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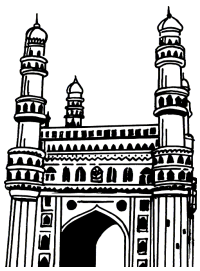

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UNIT I

Introduction, Measurement and Hypothesis Testing:

Meaning of Research - Steps involved - Identification of Problem - Steps involved in the selection of problem - Research Design - Meaning and Types- Measurement Levels/Scales - Scaling Techniques - Hypothesis - Meaning - Types – Testing Procedure.

1.1 Meaning of Research

Q1. Define Research.

(OR)

What do you meant by Research?

(OR)

What is the meaning of Research?

Ans :

Meaning

Research is a scientific investigation. Investigation means a search for new facts and ideas in any branch of knowledge. Thus, we can say that research is a search for knowledge. Research may be considered as a movement, a movement from the unknown to the known. It is actually a voyage of discovery.

Research is carried out for two purposes; one is the discovery of new facts and the second, verification of the old ones. The object of every business organization, of course, is the discovery of new facts, new relationship, and new laws governing the business phenomena. But constant verification of the old concepts is also needed especially in dynamic business environment.

Definitions

Research has been interpreted and defined by various scholars as per their fields of study and availability of resources at the given time.

(i) **According to Rocco, 2011**: "Research is a careful investigation or inquiry especially through search for new facts in any branch of knowledge." Research is a movement, a movement from the known to the unknown (Redman and Mory, 2010). Research is manipulation of things, concepts or symbols for the purpose of generalizing to extend, correct or verify knowledge, whether that knowledge aids in construction of theory or in the practice of an art.

(ii) **According to Creswell, 2008:** "Research is systematic investigation to establish the facts." In the broadest sense of the word, the definition of research includes any gathering of data, information and facts for the advancement of knowledge.

(iii) **According to Clifford woody:** "research comprises defining and redefining problems, formulating hypothesis or suggested solutions collecting, organizing and evaluating data, making deductions and reaching conclusions; to determine whether they fit the formulating hypothesis."

(iv) **According to Cambridge dictionary online, research is** "a detailed study of a subject, especially in order to discover (new) information or reach a (new) understanding."

Q2. What are the characteristics of research?

(OR)

Explain the various characteristics of research.

(OR)

Enlist various characteristics of research.

Ans : **(Imp.)**

A well-organized research must possess certain characteristics features, which are as follows:

1. Solution Oriented

The problem of research must be clearly defined and stated.

The motive of research must be mentioned in the beginning of research work. The research should provide a solution of a business problem.

2. Logical

In a research we find out facts about a phenomenon and draw conclusions about it. The inferences and generalizations thus made must be logical. For example, all illiterate people in the village live longer than the educated people in the cities leads to the conclusions that illiteracy is the cause of longevity. This is an example of illogical research conclusion.

3. Objective

Observing true picture of a phenomenon without being affected by observers own opinion is termed as 'objective'. Objectivity means knowing reality. The criterion of objectivity is that all researchers should arrive at the same conclusion about the phenomenon on which they are pursuing research.

4. Impartiality

A dishonest research may select data items of individuals to draw conclusions to his favour. This brings bias into research, which affects the objective of the study. Therefore a true research must be impartial and unbiased.

5. Accuracy

A research worker needs to gain some expertise in the study he is undertaking. This expertise results in achieving the accuracy in the solution drawn. The accuracy of conclusions is a sensitive issue as it may affect the whole decision-making.

6. Systematic

In a research there should be well-defined steps. Each step should be sequentially linked with another, so that, the whole research work is an organized structure.

7. Verifiability

The results of a research are subjective to verifications. For building a sound basis for decision making one verifies the research results by replicating the study.

8. Empirical

A research is an empirical process and involves data collection. The results are based on observed experience or empirical evidence. Research rejects assumptions and dogma as methods of established knowledge. It accepts only what is verified by empirical observations.

Q3. Describe the objectives of research.

(OR)

Explain the various objectives of research.

(OR)

"Many a time management is not convinced about the utility of research and regards it as an unnecessary activity over which no funds should be spent". Comment on this statement explaining the objectives of research.

Ans :

The main goal of research is to improve the quality and level of living in the society. The purpose of a research study is to find out the hidden facts about a business phenomenon. The obvious function of research is to add new knowledge to the existing store. It serves the government and the business organizations in forming their future policies. The objectives of a research study are listed below:

1. **Understanding a business problem:** The first and foremost objective of any study is to understand, analyze and explore a business problem. Once complete familiarity with the phenomenon is achieved, it is easier to decompose the complex problem into smaller once.
2. **Identifying the cause and effect relationship:** Individuals form groups, and groups form organizations. They are

interdependent. It is very important for a researcher to identify the functional relationships among various components of an organization. A scientific investigation is necessary in studying the cause and effect relationship of variables involved in a business phenomenon.

3. **To innovate new ideas:** One of the objectives of a researcher is to bring constant improvement in the techniques of his trade. Apart from verifying and testifying the existing assumptions, one of the functions of a research is to add new knowledge to the state of the art. Research invokes the innovation of new concepts, theories and idea in a business study. Apart from this, research also removes and discards worthless theories that are prevalent in the society.

4. **To improve the quality:** The whole exercise of any activity is done for the improvement of quality of a product, machinery, or life of human beings. For a business organization it is atmost important to improve the quality of its products. This can be achieved by a systematic and critical investigation i.e. research.

Q4. Describe the different types of research.

Ans :

Research is a multidimensional activity. It comes in various forms and is used in all social, behavioral, educational, economical and management sciences. According to the approach and method involved in a research, one can classify the following types of research.

1. Descriptive v/s Analytical research

Descriptive research basically describes what is. It mainly involves collection, recording, describing and analyzing the facts related to the study. It tries to find the existing status, trend and state of affairs in a phenomenon. Descriptive research involves surveys, but they are not merely data collection as they also involve measurement, classification, analysis, comparison and interpretation. In this type of research the variable under study are uncontrollable. One can only observe and report what is happening in a situation.

Analytical research, on the other hand deals with what will be. In this type of research, the variables involved are carefully and scientifically controlled and manipulated. Analytical research is also known as experimental research and is a very sophisticated technique. This kind of research is based on four important characteristics namely; control, manipulation, observation and replication.

2. Applied v/s Fundamental research

Applied research is action oriented or solution oriented. The main goal of an applied research is to obtain an immediate, specific and practical solution of a problem that a business organization is facing right now. It gives here and now solutions in actual problem situations. It involves scientific investigations but the methods are not so rigorous as in fundamental research. It finds solutions to be applied in local environment and they may not be universally acceptable. Applied research does not promise to add new knowledge to the discipline.

Fundamental research is carried out to scientifically enhance the organized body of knowledge of a discipline. Also know as basic research, it is concerned with formulation of theory and generalizations of principles. To evaluate and expand a formulated theory it may use empirical data. Basic research involves systematic, highly sophisticated scientific techniques. Fundamental research may not suggest the solutions of immediate problems, it rather draws long term conclusions.

3. Quantitative v/s Qualitative research

Quantitative research is based on quantitative variables, which can be measured in appropriate units. These involve objects and individuals that vary in size, quantity, amount, scale or degree. For example, prices of commodity can be measured in rupees, weight of a product is measured in kilograms and the mileage of vehicle is measured in kilometers per liter.

Qualitative research, on the other hand, is based on qualitative variables, which vary in quality of type. These variables cannot be measured on a scale or in any units. Social scientists use qualitative research for studying human behaviour. In market research surveys qualitative research is carried out to investigate the likes and dislikes of customers. It helps in understanding the current pattern of demand of a company's products.

4. Conceptual v/s Empirical research

Conceptual research involves the development of new theories, abstract ideas, and generalized principles. Philosophers, intellectuals and thinkers carry out this kind of research. On the basis of their conceptual knowledge they build theoretical models. Conceptual research is an intellectual process to develop and verify knowledge.

Empirical research is based on observation and experimentation. The information collected in the form of facts develops the conclusions and theories about a phenomenon. The models, so developed, can again be verified by a replication of data collection. To test a given hypothesis empirical research is most popular and powerful tool in the modern world.

5. Other types of research

Any research study is derivation of one or the other of above four types of research. One can further classify a research on the basis of its purpose, time taken and the discipline of knowledge it relates to. For example, Historical research is the study of past events, historical documents, remains and relics. Clinical research is employed to study the effects of a new drug. Market research is performed to forecast the potential demand of a product. One- time research is carried out on a small scale in short period with a specific purpose. Educational research is directed towards the study and development of educational system. Social research is concerned with the social problems of the society. Field research is done by going out in the field or market, where as Laboratory research is carried out with in four walls of a laboratory.

Q5. Explain the significance of research in modern times.

Ans :

(i) Research inculcates scientific and inductive thinking and it promotes the development of logical habits of thinking and. Organisation.

(ii) The role of research in several fields of applied economics, whether related to business or to the economy as a whole, has greatly increased in modern times.

(iii) Research provides the basis for nearly all government policies in our economic system.

(iv) Research has its special significance in solving various operational and planning problems of business and industry.

(v) Research is equally important for social scientists in studying social relationships and in seeking answers to various social problems.

In addition to what has been stated above, the significance of research can also be understood using view the following points:

(a) To those students who are to write a master's or Ph.D. thesis, research may mean a careerism or a way to attain a high position in the social structure;

(b) To professionals in research methodology, research may mean a source of livelihood;

(c) To philosophers and thinkers, research may mean the outlet for new ideas and insights;

(d) To literary men and women, research may mean the development of new styles and creative work;

(e) To analysts and intellectuals, research may mean the generalizations of new theories.

1.2 Steps Involved in Research

Q6. Describe the steps involved in research process.

(OR)

Describe briefly the research process and its stages.

(OR)

Explain in detail various stages of research process.

Ans : **(Imp.)**

Research is a search for knowledge. It helps in taking appropriate decisions. Research involves asking a question and then trying to find an answer to it. Research is essentially a systematic, scientific and structured inquiry seeking facts through objective methods. Therefore a research must have a clearly defined step-by-step process. A knowledge of the research process is essential both for those who conduct the research and for those who wish to be benefited by the conclusions drawn from the research. A meaningful knowledge should have a definite purpose and direction.

In developing a research process, one would like to list the sequence of step-by step activities. In a research process these steps are inter- dependent and may overlap each other. They may not follow a strict sequence and the researcher has to be vigilant of their order continuously through out the research process. However, one can broadly enlist the main steps involved in a research process as a procedural guideline to the researcher. These steps are:

1. Problem formulation
2. Literature survey
3. Development of hypothesis
4. Research design
5. Choice of sample design
6. Data collection
7. Analysis and interpretation of data
8. Hypothesis testing
9. Interpretation of results
10. Report writing

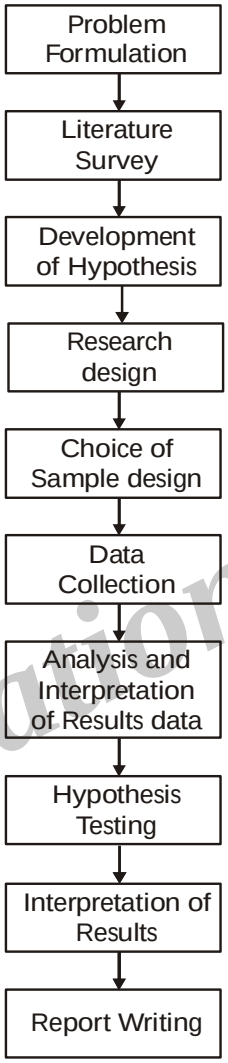


Fig.: The Research Process Flowchart

The above procedure can be depicted in a diagrammatic form as shown in the flowchart in figure. A brief description of the above steps is given below.

1. Problem formulation

Formulation of a problem is the first and foremost step in a research process. It is not always easy to identify and define a problem in an ever-changing business environment. A researcher not only discovers and defines a problem area but also a specific problem within that area concerning his interest in business. The problem should be clearly and precisely stated. The statement of the problem must be complete.

The problems in a business may sometimes be obvious and one can pinpoint them. Many a problems is not so apparent and needs explorations. Thus, first of all one has to identify a problem specifically and thoroughly, and then it has to be expressed in scientific terms so that statistical analysis can be performed on that problem.

2. Literature survey

After the formulation and identification of a problem, the next important step is the review of literature survey. An exhaustive and critical review of professional literature familiarizes the researcher with the current state of knowledge. It helps in understanding of the problems and hypothesis that others have studied. It clarifies the concepts, theories, major variables involved, operational definitions and research methods used in the past. This contributes to the cumulative nature of scientific knowledge.

Every year thousands of articles, books and monographs are published in any field of study. Therefore, it is important to sort out the relevant literature connected with the field of one's interest. It is best to begin any search for literature with one of the guides to published literature. These guides are increasingly computerized and include bibliographies, indexes and abstracts.

With the advent of Internet the modern life has changed drastically. One can find an ocean of information within the four walls of one's study room through Internet. Some of the popular search engines like google, yahoo and rediff are becoming more popular in searching for literature on any topic.

3. Development of hypothesis

Once a problem is defined and a review of literature is made, the next step is to define clearly the hypothesis in a research problem. A hypothesis is a tentative assumption in a research problem, which has to be tested empirically with the help of observed data. When formulating a hypothesis, a researcher does not know whether it will be rejected or accepted. A hypothesis is constructed and tested; if it is rejected, another one is formulated; if it is accepted, it is incorporated in the scientific body of knowledge.

One should arrive at a clear and specific working hypothesis for which research methods already exist. A good hypothesis states a research problem in concise and precise terms so that the researcher is focused on the problem at hand.

4. Research design

A research design is a well-defined plan of action. It is a planned sequence of the entire research process. It is a blue print of research activity. In a big business scenario designing a research study is very complex. Therefore, a research design may change during the operation of a project. A good research design must use minimum of resources like time, money and manpower. A research design must be able to translate the general scientific model into a practical research operation. A scientifically developed research design possess the characteristics like

i) Objectivity

ii) Reliability

iii) Validity

iv) Generalization

5. Choice of sample design

In any investigation the group of all items, objects or individuals under study is called 'population' or 'universe'. For all purpose of determining population characteristics, instead of enumerating entire population, some items of the population, called a sample, are observed. Then the sample characteristics are utilized to approximately determine or estimate the population. For example, on examining the sample of particular product, we arrive at a decision of purchasing or rejecting that product. There will be surely some error in such an approximation and is inherent and unavoidable in any and every sampling scheme. But samples results in considerable gains in terms of time, money, accuracy and efforts.

Drawing a sample of some predetermined size from an entire population is not a child's play. These have to be a systematic plan to choose the sample items. This plan or a technique of drawing a sample is known as sample design or sample plan or sampling technique. Researchers have suggested various sample designs. One research situation may be different from another, therefore, simple random sample, though most popular, may not be suitable in each case. Depending on the requirement of a situation one can choose one of the following sample designs:

i) Purposive or Judgment Sampling
ii) Simple Random Sampling
iii) Stratified Random Sampling
iv) Systematic Sampling
v) Cluster Sampling
vi) Area Sampling
vii) Multi-stage Sampling
viii) Multi-phase Sampling

6. Data collection

Once a sample design is formulated, the next step in a research process is the collection of relevant data. There can be two sources of data

i) Internal data, that refers to the happenings and functions of a business organization. For example, the sale purchases details of a company.

ii) External data, which is related to outside sources and external agencies. There are two types of data

(a) Primary data

(b) Secondary data.

