CPA COLLEGE OF GLOBAL STUDIES, PUTHANATHANI

DEPARTMENT OF BOTANY

METHODOLOGY AND PERSPECTIVE IN PLANT SCIENCE

4th SEMESTER BOTANY

Module 1: BIOSTATISTICS

- Biostatistics can be defined as the application of the mathematical tools used in statistics to the fields of biological sciences and medicine.
- Biostatistics is the discipline concerned with the design and analysis of data from biomedical studies.
- It comprises a set of principles and methods for generating and using quantitative evidence to address scientific questions, for estimating unknown quantities and for quantifying the uncertainty in our estimates.
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- Methods of data collection
  1. complete enumeration survey
     - It is the method of data collection in which all the units of study are visited for data collection.
     - The units of study together constitute the study population.
     - The method of collection data from all the units of study is called census method or complete enumeration. This is highly reliable method but it is time and money consuming.
  2. Sampling
     - Studying a whole population on the basis of the study of samples drawn from it.
     - A sample is a representative sub set of whole population. It represent the whole population in respect of the specific characteristics under investigation.
     - Study of the sample gives information about the whole population. It is called statistical inference.
     - Samplings involves three principal steps
       1. Selection of sample.
       2. Collection of information about them.
       3. Making inference about whole population.
     - The theory of sampling is based on certain principles derived from the theory of probability
       1. Principle of statistical regularity
          - ✓ It holds that a moderately large number of items chosen at random from a large group are almost sure to possess the major characteristics of the group as a whole.

- ✓ It maintains that if samples are taken at random from a population, they are likely to possess the characteristics of the population in general.

2. Principle of inertia of large numbers.
   - ✓ It is the concept that the larger the size of the sample, the more accurate the results are likely to be. Eg., If a coin is tossed ten times, we expect equal chance for head and tail.

a. random sampling

I. simple or unrestricted random sampling
   - ✓ Random sampling in which all items of the population get an equal chance of being included in the sample.
   - ✓ The selection is free from personal bias.
   - ✓ For random selection we choose
     1. Lottery method- lot method
     2. Table of random sampling

II. restricted random sampling
   - ✓ Random sampling, in which certain restrictions are imposed while sampling.

1) stratified sampling
   - Here the whole population divided into homogenous groups called strata.
   - A specific number of random samples drawn from each stratum, and finally all these samples thus selected polled together.
   - The method of random sampling with greater accuracy and greater geographical concentration.
   - This method should be done with the complete supervision of skilled person.

2) systematic sampling/ quasi random sampling
   - Random sampling technique in which the population is arranged in order, the first item is selected at random and further items are selected at specific intervals.
   - Simple, effective and convenient method and the time and effort involved are relatively lesser.
   - The main limitation is that it becomes less representative, if the populations have hidden periodicities.

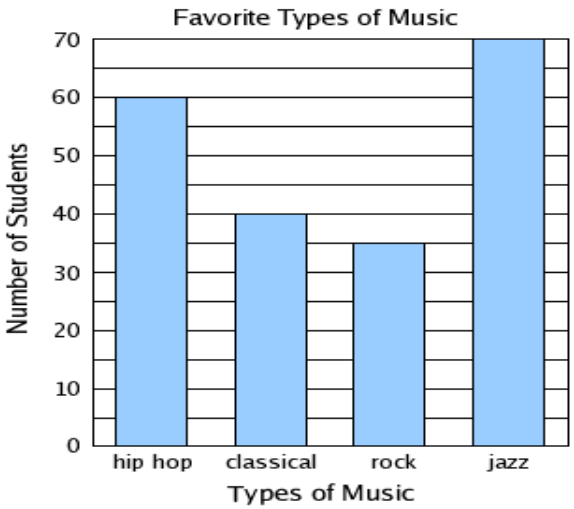
3) multistage or cluster sampling
   - Sampling procedure carried out in several stages.
   - The population is divided into several groups, called clusters, and a desired sample is selected from them to represent the whole population.
   - This system introduces flexibility to the sampling method and enables existing division and subdivisions of the populations to be used as unit at various stages.
   - It enables intensive field work and coverage of large areas.

b. non-random sampling
    I. judgment sampling
        - ✓ This is the method of sampling in which the choice of sample items depends exclusively on the discretion of the investigator.
        - ✓ The investigators use his judgement in the choice and include those items in the sample which he thinks are most typical of the universe with regard to the characteristic under investigation.
    II. convenience sampling
        - ✓ In this method, each unit is selected only for convenience. A unit selected in this way is called a chunk.
        - ✓ A chunk refers to a fraction of population, selected only because of convenience.
        - ✓ The results obtained following convenience sampling can hardly be representative of the population. They are generally biased and unsatisfactory.
    III. quota sampling
        - ✓ Type of judgement sampling.
        - ✓ Quotas are setup according to some specific characteristics, such as so many in each of several flower colour groups.

