: An important function of statistics is that it can transform facts into numbers, which is easy to understand by anyone.

3. **Presentation of data in condensed form**: The data collected are usually in raw form, which is complex and unorganized. Hence, it requires to be presented in a simple form so as to reach a final conclusion. With the help of statistics, a large amount of data can be presented in condensed form.

4. **Increases the individual knowledge and experience**: As the presentation of data is simple, it enhances the knowledge and experience of people by making it simple and easy to understand, without having knowledge of each and every field.

5. **Different phenomena are compared**: Statistics helps in comparing data and measuring the relationship between them. For example: Suppose a researcher wants to measure the level of production of soybean in two states, then he/she would use statistics.

6. **Helpful in the formulation of policies**: Plans and policies are developed beforehand in an organization. And statistics plays a very crucial role in determining the future trends, so as to frame them, by providing the required information.

7. **Helpful in prediction and forecasting**: The knowledge of statistics is not just helpful in estimating the present but it also helps in forecasting the future.

1.4 Limitation of Statistics

Although Statistics has wide applications in every sphere of human knowledge, it is not free from limitations. The following are some of its important limitations:

- Statistics does not deal with individuals.
- Only dealing with quantitative data.
- It may mislead to wrong conclusion in the absence of control.
- statistical laws are truly on averages.
- It does not reveal the entire story.
- Data should be uniform and homogeneous.
- Statistics is labeled to be misused.

1. **Statistics does not deal with individuals**: Since statistics deals with aggregates of facts, the study of individual measurements lies outside the scope of statistics. Data are statistical when they relate to measurement of masses, not statistical when they relate to an individual item or event as a separate entity. For example, the wage earned by an individual worker at any one time taken by itself is not a statistical datum. But the wages of a factory worker can be used statistically. Similarly, the marks obtained by one student of a class or his height are not the subject matter of the study of statistics, but the average marks of the average height has statistical relevance.

2. **Only deals with quantitative data**: Statistics are numerical statements of facts. Such characteristics cannot be expressed in numbers are incapable of statistical analysis. Thus, qualitative characteristics like honesty, efficiency, intelligence, blindness, and deafness cannot be studied directly. However, it may be possible to analyse such problems statistically by expressing them numerically. For example, we may study the intelligence of boys on the basis of the marks they obtained in an examination.

3. **statistical laws are truly on averages**: The conclusions obtained statistically are not universally true; they are true only under certain conditions. This is because statistics as a sciences is less exact as compared to natural sciences.

4. **Statistics is labeled to be misused**: One of the biggest drawbacks of statistics is its susceptibility to misuse. There are various factors that can contribute to the improper use of statistical data. Statistics can be manipulated, much like clay, to support various conclusions, whether correct or incorrect. As W.I. King noted, "a major flaw of statistics is that their quality is not immediately apparent." Additionally, not everyone can work with statistics effectively. Proper interpretation of data requires expertise and proficiency; without these, there is a high risk of incorrect conclusions. This potential for misinterpretation by those lacking experience diminishes the widespread acceptance of this valuable science. Furthermore, effective use of statistics is hindered without a thorough understanding of the subject to which they are applied.

1.5 Motivation to study the intended course

1.6 Important Definitions

Definition 1. ***Population***: *Population is the totality or collection of all objects or individuals on which observations are taken on the basis of some characteristics of the objects in any field of inquiry.*

Definition 2. ***Population***: *A statistical population is the collection of all items of interest in a particular study.*

Remark. *The term population does not necessarily refer to people but is a technical term used to describe the complete group of persons or objects for which the results are to apply.*

Examples:

1. All workers of a factory
2. All employees of a firm

Note: Example of biased sample is in the book-Ross-page-3.

Definition 3. ***Sample***: *A sample is a sub-set or part of the population selected to represent the population (Contains finite number of observations).*

Definition 4. ***Experimental Unit****: Each individual of a population is called an experimental unit. Observations are collected on experimental units.*

Examples: Workers, employees are the experimental unit.
There are two types of population.