(a) Primary date: Primary data are those observations, which are collected by an investigator for the first time.

Methods of collecting primary data are:

i) by direct observation and experimentations
ii) by direct personal interview
iii) by direct interviews through phone, sms and email.
iv) by indirect personal interview
v) by mailed / emailed Questionnaire
vi) by schedules through enumerators

(b) Secondary date: Secondary data are already available in the records and have been collected by some other researcher for the purpose of studying a similar problem.

Methods of collecting secondary data

i) International organizations like WHO, UNO etc.
ii) Government publications like economic survey, CSO, NSSO.
iii) Journal and Newspapers
iv) Research articles
v) Reports of business organization and financial institutions.

A method and source of data collection is chosen by an investigator taking into account the objectives and requirements of the inquiry. The adopted method should incur minimum cost and time should have a reasonable level of accuracy and unbiasedness.

7. Analysis and interpretation of data

After the collection of data, what we have is a huge chunk of observations and numerical values. The data at the beginning are in raw form. For the purpose of applying further statistical techniques, one has to put the raw data in a useful form by classification, tabulation and categorization of data. If one has to feed the data in a computer, the data should bear the same form as required by the software used. This kind of processing of data involves one or more of the following activities:

i) coding
ii) labeling
iii) editing
iv) tabulation
v) classification

8. Hypothesis testing

After analyzing and processing of data, it is time now to test the hypothesis that were formed in step 3 of the research process. A hypothesis is skeptically formulated regarding the relationship between phenomena and variables involved in a study. Then by empirical investigation the hypothesis is tested for possible acceptance or rejection. In other words, the researcher decides on the basis of the observed facts that he has collected, whether or not an assumption is valid. A hypothesis is tested by making use of a predefined decision rules established in statistical methods. Some of the popular statistical tests are, Z- test, Chi- square test, t-test and F- test.

In a situation where no hypothesis is formulated in a study, the observations are made on the data directly and conclusions are drawn to formulate new generalizations and assumptions for future purposes.

9. Interpretations of results

After the data collection and testing of hypothesis one has to reach to the conclusions of the research study. These conclusions are the most vital outcomes of the study and have to be dealt with very carefully. On the basis of findings of the research work done we draw inferences about the phenomenon under study. This is a useful activity as without any outcome a research study is fruitless. The results obtained from the analysis of data are to be interpreted skillfully. A wrong interpretation my lead to wrong decisions. Interpretation may also lead to generalizations of the phenomena understudy. It may also help in developing new theories and can suggest new research problems to be explored in future.

10. Report writing

Last but not the least is the step of reporting the facts and findings of the research study. A report is a summary of the whole research process. The layout of a report must be attractive. The words used in the text must be easily comprehensive to a reader. Even a non- technical person understands a good report. In the beginning of the report one should give the title, time period of work, acknowledgment and preface. In the main text an introduction to the problem, summary of findings, results and inferences, and then the recommendations of the researcher are given. The report should conclude with appendices, bibliography and a subject or / and author indexes.

Q7, What is research methodology? Explain the mathematical tools for the analysis of research methodology.

Ans :

Research methodology refers to the system of models, procedures and techniques which are used to determine the results of a research problem. It simply refers to the systematic procedure of solving any research problem. It is variable in nature and may vary from one research to another. It has a narrower scope and is not common for every research. It basically aims at only collecting and arranging the factual information related with the research topic. The different types of research methodology include observation, interviews, questionnaire documentary study and so on.

1. Statistical Methods or Techniques

The statistical methods which are used in the process of analysis are further classified into various methods such as,

(i) Mean, median and mode are the methods which are used to find the measures of central tendency.

(ii) Variance, coefficient of variance, quartile deviation coefficient of skewness etc., are used to find measures of dispersion.

(iii) Forecasting methods

(iv) Conjoint analysis

(v) Sampling methods

(vi) Discriminant analysis

(vii) Test of hypothesis

(viii) Factor analysis

(ix) Factorial design.

2. Operation Research Methods or Models

The methods of operation research includes the following,

(i) Linear programming

(ii) Non-linear programming

(iii) Goal programming

(iv) Integer programming

(v) Dynamic programming

(vi) Distance related network techniques

(vii) Project management

(viii) Game theory

(ix) Queueing theory

1.3 Identification of Problem

Q8. What are the variables reviewed in identifying a problem?

Ans : **(Imp.)**

An organization while dealing with the market dynamics encounters numerous problems that lot be identified clearly. Hence it is imperative that the researcher understands the context of the problem and manages to successfully identify the problem. The task of identification of the problem involves a comprehensive discussion and analysis of the associated content.

(a) Discussion With Management

The starting point for identifying the research problem is the management itself. A discussion with the management will help understand the nature and kind of decision that the managers have to make. This will help the researcher understand the kind of information that the management is expecting from the research results.. Basically, while interacting with the management the researcher moves from understanding the management problem to defining the research problem. The management can provide valuable input to the researcher in understanding the genesis of the problem and the impact that the problem is having on the key performance variables. It can be said that the management can convey to the researcher the symptoms of the problem that they are encountering and leave the cause identification to the researcher e.g. the manager can convey that they are facing the problem of declining market share in a particular segment and can leave it to the researcher thereby to find out the causes of the declining market share

(b) Expert Review

The next variable involved in the problem identification stage are the experts, who can be people having considerable experience and knowledge about the market dynamics of the concerned industry. The modus operandi for extracting information from the experts is an unstructured personal interview, where the researcher goes are with a list of topics that he would like to discuss with the experts but leaves it to the experts to provide their input freely. The selection of the experts is done subjectively by the researcher himself, hence a word of caution while creating his list of experts. The researcher should be careful that he includes only those people who are genuinely possess the relevant experience and not those who claim to be the owners of the experience. Secondly while developing his list he should also ensure their availability and accessibility.

(c) Literature Review

The researcher at this stage may review all the available conceptual literature concerning the theories and concepts related to the problem as well as the empirical literature comprising of studies done earlier and bearing similarity to the problem under study. It is also possible for the researcher to get in touch with people who have authored books or conducted research relevant to his area of study. Literature review helps the researcher in two ways ; firstly it helps him in specifying his research problem in a meaningful context, secondly it would provide him with an insight into the methods and techniques adopted for handling such problems. The researcher can either access bibliographic databases which

display only the bibliographic citations like name of the author, title of the book, publisher, year, volume and page number. He can also use abstract database which along with bibliographic citations also provides him with an abstract of the article. The researcher can also use full text databases which contain the entire text.

(d) Environment Analysis

This allows the researcher to understand the background of the client's firm as well as the industry in which he is operating. The competitive position of the firm in the industry becomes clear after reviewing the environmental variables. The researcher often reviews the previous trends and forecasts that are available and compares the current situation in light of such data. The researcher also reviews various macro-economic variables like the political, economic and legal environment as it effects the firm of his client. This helps him to get a better understanding of the opportunities and the threats that the firm is facing.

1.3.1 Steps Involved in the Selection of Problem

Q9. Explain the process of defining a problem.

(OR)

Describe various steps involved in the selection of problem.

Ans :

The following steps can be followed when defining the problem :

1. The researcher should develop a conceptual framework of the problem. The background of the study, underlying theoretical and conceptual basis should be carefully understood. The researcher should make a critical examination of the related studies.
2. In the next step the researcher should state the unit of analysis. It would help him to define the limit of his study. The unit of analysis could be an individual, a social structure like a household or an organization etc. e.g. to study drug abuse, one may use students or labourers as their unit of analysis. In case of a study on vehicle ownership a household can be a unit of analysis. It is important to keep in mind that the unit of analysis suits our purpose of study. If the objective of the study is to study individual behaviour e.g. in the above example on drug abuse study, the unit of analysis is an individual, student or a worker rather than a school, institution or an organization.
3. The researcher should now determine the essential and relevant variables. A variable is something that can be observed, manipulated and changes in value in response to certain stimuli. The variables which directly affect the study are made a part of the study. The variable that is to be predicted or explained is called as the dependent variable and the variable that influences the dependent variable is called as the independent variable. The research may also need to identify the extraneous variables i.e. those variables that are not directly a part of the study but may influence the outcome of the study e.g., a study on relationship between tuitions (independent variable) and performance (dependent variable) may have IQ as an extraneous variable. A clear identification of the variables will help in formulating the correct relationships and controlling the extraneous variables effectively.
4. Now the researcher must specify the relationship which in his opinion exists between the variables. Depending on the purpose of the study the researcher has to decide which relationship would form a part of the study and which are to be ignored. A well thought decision will help the researcher in having a precise set of objectives and the resources would be optimally utilized on the stated objectives.
5. The last stage is of developing a hypothesis. Once the problem to be tackled has been finalized, the variables identified, the relationship stated, the researcher should now formulate a tentative solution to the problem. These proposed solutions are called

as hypothesis, which the researcher would proceed to formulate on the basis of facts known or collected by him. Whether these relationships are scientifically maintainable or not, will be decided after the researcher collects and analyses his data. In case of studies, which are not hypothesis-testing, the researcher may frame a set of research objectives. After the formulation of the working hypothesis, the researcher is now ready to prepare the research proposal.

1.4 RESEARCH DESIGN

1.4.1 Meaning

Q10. Give various definitions of research design explaining its meaning.

(OR)

What is a research design?

(OR)

Define research design.

Ans :

Meaning

A research design is a controlling plan for a research study in which the methods and procedures for collecting and analyzing the information to be collected is specified. It is a framework or plan for study that guides the collection and analysis of data.

The word 'design' means to work out the structure of form', as by making a sketch or plan. Thus, 'Research Design' is planning a strategy or drawing a blue print of conducting research. It is a guideline for collecting and utilizing data so that desired information can be obtained with sufficient precision and hypothesis can be tested properly. A research is designed for the purpose of producing results that may be applied to real world situations. It not only enables a researcher to anticipate potential problems that can occur during the actual operation of the research, but also to limit boundaries of research study.

Definitions

Some of the popular definitions of research design are:

(i) **According to Miller,** "Research design is the planned sequence of the entire process involved in conducting a research study."

(ii) **According to Selltiz and others,** "Research design is a catalogue of the various phases and facts relating to the formulation of a research effort. It is an arrangement of the essential conditions for collection and analysis of data in a form that aims to combine relevance to research purpose with economy in the procedure".

(iii) **According to Anonymous,** "A research designates the logical manner in which individuals or other units are compared and analyzed, it is the basis of making interpretations from the data".

Q11. Explain the need for research design.

Ans :

Research is a scientific investigation of a problem for which we need a systematic planning of research.

For a successful research we need a research design because it includes

(i) The formulation of a strategy to resolve a particular question

(ii) The collection and recording of information and evidence

(iii) The processing and analysis of these data and their interpretation and

(iv) The publication of results.

A research design states structure and process of conducting a research process. Thus, it shows a path to researcher without which he may be lost or confused as to what next step he has to take. More so, it also takes care of budget and time frame of the research study. All this planning can only make a research study a success story.

Q12. Elaborate important features of a good research design.

(OR)

Explain the various features of research design.

Ans :

There are some features, however, a good research design should posses.

1. Freedom from bias

A good research design should ensure that the method of data collection and analysis would not cause the data to vary in a systematic way. That is to say that the data should be free from systematic errors.

2. Freedom from confounding

In a good research design the variables involved in the study are separated from each other so that they do not influence each other.

3. Control of extraneous variables

In a well-designed research study the variables that are not under scrutiny do not influence the experimental variables in a systematic way for example things like temperature, time of day etc.

4. Statistical precision for testing hypothesis

A research design should ensure that the data are recorded at a level of precision that will yield statistically meaningful results.

5. With in resources

A design should draw limits of a research study so that it could be completed within available resources like time, money and staff.

6. Optimality

The best research design is one, which yields maximum precision in terms of bias and variance using minimum resources in terms sample size, time and money.

7. Objectivity

If operated by more than one researcher a good research design obtains same results. Thus, a good research design should be free from the subjectivity of its performer.

8. Flexibility

It is often observed that one has to deviate from the basic research design during the operation of the research study due to real world problems. A good research design is one, which not only has the potential to predict such practical problems, but also is flexible enough to incorporate changes in it whenever needed.

1.4.2 Types

Q13. Explain the major types of research design.

(OR)

Discuss in detail classification / types of research design.

Ans : **(Imp.)**

After the formulation and definition of research problem, the next step is to choose an appropriate research design. Every research study is unique in itself, but there are certain things common in these studies. On the basis of these commonalities one can categorize the research studies by research methods and procedures used to collect and analyze data. Accordingly a research design is chosen. There are three basic types of research designs:

1. Exploratory Research Design
2. Descriptive or diagnostic research design
3. Causal or Hypothesis testing or Experimental research design

1. Exploratory Research Design

Exploratory research is defined as collecting information in an unstructured and informal way. For example, a restaurant owner may regularly visit other competing restaurants in order to gather information about menu selection, prices and service quality.

In exploratory type of research, the investigation may be conducted because a problem has not been clearly defined. It helps in determining the best research design, data collection method and selection of subjects. Usually exploratory research is qualitative in nature. Some times exploratory research may even conclude that a perceived problem does not actually exist.

Generally an exploratory research design helps in finding out the feasibility of the research problem, getting familiar with various components of the study, generating new ideas, and formulating the hypothesis. Exploratory research designs are of different forms depending on the nature and objectives of the study. The following three forms are most popular:

(a) Literature Survey: In any research, review of literature is an essential part. The literature survey is carried out at a preliminary stage of the research. Through the review, one understands the work that has already been done and what more can be explored in one's chosen field. The theories and techniques used in the existing literature can be used in the present analysis or these can be modified to give better results.

The literature are the documentary sources of information which are contained in the published and unpublished documents, reports, statistics, manuscripts, letters, diaries, and so on. It is important for scientific workers to scrutinize these sources very closely. Since not all documents can be consulted, it is best to start a selective process early. The theory and techniques of the literature must serve useful purpose in the present study. And, their meaning should not have altered with changing circumstances with the passage of time.

(b) Expert Survey: Expert Survey or experience survey means consulting the experienced researchers who are experts in the field of study. One should not be shy in taking advice and guidance of such people. They should be given sometime with the problem before asking them questions about the study, so that they can give their opinion after a good thought on the problem.

(c) Example Survey: In case of a new type of studies sometimes neither much literature nor expert advice is available. In such situations it is advisable to go through some case studies performed in the past. This refers to 'insight stimulating examples'. Single cases or a group of cases, as may be relevant to the research study are selected and studied in order to collect data for main study.

2. Descriptive (or) diagnostic research design

Descriptive research refers to a set of methods and procedures that describe the study variables. Descriptive studies portray these variables by answering who, what, why and how questions. These types of research studies may describe such things as consumer's attitudes, intentions, behaviors or the number of competitors and their strategies.

Descriptive research is also known as statistical research or diagnostic research. It describes data and characteristics about the population or phenomenon being studied. The description is used for frequencies, averages and other statistical calculations.

The process of conducting descriptive research can be linked to that of passing an idea through an hourglass. The research starts with a consideration of the larger issues of interest, and these are then narrowed into a specific questions (hypothesis) that can only be evaluated with some degree of control. The components of the hypothesis are operationalized into observable units and behaviors to ensure that the independent and dependent variables can be observed and measured. Research is then conducted to observe the relationships of interest, in the context of the specified research environment. Observations are made, and data are collected to reflect behaviors, changes and other indicators of interest. The data are filtered and analyzed in order to generate conclusions that may support or refute the hypothesis, and then everything is considered in the context of the bigger picture, which usually includes reference and association to the board issues that started the process.