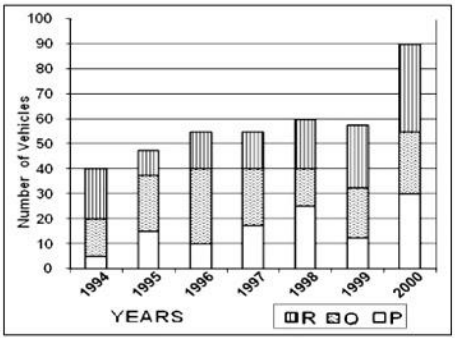
- organization of statistical data
    - ✓ The data corrected from readily available published sources will be in an organized form.
    - ✓ The different steps involved in organization of data are editing, classification and tabulation.
- classification and tabulation of data
    - ✓ classification of data based on certain characteristics
    - ✓ major types of classifications are
        1. chronological classification
        2. geographical classification
        3. qualitative classification
        4. quantitative classification
        5. conventional classification
    - ✓ Tabulation is the process of summarizing and representing data in the form of tables.
    - ✓ This tabulation of data simplifies the complex data and the data presented are easily understood.
    - ✓ It facilitates computation of various statistical measures like averages, dispersion, correlation etc.
    - ✓ A table present facts in minimum possible space and unnecessary repetitions and explanations are avoided.
    - ✓ Tabulation is a good reference for making the the complete information in the form of graphs and diagrams.
    - ✓ An ideal table should have
        1. Table number
        2. Title

3. Captions or column headings
4. Stubs or row designations
5. Body
6. Foot notes
7. Sources of data

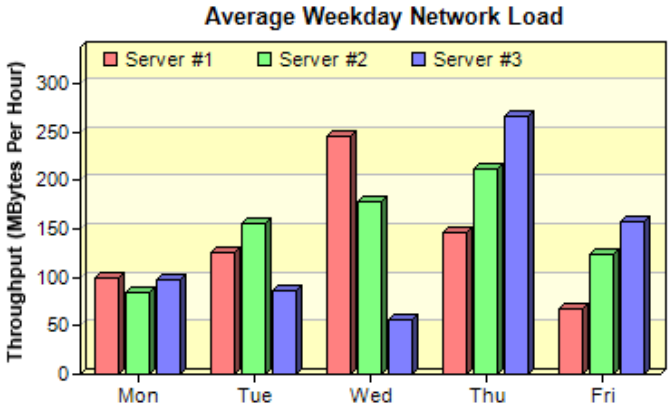
- Types of tables
  1. Time of time series
     It carries data based on the chronology of time.
  2. Frequency table
     A frequency tables is constructed by arranging collected data values in ascending order of magnitude with their corresponding frequencies.
     a. Discrete frequency tables- variables have a definite gap between two values.
     b. Continuous frequency tables- variables that have all possible intermediates
- diagrammatic and graphic representation of data
  - ✓ Collected data can be represented in diagrams and graphs.
  - ✓ Diagrams are different types
    1. One diamensional diagrams
       Bar-diagrams
       a. Simple bar diagram



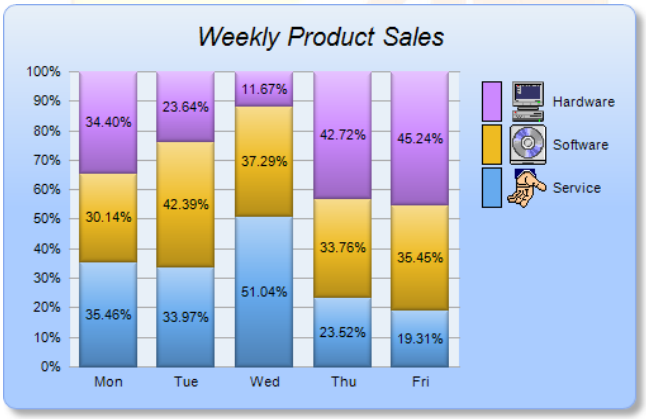
       b. Sub-divided bar diagrams



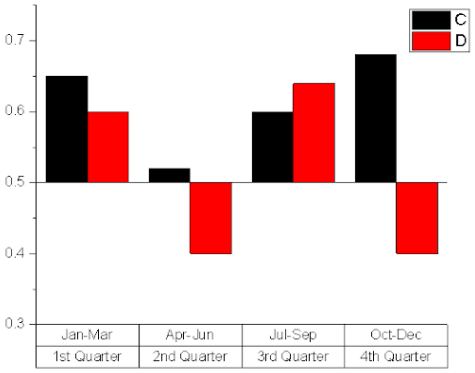
c. Multiple bar diagrams



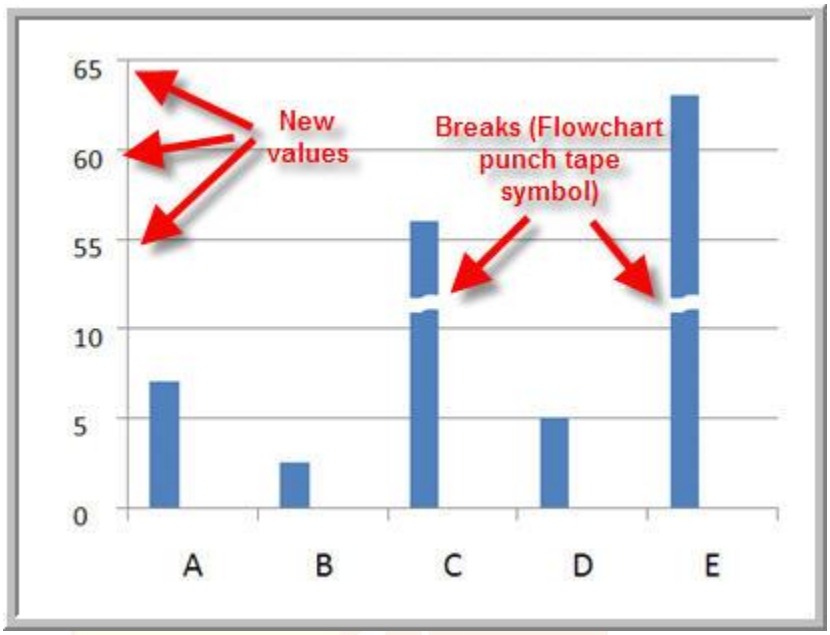
d. Percentage bar diagrams



e. Deviation bar diagrams



f. Broken bars



2. Two dimensional diagrams

Here the length as well as the width of the bars is considered. Thus the areas of the bars represent the given data.

a. Rectangles

The area of the rectangles is equals to the product of its length and width.