1. Finite Population: Contains finite number of experimental units. (Ex- workers of a firm)
2. Infinite Population: Contains infinite number of experimental units. (Ex- no. of tosses required to get a head in a coin tossing experiment, the length of the life of a bulb)

Definition 5. ***Variable****: A variable is a changeable characteristic of the experimental units under consideration. Actually it is the characteristic of experimental units which varies from unit to unit. It is customary to represent variables by the last capital letters of English such as X,Y,Z etc.*

Definition 6. ***Variable****: A variable is a value or characteristic that changes among members of the population.*

Examples:

- Religion of a student
- Age of a worker
- Wage of a worker
- Gender of a garment worker
- Height of a student

Definition 7. ***Data****: Data are the counts, measurements, or observations gathered about a specific variable in a population in order to study it.*

Definition 8. ***Data****: A set of observations obtained from a particular enquiry is called data or data set.*

Definition 9. ***Data****: Data are observations or chances of outcomes that occur in a planned experiment or scientific investigation.*

Usually data are the numerical results of scientific measurements. which we can think of as the raw and disorganized facts and figures in any field of enquiry.
Examples:

- Income of workers
- IQ scores of students
- examination marks of students in a class

1.7 Types of Data

1. According to origin (population or census data, sample data)
2. According to variable (Qualitative, Quantitative)
3. According to scale of measurement (Nominal, ordinal, interval and ratio)
4. According to time (Time series, cross-section, panel data)
5. According to sources (primary, secondary)
6. According to subject (Business data, Agriculture data, medical data, economic data)

1.7.1 Data vs information

Data is the value assigned to an observation or a measurement and is the building blocks of statistical analysis.
Information is data that is transformed into useful facts that can be used for a specific purpose such as making a decision.
NOTE: if the sample size $n \geq 0$, then it is said to be a large sample.
If the sample size $n < 30$, then it is said to be a small sample or an exact sample.

Definition 10. ***Qualitative Data/ Categorical Or Count Data***: *Qualitative data are obtained when the qualitative characteristic is measured in each experimental unit.*

Examples:

- The detective status (defective or non-defective) of each 100 bulbs produced in a factory.
- Working efficiency of 60 workers in a factory (Excellent, good, satisfactory, poor)
- Gender (male, female) of 5000 workers of a garment factory
- The eyesight (excellent, good, poor) of a sample of 100 students of CUET.

The assigned numerical values can not be meaningfully added, subtracted, multiplied or divided.

Definition 11. ***Quantitative Data***: *Quantitative data are obtained when a quantitative variable is measured in each experimental unit.*

Examples:

- The daily production of a family for last one month.

- The body temperature of 60 patients of a clinic.

Quantitative data are of two types:

1. Discrete
2. Continuous

Definition 12. ***Discrete***: *Data generated from a discrete variable is called discrete data.*

Examples:

- No. of babies born in Chittagong Medical in 2024
- No. of children per family of 150 families of a village.

Continuos Data

Data that originated from a continuous variable is called continuous data.

Examples:

- Weight in kg of 50 students in a class.
- Body temperature of 70 patients of a hospital.

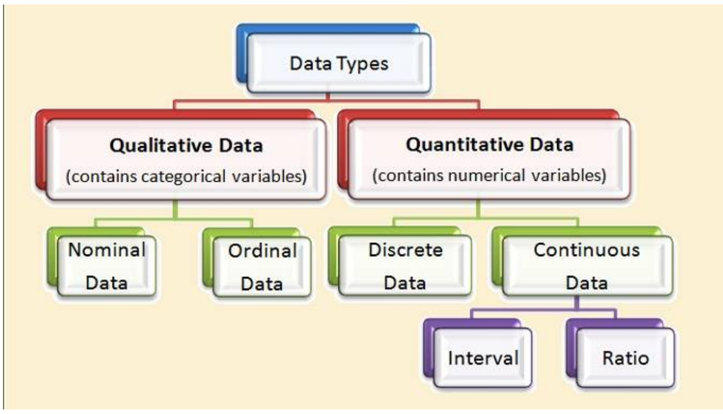

Figure 1.1: Data types

Measurement

It is a process of assigning numbers to some characteristics or variables or events according to scientific rules.

All variables under statistical study can be measured.

There are four levels or scales of measurements. They are:

- Nominal scale,
- Ordinal scale,
- Interval scale and
- Ratio scale.

Each scale represents a method of assigning numbers to variables and each comes with its own limitations and level of precision. Based on the different scales of measurements, variables are referred to as nominal, ordinal, interval, and ratio. Qualitative variables are measured by nominal and ordinal scales whereas quantitative variables are measured by interval and ratio scales.

Nominal Scale

The scale of measurement by which we can classify and identify a qualitative variable according to different categories is called the nominal scale. Ordering of the variables is not applicable in this scale.

It is the weakest level of measurement. These measurements are not measured on a natural numerical scale. But sometimes they are denoted by numbers or alphabets or both. However, this number cannot be used for mathematical operations such as addition, subtraction, multiplication, or division. For example, the model or registration number of a car, the holding number of the house, etc.
Examples:

- **The defective status** (defective or not defective) of each of 100 piece of clothes produced by a factory.
- **Gender** of a garment worker (male, female)
- **Color** of eyes of a worker (Black, Green, Blue)
- **Religion** of a worker (Muslim, Hindu, Buddhist, Christian)
- **Marital** status of a worker(single, marriage, widowed, divorced or separate)

Ordinal Scale

The scale of measurement by which we can classify, identify and rank a qualitative variable according to the different categories is called ordinal scale.