Although data description is factual, accurate and systematic, the research cannot describe what caused a situation. Thus, descriptive research cannot be used to create causal relationship where one variable affects another.

3. Causal (or) Hypothesis testing or Experimental research design

Causal research designs are used in hypothesis testing research or experimental research studies. This type of research design is conducted by controlling various factors to determine which factors are causing the problem. It isolates causes and effects. By changing one factor, say price you can monitor its effects on a key consequence such as sales. Although experimental research can give a high level of understanding of the variables under study, the designs often require experiments that are complex and expensive. Some of the popular experimental designs are:

(a) Completely randomized design

(b) Randomized block design

(c) Latin square design

(d) Factorial design

Q14. How do exploratory, descriptive and casual studies differs from each other?

(OR)

Compare and contrast exploratory, descriptive and casual studies.

Ans : **(Imp.)**

S.No.	Exploratory Research	Descriptive Research	Causal Research
1.	As the name indicates exploratory, it aims at understanding and discovering ideas.	As the name indicates descriptive, it describes the characteristics of market.	As the name indicates causal, its main objective is to identify cause and effect relationship among variables.
2.	Exploratory research is conducted for the following purposes: Develop hypothesis, define problem more precisely, identify alternative course of action etc.	Descriptive research is conducted for the following reasons: To describe characteristics of relevant perceptions of group, to determine product characteristics, to determine the degree in which marketing variables are available etc.	Causal research is conducted for the following purposes: To understand which variable are the cause and which are effects, to determine relationship between causal variable and the effect to be predicted.
3.	It is informal, unstructured, flexible and involve small samples.	It is formal, pre-planned, structured and based on large samples.	It manipulates one or more independent variables. It is planned and has structured design.
4.	It focuses on qualitative analysis.	It focuses on quantitative data.	It also focuses on quantitative analysis.
5.	It produces uncertain results.	It produces the conclusive results.	It also produces conclusive results.
6.	Exploratory research uses different methods such as, expect survey, pilot survey, secondary data analysis and qualitative analysis.	Descriptive research uses secondary data sources, survey of large sample panel and distribution.	Causal research uses experiment method.
7.	It is mostly followed by further exploratory or conclusive research.	To know the outcome, findings are directly used as input into decision making.	To know the outcome, findings are used as input into decision making.
8.	Exploratory research is possible only in early stages of decision making where the researcher is uncertain about the nature of the problem.	Descriptive research can be conducted only when management is aware of problem but does not have complete knowledge.	It identifies cause and effect relationship if the research problem is been narrow defined.
9.	Exploratory research deals with ambiguous problem.	Descriptive research deals with partially defined problem.	In causal research, the problem is j clearly defined.

Q15. What is experimental design? Explain different types of experimental design.

Ans :

An experimental design is a set of procedures specifying,

(i) How are these units to be divided into homogeneous sub samples?

(ii) What independent variables or treatments are to be modified?

(iii) What dependant variables are to be measured?

(iv) How the extraneous variables are to be controlled?

Under experimental design, the researcher designs an experiment where a change in a dependent variable could be attributed to any one particular independent variable.

Types

There are different types of experimental designs. Four major types are as follows,

1. Factorial Design

Factorial design is a statistical experimental design that measures the effects of multiple independent variables by allowing interactions between variables. The main features of this design is that it explains the simultaneous effect of multiple variables that differ from the sum of their effects taken separately. For

instance, a respondent likes chocolates and is also fond of fruits. But the same respondent doesn't like fruit-based chocolates.

The drawback of this design is that, it gives numerous treatment combinations even with a small increase in the number of variables and provide unnecessary information to the researcher.

2. One-shot Case Study/After-only Design

In this design, an independent variable is modified and the dependent variable is measured after the lapse of a reasonable time.

XO_1

Where,

X = Change in the independent variable

Distance between X and O = Time duration

O_1 = Measurement of the dependent variable.

However, since the test ignores the value of dependent variable before an experiment, it is not a true experimental design. Also, it excludes the effects of extraneous variables and hence is a quasi-experimental design. Researchers select test units arbitrarily so symbol R is not used. When an after-only design takes into consideration extraneous variables, it is called 'after-only' control group design or static group design.

3. One-group, Pretest Design/Before-After, One Group Design

In this design, we measure the dependent variable before test and after changing the independent variable, it is measured once again to see the effects of the changes. These effects are calculated as $O_2 - O_1$ the validity of this calculation may be inaccurate because extraneous variables are uncontrollable.

$O_1 X O_2$

Where,

O = Measurement of dependent variable before test

X = Change in the independent variable

O_2 = Measurement of dependent variable after test.

Since there is only one group of survey to change the independent variable, so it is termed as the experimental group and it excludes extraneous variables so, this is also a quasi-experimental design.

4. Before-after with Control Group

'Control Group' is that, which consists of subjects that are not being tested with the modification of independent variable. A true experimental design can be established by considering experimental group and control group. This design is also termed as pre-test (or) post-test, control group design or external group design.

Dependent variables are measured for both the groups before and after the test. The comparison gives the effect of an experiment.

Diagram

Experimental group	O_1	X	O_2
Control group	O_3	X	O_4

$$E = (O_2 - O_1) - (O_4 - 0_3)$$

Where,

E = Experimental effect.

5. Four-group, Six-study Design

This design is used when there is a close relationship between respondents and the interview method. It is mostly used when the information is sought directly in an undisguised method. Following is the symbolic representation of the design.

R	O_1	X	O_2
R	O_3		O_4
R		X	O_5
R			O_6

The experiment result is measured in different ways such as O_2–O_1, O_4–O_2, O_6–O_5, O_4-O_3 and also (O_2–O_1)–(O_4–O_3). The following 2 × 2 table shows the after measurements:

	NoX	X
Taking 'before measurement'	O_4	O_2
Without taking 'before measurement'	O_6	O_5

The difference between the means of these two columns, show the result or experiment. The difference between the row means, shows the basis for estimating the testing effect. Lastly, the effect of extraneous variables related to history and maturation is measured by O_6–O_1, O_6–O_3 and O_4–O_1.

Four-group, six study design is a before-after with control experiment run simultaneously with an after-only with control experiment. Thus, it controls all the sources of experimental errors subject to control by designs.

Experimental design is better than descriptive research design because it explains the cause and effect relationship. With controlled experiments, the researcher can have a clear understanding of the cause and effect relationship of a research problem. Thus, it serves better than Descriptive Research to the management in decision making.

Q16. Explain various steps involved in research design process.

Ans :

Step-1: Identification of the Research Problem

Identifying the research problem is one of the most important part of the research process. It involves the specification of the information that is required by the management. If a problem is not defined properly, then the information gathered through research is of no value. Identification of the research problem involves four interdependent steps. They are,

(i) Clarification of management problem/ opportunity.

(ii) Analysis of the situation

(iii) Development of the model, and

(iv) Requirements of the information should be clearly specified.

Step-2: Assessment of the Value of Information

Once the research problem is identified, the decision maker moves towards its selection by collecting information from their past experiences.

Decision maker buys the additional information depending on the quality and price of the information. If information is reliable, then the decision maker will purchase it at any cost without any delay. To evaluate the value of information, two different approaches are used. They are Intuitive Approach and Expected Value Approach.

Step-3: Appropriate Selection of Data Collection Approach

The selection of data collection method (s) is an important task in a research design. In this stage of the design process, creativity and judgement play an important role but are also influenced by the type of information required, its value and the features of the respondents. Based on the nature of the problem, data collection methods which can be used are secondary data, survey data and experimental data.

Step-4: Selection of Measurement Technique

In research design, selection of measurement technique is mainly dependent on the nature and value of information. The step of selecting measurement techniques must consider the information of both preceding and succeeding steps in a design process. Questionnaires, attitude scales, observation and depth interviews serve as the important measurement techniques in marketing research.

Step-5: Selection of Sample

Usually, marketing studies involve a sample rather than census of the whole group. Sample refers to a subgroup of total population related to the problem. Most of the statistical techniques consider probability sampling techniques.

Step-6: Selection of Method(s) of Analysis

Data analysis is a process of converting a sequence of recorded observations into descriptive statements or conclusions about relationships. In the nature of the sampling process, the measurement instrument and the data collection methods influence the decision of selecting an analysis. If this step is not carried out in advance, then it may cause a complete failure of the research project.

Step-7: Evaluate the Ethics of the Research

Marketing researchers limit their research activities only to the ethically sound activities. Ethically sound research involves the interests of the common people, the respondents, the client and the research profession of researcher.

Step-8: Forecasting Time and Financial Requirements

After evaluating the ethical soundness of a research design, the researcher must forecast the requirements of resources. Both time and the financial requirements need to be assessed. It is seen that both requirements are found to be independent because depending upon situations, time and money are found to be interchangeable.

Step-9: Preparation of Research Proposal

The research design process provides a framework to the researcher for both the establishment and control of the research project. It is usually documented and known as research proposal.

1.5 Measurement Levels / Scales

Q17. Define Measurement. Explain the objectives of Measurement.

Ans :

Definition

According to W.S. Torgerson "Measure ment is the assignment of numbers to objects to represent amounts or degrees of a property possessed by all of the objects'.

Scales

Scales in marketing need not necessarily imply all the physical measures. For example, a rank scale

does not possess additive property. It makes no sense to add two brands of ranks 1 and 2 to get a brand of rank 3.

Scaling is an advancement of the measuring concept that refers to the continuum on which, the objects to be measured are marked. While measurement is the actual assignment of numbers or symbols, scaling is the arrangement of these numbers in an order on a continuum. Such information helps the researcher in gaining the research objective of determining the stores image.

Objectives

The following are the objectives of measurement.

(a) Reliability

The measurement should be reliable by producing consistent results when certain research methods are repeated.

(b) Validity

An instrument is valid when it measures what it is supposed to measure, but since attitudes are elusive, validity is not possible.

(c) Sensitivity

The measurement should result in identifying changes or differences.

(d) Relevance

Facilitates the decision-maker by producing relevant information.

(e) Versatility

Versatility or robustness of measurement for various statistical interpretations is a desired goal, especially for assessing the results validity and for drawing maximum meaning.

Q18. Discuss in detail classification of measurement scales with examples.

(OR)

Discuss the four categories of measurement scales.

Ans : **(Imp.)**

There are four kinds of measurement of scales are :

1. Nominal scales
2. Ordinal scales / Ranking scale
3. Interval scales
4. Ratio scales

1. Nominal scales

In this scale, numbers are used to identify' the objects. For example. University Registration numbers assigned to students, numbers on their jerseys.

The purpose of marking numbers, symbols, labels etc. in this type of scaling is not to establish an order but it is to simply put labels in order to identify events and count the objects and subjects. This measurement scale is used to classify individuals, companies, products, brands or other entities into categories where no order is implied. Indeed, it is often referred to as a categorical scale. It is a system of classification and does not place the entity along a continuum. It involves a simple count of the frequency of the cases assigned to the various categories, and if desired numbers can be nominally assigned to label each category.

Characteristics

1. It has no arithmetic origin.
2. It shows no order or distance relationship.
3. It distinguishes things by putting them into various groups.

Use

This scale is generally used in conducting in survey's and ex-post-facto research

Example

Have you ever visited Bangalore?

'Yes' is coded as 'One' and 'No' is coded as Two'. The numeric attached to the answers has no meaning, and is a mere identification. If numbers are interchanged as one for No' and two for Yes', it won't affect the answers given by respondents. The numbers used in nominal scales serve only the purpose of counting.

The telephone numbers are an example of nominal scale, where one number is assigned to one subscriber. The idea of using nominal scale is

to make sure that no two persons or objects receive the same number. Similarly', bus route numbers are the example of nominal scale.

"How old are you"? This is an example of a nominal scale. "What is your PAN Card number?

Arranging the books in the library; subject wise, author wise - we use nominal scale.

It should be kept in mind that nominal scale has certain limitation, viz.

1. There is no rank ordering.
2. No mathematical operation is possible.
3. Statistical implication - Calculation of the standard deviation and the mean is not possible. It is possible to express the mode.

2. Ordinal scale / Ranking scale

It is a ranking scale wherein, assigning numbers to objects imply the extent of presence of some characteristics. For e.g., students in a class are ranked 1 to 10 as per the marks they obtained. Here, 1st rank indicates the student's better performance over the student ranking 10th. It should be noted that the scale indicates only the position or relative size differences and not the magnitude of a respondent or object. In the above example, we know the student ranking 1st is better than the other students but we do not know how better is the student than the others.

Example of this scales are: Occupational status - peon, steward, employee, manager and CEO, socio-economic classes - lower class, middle class and upper middle class etc. Statistics like rank correlation, percentile, quartile and median can be computed with this scale.

3. Interval scales

Interval scale is more powerful than the nominal and ordinal scales. The distance given on the scale represents equal distance on the property being measured. Interval scale may tell us "How far the objects are apart with respect to an attribute?" This means that the difference can be compared. The difference between "1" and "2" is equal to the difference between "2" and "3".

Interval scale uses the principle of "equality of interval" i.e.. the intervals are used as the basis for making the units equal assuming that intervals are equal.

It is only with an interval scaled data that researchers can justify the use of the arithmetic mean as the measure of average. The interval or cardinal scale has equal units of measurement thus, making it possible to interpret not only the order of scale scores but also the distance between them. However, it must be recognized that the zero point on an interval scale is arbitrary and is not a true zero. This, of course, has implications for the type of data manipulation and analysis we can carry out on data collected in this form It is possible to add or subtract a constant to all of the scale values without affecting the form of the scale but one cannot multiply or divide the values. It can be said that two respondents with scale positions 1 and 2 are as far apart as two respondents with scale positions 4 and 5. but not that a person with score 10 feels twice as strongly as one with score 5. Temperature is interval scaled, being measured either in Centigrade or Fahrenheit. We cannot speak of 50°F being twice as hot as 25°F since the corresponding temperatures on the centigrade scale. 100°C and -3.9°C, are not in the ratio 2:1.

Interval scales may be either numeric or semantic.

Characteristics

1. Interval scales have no absolute zero. It is set arbitrarily.
2. For measuring central tendency, mean is used.
3. For measuring dispersion, standard deviation is used.
4. For test of significance, t-test and f-test are used.
5. Scale is based on the equality of intervals.

Use

Most of the common statistical methods of analysis require only interval scales in order that they might be used. These are not recounted here because they are so common and can be found in virtually all basic texts on statistics.

Example

1. Suppose we want to measure the rating of a refrigerator using interval scale.

   It will appear as follows:

   (a) Brand name Poor.....Good

   (b) Price High Low High.....Low

   (c) Service after-sales Poor.....Good

   (d) Utility Poor.....Good

   The researcher cannot conclude that the respondent who gives a rating of 6 is 3 times more favourable towards a product under study than another respondent who awards the rating of 2.

2. How many hours you spend to do class assignment every day?

   (a) < 30 min.

   (b) 30 min to 1 hr.

   (c) 1 hr. to 1 ½ hrs.

   (d) > ½ hrs.

Statistical implications

We can compute the range, mean, median, etc.

4. Ratio scales

Ratio scale is a special kind of internal scale that has a meaningful zero point. With this scale, length, weight or distance can be measured. In this scale, it is possible to say, how many tunes greater or smaller one object is being compared to the other.