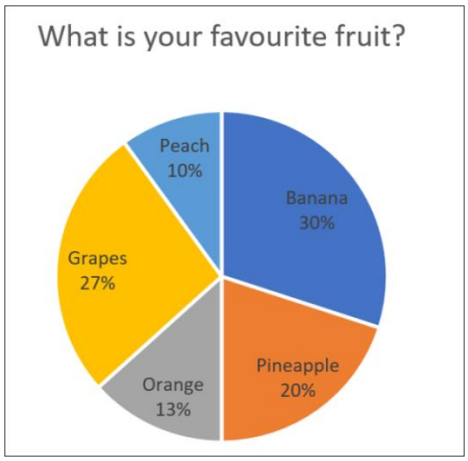
b. Squares

The method of drawing a square diagram is very simple. One has the square root of the values of various items that are to be shown in the diagrams and then select a suitable scale to draw the square.

c. Circles

The circles are to be compared on area basis rather than on diameter basis.

d. Pie diagram



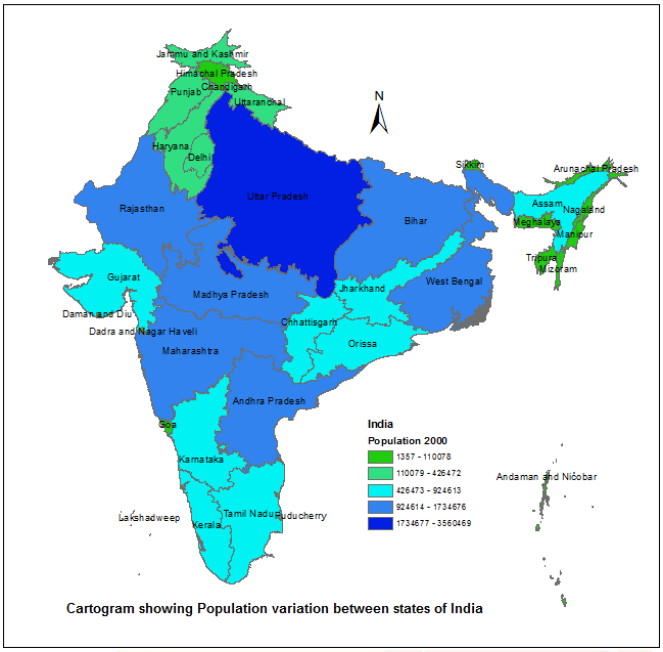
3. Three diamensional diagrams
   This is also known as volume diagrams and it consist of cubes, cylinders, blocks etc. Here length, width and height have to be taken in account.
4. Pictograms and cartograms
   - Pictogram

   These are pictures used in representing statistical data.
   It really depicts the kind of data with pictures.
   Pictures are attractive and easy to comprehend and such this method is particularly useful presenting statictics to laymen.

Symbols used to depicts certain actions

- Cartogram

These are the statistical map used to give quantitative information on a geographical basis.
Used to representing spatial distribution.



Cartogram showing Population variation between states of India

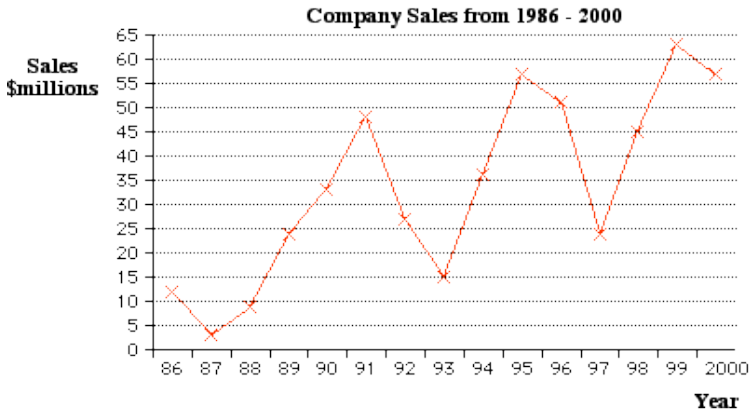
- ✓ Graphs
- ✓ Graphs are broadly classified into two

1. Graphs of time series or line graphs

Simplest form of graphical representation.

Graphs of time series can be constructed either on a natural scale or on a ratio scale.

Here the variables at different point of time, the series so formed is known to be time series.