It preserves all the characteristics of the nominal scale. The values of the qualitative variables are meaningfully ranked or ordered and then classified according to different categories. Here, mathematical notation '<' (less than) or '>'(greater than) may be useful. However, addition, subtraction, multiplication, or division are not possible on an ordinal scale. For example, efficiency(excellent, good, fair, poor) of each 75 workers of a factory is an example of an ordinal scale.
Examples:

- **Grading** of a student(A, B, C, D)
- **Size** of a worker (Tall, Medium, Short)
- **Size** of a factory (big, medium, small)
- **Rating** of an executive (excellent, good, fair, poor)
- **Economic** status office citizen (higher class, middle class, poor)
- **Health status** office worker (excellent, good, poor)

Interval Scale

The scale of measurement by which we can measure a quantitative variable numerically on experimental unit with arbitrary zer origin is called interval scale.

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it preserves all the characteristics of nominal and ordinal scale.
Examples:

- Body **temperature** of a patient
- **Marks** obtained by students in an examination
- Calendar **time**.

1.8 Difference between Population and Sample

There are some differences between these two, and they are:

1.8.1 Population

A population or a statistical population is a collection or set of all possible observations whether finite or infinite, relevant to some characteristic of interest. A statistical population may be real, such as the heights of all college students, or hypothetical, such as all the possible outcomes from the toss of a coin. The number of observations in a finite population is called the size of the population and is denoted by the letter N. Numerical quantities that describe a population are called *parameters*,are customarily represented by Greek letters. It is important to note that in statistics the word population is a technical term not necessarily referring to all people in a specified area, rather denoting the aggregate of measurements or counts of some characteristic for the entire group of objects or individuals.

1.8.2 Sample

A *statistic* is a part or subset of a population. Generally it consists of some of the observations rise in certain situations, it may include the whole of the population. It may include the whole of the population. The number of observations included in a sample is called the size of the sample and is denoted by the letter n. A numerical quantity computed from a sample, is called a *statistic*, which is usually represented by ordinary Latin letter. The information derived from sample data is used to draw conclusions about the population.

Population	Sample
Whole group	Part of the group
Group we want to know about	Group we do know about
Characteristics are called parameters	Characteristics are called statistic
Parameters are generally unknown	Statistic are always known
Parameters are fixed	Statistic change with the sample

Table 1.1: Difference between Population and Sample

Parameter

A descriptive measure of a population is called parameter.

For example, the percentage of Chattogram voters who will vote for Mr. PNC.

Statistic

Any numerical value which we calculate from the sample is called a statistic. Or, A descriptive measure of a sample is called statistic.

For example, out of 1000 polled voters, 550 indicated that they voted for Mr. PNC. So $\frac{550}{1000} = 0.55$ or 50%

1.9 Variable (Data Point)

Variable

A variable is a characterisitic, often but not always quantitatively measured, containing two or more values or categories that can vary from person to person, object to object or from phenomenon to phenomenon.

A logical opposite of a variable is constant. A constant is a particular type of variable that does not vary from one member of a group to another.

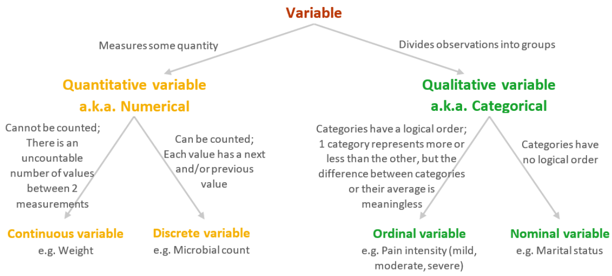

Figure 1.2: Variable Types

1.10 Types of series

1. Individual Series: 2, 3, 10, 0, 5, 6, 1, 3, 7, 8, 2, 5, 6, 9, 10
2. Discrete Series:

Marks	No. of Students
0	4
1	6
2	6
3	10
4	9
5	11
6	12

Table 1.2: Discrete Series

3. Continuous series:
   a) Inclusive series:

Marks	No. of Students
0-1	2
2-3	5
4-5	7
6-7	3
8-9	4
10-11	5

Table 1.3: Inclusive Series

Note: If the classes are not continuous then it can be made continuous by introducing Correction factor (CF),

$$CF = \frac{\text{Lower limit of second class} - \text{Upper limit of first class}}{2}$$

   b) Exclusive series:

Marks	No. of Students
0-10	2
10-20	5
20-3-	7
30-40	3
40-50	4
50-60	5

Table 1.4: Exclusive Series

1.11 Frequency distribution table

- The number of classes in a table should be between 5 and 20.
- Range, R = Largest Value(L) − Smallest Value(S)
- No. of classes, $K = \dfrac{\text{Range}}{\text{Class width (w)}} \implies K = \dfrac{R}{w}$
- $K = 1 + 3.322 \log_{10} N$
- Class width, $W = \dfrac{R}{K} = \dfrac{R}{1 + 3.322 \log_{10} N}$
- **Alternative formula:** $2^K \geq N$, the value of K for which this statement is true will give the no. of classes. Let $N = 50$, then $2^5 = 32$, $2^6 = 64 > 50 = N$. So there will be 6 classes.

1.12 Other forms of Frequency Distribution

The other ways of presenting frequency distribution are,

- percentage frequency distribution
- Relative frequency distribution
- cumulative distribution

1.12.1 Percentage distribution

If f_i is the frequency of the i-th class of a frequency distribution and N be the total frequency, then the percentages of cases falling in the i-th class is, $P_i = \dfrac{f_i}{N} \times 100$. Note that the total frequency in a percent distribution will increase to 100,i.e. $\sum(\dfrac{f_i}{N} \times 100) = 100$.

1.12.2 Relative frequency distribution

Relative frequency of i^{th} class = $\dfrac{f_i}{N}$. The total relative frequency will add up to 1, i.e., $\sum \dfrac{f_i}{N} = 1$.

1.12.3 Different frequency distribution calculation

1.13 Degrees of freedom

We can define them as the number of values we can choose freely. Suppose that the sum of two values is 36, if one number is 10, then the second number can be determined easily.

This example shows that when there are two elements in a sample & we know the sample sum of these two elements, we are free to specify only one of the elements because the other element

Class boundaries	Absolute Frequency	Percentage Frequency	Relative Frequency
49.5-57.5	6	12.0	0.12
57.5-65.5	7	14.0	0.14
65.5-73.5	14	28.0	0.28
73.5-81.5	10	20.0	0.20
81.5-89.5	10	20.0	0.20
89.5-97.5	3	6.0	0.6
Total	50	100.0	1.00

Table 1.5: Other frequency distribution

can then be determined mathematically. Statistically, "we have one degree of freedom",i.e. $2 - 1 = 1$. Example-2: There are seven elements in our sample, and we learn that the mean of these elements is 16. Symbolically, $\dfrac{a+b+c+d+e+f+g}{7} = 16$.
Here, we are free to give values to six variables, and then we are no longer free to specify the 7^{th} variable. It can be determined automatically. In this case, the degrees of freedom, or the number of variables that we can freely specify, are $7 - 1 = 6$. Similarly, a sample of 23 would give us 22 degrees of freedom.

In general the number of degrees of freedom is equal to the total number of observations less than the number of independent constraints imposed on the observations. For example, in a data set of n observations, if k is the number of independent constraints, then $\mu = n - k$.

1.14 Graphical Representation of Quantitative data

Important graphs for representing frequency distribution of quantitative data are:

1. Dot Plot
2. Histogram
3. Frequency Polygon
4. Frequency Curve
5. Cumulative Frequency Polygon or Ogive Polygon
6. Ogive Curve
7. Line Graph of time series data
8. Scatter Diagram

1.14.1 Histogram

The histogram is one of the most popular and widely used graphical methods to represent a frequency distribution where the given data are plotted in the form of a series of rectangles.

We can construct a histogram in three different ways depending on the nature of the data.

(a) For discrete frequency.

(b) For continuous frequency distribution with equal class interval.

(c) For continuous frequency with unequal class interval.

Histogram for discrete frequency

In this case, the class intervals or the values of the variable taken as class intervals are discrete in nature. So, in the first step we convert the class intervals into class boundaries to make them continuous. Then, the class boundaries are plotted along $X - axis$ and the frequencies of the class boundaries along $Y - axis$.

Histogram for continuous data with equal class interval

In this case, the class intervals or class boundaries are plotted along $X - axis$ and the corresponding frequencies are plotted along $Y - axis$ and adjacent rectangles are constructed to obtain the required histogram.