These scales are used to measure actual variables. The highest level of measurement is a ratio scale. Tins has the properties of an interval scale together with a fixed origin or zero point. Examples of variables which are ratio scaled include weights, lengths and times. Ratio scales permit the researcher to compare both differences in scores and in the relative magnitude of scores. For instance, the difference between 5 and 10 minutes is the same as that between 10 and 15 minutes, and 10 minutes is twice as long as 5 minutes.

Given that sociological and management research seldom aspires beyond the interval level of measurement, it is not proposed that particular attention be given to this level of analysis. Suffice it, to say that virtually all statistical operations can be performed on ratio scales.

Characteristics

1. This scale has an absolute zero measurement.
2. For measuring central tendency, geometric and harmonic means are used.

Use

Ratio scale can be used in all statistical techniques.

Example

Sales this year for product A are twice the sales of the same product last year.

Statistical implications

All statistical operations can be performed on this scale.

Q19. Compare and contrast Nominal scale, Ordinal scale, Interval scale and Ratio scale.

(OR)

Distinguish between Nominal scale, Ordinal scale, Interval scale and Ratio scale.

Ans :

The following are the differences between nominal, ordinal, interval and ratio scales.

S.No.	Nominal Scale	Ordinal Scale	Interval Scale	Ratio Scale
1.	Nominal scale involves labels. It is a qualitative scale in which numbers are regarded as labels (or) tags for identifying and classifying the objects.	Ordinal scale is a ranking scale in which the numbers assigned to the objects represents its characteristics or positions.	Interval scale helps in comparing the differences taking place between the objects. The zero point and the units of measurement are taken randomly.	Ratio scale helps the researchers to identify and rank the objects and compare the intervals or differences taking place between them. The ratios of scale values are also computed with the help of this scale. This scale has a fixed zero point.
2.	In marketing research, nominal scales help in identifying the respondents, brands, attitudes, stores and other objects.	In marketing research, ordinal scales help in measuring the attitudes, opinions, perceptions and preferences of the individuals.	In marketing research, interval scales help in measuring the attitudes, opinions and index numbers.	In marketing research, ratio scales help in measuring the sales, costs, market share and number of variables.
3.	The accuracy of nominal scales can be measured with the help of chi-square and binominal test.	The accuracy of ordinal scales can be measured with the help of rank order correlation, Friedman and ANOVA.	The accuracy of interval scales can be measured with the help of product moment correlations, t-tests ANOVA and regression factor analysis.	The accuracy of ratio scales can be measured with the help of coefficient of variation.

Q20. Define validity? Discuss in detail the different types of validity.

Ans : **(Imp)**

Meaning

Validity refers to the scale's ability to measure what is intended to measure. The problems may arise if the scale does not measure the intended measurement.

Types

There are three main approaches that deal with validity assessment. They are,

1. Face validity or content validity
2. Criterion validity
   (a) Concurrent validity
   (b) Predictive validity
3. Construct validity.

Let us discuss each validity measure in detail,

1. Face Validity or Content Validity

It refers to the subjective agreement between professionals that a scale logically seemed to show correctly what is intends to measure. The scale's content is appeared to be enough. A measure is said to have face validity, when the experts realize that the measure offers sufficient coverage of a concept.

The question such as "How many siblings do you have" is agreed to have face validity. But in scientific studies, the researchers want strong evidence due to the exclusive nature of measuring attitude and other cognitive phenomenon.

2. Criterion Validity

Criterion validity refers to the ability of any measure to correlate with other measures of the same construct. Criterion validity may be further classified into concurrent validity (or) predictive validity on the basis of their time sequence. Wherein "new" measurement scale and the criterion measure are correlated.

(a) Concurrent Validity: A concurrent validity is observed when the new measure is taken into consideration at the same time as the criterion measure and it is stated to be valid.

(b) Predictive Validity: Predictive validity is developed when a new measure forecasts a new event or when it correlates with a criterion measure managed at a later time.

3. Construct Validity

The construct validity is the ability of a measure to validate a network of related hypotheses created out of a theory on the basis of concepts. This type of validity is developed at the time of statistical analysis of the data. A researcher for achieving construct validity, should have already analyzed the meaning of the measure by developing convergent validity and discriminant validity.

(a) Convergent Validity: A convergent validity is similar to the criterion validity. To develop validity, the new measure must converge other measures of similar types. The measure of a theoretical concept includes convergent validity, when it is highly correlated with various measures of similar constructs.

(b) Discriminant Validity: A measure is considered to have discriminant validity when it has a low correlation with measures of dissimilar correlation concepts. Discriminant validity is a quite complex method of developing validity and it is not much concerned to applied researchers.

Q21. Define reliability. Discuss the various methods to measure the reliability of scale.

Ans : **(Imp.)**

Meaning

Reliability means the extent to which the scaling results are free from experimental error. In this case one would be concerned with the consistency of test results over groups of individuals or over the same individual at different times. Reliability, however, establishes an upper bound on validity. An unreliable scale cannot be a valid one.

Methods

In general, measurement of the reliability of a scale (or measurement instrument) can be obtained by any one of three methods,

1. Test-Retest

In measuring the reliability of a scale, the interest may some times center on the extent to which repeated applications of the instrument achieve consistent results, assuming that the relevant characteristics of the subject(s) are stable over trials. The test-retest method examines the stability of response.

One potential problem, of course, is that the first measurement may have an effect on the second one. Such effects can be reduced when there is sufficient time interval between measurements. If possible the researcher should allow a minimum of two weeks to elapse between measurements.

Reliability may be estimated by any appropriate statistical technique for examining differences between measures.

2. Alternative Forms

The Alternative Form Method attempts to overcome the shortcomings of the test-retest method by administering successively the same sample alternate equivalent forms of the measure. Equivalent forms can be used as instruments that are built in the same way to accomplish the same

thing but consists of different samples of items in the defined area of interest. The same types and structures of questions should be included in each form, but the specific questions would differ.

In applying the forms of the measurement device, they may be given one after the other or after a specified time interval depending upon the investigator's interest in stability over time.

Reliability is estimated by correlating the results of the two "equivalent" forms.

3. Internal Consistency

The internal consistency method estimates reliability within single testing occasion. In a sense, it is a modification of the alternative form approach, although it differs in that only scoring involves "alternatives". One application of the measurement instrument is sufficient to obtain the measure.

The basic form of this method is split-half reliability, in which items are divided into equivalent groups (i.e., odd- versus-even numbered questions or even a random split) and the item responses are correlated.

In practice, any split can be made. To correct the situation, a full-length scale will be more reliable than; a split (i.e., any ratio of altered test length to the original length). The generalized Spearman-Brown formula is applied.

$$r_n = \frac{nr}{1+(n-1)r}$$

Where,

r_n – Estimated reliability of the entire instrument.

r – The correlation between the half-length measurements.

n – The ratio of the number of items in the changed instrument to the number in the original.

When the length is doubled, as in the split-half method, the formula becomes,

$$r_n = \frac{2r}{1+r}$$

One obvious condition is that each split scale must contain enough item to be reliable. For a split-half scale, this is often considered to be eight to ten items, which means that the entire scale should consist of at least sixteen on twenty items. A potential problem arises for split-half, where the results may vary depending on how the items are split in half.

A way of overcoming this is to use coefficient 'alpha', which is a type of mean reliability coefficient for all possible way of splitting an item into half. Whenever possible, alpha should be used as a measure of the internal consistency of multi-item scales. Another approach of measuring internal consistency utilizes estimation of variances. In this case, reliability is defined as the proportion of the "true" variance to the total variance of the data obtained from a measurement instrument, or

$$r_{tt} = \frac{V_t - V_e}{V_t}$$

Where,

r_{tt} is the coefficient of reliability,

V_e is the error variance, and

V_t is the total variance.

If the measuring instrument is split into subsamples, such as a split-half, this formula gives results approximately the same as the Spearman-Brown correction.

Q22. Describe various sources of errors in measurement.

Ans :

(a) Respondent

At times the respondent may be reluctant to express strong negative feelings or it is just possible that he may have very little knowledge but may not admit his ignorance. All this reluctance is likely to result in an interview of 'guesses.' Transient factors like fatigue, boredom, anxiety, etc. may limit the ability of the respondent to respond accurately and fully.

(b) Situation

Situational factors may also come in the way of correct measurement. Any condition which places a strain on interview can have serious effects on the interviewer-respondent rapport. For instance, if someone else is

present, he can distort responses by joining in or merely by being present. If the respondent feels that anonymity is not assured, he may be reluctant to express certain feelings.

(c) Measurer

The interviewer can distort responses by rewording or reordering questions. His behaviour, style and looks may encourage or discourage certain replies from respondents. Careless mechanical processing may distort the findings. Errors may also creep in because of incorrect coding, faulty tabulation and/or statistical calculations, particularly in the data-analysis stage.

(d) Instrument

Error may arise because of the defective measuring instrument. The use of complex words, beyond the comprehension of the respondent, ambiguous meanings, poor printing, inadequate space for replies, response choice omissions, etc. are a few things that make the measuring instrument defective and may result in measurement errors. Another type of instrument deficiency is the poor sampling of the universe of items of concern.

1.6 SCALING

Q23. Define Scaling.

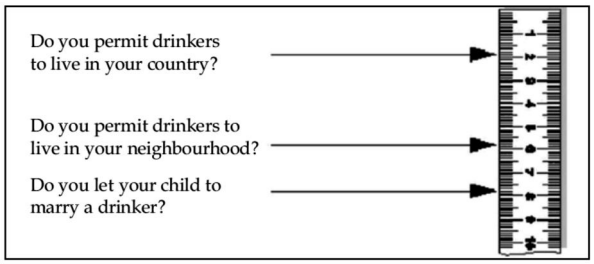
(OR)

What is meant by Scaling?

Ans :

Meaning

Scaling is a process or set of procedures, which is used to assess the attitude of an individual. Scaling is defined as the assignment of objects to numbers according to a rule. The objects in the definition are text statements, which can be the statements of attitude or principle. Attitude of an individual is not measured directly by scaling. It is first migrated to statements and then the numbers are assigned to them. Figure below shows the how to scale the attitude of individuals.



In the above figure, we are going to assess the attitude of an individual by analysing his thoughts about drinkers. You can see that as you move down, the attitude or behaviour of people towards drinkers become more provisional. If an individual agrees with a statement in the list, then it is more likely that he will also agree with all of the assertions above that statement. Thus in this example, the rule is growing one. So this is called scaling. Scaling is done in the research process to test the hypothesis. Sometimes, you can also use scaling as the part of probing research.

1.6.1 Scaling Techniques

Q24. Explain different types of Scaling Techniques.

Ans :

Conventional Scales

Conventional scales generally uses questionnaire format and it is further categorised into two types,

1. Comparative scales
2. Non-Comparative scales.

1. Comparative Scales

Comparative scales involve comparison of the object with the other similar objects of different companies. E.g. Pizza Hut's Pizza is better than Pizza Comer's pizza. Comparative scales can be either graphic or itemized. Graphic scales refers to responding on a line on a graph and itemised scale refers to responding by selecting a category from the given order.

Comparison can be made in pairs too. When a brand is selected by comparing multiple brands at a time, in pairs, it is known as paired comparison. If the number of brands is n, then the number of comparisons would be n(n – l)/2. For example,

brands are paired like and b, a and c, c and d, b and c, etc. now, the respondents select one from each such pair.

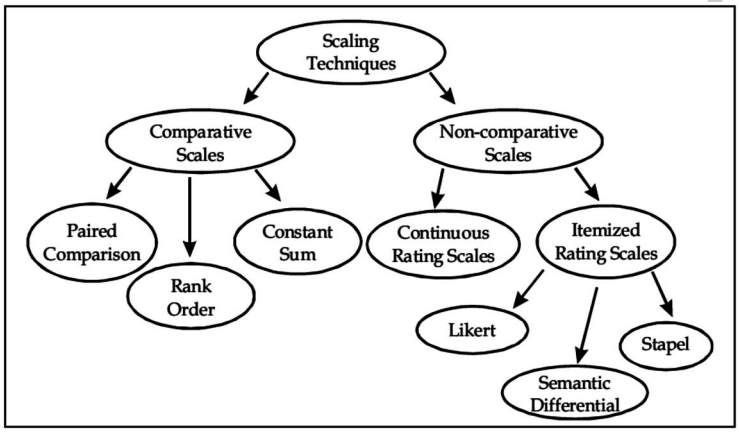
Example:

While choosing a restaurant, a consumer may rank the given factors in order of importance. He may assign ranks between 1 to 5 as most important factor.

The ranks given by the consumer will indicate the relative importance associated with different factors.

These comparative scales use ordinal scale and are measured in relative terms resulting in non-metric data.

Factor	Rank
Price	1
Variety of food	3
Food quality	2
Quality service	3
Seating arrangement	5



2. Non-comparative Rating Scales

Non-comparative rating scale, involves single brand rating. Non-comparative rating scales can also be either graphic or itemized.

Example:

In a study of consumer preferences for different restaurants, the customer is asked to rate the list of factors he would prefer while choosing a restaurant and mark (V) against the suitable rating. Rate 1 to 2 least important and Rate 5 to 3 most important factor.

Factor	1-Least Important 2 3 4 5-most important
Price	
Variety of food	
Food quality	
Quality service	
Seating arrangement	

Fig.: Classifying Scaling Techniques

Q26. Discuss in detail commonly used comparative scaling techniques with examples.

Ans : **(Imp.)**

The most commonly used comparative scaling techniques are as follows :

1. Paired Comparison

Here a respondent is asked to show his preferences from among five brands of coffee - A, B, C, D and E with respect to flavours. He is required to indicate his preference in pairs. A number of pairs are calculated as follows. The brands to be rated are presented two at a time, so each brand in the category is compared once to every other brand. In each pair, the respondents were asked to divide 100 points on the basis of how much they liked one compared to the other. The score is totally for each brand.

$$\text{No.of pairs} = \frac{N(N-1)}{2}$$

$$\text{In this case, it is} = \frac{5(5-1)}{2}$$

A & B	B & D
A & C	B & E
A & D	C & D
A & E	C & E
B & C	D & E

If there are 15 brands to be evaluated, then we have 105 paired comparison(s) and that is the limitation of this method.

Example:

For each pair of professors, please indicate the professor from whom you prefer to take classes with a 1.

	Cunningham	Day	Parker	Thomas
Cunningham	0	0	0	
Day	1		1	0
Parker	1	0		0
Thomas	1	1	1	0
# of timesPreferred	3	1	2	0

2. Rank Order Scaling

- Respondents are presented with several objects simultaneously
- Then asked to order or rank them according to some criterion
- Data obtained are ordinal in nature-Arranged or ranked in order of magnitude
- Commonly used to measure preferences among brands and brand attributes

Example:

Please rank the instructors listed below in order of preference. For the instructor you prefer the most, assign a "1", assign a "2" to the instructor you prefer the 2nd most, assign a "3" to the instructor that you prefer 3rd most, and assign a "4" to the instructor that you prefer the least.

Instructor	Ranking
Cunningham	1
Day	3
Parker	2
Thomas	4

3. Constant Sum Scaling

- Respondents are asked to allocate a constant sum of units among a set of stimulus objects with respect to some criterion
- Units allocated represent the importance attached to the objects
- Data obtained are interval in nature
- Allows for fine discrimination among alternatives

Example

Listed below are 4 marketing professors, as well as 3 aspects that students typically find important. For each aspect, please assign a number that reflects how well you believe each instructor performs on the aspect. Higher numbers represent higher scores. The total of all the instructors' scores on an aspect should equal 100.