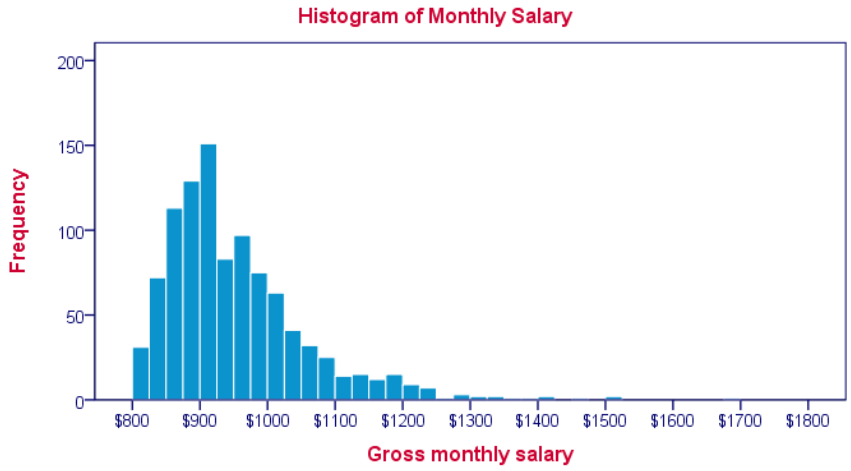
2. Graphs of frequency distribution

   Here frequencies are distributed over the different classes.

   The frequency distribution can be presented graphically in three ways

   a. Histogram

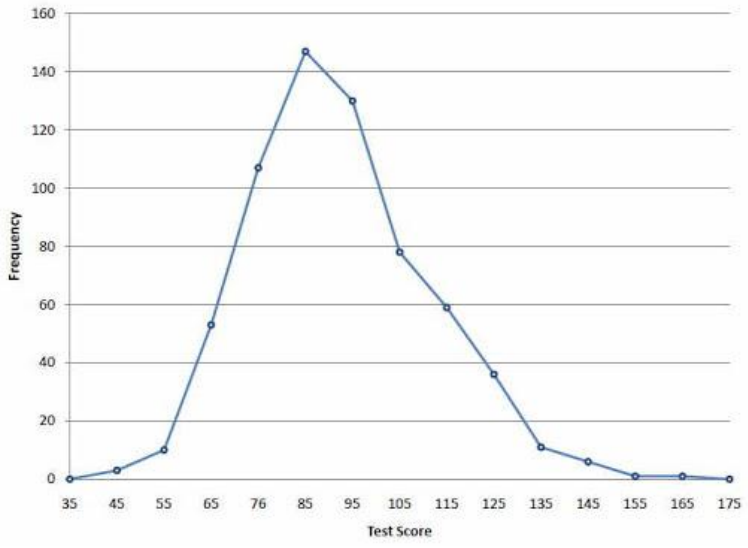
      A histogram is a set of bars whose areas are proportionate to the frequencies represented.



   b. Frequency polygon

      It is the graph of frequency distribution. It is particularly effective in comparing two or more frequency distributions.

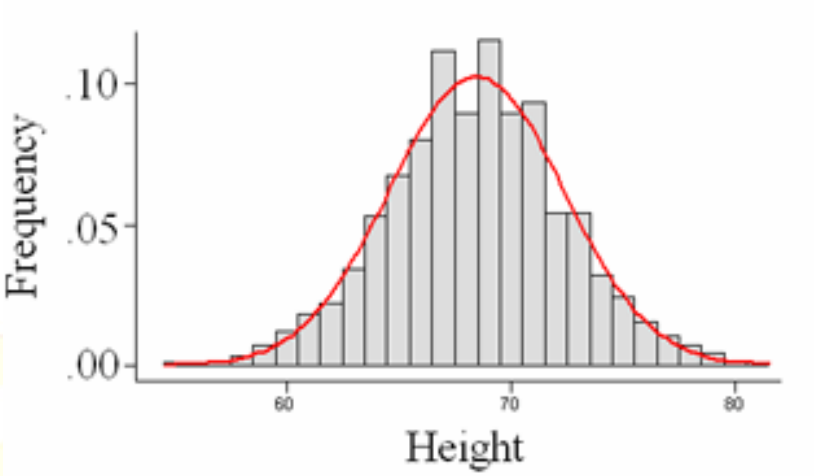
      It has a special advantage over histogram. The frequency polygon of several distribution can be plotted on the same axis, thereby making certain comparisons possible histograms are preferable when classes are numerous.



c. Smoothed frequency curve

It can be drawn through the various points of the polygon.

The curve is drawn free hand in such a manner that the area included under the curve approximately the same as that of polygon.



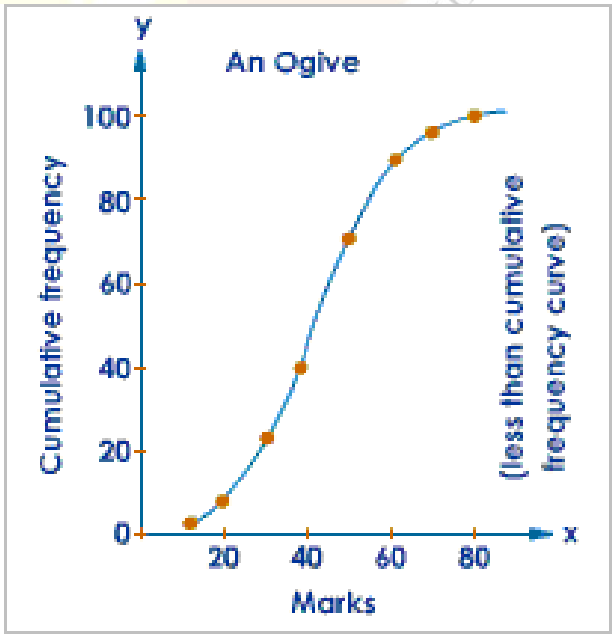
We can observe skewness and kurtosis of this curve.

d. Cumulative frequency curve

While plotting a graph the frequencies are added, are called cumulative frequencies.