Histogram for continuous data with unequal class interval

When class intervals are unequal, the frequencies must be adjusted before constructing the histogram. Since the area of rectangle over a class is proportional to its frequency, the height of a rectangle is equal to the frequency divided by its width of the interval. This is sometimes called frequency density. Now class intervals are plotted along the $X - axis$ and the height of rectangles are plotted along the $Y - axis$ and construct adjacent rectangles to get the required histogram.

What is the difference between Histogram and Bar Diagram?

1.14.2 Frequency Polygon

It is particularly effective in comparing two or more frequency distribution. Since it is a polygon, it has more than four sides.

There are two ways in which a frequency polygon may be constructed.

- Frequency Polygon from Histogram.
- Frequency Polygon from frequency distribution.

Frequency Polygon from Histogram

First a histogram is to be constructed from the frequency distribution. Then midpoints of the upper horizontal side of each rectangle are joined by a straight line with the adjacent rectangle. The figure so formed is called frequency polygon. The figure is so formed is called frequency polygon. Both the ends of the polygon are then extended to the base line. This extension is made with the object of making the area under polygon equal to the area under the corresponding histogram.

Frequency Polygon from frequency distribution

First mid-values of various class intervals are calculated. These mid-values are plotted along the $X - axis$ and the corresponding frequencies along $Y - axis$. Then all the points joined together by straight line and the frequency polygon will be obtained.
Frequency polygon can also be constructed for discrete frequency distribution. The different values of the variable are plotted along the $X - axis$ and then the frequency corresponding to each value of the variable is plotted along the $Y - axis$. Then the points are joined by straight lines.

1.14.3 Frequency Polygon

A frequency curve is obtained by drawing a smooth freehand curve through the various points of a frequency polygon. That is, when a frequency polygon is smoothed; the resulting curve is called a frequency curve. The object of drawing a smooth frequency curve is to eliminate as far as possible all accidental variations that might be present in the data. The smoothing of the polygon can not be done properly without a histogram. Hence, it is desirable to draw a histogram first, then a polygon and lastly to smooth it to obtain the frequency curve. The curve is extended to the mid points of the class-intervals just outsides the histogram in both ends.The area under the curve should represent the total number of frequencies in the entire distribution. The following points should be kept in mind while smoothing a frequency graph.

1. Only the frequency distributions based on samples should be smoothed.
2. Only continuous series should be smoothed.
3. The total area under the curve should be equal to the area under the original histogram or polygon.

1.14.4 Cumulative frequency Polygon, Cumulative Frequency Curve Or Ogive

A cumulative frequency polygon or Ogive curve is the graphical representation of a cumulative frequency distribution. There are two methods of constructing cumulative frequency polygon or ogive, namely:

1. The less than method, and
2. The more than method

Cumulative frequency Polygon or Ogive by less than method

In this method we start with the upper limits of the classes and go on adding the frequencies to get the "less than cumulative frequency table". Now upper limits (upper class boundaries) of the class intervals are plotted on the $X - axis$ and the cumulative frequencies are plotted in the $Y - axis$. A point is then plotted directly above each upper class limit at a height corresponding to the cumulative frequency. One additional point is then plotted above the lower class limit for the first class at a height of zero cumulative frequency. These points are then joined by straight

line and the resulting polygon is called a less than cumulative frequency polygon.
When the points are connected by a smooth freehand curve, the resulting curve is called a less than ogive or a less than cumulative frequency curve. That is a smooth cumulative frequency polygon is called a cumulative frequency curve or an ogive. It is an elongated S-shaped curve.

Cumulative frequency polygon or ogive by more than method

In this method we start with the lower limits of the classes and form the total frequencies we subtract the frequency of each class to get the "more than cumulative frequency table". In this table total frequency is put corresponding to the lower limit of the first class. Now lower limits (lower class boundaries) of the class intervals are plotted on the $X - axis$ and the cumulative frequencies are plotted in the $Y - axis$. A point is then plotted directly above each lower class limit at a height corresponding to the cumulative frequency at that lower class limit. One additional point is to be plotted above the upper class limit of the last class at a height of zero cumulative frequency. These points are then joined by straight line and the resulting polygon is called a more than cumulative frequency polygon.

When the points are connected by a smooth freehand curve, the resulting curve is called 'more than ogive' or 'a more than cumulative frequency curve'. It is a declining curve.

Remark.

- *Actually ogive means less than ogive. It is mainly used for finding different position measures such as median, quartiles, deciles, and percentiles.*
- *Ogive can also be drawn from the relative cumulative frequency or percent cumulative frequency distribution in a similar way. The will take the same form and serve the same purpose.*
- *less than and more than ogives are required to identify the position of median only. If we draw less and more than ogive on the same graph paper, they will make $\chi - shape$ and the intersecting point between the two ogives helps to identify the median.*

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