Instructor	Availability	Fairness	Easy Tests
Cunningham	30	35	25
Day	30	25	25
Parker	25	25	25
Thomas	15	15	25
Sum Total	100	100	100

Q27. State the various commonly used non-comparative scaling techniques?

Ans :

There are four commonly used non-comparative scaling techniques. They are :

1. Continuous rating scale
2. Itemised rating scale
3. Simple/multiple category scale
4. Verbal frequency scale

Q28. Explain continuous rating scale with an example.

Ans :

The continuous rating scale is also known as a "Graphic Rating" scale. In this type of Non-comparative scaling technique, the respondents give their ratings by marking on a continuous line. Two opposite words

are labelled at both ends of the line. The line may have points like 1 to 100 for the understanding of the respondent. For example, while choosing a mobile, rating is given to the following criteria based on the importance given by respondent and criteria are marked at a proper distance.

	Attributes	Ranking
1.	Price Most	90 80 70 60 50 40 30 20 10 least
2.	Picture quality Most	90 80 70 60 50 40 30 20 10 least
3.	Internal-Memory Most	90 80 70 60 50 40 30 20 10 least
4.	Sound quality Most	90 80 70 60 50 40 30 20 10 least
5.	Camera Most	90 80 70 60 50 40 30 20 10 least

Therefore, the data received from continuous rating scale is in numeric form. But in comparison to other techniques it is very time consuming, and difficult for coding and editing.

Factors:

In continuous rating scale, few factors are taken into consideration. They are as follows,

(i) This technique is suitable only if the evaluative responses are taken on a single dimension.

(ii) The scale with numbers is more preferable than the scale with words.

Q29. Write about itemized rating scales? Explain them with an examples.

(OR)

Explain the construction of Likert Scale.

(OR)

Explain the construction of Semantic differential scale.

(OR)

Explain the construction of Staple scale.

Ans :

Itemized Rating Scales

Itemised rating scales are the scales with numbers or brief descriptions against each category that are ordered in terms of scale. The descriptions often include attitudes or behavioural measures. Therefore, these scales are also termed as attitude scales. Respondents mark the particular category on the scale that matches their response.

The itemised rating scales are further classified as,

1. Likert Scale

It is known as summated rating scale. This consists of a series of statements concerning an attitude object. Each statement has '5 points'. Agree and Disagree on the scale. They are also called summated scales, because scores of individual items are summated to produce a total score for the respondent. The Likert Scale consists of two parts-item part and evaluation part. Item part is usually a statement about a certain product, event or attitude. Evaluation part is a list of responses like "strongly agree" to "strongly disagree".

The five point-scale is used here. The numbers like +2. +1. 0. -1. -2 are used. Now.

let us see with an example how the attitude of a customer is measured with respect to a shopping mall.

S.No.	Likert scale items	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
1.	Salesmen at the shopping mall are courteous	-	-	-	-	-
2.	Shopping mall does not have enough parking space	-	-	-	-	-
3.	Prices of items are reasonable.	-	-	-	-	-
4.	Mall has wide range of products to choose	-	-	-	-	-
5.	Mall operating hours are inconvenient	-	-	-	-	-
6.	The arrangement of items in the mall is confusing	-	-	-	-	-

Table.: Evaluation of Globus-the Super Market by Respondents

The respondents overall attitude is measured by summing up his (her) numerical rating on the statement making tip the scale. Since some statements are favourable and others unfavourable, it is the one important task to be done before summing up the ratings. In other words, "strongly agree" category attached to favourable statement and "strongly disagree" category attached to unfavourable. The statement must always be assigned the same number, such as +2. or -2. The success of the Likert Scale depends on "How well the statements are generated?" The higher the respondent's score, the more favourable is the attitude. For example, if there are two shopping malls. ABC and XYZ and if the scores using the Likert Scale are 30 and 60 respectively, we can conclude that the customers' attitude towards XYZ is more favourable than ABC.

2. Semantic Differential Scale

This is very similar to the Likert Scale. It also consists of a number of items to be rated by the respondents. The essential difference between Likert and Semantic Differential Scale is as follows:

It uses "Bipolar" adjectives and phrases. There are no statements in the Semantic Differential Scale.

Each pair of adjective is separated by a seven point scale.

Notes:

Some individuals have favourable descriptions on the right side, while some have on the left side. The reason for the reversal is to have a combination of both favourable and unfavourable statements.

Semantic Differential Scale Items

Please rate the five real estate developers mentioned below on the given scales for each of the five aspects. Developers are

S. No.	Scale items	–3	–2	–1	0	+1	+2	+3	-
1.	Not reliable	_	_	_	_	_	_	_	Reliable
2.	Expensive	_	_	_	_	_	_	_	Not expensive
3.	Trustworthy	_	_	_	_	_	_	_	Not trustworthy
4.	Untimely delivery	_	_	_	_	_	_	_	Timely delivery
5.	Strong Brand Image	_	_	_	_	_	_	_	Poor brand image

The respondents were asked to tick one of the seven categories which describes their views on attitude. Computation is being done exactly the same way as in the Likert Scale. Suppose, we are trying to evaluate the packaging of a particular product. The seven point scale will be as follows:

"I feel.....

1. Delighted
2. Pleased
3. Mostly satisfied
4. Equally satisfied and dissatisfied
5. Mostly dissatisfied
6. Unhappy
7. Terrible.

3. Staple scale

Staple scale is a modification of semantic differential scale. Staple scale is a unipolar vertical scale with ten categories that measures attitudes. The respondents are required to show their accuracy on numerical response categories ranging from -5 to +5 without a zero point. A single adjective describing the object is placed in the middle of the scale.

Example

	+3		+3		+3
	+2		+2		+2
	+1		+1		+1
Strong scale	Moderate scale			Strong no-scale	
	–1		–1		–1
	–2		–2		–2
	–3		–3		–3

The data collected in staple scales is interval data. It is also used for the collecting the data through telephonic interview.

Factors:

The factors which are considered while using staple scale are as follows:

(i) The method of staple scale is specifically used where responses are rated on a single dimension.

(ii) This scale is much economical when more than one item are rated on a single dimension.

(iii) Discerning selective respondents are very much important in this method. Absence of these respondents may lead to errors in the data.

Q30. What are the major differences between Likert Scale and Semantic Differential Scale?

Ans :

The major differences between Likert and Semantic differential scales are as follows,

S.No.	Likert Scale	S.No.	Semantic Differential Scale
1.	Likert scale was developed by Rensis Likert which is also called "summated scale".	1.	Semantic differential scale was developed by Osgood and others. Semantic differential scale is also called "sensitivity (or) intensity scale".
2.	One main feature of Likert scale is that it is an attitude measurement scale, where attitudes are measured on the basis of 5 rated scale.	2.	Semantic differential scale is also an attitude measurement scale where each scale consists of two opposing adjectives such as good/bad, clean/dirty etc., Which are separated by continuum divided into 7 segments.
3.	In this scale, scores are assigned to each statement ranging from 1-5 (or) -2 to +2.	3.	In this scale, scores are assigned to each individual item ranging from 1-7 (or) -3 to +3.
4.	Usually, summated approach is used to analyze the collected responses.	4.	Usually, profile analysis approach is used to analyze the collected responses.
5.	Likert scale is used in conducting surveys. For example, in telephone surveys, internet surveys and face-to-face interviews.	5.	Semantic differential scale is used to compare various company brands, in the planning and development of marketing strategies and in conducting researches on customer satisfaction levels, brand awareness etc.

Q31. Compare and contrast comparative scales and non-comparative scales.

Ans :

S.No.	Comparative Scales	S.No.	Non-Comparative Scales
1.	Comparative scales involve comparison of the object with the other similar objects of different companies.	1.	Non-comparative rating scale involves scaling of each object independently of other objects.
2.	It is also known as non-metric scales.	2.	It is also known as metric scales or monadic scales.
3.	It uses ordinal scale for data generation.	3.	It uses interval scale for data generation.
4.	It generates non-metric data/non-numerical data.	4.	It can generate metric data/numerical data.
5.	The various comparative scaling techniques are, • Paired comparison • Rank order scaling • Constant sum scaling.	5.	The various non-comparative scaling techniques are, • Continuous rating scale • Itemized rating scale (likert scale, semantic differentia scale, staple scale) • Simple/Multiple category scale • Verbal frequency scale.

1.7 HYPOTHESIS

1.7.1 Meaning

Q32. Define Hypothesis. Explain the characteristics of Hypothesis.

Ans :

Meaning

Hypothesis testing begins with an assumption, called a Hypothesis, that we make about a population parameter. A hypothesis is a supposition made as a basis for reasoning.

Definition

i) **According to Prof. Morris Hamburg.** "A hypothesis in statistics is simply a quantitative statement about a population.

ii) **According to James E. Greighton,** "It is a tentative supposition or provisional guess which seems to explain the situation under observation".

iii) **According to Bruce W. Tuckman,** "A hypothesis then could be defined as an expectation about events based on generalization of the assumed relationship between variables".

iv) **According to George, J. Mouly,** "Hypothesis is an assumption or proposition whose testability is to be tested on the basis of the computability of its implications with empirical evidence with previous knowledge".

Characteristics

Hypothesis must possess the following characteristics:

(i) Hypothesis should be clear and precise. If the hypothesis is not clear and precise, the inferences drawn on its basis cannot be taken as reliable.

(ii) Hypothesis should be capable of being tested. In a swamp of untestable hypotheses, many a time the research programmes have bogged down. Some prior study may be done by researcher in order to make hypothesis a testable one. A hypothesis "is testable if other deductions can be made from it which, in turn, can be confirmed or disproved by observation.

(iii) Hypothesis should state relationship between variables, if it happens to be a relational hypothesis.

(iv) Hypothesis should be limited in scope and must be specific. A researcher must remember that narrower hypotheses are generally more testable and he should develop such hypotheses.

(v) Hypothesis should be stated as far as possible in most simple terms so that the same is easily understandable by all concerned. But one must remember that simplicity of hypothesis has nothing to do with its significance.

(vi) Hypothesis should be consistent with most known facts i.e., it must be consistent with a substantial body of established facts. In other words, it should be one which judges accept as being the most likely.

(vii) Hypothesis should be amenable to testing within a reasonable time. One should not use even an excellent hypothesis, if the same cannot be tested in reasonable time for one cannot spend a life-time collecting data to test it.

(viii) Hypothesis must explain the facts that gave rise to the need for explanation. This means that by using the hypothesis plus other known and accepted generalizations, one should be able to deduce the original problem condition. Thus hypothesis must actually explain what it claims to explain; it should have empirical reference.

Q33. Explain basic concepts related to hypothesis testing.

Ans : **(Imp.)**

1. Null Hypotheses and Alternative Hypothesis

In a classical statistical test two types of hypothesis are used viz Null hypothesis and Alternate hypothesis. Tire Null hypothesis (denoted as H_0) states that there is no difference between the population parameter and the sample statistic being compared. As against this, the Alternative hypothesis (denoted as H_a) states that there is a difference between the population parameter and sample statistic This can be illustrated using an example.

For example, if we want to test that the average number of students in a postgraduate class is 30 then the hypothesis can be expressed as follows

Null Hypothesis :

$H_0 : \mu = \mu_{H_0} = 30$

Where p = Population mean and

μ_{H_0} = Hypothesised mean

The alternative hypothesis can be stated in any of the three forms

(i) $H_a : \mu \neq \mu_{H_0}$

This means that population mean is not equal to the hypothesised mean i.e. it may be more or less than 30

(ii) $H_a : \mu > \mu_{H_0}$

This is to be interpreted that the population mean is greater than hypothesized mean of 30.

(iii) $H_a : \mu < \mu_{H_0}$

This implies that the population mean is less than 30 i.e. the hypothesized mean.

It is very obvious that when we conclude that null hypothesis is to be rejected, we are automatically accepting the alternative hypothesis. In other words, the set of alternative options to the null hypothesis are termed as alternative hypothesis. A point to remember is that a researcher should always frame the hypothesis before the sample is drawn and data is collected so that it avoids the mistake of deriving the hypothesis from the collected data and testing the hypothesis from the same data.

While framing a null hypothesis, few things need to be kept in mind :

(i) Null hypothesis should be stated in clear and specific terms. If approximate values are used then the hypothesis testing cannot be used definitively.

(ii) A null hypothesis is the one which a researcher is trying to disapprove or reject whereas an alternative hypothesis is one which the researcher is trying to prove and hence represents all possible alternatives.

(iii) If there is a risk involved of rejecting a hypothesis that is actually true then it will be taken as a null hypothesis. The reason for this is that by fixing the level of significance we can fix the probability of rejecting a null hypothesis that is true.

(iv) Hypothesis testing is done on the basis of a null hypothesis because it is possible to assign probabilities to null hypothesis being true for different possible results. Hence it is often referred to as statistical hypothesis.

2. One-tailed and Two-tailed Test

A hypothesis test can be a two-tailed test or one tailed test. It is the alternative hypothesis that determines whether a test will be two-tailed or one tailed.

A two-tailed test is represented by the following

$H_0 : \mu = \mu_{H_0}$

$H_a : \mu \neq \mu_{H_0}$

In this the alternative hypothesis does not imply any direction, it is simply expressed as 'not equal' i.e. the population mean may be less than or more than i.e. $\mu >$ or $\mu <$. The two-tailed test is a non-directional test as it considers two possibilities. It can be represented using standard normal curve.

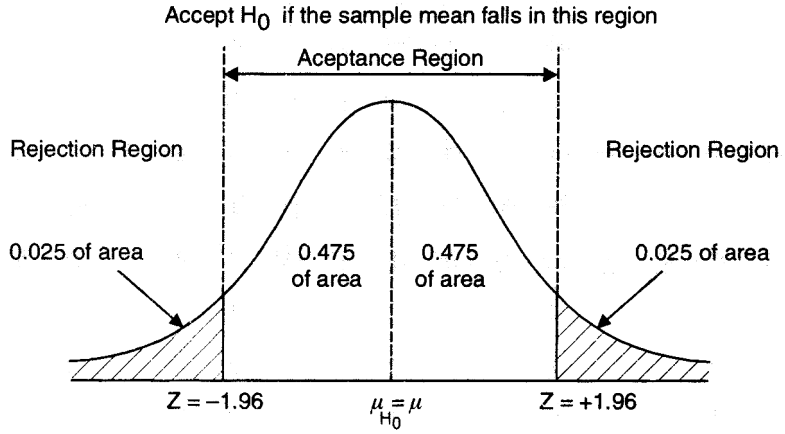


Fig. : Acceptance & Rejection region for two tailed test (at 5% level of significance)

From Figure, we can develop the acceptance and rejection criteria for Z test at 5% level of significance.

Acceptance Criteria A : $|Z| \leq 1.96$

Rejection Criteria R : $|Z| > 1.96$

In case of a two-tailed test, at the level of significance of 5%, the area under rejection region .05 is divided equally on both sides at Z value of 1.96 on either side marking the limit of acceptance region. If the Z-calculated value is greater than 11.961 then null hypothesis is rejected.