These frequencies are then listed in a table called a cumulative frequency table.

The curve obtained plotting cumulative frequencies is called a cumulative frequency curve or ogive.



OBSERVATION

- Scientific observation will lead the investigation or any research to the success.
- A keen observation the study area or field will gave the correct or accurate results.
- Observation can be classified under 4 major categories
  1. Direct and indirect observation
     This is the observation of an event personally by the observer. This method is very much flexible and it allows the observer to see and record the necessary aspects of an event or behaviour.
     Indirect observation which does not involve the physical presence of the observer, and the recording of observation is done by mechanical, photographic or electronic devices.
  2. Controlled and uncontrolled observation
     In a controlled study, researchers are able to determine which of their subjects receive the factor that is being tested for having a causal influence upon another factor. This type of observation may be carried out in a laboratory type situation and because variables are manipulated is said to be high in control.
     In uncontrolled or observational studies, researchers have no such control over whether their subjects receive the treatment being investigated
  3. Structured and unstructured observation
     Structured observations are planned and systematic observation which records information or data in a standard way, following certain designs, patterns and rules.
     Unstructured is opposite to structured. It is casual, unplanned and nonsystematic observation, without following any rules and directions.

  4. Human and machine observation
     In human observation no technical devices are used. It is made in the natural environment, using the scene of observer.
     Machine observation carried with the help of technical devices or precision instruments.

Module 2: BIOSTATISTICS

ANALYSIS OF NUMERICAL DATA

- Quantitative data collected from experimental populations are analyzed with the help of different statistical tools as to reach inferences on different aspects under study.
- The techniques are listed below
  1. Study of central tendencies
  2. Study of dispersion
  3. Correlation studies
  4. Regression studies etc.

1. Analysis of central tendencies

a. Arithmetic mean

- ✓ Mean is the sum of all the results included in the sample divided by the number of observation.
- ✓ It is quick and easy to calculate but it may not representative of whole sample.
- ✓ Arithmetic mean can be obtained in different formula

1. Individual observations(unorganized data)

   Arithmetic mean, $\bar{X} = \frac{\sum X}{N}$

   X= Number of observation in the data

   N= Number of observation

2. Discrete frequency table

   Arithmetic mean, $\bar{X} = \frac{\sum fX}{N}$

   f =frequency of corresponding X in the frequency table

   N= $\sum f$

3. Continuous frequency table

   Arithmetic mean, $\bar{X} = \frac{\sum fm}{N}$

   m = mid value of the frequency classes of the data.

   f =frequency of corresponding X in the frequency table

   N= $\sum f$

b. Median

- ✓ Middle value of all the numbers in the sample.
- ✓ It is the value that divides the set of data in 50% of the observations being above it and 50% being below it.
- ✓ Median can be obtained in different formula

1. Individual observations(unorganized data)

   Median= size of the $\frac{N+1}{2}$th term

   N= number of observation

2. Discrete frequency table

   Median= size of the $\frac{N+1}{2}$th term

   N= number of observation

3. Continuous frequency table

   Median = $L + \frac{N/2 - cf}{f} \times i$

   L= lower limit of the median class

   N= number of observations

   cf =cumulative frequency of the class preceding the median class

   f = frequency of the median class

   i = class interval of the median class

c. Mode
   - ✓ It is the most frequently observed value of the measurements in the sample.
   - ✓ There can be more than one mode or no mode.
   - ✓ Mode can be obtained in different formula
     1. Individual observations(unorganized data)
        Mode = the observation or value occurring the highest number of times in a distribution is the mode value
     2. Discrete frequency table
        The class with the highest frequency is the mode class. The value of the variable corresponding to the highest frequency is the mode.
     3. Continuous frequency table
        Mode = $L + \frac{(\Delta 1)}{\Delta 1+\Delta 2} \times i$
        L= lower limit of the modal class
        $\Delta 1 =$ The difference between the frequency of the modal class and the frequency of the premodal class

        $\Delta 2 =$ The difference between the frequency of the modal class and the frequency of the postmodal class
        $i = class\ interval$

2. Measures of dispersion

- Measures of dispersion or variation are the statistical values under study from the central values of the variables under study from the central values.
- Major measures of dispersion being used in statistical analysis are listed below

a. Range
   - ✓ It is the simplest method of studying dispersion of the values of the variable under study.
   - ✓ It is the difference between the value of the smallest item and the value of the largest item of the distribution.
   - ✓ It is based on the extreme items of the distribution only.
   - ✓ Range R= L-S, L=largest value of the variable. S= smallest value of the variable.

b. Variance
   - ✓ It is the mean of the squared deviations of the individual values from the mean of the distribution.
   - ✓ Variance can be obtained in different formula
     1. Individual observations(unorganized data)

Variance = $\frac{\sum d^2}{N}$

d = $X - \bar{X}$

2. Discrete frequency table

Variance = $\frac{\sum d^2}{N}$

d = $X - \bar{X}$

3. Continuous frequency table

Variance = $\frac{\sum fd^2}{N}$

d = $mid\ X - \bar{X}$

c. Quartile deviation

- ✓ It gives the average quantity by which the two quartile differs from the median.
- ✓ In a symmetrical distribution, 2 quartiles $Q_1$and Q_3 are equidistant from the median.
- ✓ When quartile deviation is very small, it describes high uniformity or small variation of the central 50% items and a high quartile deviation means that the variation among the central items is large.
- ✓ An interquartile range is a measure developed for this purpose. This is the range which includes the middle 50% of the distribution.

  Interquartile range = Q_3- Q_1

  $Q_{1= N/4}$ th term of the distribution.

  $Q_{3=3N/4}$ th term of the distribution.
- ✓ Quartile deviation is an absolute measure of dispersion. The relative measures corresponding to this measure, called the coefficient of quartile deviation.

  Coefficient of quartile deviation= $\frac{Q3-Q}{Q3+Q1}$

d. Mean deviation

- ✓ It is the average difference between the items in a distribution and the median or mean of that series.
- ✓ Mean deviation can be obtained in different formula

1. Individual observations(unorganized data)

MD= $\sum \frac{|x_i-a|}{N}$

a = average about which M.D is calculating

N= total number of observation

x_i = observations

2. Discrete frequency table

   MD= $\frac{1}{N}\sum f_i \ |x_i - a|$

   f = frequency

   a = average about which M.D is calculating

   N= total number of observation

   x_i = observations

e. Standard deviation

- ✓ Known as the root-mean square deviation.
- ✓ It is the square root of the means of the squared deviations from arithmetic mean.
- ✓ Standard deviation measures the absolute dispersion or variability of a distribution. Greater the amount of dispersion then greater the SD., for the greater will be the magnitude of the deviations of the values from their means.
- ✓ Small SD means a high degree of uniformity of the observations.
- ✓ Two or more comparable series with identical or nearly identical means it is the distribution with the smallest SD has the most representative mean
- ✓ Standard deviation can be obtained by

  1. Individual observations(unorganized data)

     S.D, $\sigma = \sqrt{\frac{\sum(x_i - \bar{x})^2}{n}}$

  2. Discrete frequency table

     S.D, $\sigma = \sqrt{\frac{\sum fi(x_i - \bar{x})^2}{N}}$

     f_i= frequency of each observation

f. Coefficient of variation

- ✓ It is the relative measures of SD.
- ✓ Used to compare the variability of two or more than two series.
- ✓ The series with greater coefficient of variation of variation is more variable
- ✓ Coefficient of variation = $\frac{\sigma \times 100}{x}$
- ✓ Coefficient of SD= $\frac{\sigma}{x}$

3. Correlation analysis

- Statistical correlation is the conditions in which 2 variables are intimately interrelated so that a change in the values of one variable may cause a corresponding change in the value of the other.
- Correlation analysis helps to determine the degree of linear relationships between variables.
- Types of correlation
  1. Positive and negative correlation
  2. Linear and non-linear correlations
  3. Simple, multiple and partial correlation
- Coefficient of correlation is a measure of the degree to which there is alinear relationship between to variables.
- Coefficient of correlation indicates how far a change in one variable is related to the change in another.
- Coefficient of correlation varies from -1 to +1. If it is -1, the correlation is perfect negative; +1 , correlation is perfect positive. If it is zero correlation is zero, there is no correlation.

  Coefficient of correlation , $r = \frac{\sum xy}{\sqrt{\sum x^2 \times \sum y^2}}$

$$x = X - \bar{X}, \quad y = Y - \bar{Y}$$

4. Regression analysis

- Regression is the statistical method or tool which helps to estimate the unknown values of one variable from the known values of another related variable.
- The measurement of the probable form of relationship between two related variables known as regression analysis.
- It helps to establish nature of the linear relationship between variables.
- Regression equations
  - ✓ There are two regression lines of two variables X and Y.
  - ✓ There are two regression equations.
    1. Equation of X on Y
       - Used to describe the variation in the value of X for given changes in Y.

$$X - \bar{X} = r\,\frac{\boldsymbol{\sigma x}}{\boldsymbol{\sigma y}}(Y - \bar{Y})$$

$r\,\frac{\boldsymbol{\sigma x}}{\boldsymbol{\sigma y}}$ is the regression coeffient of X on Y is denoted by bxy or b_1

bxy or $r\,\frac{\boldsymbol{\sigma x}}{\boldsymbol{\sigma y}} = \frac{\sum \boldsymbol{xy}}{\sum \boldsymbol{y^2}}$

2. Equation of Y on X
   - Used to describe the variation in the values of Y for given changes in X.
     - $Y - \bar{Y} = r\ \frac{\sigma y}{\sigma x}(X - \bar{X})$

$r\ \frac{\sigma y}{\sigma x}$ is the regression coeffient of X on Y is denoted by byx or b_2

byx or $r\ \frac{\sigma y}{\sigma x} = \frac{\sum xy}{\sum x^2}$

- Coefficient of correlation and regression will have the same signs.
  Coefficient of correlation= $= \sqrt{bxy \times byx}$

Probability and probability distribution

- Probability is the chance of occurrence of particular even among a group of events. Or it is the relative frequency of occurrence of an event among a total number of events.
  In a random experiment , if there are n events, and are mutually exclusive , the probability of each of the mutually exclusive events is given by 1/n.
- There are different types of events taking place in nature.
- A random experiments is the experiment when the outcome of it cannot be predicted in any trail.
- Based on the occurrence, there are different types of events
  1. Mutually exclusive events
  2. Independent events
  3. Dependent events
  4. Equally likely events
  5. Simple or compound events
- Theorems of probability
  1. Addition theorem
     p(AUB) = p(A)+ p(B) – p(A∩B)
  2. Multiplication theorem
     p(A∩B) or p(A and B) = p(A). p(B)
     Consider p is the probability of success in an experiment. Then q is the probability of failure.
     p+q = 1
- Probability distribution
  1. Binomial distribution
     - ✓ Also called Bernoulli distribution.
     - ✓ The probability of distribution expressing the probability of one set of dichotomous alternatives i.e, failure and success.
     - ✓ Example ; when one coin tossed two outcomes, namely tail or head occurs. probability become ½ for each.