A one-tailed test is used when the alternative hypothesis specifies the population mean to be higher or lower than the hypothesized mean. A one-tailed test is also called a directional test because it places the entire probability of occurrence with a single tail as specified by the alternative hypothesis. It can be a right-tailed or a left-tailed test.

(i) Right-tailed test is given by the alternative hypothesis

$H_0 : \mu = \mu_{H_0}$

$Ha : \mu > \mu_{H_0}$

Diagrammatically it is shown using a standard normal curve

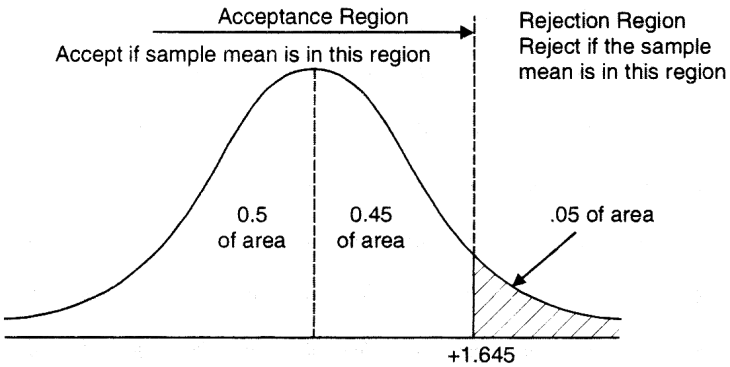


Fig.: Acceptance and Rejection region or Right-tailed Test (At 5% level of significance)

The acceptance and rejection criteria for a right-tailed test can be given as follows :

Acceptance Criteria A : $Z \leq 1.645$

Rejection Criteria R: $Z > 1.645$

In this case the alternative hypothesis states that population mean is greater then the hypothesized mean, hence at 5% level of significance the entire rejection region 0.05 is lying on the right tail of the curve.

(ii) Left tailed test is used when the alternative hypothesis has been stated as follows

$H_0 : \mu = \mu_{H_0}$

$H_a : \mu < H_0$

Diagrammatically it can be represented as follows :

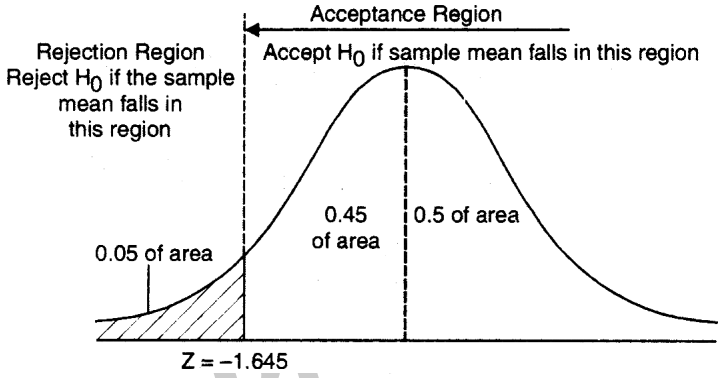


Fig.: Acceptance and Rejection region for Left-tailed Test (At 5% level of significance)

As shown in figure 5.3 the acceptance and rejection of null hypothesis will be done on the following criteria of Z-calculated value

Acceptance Criteria A : $Z > -1.645$

Rejection Criteria R: $Z \leq -1.645$

Similarly Z acceptance and rejection values for other levels of significance can be worked out by looking at the table showing area under standard normal curve.

3. Type I and Type-II Errors

While testing the null hypothesis, a researcher can commit two types of errors; of accepting a null hypothesis when it is wrong and of rejecting a null hypothesis when it is correct. The latter is known as Type-I error and the former is known as Type-II error. The concept of Type-I and Type-II error car. be explained with the help of figure.

When a null hypothesis that is true is accepted, then it is termed as a correct deer- ‘ However when it is true and still rejected then it is termed as Type-I error. Comparing it to a analogy, one can say that if an innocent person is declared not guilty then it is a correct decision, however when an innocent person is unjustly declared guilty and convicted it is a type I error. The probability of type-I error is known as significance level and is determined in advance e.g. if level of significance is 10% *i.e.* type-I error is fixed at 10% then it means that there are about 10 chances in 100 that we will reject a null hypothesis that is true. The chances of committing type-I error can be controlled by fixing the significance level at a lower level *e.g.* at 1%.

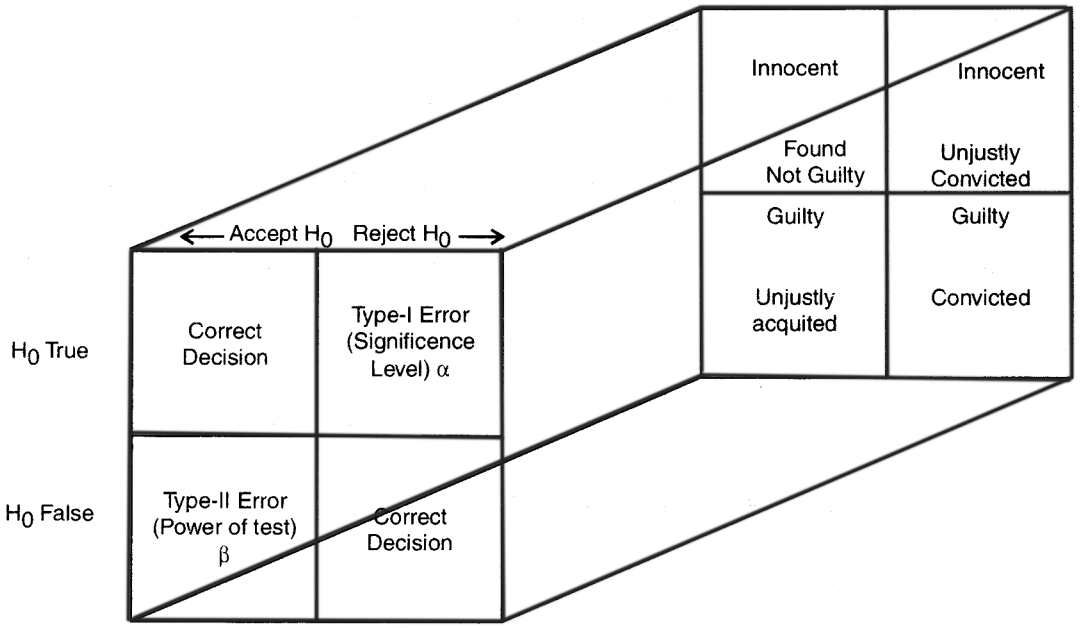


Fig.: Types of Errors

However when a null hypothesis is false, then rejecting it is the correct decision. However if a null hypothesis that is false is accepted, it is a wrong decision and type-II error has been committed. Taking the same example, if a guilty person is convicted then it is a correct decision, however if a guilty person is allowed to go Scott free then it is a wrong decision and type-II error has been committed.

There is a trade-off between the two types of errors i.e. in a fixed sample size n if the probability of type-I error is reduced then the probability of committing type-II error is increased. Hence while fixing the type-I error the cost associated with both the errors should be analysed. To illustrate, let us take the example of a pharmaceutical firm which has to set the significance level for accepting a batch of medicines. In such a situation, the cost associated with committing a type-I error is the cost and time involved in reworking a new batch of medicines, when the earlier batch should have been accepted. For type-II error, the cost of this error would be the lives of people who will consume the wrong batch of medicines. It is obvious that in such a situation the probability of type-II error should be very low, hence we fix the significance level at a high value.

4. Level of Significance

As stated earlier, the level of significance implies the probability of rejecting a true null hypothesis. It is generally fixed at 1%, 5%, 10% or 25% and is denoted by symbol a. The choice of the level of significance is made after evaluating how much risk the researcher is willing to accept and what impact will it have on (3 risk. If the probability of committing type II error is to be reduced then type I error probability should be high e.g. we may fix 25% as level of significance. This means there are 25 out of 100 chances of committing type I error.

5. Power of a Test

The power of a test states how well the test is working. A good test of hypothesis would be one that rejects a null hypothesis when it is false or lowers the probability of accepting a null hypothesis that is false (β). It can also be said that a good test should have a high ($1-\beta$). The closer the value of ($1-\beta$) to 1, the better is the test working. A high ($1-\beta$) ensures that the researcher has the best chance of rejecting a null hypothesis.

The power of test depends on three parameters :

(i) Significance level of the test

(ii) The reliability of the sample size

(iii) The effect size. (It is the difference between the assumed value under the null and the true but unknown value)

If the 1– β value of all possible values of a population parameter are plotted, for which the H_0 is not true, the resulting curve is known as the power curve. It shows the conditional probability associated with rejecting H_0 as a function of two things namely population parameter and sample size. The function that defines this power curve is known as power function. The power function of a test gives the probability of rejecting Ho for all values of the population parameter. The value of power function, for a specific value of parameter point is termed as the power of test at that point.

1.7.2 Types

Q34. Explain different types of hypothesis tests.

(OR)

Classify the different types of hypothesis test.

Ans : **(Imp.)**

1. Question Hypothesis

It is regarded as the simplest form of empirical observation. Under this type, the hypothesis is usually represented in a simple question form. However, it does not serve as the definition of hypothesis i.e., it does not convey the meaning of hypothesis. This type of hypothesis is mostly used in those research projects which needs to find out an answer to a simple question.

Example

Is there any effect of reinforced advertisement on the product sales volume?

2. Declaration Statement

It declaration hypothesis, the researcher basically builds/develops an imaginary relationship between two independent variables. On the basis of study by using the historical data.

3. Directional Hypothesis

Directional hypothesis, basically emphasizes upon drawing an expected direction for the existing relationship between different variables.

4. Null/Non-Directional Hypothesis

The non-directional hypothesis is explained in the null (Negative) form i.e., it states that there exists no relationship between the two different variables. This type of hypothesis is statistical in nature and can be measured within the framework of the probability theory. It usually gives a negative outcome to the researcher. Therefore, it is considered and called as non-directional in nature.

1.7.3 Testing Procedure

Q35. Explain in detail the procedure of testing a hypothesis.

Ans : **(Imp.)**

The procedure of testing hypotheses is briefly described below:

1. Set up a hypothesis

The first thing in hypothesis testing is to set up a hypothesis about a population parameter. Then we collect sample data, produce sample statistics, and use this information to decide how likely it is that our hypothesized population parameter is correct. Say, we assume a certain value for a population mean. To test the validity of our assumption, we gather sample data and determine the difference between the hypothesized value and the actual value of the sample mean. Then we judge whether the difference is significant. The smaller the difference, the greater the likelihood that our hypothesized value for the mean is correct. The larger the difference, the smaller the likelihood.

The conventional approach to hypothesis testing is not to construct a single hypothesis about the population parameter, but rather to set up two different hypotheses. These hypotheses must be so constructed that if one hypothesis is accepted, the other is rejected and vice versa.

The two hypotheses in a statistical test are normally referred to as:

(i) Null hypothesis, and

(ii) Alternative hypothesis

The null hypothesis is a very useful tool in testing the significance of difference. In its simplest form the hypothesis asserts that there is no real difference in the sample and the population in the particular matter under consideration (hence the word "null" which means invalid, void, or amounting to nothing) and that the difference found is accidental and unimportant arising out of fluctuations of sampling. The null hypothesis is akin to the legal principle that a man is innocent until he is proved guilty. It constitutes a challenge: and the function of the experiment is to give the facts a chance to refute (or fail to refute) this challenge. For example, if we want to find out whether extra coaching has benefited the students or not, we shall set up a null hypothesis that "extra coaching has not benefited the students". Similarly, if we want to find out whether a particular drug is effective in curing malaria we will take the null hypothesis that "the drug is not effective in curing malaria". The rejection of the null hypothesis indicates that the differences have statistical significance and the acceptance of the null hypothesis indicates that the differences are due to chance. Since many practical problems aim at establishment of statistical significance of differences, rejection of the null hypothesis may thus indicate success in statistical project.

As against the null hypothesis, the alternative hypothesis specifies those values that the researcher believes to hold true, and, of course, he hopes that the sample data lead to acceptance of this hypothesis as true. The alternative hypothesis may embrace the whole range of values rather than single point. Now a days, it is usually accepted common practice not to associate any special meaning to the null or alternative hypothesis but merely to let these terms represent to different assumptions about the population parameter. However, for statistical convenience it will make a difference as to which hypothesis is called the null hypothesis and which is called the alternative.

The null and alternative hypotheses are distinguished by the use of two different symbols, Ho representing the null hypothesis and H_a the alternative hypothesis. Thus a psychologist who wishes to test whether or not a certain class of people have a mean I.Q. higher than 100 might establish the following null and alternative hypotheses :

$H_0 : \mu = 100$ (null hypothesis)

$H_a : \mu \neq 100$ (alternative hypothesis)*

Or, if he is interested in testing the differences between the mean I.Q. of two groups, this psychologist may like to establish the null hypothesis that the two groups have equal means ($\mu_1 - \mu_2 = 0$) and the alternative hypothesis that their means are not equal ($\mu_1 - \mu_2 \neq 0$)

$H_0 : \mu_1 - \mu_2 = 0$ (null hypothesis)

$H_a : \mu_1 - \mu_2 \neq 0$ (alternative hypothesis)

2. Set up s suitable significance level

Having set up the hypothesis, the next step is to test the validity of H_o against that of H_a at as certain level of significance. The confidence with which an experimenter rejects or retains a null hypothesis depends upon the significance level adopted.

3. Setting a test criterion

The third step in hypotheses testing procedure Is to construct a test criterion. This involves selecting an appropriate probability distribution for the particular test, that is, a probability distribution which can properly be applied. Some probability distributions that are commonly used in testing procedures are t, F and χ^2- Test criteria must employ an appropriate probability distribution; for example, if only small sample information is available, the use of the normal distribution would be inappropriate.

4. Doing computations

Having taken the first three steps, we have completely designed a statistical test. We now proceed to the fourth step performance of various computations from a random sample of size n, necessary for the test. These calculations include the testing statistic and the standard error of the testing statistic.

5. Making decisions

Finally, as a fifth step, we may draw statistical conclusions and take decisions. A statistical conclusion or statistical decision is a decision either to reject or to accept the null hypothesis. The decision will depend on whether the computed value of the test criterion falls in the region of rejection or the region of acceptance.

Short Question and Answers

1. Define Research.

Ans :

Meaning

Research is a scientific investigation. Investigation means a search for new facts and ideas in any branch of knowledge. Thus, we can say that research is a search for knowledge. Research may be considered as a movement, a movement from the unknown to the known. It is actually a voyage of discovery.

Research is carried out for two purposes; one is the discovery of new facts and the second, verification of the old ones. The object of every business organization, of course, is the discovery of new facts, new relationship, and new laws governing the business phenomena. But constant verification of the old concepts is also needed especially in dynamic business environment.

Definitions

Research has been interpreted and defined by various scholars as per their fields of study and availability of resources at the given time.

2. Describe the objectives of research.

Ans :

The objectives of a research study are listed below:

i) **Understanding a business problem:** The first and foremost objective of any study is to understand, analyze and explore a business problem. Once complete familiarity with the phenomenon is achieved, it is easier to decompose the complex problem into smaller once.

ii) **Identifying the cause and effect relationship:** Individuals form groups, and groups form organizations. They are interdependent. It is very important for a researcher to identify the functional relationships among various components of an organization. A scientific investigation is necessary in studying the cause and effect relationship of variables involved in a business phenomenon.

iii) **To innovate new ideas:** One of the objectives of a researcher is to bring constant improvement in the techniques of his trade. Apart from verifying and testifying the existing assumptions, one of the functions of a research is to add new knowledge to the state of the art. Research invokes the innovation of new concepts, theories and idea in a business study. Apart from this, research also removes and discards worthless theories that are prevalent in the society.

iv) **To improve the quality:** The whole exercise of any activity is done for the improvement of quality of a product, machinery, or life of human beings. For a business organization it is atmost important to improve the quality of its products. This can be achieved by a systematic and critical investigation i.e. research.