- ✓ The total occurance of different outcome will be expressed as $(p+q)^n = p^n + np^{n-1}q + \ldots\ldots\ldots + q^n$
- ✓ The number of tems in a binomial expansion is always n+1
- ✓ The exponents of p and q, for any single term, when added together, always sum to n.
- ✓ The exponents of p are n, n-1,n-2……1,0, respectively and the exponents of q are 0,1,2…….n-1, n respectively.

2. Poisson distribution
   - ✓ Discrete probability distribution and widely used in statistical work.
   - ✓ Limiting form of the binomial distribution as n becomes infinitely large and p approaches zero.
   - ✓ Distribution is used to describe the behaviour of rare events and has been called law of improbable events.
   - ✓ Formula for poisson probability

$$f(X) = \frac{\mu^x e^{-\mu}}{x!}$$

3. Normal distribution

   - ✓ Approximation of binomial distribution.
   - ✓ Most useful theoretical distribution for continuous variables.
   - ✓ It has numerous mathematical properties which makes it popular and comparatively easy to manipulate.
   - ✓ In theoretical statistics, many problems can be solved only under this assumption of a normal population.
   - ✓ Normal distributions have a symmetrical curve about the mean. with maximum height at the mean.
   - ✓ Normal distribution under certain conditions.

RESERCH METHODOLOGY

Chapter 1: Scientific methods

- Scientific method is the systematic procedure and technique used in scientific inquiries and investigations for explaining natural observations, acquiring new knowledge, correcting or integrating previous knowledge, correcting or integrating previous knowledge, formulating generalization and making predictions.
- Major steps in scientific methods
  1. Observation
     - ✓ Should be correct and repeatable.
     - ✓ Observation can be direct, using our sense organs or indirect with the help of instruments.
  2. Defining a problem

- ✓ A problem should be defined in such a way that the different aspects of the observed phenomena are amenable to investigation.
- ✓ Asking questions about what? , why? , how? of the observation have to be subjected to scientific analysis.

3. Collection of information
   - ✓ Helps to know more about previous works and to avoid repetition.
   - ✓ Investigator collects and makes use of all the available information and data about the problem.
4. Framing a hypothesis
   - ✓ Hypothesis is a supposition, assumption or provisional explanation which has to be proved or disproved in the light of accepted facts.
   - ✓ It will provide a logical answer to a question and also helps to predict new facts.
5. Testing or experimenting
   - ✓ The correctness, validity or acceptability of a hypothesis has to be tested with the help of a controlled experiment.
6. Theorizing
   - ✓ A theory should be formulated on the basis of s experimental evidences or on the basis of the analysis of interrelated facts.
   - ✓ A hypothesis become a theory when it is supported by a large body of observations and experimental evidences

- Methods of scientific enquiry
  - ➢ Scientific methods are truly empirical. Empiricism is the theory of knowledge which holds that an experience through senses is the only source of knowledge.
  - ➢ There are 4 empirical methods of scientific enquiry,
    1. Inductive method or induction
       - ✓ In this method the final conclusion and generalization are drawn from specific observations and analysis of known facts.
       - ✓ Inductive method begins with specific observations and measures, proceeds through the analysis of data and the formulation of tentative hypotheses, and finally ends in general conclusions and theories.
       - ✓ Called data collection- analysis method.
       - ✓ Top to bottom approach.
    2. Deductive method or deduction
       - ✓ In deductive method, a scientific inquiry starts from a theory, then moves on to data collection, and finally ends in analysis.
       - ✓ Also called theory-data collection-analysis method.
       - ✓ Bottom to top method.
       - ✓ In this method scientific inference in which conclusions are drawn by reasoning from a general principle to a particular case.
    3. Constructive method
       - ✓ Variant of deductive method.

- ✓ It involves the deductive construction of scientific theories in mathematics and logic.
- ✓ Constructive method is applied solely to formal sciences , such as mathematics, statistics and logic.

4. Hypothetico-deductive method
   - ✓ In this method, initial hypothesis gets evaluated by a complex and step-by-step procedure leading either to its substantiation and acceptance or to its rejection.