3. Descriptive research.

Ans :

Descriptive research basically describes what is. It mainly involves collection, recording, describing and analyzing the facts related to the study. It tries to find the existing status, trend and state of affairs in a phenomenon. Descriptive research involves surveys, but they are not merely data collection as they also involve measurement, classification, analysis, comparison and interpretation. In this type of research the variable under study are uncontrollable. One can only observe and report what is happening in a situation.

4. Analytical research.

Ans :

Analytical research, on the other hand deals with what will be. In this type of research, the variables involved are carefully and scientifically controlled and manipulated. Analytical research is also known as experimental research and is a very sophisticated technique. This kind of research is based on four important characteristics namely; control, manipulation, observation and replication.

5. Fundamental research

Ans :

Fundamental research is carried out to scientifically enhance the organized body of knowledge of a discipline. Also know as basic research, it is concerned with formulation of theory and generalizations of principles. To evaluate and expand a formulated theory it may use empirical data. Basic research involves systematic, highly sophisticated scientific techniques. Fundamental research may not suggest the solutions of immediate problems, it rather draws long term conclusions.

6. Empirical research

Ans :

Empirical research is based on observation and experimentation. The information collected in the form of facts develops the conclusions and theories about a phenomenon. The models, so developed, can again be verified by a replication of data collection. To test a given hypothesis empirical research is most popular and powerful tool in the modern world.

7, What is research methodology

Ans :

Research methodology refers to the system of models, procedures and techniques which are used to determine the results of a research problem. It simply refers to the systematic procedure of solving any research problem. It is variable in nature and may vary from one research to another. It has a narrower scope and is not common for every research. It basically aims at only collecting and arranging the factual information related with the research topic. The different types of research methodology include observation, interviews, questionnaire documentary study and so on.

8. Research Design

Ans :

A research design is a controlling plan for a research study in which the methods and procedures for collecting and analyzing the information to be collected is specified. It is a framework or plan for study that guides the collection and analysis of data.

The word 'design' means to work out the structure of form', as by making a sketch or plan. Thus, 'Research Design' is planning a strategy or drawing a blue print of conducting research. It is a guideline for collecting and utilizing data so that desired information can be obtained with sufficient precision and hypothesis can be tested properly. A research is designed for the purpose of producing results that may be applied to real world situations. It not only enables a researcher to anticipate potential problems that can occur during the actual operation of the research, but also to limit boundaries of research study.

Definitions

Some of the popular definitions of research design are:

(i) According to Miller, "Research design is the planned sequence of the entire process involved in conducting a research study."

(ii) According to Selltiz and others, "Research design is a catalogue of the various phases and facts relating to the formulation of a research effort. It is an arrangement of the essential conditions for collection and analysis of data in a form that aims to combine relevance to research purpose with economy in the procedure".

(iii) According to Anonymous, "A research designates the logical manner in which individuals or other units are compared and analyzed, it is the basis of making interpreta-tions from the data".

9. Objectives of measurement.

Ans :

(a) Reliability

The measurement should be reliable by producing consistent results when certain research methods are repeated.

(b) Validity

An instrument is valid when it measures what it is supposed to measure, but since attitudes are elusive, validity is not possible.

(c) Sensitivity

The measurement should result in identifying changes or differences.

(d) Relevance

Facilitates the decision-maker by producing relevant information.

(e) Versatility

Versatility or robustness of measurement for various statistical interpretations is a desired goal, especially for assessing the results validity and for drawing maximum meaning.

10. Define Scaling.

Ans :

Scaling is a process or set of procedures, which is used to assess the attitude of an individual. Scaling is defined as the assignment of objects to numbers according to a rule. The objects in the definition are text statements, which can be the statements of attitude or principle. Attitude of an individual is not measured directly by scaling. It is first migrated to statements and then the numbers are assigned to them.

Choose the Correct Answers

1. Marketing research is. [d]
   (a) Empirical (b) Theoretical
   (c) Non-ethical (d) All of the above
2. Which of the following is not the significance of research? [a]
   (a) Precision (b) Provide Guidelines
   (c) Helpful in developing theories (d) Foundations for Government policies.
3. _____ is a decision making process. [a]
   (a) Management (b) Authority
   (c) Both (d) None of the above
4. Research is _____ [c]
   (a) Intellectual and Innovative activity (b) Creation of original ideas
   (c) Both of above (d) None of these
5. Marketing research is _____ [d]
   (a) Systematic study (b) Scientific study
   (c) Managerial tool (d) All of the above
6. Scope of the Marketing research does not include. [a]
   (a) Financial and accounting research (b) Market research
   (c) Product research (d) Consumer research
7. What roles are played by marketing research in decision making ? [d]
   (a) Knowledge of market and consumers (b) Helpful in coping with change
   (c) Management of risk and uncertainty (d) Above all
8. From objective point of view research is _____ [c]
   (a) Descriptive (b) Exploratory
   (c) Both (d) None
9. The research process has the following steps. [d]
   (a) Formulating the research problem (b) Preparing the research design
   (c) Testing the hypothesis (d) Above all
10. Research process encompasses. [a]
   (a) Collection of data (b) Analysis of data
   (c) Interpretation of data (d) Above all

11. The measure of how well is a technique, concept or process is considered as [c]

(a) Continuity of variables (b) Goodness of variables

(c) Validity (d) Reliability

12. The scale which categorize the events in collectively exhaustive manner and mutually exclusive manner is classified as [d]

(a) Discrete scale (b) Continuous scale

(c) Valid scale (d) Nominal scale

13. The type of rating scale which represents response of respondents by marking at appropriate point is classified as [a]

(a) Graphic rating scale (b) Responsive scale

(c) Pointed scale (d) Marking scale

14. The scale which is used to determine the ratios equality is considered as [b]

(a) Satisfactory scale (b) Ratio scale

(c) Goodness scale (d) Exponential scale

15. The measurement scale in which the values are categorized to represent qualitative differences and ranked in meaningful manner is classified as [c]

(a) Valid scale (b) Discrete scale

(c) Ordinal scale (d) Continuous scale

16. Variation between the information sought by the researcher and the information produced by the measurement process is, [b]

(a) Surrogate Information Error (b) Measurement Error

(c) Experimental Error (d) Sampling Error

17. A ranking scale which assigns numbers to objects that implies the extent of presence of some characteristics is. [c]

(a) Nominal Scale (b) Interval Scale

(c) Ordinal Scale (d) Ratio Scale

18. Which of the following are objectives of measurement, [d]

(a) Reliability (b) Validity

(c) Sensitivity (d) All the above

19. An attitude scale, where researchers design statements of attitudes and experts assign ranking scale values, [a]

(a) Thurstone Interval Scale (b) Guttman's Analysis

(c) Likert's Scale (d) Semantic Differential Scale

20. In _____ approach, a researcher can assess reliability of a scale that involves summation of multiple items, [b]

(a) Alternative forms approach (b) Internal consistency approach

(c) Test-retest method (d) None of the above

Fill in the blanks

1. Research design is _____.
2. Nature of research design reflects _____.
3. The characteristics of good research design are _____.
4. The exploratory research design does not include _____.
5. The descriptive research design focus on the following aspect _____.
6. _____ is the process of designing, gathering analyzing and reporting information that may be used to solve a specific problem.
7. _____ design is the specification of method and procedures for acquiring the information needed.
8. Descriptive studies can be categorized into two. They are, cross-sectional studies and _____ studies.
9. An _____ may be defined as 'manipulating an independent variable to see how it affects a dependent variable, while also controlling the effects of entraneous variables.
10. _____ is the doubt and anxiety suffered by a customer at the point of purchase.
11. _____ refer to the body of individuals or organisations, working together to provide information on a periodical basis.
12. _____ is the assignment of numbers to objects to represent amounts or degrees of a property possessed by all of the objects.
13. An ideal measurement is the one that is _____ and _____.
14. In Guttman's technique, a table of responses of an individual is formed, known as _____.
15. Objective of measurement _____.
16. _____ developed an attitude measurement scale.
17. _____ scale range of value from –5 to +5 without a neutral point(zero).
18. Likert scale was developed by _____.
19. Semantic differential scale was developed by _____.
20. _____ is commonly used to measure preferences for brands as well as attributes.

ANSWERS

1. Conceptual structure.
2. Reliability
3. Minimum Bias
4. Literature review
5. Designing the data collection methods

6. Marketing research
7. Research
8. Longitudinal
9. Experiment
10. Cognitive dissonance
11. Panels
12. Measurement
13. Reliable and Valid
14. Scalogram
15. Validity
16. Rensis Likert
17. Stapel
18. Rensis Likert
19. Osgood
20. Paired comparisons

UNIT II

Parametric and Non-parametric Tests and Research Report:

Introduction - t-Test - F-Test - Chi Square Test - Anova (One-Way Anova, Two-Way Anova). Concepts only Contents of a Research Report.

2.1 Parametric Test and Non-Parametric Tests

2.1.1 Introduction

Q1. Define the terms :

(a) Population

(b) Sample

(c) Sampling

Ans :

(a) Population

The term population refers to information of group of observations about which inferences are to be made. Population size denoted as 'N' which represents the number of objects or observations in the population. Population may be finite or infinite depending upon N being finite or infinite.

(b) Sample

The term sample refers to a finite subset of the population. Sample size is represented as 'n' denoting the number of objects or observation in the sample.

(c) Sampling

Sampling may be defined as the selection of some part of an aggregate or totality on the basis of which a judgement or inference about the aggregate or totality is made. In other words, it is the process of obtaining information about an entire population by examining only a part of it.

Need

The following is the need for sampling,

1. It can save time and money. A sample study is usually less expensive than a census study and produces results at a relatively faster speed.
2. It is the only way when population contains infinitely many members.
3. It may enable more accurate measurements for a sample study. It is generally conducted by trained and experienced investigators.
4. It remains the only choice when a test involves the destruction of the items under study.
5. It usually enables to estimate the sampling error and thus, assists in obtaining information concerning some characteristics of the population.

Q2. Explain briefly about various methods of sampling.

(OR)

Write briefly about the various sampling techniques.

Ans : **(Imp.)**

The various technique of sampling can be divided into two broad categories probability sampling that is also known as random sampling and non-probability or non random sampling.

1. Probability Sampling Methods

It is that method in which every item in the universe has a known chance or a probability of

being chosen for the sample. This implies that the selection of sample items is independent of the person making the study.

Probability sampling methods are discussed as follow :

(A) Random Sampling

It is the most effective and commonly used method of selecting a sample. It is also known as 'chance sampling' (or) 'probability sampling'. This method provides an equal chance of selection to each and every item of the universe in the sample. According to F. Yates, "Random sample is the one in which every number of the parent population has had an equal chance of being included".

Following are some of the methods to establish randomness in framing the sample :

(i) Lottery Method: In this method all the items or the units of the population are assigned different numbers which are noted on small paper slips, folded and put into a box. These are then properly reshuffled or mixed. A blindfold selection is then made from the number of slips required to constitute the desired sample size. The selection of items purely depends on chance.

(ii) Random Number Tables: Some Random number tables have been developed by statisticians which can be used for selecting a sample from the given population of all these random number tables, Tippet's Table (1927) is most widely used. Tippet's random number table consists of 10,400 four-digit numbers, giving in all 10, $400 \times 4 = 41,600$ digits selected at random.

Selecting sample using Tippet's random number table involves following steps :

- First, arrange all the items of population in a serial order.
- Then by using Tippet's number table, numbers are selected on the basis of size of sample to be drawn. The numbers from the table can be selected either horizontally or vertically or diagonally.

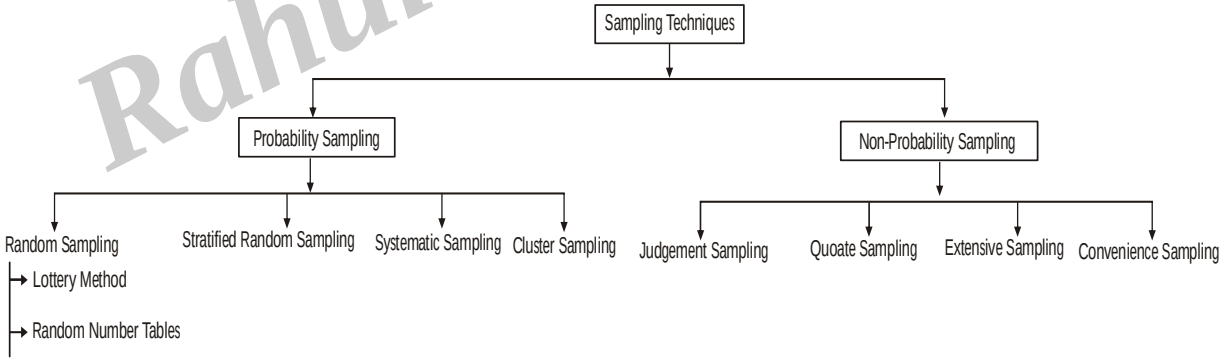


Fig.: Sampling Techniques Process

(B) Stratified Random Sampling

Stratified sampling is based on the concept of homogeneity and heterogeneity. The process of dividing heterogeneous population into relatively homogeneous strata is termed as stratified sampling. It is a two-step process in which population is divided into subgroups or strata. The strata should be mutually exclusive and collectively exhaustive. The element within a stratum should be as homogeneous as possible, but the element in different stratum should be as heterogeneous as possible. It is pertinent to mention here that though the sampling is selected in various stages yet the last sample of the subject is studied.

When the population has different sectors with different characteristics i.e. the population is divided on heterogeneous basis, we cannot get representative sample by the random sampling technique. In this case we use stratified random sampling. In the first step, the population is divided into 'strata' or groups on some homogeneous basis, and in the second step the selection of appropriate number of items is made from each sub-groups on random basis. The sum total of all the items taken separately from each sub-group or strata will form a stratified sample. Stratified sampling is much effectively used in market research where the division of the universe is fairly clear on the basis of occupational, economic, social or religious basis.

(C) Systematic Sampling

Systematic sampling involves the selection of sample units at equal intervals, after all the units in the population are arranged in some systematic order such as alphabetical, chronological, geographical order etc. systematic sampling is also called 'quasi-random sampling'. In systematic sampling, the sample size is usually taken in such a way that it completely divides the population size. Let us suppose that N sampling units in the population are arranged in some systematic order and serially numbered 1 to N. Our sample size 'n' should be such that it completely divides N. $\frac{N}{n} = K$ this K is called that sample interval. If K is in fraction then it is to be rounded off to get an integral value e.g., if we want to have a sample of size 5 from a population of size 100. Then K will be

$K = \frac{100}{5} = 20.$

In this case the subsequent items are selected by taking every K^{th} items i.e. 20^{th} items, refers to sample interval or sample ratio. The ratio of population size to the size of the sample.