- Hypothesis
  - ✓ Hypothesis is a testable tentative or provisional generalization based on previous knowledge and it forms the basis for reasoning.
  - ✓ Hypothesis serves the following purposes.
    1. Offers adequate explanation of related facts.
    2. Helps in the formulation of laws, explaining facts.
    3. Helps in the selection of the appropriate method of testing and verification.
    4. Channels scientific inquiries in the right direction, suggesting experiments and observations, and helping the collection of evidences.
    5. Helps in drawing conclusions to expand the horizon of knowledge.
  - ✓ Features of good or valid hypothesis
    1. It provides answer to the problem of inquiry.
    2. It must be straight forward, definite and unambiguous.
    3. Hypothesis must be empirically testable or verifiable so that it can be ultimately accepted, rejected or revised.
    4. It must be simple with very high predictability.
    5. Its explanation must be true to the existing state of knowledge.
- Types of hypothesis

1. Crude and refined hypothesis
   - ✓ Crude hypothesis indicate the kind of data to be collected, does not lead to the formulation of theories.
   - ✓ Refined hypothesis lead to the formulation of theories.
   - ✓ Refined hypothesis classified into three
     a. Simple- does not involve much of testing and verification.
     b. Ideal- one which examine the causes and relations of natural phenomena.
     c. Complex hypothesis-concerned with the interrelations of multiple variables
2. Null hypothesis
   - ✓ This is the hypothesis nullified by the negative evidence of testing.
   - ✓ Null hypothesis was put forward on the belief that might be true and could be used in collecting data.
   - ✓ This is used in sampling theory and providing additional support to an accepted hypothesis.

- Formulation of hypothesis
  - ✓ Scientific hypothesis originate from different thought processes, such as analogy, induction, deduction and intuition.
- Verification and proof of hypothesis

- ✓ Verification of a hypothesis means the testing of the truth of the hypothesis in the light of facts. Verification can be direct or indirect.
- ✓ Direct verification is through simple observation or experiment. In indirect verification, the consequence deduced from the hypothesis is compared to actual facts.
- ✓ In order to prove a hypothesis, it is essential first to verify.

Module 1: research methodology

- Structure of research report
  - ✓ Report of research program that has been designed and carried out with a definite objective.
  - ✓ A report intended to describe the different aspects of research project, including its findings, in such a way that the reader gets very clear idea of the objective, methodology, findings and recommendations of the study.
  - ✓ The language of report should be clear and scientific.
  - ✓ Research reports are prepared keeping in mind the different target groups and the purpose of research, the importance of the outcome and the relevance of its application.
  - ✓ A research report or dissertation has three major sections
    1. Preliminary section
       - It consists of the initial pages of the report.
       - It includes
         - title page
         - certificate
         - acknowledgement
         - table of content
         - list of tables and figures
         - abstract
    2. Main body or text
       - Most important part of the report.
       - Contains detailed accounts of the general background of the study and its objectives, details of previous study, the details of the methodology adopted and observations, the discussion, major findings and conclusions.
       - It includes
         - Introduction
         - Review of literature
         - Materials and methods
         - Observations
         - Discussions
         - Summary and conclusion
    3. Reference section

- Third section of report.
- It contains references or bibliography and the appendix.
- In this section the list of references and list of source of information are included.

- Styles of citations
  - ✓ The sources of all information collected and used by the researcher to be cited properly using a standard style of citations.
  - ✓ In the text the name of the author and the year of publication are to be given. The reference indicated using numbers in the text part.
  - ✓ The details of the sources are to be cited in the reference section appropriately.
  - ✓ There are different styles of citations are used in research reports.
    1. M.L.A (Modern language association) style.
    2. A.P.A. (American Psychological Association) style
    3. Chicago style
    4. CSE (council of Science Editors) Style
- Biological journals
  - ✓ Research journals are periodical publications in which research papers and review papers are published.
  - ✓ Several research journals in biological sciences.
  - ✓ *Nature* is a journal which provides the most important findings in biology.
  - ✓ Some important journals in biology are listed below
    1. *Journal of molecular biology*
    2. *Journal of biology*
    3. *Molecular and cellular biology*
    4. *Cell*
    5. *Genome biology*
    6. *Molecular systems biology*
    7. *Molecular biology and evolution*
  - ✓ Some botany related journals
    1. *Blumea*
    2. *Phytotaxa*
    3. *Photosynthetica*
    4. *American journal of botany*
    5. *Annals of botany*
    6. *The bryologist*
    7. *Rheedea*
    8. *Journal of plantation crops*
    9. *Indian journal of plantation crops*
- Impact factor
  - ✓ Used as an indicator relative importance of the journal.

- ✓ Journals with higher impact factors are considered important.
- ✓ It is the scientometric index that reflects the yearly average number of citations of the papers published in an academic journal.
- ✓ For any given year, the impact factor is calculated as the ratio between the number of citations received by publications published in the two preceding years in that particular year and the total number of citable items published in that journal during the two preceding years.

- Sources of references
  - ✓ There are different sources which gives a detailed picture on the references or previous works, which is already carried out in research areas related to a particular research project.
  - ✓ Indexing and abstracting services are available in different disciplines to get the abstract of papers related to any project or field of study.
  - ✓ There are different references sources are used in different disciplines of study
    1. Citation indexes
    2. Google scholar
    3. INFLIBNET
    4. Shodhganga
    5. e-PG Pathasala
    6. ePathasala
    7. NCBI

- Latest method of presentation

  - ✓ In modern science there are different software companies have developed novel types of software for effective and comprehensive presentation of information and very efficient communication with the viewers.
  - ✓ In most caes slides are prepared using softwares like Microsoft Powerpoint,Open Office Impress, Apple Keynote And Corel Presentation. And projected using LCD, LED or DLP projectors.
  - ✓ The major presentation software are

  1. Microsoft Power Point
  2. Open Office Impress
  3. Apple Keynote
  4. Corel Presentation