(D) Cluster Sampling

This sampling implies dividing population into clusters and drawing random sample either from all clusters or selected clusters. Cluster Sampling is similar to stratified sampling. In the cluster sampling the universe is divided into number of relatively small subdivisions or clusters and then some of these clusters are randomly selected for inclusion in the overall sample. The element within cluster should be heterogeneous as possible, but cluster themselves should be as homogeneous as possible. The common form of cluster sampling is area or geographical sampling.

For example, if we are interested in obtaining the income or opinion data in a city, the whole city may be divided into N different blocks or localities (which determine the clusters) and a simple random sample of n blocks is drawn. The individuals in the selected blocks determine the cluster sample. The difference between cluster sampling and stratified sampling is that in case of cluster sampling only a sample of subgroups or clusters is chosen, whereas in stratified sampling all subpopulations or strata are selected for further sampling. The objectives of the both methods are also different. The objective of cluster sampling is to increase the efficiency by decreasing the costs, whereas the objective of stratified sampling is to increase the precision.

2. Non-Probability Sampling Methods

Non probability sample methods are those which do not provide every item in the universe with a known chance of being included in the sample. The selection process is atleast partially subjective. Non-probability sampling methods are discussed as follow :

(A) Judgment Sampling

In judgment sampling, selection of sample units depends on the discretion or judgment of investigator. The investigator chooses the units form the universe according to his own judgment and includes all those items in the sample which he thinks best and typical of the universe.

(B) Quota Sampling

This method is suitable in making investigations concerning public opinion. Investigator define quotas according to some specific features of population like social classes, age groups and so on. The quotas confirm the total number of items in the sample taken as a whole. The selected sample units with the quotas depend on the personal judgments of the interviewer. For instance, in the market survey of tooth paste, the researcher may be asked to interview 100 people in certain areas of Shimla, and that out of 100 persons 40 are male, 40 are female and 20 are children under the age group of 15. With these quotas researcher is free to select the respondents to be interviewed.

Merits

The following are the merits of quota sampling :

1. Reliability

This method is more reliable as there is greater possibility of in important units of population in the sample.

2. Public Opinion Surveys

This method is more suitable for public opinion surveys.

3. Organized Method

This is more organized method than other non-probability methods. It enjoys the benefits of both stratified and purposive sampling.

Demerits

The following are the demerits :

1. Prejudice

Because of biased opinion of the investigator, it has less practical import negligence on the part of the investigator may lead to errors.

2. Need More Skill

The success of this method depends upon the expertise of the researcher. A little negligence on the part of researcher may lead to drastic error.

(C) Extensive Sampling

This method enables us to study a large universe. By this method a very large sample is collected and those items which are a sort of liability on the statistical operations or the items from which it is difficult to collect any information are dropped out.

(D) Convenience Sampling

In this method, the selection of sample is done on the basis of convenience of the investigator. This sampling is not representative of any definable population. A sample obtained from readily available lists such as telephone directory or trade directory is an example of convenience sampling. Sample drawn by this method is called convenience sample.

Q3. Define the terms

(i) Parametric Test

(ii) Non-Parametric Test

Ans :

(i) Parametric Test

These tests are based on some assumptions about the parent population from which the sample has been drawn. These assumptions can be with respect to sample size, type of distribution or on population parameters like mean, standard deviation etc. The most commonly used parametric tests are Z-test, t-test and χ^2 test (however when y is used as a test of good of fit or as a test of independence, it is termed as a nonparametric test). Parametric tests are more powerful than nonparametric tests as they use interval and ratio data.

Parametric tests are based on certain assumptions.

- The observations being tested should be independent so that inclusion of one set of observation does not affect the subsequent observations.
- Parametric tests assume normality of distribution.
- Parametric tests require interval or ratio measurement scales, so that arithmetic operations can be applied on them.

(ii) Non-Parametric Test

Non-parametric tests are the study of statistical tests but it does not relate to parameter estimation or precise distributional assumptions. The type of test which non-parametric tests include are chi-square test, sign test, S-median test, Wilcoxon signed rank test etc. Assumptions of normal population are not considered under non-parametric test. Under these tests, inverse hypothesis is created and the inferences are made by testing variables. These tests are also called as "Distribution free tests". In case of non- parametric tests, the population distribution are same for null hypothesis and the power of non-parametric tests are low. These tests use Mann-Whitney U-test and Wilcoxon signed ranks test. Non-parametric tests also use Kruskal Wallis test and Friedman test. Nature of Non-Parametric

Non parametric test is a statistical test in which,

1. Parameter such as mean, variance is not involved.
2. Frequency function of sample is unknown.
3. Specific distribution of data is not followed.
4. No assumption about population is made.

Q4. Compare and contrast Parametric Test and Non-Parametric Test.

Ans : **(Imp.)**

S.No.	Nature	Parametric Test	Non-Parametric Test
1.	**Definition**	A parametric test is one which has complete information about the population parameter or that can make assumptions about the parameters (defining properties) of the population distribution from which the samples are drawn.	A nonoparametric test is none where the researcher has no knowledge about the population parameter, neither he can make specific assumptions, but still it is required to test the hypothesis of the population.
2.	**Information about population**	Completely known	Not known / Unavailable
3.	**Basis of test statistic**	Uses a normal probabilistic distribution	The distribution is non-normal / arbitrary
4.	**Measurement level**	Applied when scale of measurement is a metric scale i.e., interval or Ratio	Applied for Norminal or Ordinal scale
5.	**Measure of central tendency**	Mean	Median
6.	**Applicability**	Variables	Variables and attributes
7.	**Correlation test**	Pearson	Spearman

2.2 T-TEST

Q5. What is Small sample test ?

Ans :

Meaning

Small sample size referred to size of sample which is less than 30. In case of small sample size the z-test is not appropriate test statistic as the assumptions on which it is based do not hold good in case of small sample. The theoretical work on t-distribution was done by W.S. Gosset (1876-1937) under the pen

name "student' as he was the employee of the company Guinness & Sons, a Dublin bravery, Ireland, which did not allowed it employees to publish research findings under their own names. The t-distribution is used when sample size is less than 30 and the population standard deviation is not known.

Q6. Explain briefly about T-test. State the assumptions of T-test.

Ans :

When the size of the sample is small i.e., less than 30, the Z-tests using normal distribution are not applicable because the assumptions on which they are based generally do not hold good in case of small samples. The sampling distribution of small samples follow student's t-distribution. The student's t-distribution has a greater dispersion than the standard normal distribution. As 'n' gets larger, the t-distribution approaches the normal form.

Degree of Freedom: Degree of freedom is used to see the table value for testing the hypothesis as V = n –1. If hypothesis is to be tested 5% level of significance under one tail, then the value is to be seen below the 0.025 level. If the value of table is two tails, then the value is to be seen below the 0.05.

Assumptions of t-test

The following are the pre-requisites for the application of t-test :

1. The population from which a sample is drawn is normal.
2. The samples have been drawn at random.
3. The population standard deviation is not known.
4. Sample size should small i.e., less than 30.

Q7. What are the properties of t-distribution?

Ans :

1. The shape of t-distribution is bell-shaped, which is similar to that of a normal distribution and is symmetrical about the mean.
2. The t-distribution curve is also asymptotic to the t-axis, i.e., the two tails of the curve on both sides of t = 0 extends to infinity.

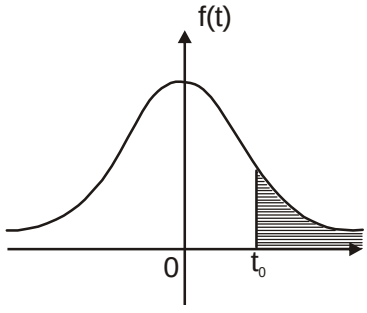


Fig.: t-distribution

3. It is symmetrical about the line t = 0 .
4. The form of the probability curve varies with degrees of freedom i.e., with sample size.
5. It is unimodel with Mean = Median = Mode.
6. The mean of standard normal distribution and as well as t-distribution zero but the variance of t-distribution depends upon the parameter v which is called the degrees of freedom.

Q8. State the applications of the t-distribution.

Ans :

The t - distribution has a wide number of applications in Statistics, some of them are given below :

1. To test the significance of the sample mean, when population variance is not given
2. To test the significance of the mean of the sample i.e., to test if the sample mean differs significantly from the population mean.
3. To test the significance of the difference between two sample means or to compare two samples.
4. To test the significance of an observed sample correlation coefficient and sample regression coefficient.

Q9. Explain the test concerning the significance of single and two mean

Ans :

T-test for Single Mean

(i) If a random sample x. of size n has been drawn from a normal population with a specified mean p.

(ii) If the sample mean differs significantly from the hypothetical value p the population mean.

In this case the statistic is given by $t = \frac{\bar{x} - \mu}{S/\sqrt{n}} \sim t_{(n-1)}$ where $\bar{x}$, μ, S, n have usual meanings.

Let a random sample of size n (n < 30) has a sample mean $\bar{x}$. To test the hypothesis that the population mean p has a specified value p_0 when population S. D. σ is not known.

Let the Null Hypothesis be $H_0: \mu = \mu_0$

Then the Alternative Hypothesis is $H_1: \mu \neq \mu_0$

Assuming that H_0 is true, the test statistic given by $t = \frac{\bar{x} - \mu}{s/\sqrt{n-1}}$, where s is the sample S. D. follows t-distribution with v = (n – l) d.f.

We calculate the value of 11 \ and compare this value with the table value of t α level of significance. If the calculated value of t > the table value of t, we reject H_0 at α level. Otherwise we accept H_0.

In this case, 95% confidence limits for the population mean μ are $\bar{x} \pm t_\alpha \cdot \frac{s}{\sqrt{n-1}}$ where α =0.025

for two-tailed test and 5 = sample S. D. and 99% confidence limits μ are $\bar{x} \pm t_\alpha \cdot \frac{s}{\sqrt{n-1}}$ where α = 0.05.

For a two-tailed test at α level of significance, value of α / 2 is taken for α.

The more common situation involving tests on two means are those in which variances are unknown. If we assume that distributions are normal and that $\sigma_1 = \sigma_2 = \sigma$. The pooled t-test (often called the two-sample t-test) may be used. The test statistic is given by the following test procedure,

$$t = \frac{\bar{X} - \bar{Y}}{S\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}} \text{ (or) } t = \frac{\bar{X} - \bar{Y}}{S^2\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$$

With $n_1 + n_2 - 2$ degrees of freedom.

Where,

$$S^2 = \frac{\Sigma(X_i - \bar{X}) + \Sigma(Y_i - \bar{Y})^2}{n_1 + n_2 - 2}$$

Where $\bar{x}_1$, $\bar{x}_2$ are the means of two samples of size n_1 and n_2.

The critical region with this t-distribution can be obtained in a similar war.

For example, when A.H is $\mu_1 - \mu_2 \neq \delta$, the null hypothesis ($H_0$) is not rejected when, $-t_{\frac{\alpha}{2},n_1+n_2-2} < t < t_{\frac{\alpha}{2},n_1+n_2-2}$ and the critical region is $t < -t_{\frac{\alpha}{2},n_1+n_2-2}$ (or) $t_{\frac{\alpha}{2},n_1+n_2-2}$

Critical region for testing $H_0 : \mu_1 - \mu_2 = \delta$

Alternate hypothesis; Reject null hypothesis if ( ),

(i) $\mu_1 - \mu_2 \neq \delta$ $\quad t < -t_{\alpha/2}$ (or) $t > t_{\alpha/2}$

(ii) $\mu_1 - \mu_2 > \delta$ $\quad t > t_\alpha$

(iii) $\mu_1 - \mu_2 < \delta$ $\quad t < -t_\alpha$

Note :

1. The two-sample t-test can not be used if $\sigma_1 \neq \sigma_2$.
2. The two-sample t-test can not be used for 'before and after' kind of data, where the is naturally paired.

   In other words the samples must be 'independent' for two sample t-test.

PROBLEMS

1. A mechanist making engine parts with axle diameters of 0.700 inch. A random sample of 10 parts shows a mean diameter of 0.742 inch with a S.D. of 0.040 inch. Compute the statistic you would use to test whether the work is meeting the specification at level of significance.

Sol :

Here the sample size n – 10 < 30

Hence the sample is small sample.

Also sample mean $\bar{x}$ = 0.742 inches , the population mean μ = 0.700 inches and S.D.= 0.040 inches are given.

$\therefore$ We use student's t-Test

(i) Null Hypothesis H_0 : The product is confirming to specification.

(ii) Alternative Hypothesis H_1 : $\mu \neq 0.700$

(iii) Level of significance is, α = 0.05

(iv) The test statistic is, $t = \frac{\bar{x} - \mu}{s / \sqrt{n-1}}$

Here $\bar{x}$ = 0.742 inches, μ = 0.700 inches, S.D. = 0.040 inches and n = 10. Degrees of freedom (d.f) = w- l = 10 – l = 9

$$\therefore \quad t = \frac{0.742 - 0.700}{\frac{0.040}{\sqrt{10-1}}} = 3.15$$

$\therefore$ The calculated value of t = 3.15

The tabulated value of t at 5% level with 9 degrees of freedom is t_{005} = 2.26

Since calculated value of t > tabulated value of t, therefore, H_0 is rejected.

$\therefore$ The product is not meeting the specification.

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2. A sample 26 bulbs gives a mean life of 990 hours with a S.D. of 20 hours. The manufacturer claims that the mean life of bulbs is 1000 hours. Is the sample not upto the standard.

Sol :

Here sample size, n = 26 < 30

$\therefore$ The sample is small sample.

Also given, sample mean, $\bar{x}$ = 990

Population mean, μ = 1000 and S.D., s = 20

Degrees of freedom = n – 1 = 26 – 1 = 25

Here we know x, p, S.D. and n.

$\therefore$ We use students 't' test.

(i) Null Hypothesis H_0 **:** The sample is upto the standard.

(ii) Alternative Hypothesis H_1 : μ < 1000

(The sample is below standard) (left-tail test)

(iii) Level of significance : α = 0.05

(iv) The test statistic is $t = \frac{\bar{x} - \mu}{s/\sqrt{n-1}} = \frac{990 - 1000}{20/\sqrt{25}} = -2.5$

$\therefore$ |t| = 2.5

i.e., Calculated value of t = 2.5

Tabulated value of 't' at 5% level with 25 degrees of freedom for left-tailed test is 1.708.

Since calculated t > tabulated t, we reject the null hypothesis H_0

Conclusion: The sample is not upto the standard.

3. A machine is designed to produce insulating washers for electrical device of average thickness of 0.025 cm. A random sample of 10 washers was found to have a thickness of 0.024 cm with a S.D of 0.002 cm. Test the significance of the deviation. Value of t for 9 degrees of freedom at 5% level is 2.262.

Sol :

Here the sample size is 10 < 30

$\therefore$ The sample is small

Also given Sample mean, $\bar{x}$ = 0.024 cm

Population mean, μ = 0.025 cm

S.D. = 0.002 cm

Degrees of freedom (d.f) = n – 1 = 10 – 1 = 9

(i) Null Hypothesis H_0 : The difference between $\bar{x}$ and μ is not significant.

(ii) Alternative Hypothesis H_1 : $\mu_1 \neq 0.025$

(iii) Level of significance : α = 0.05

(iv) The test statistic is 't' = $\frac{\bar{x} - \mu}{s/\sqrt{n-1}} = \frac{0.024 - 0.025}{\frac{0.002}{\sqrt{10-1}}} = -1.5$

$\Rightarrow$ |t| = 1.5

$\therefore$ Calculated value of t = 1.5 for two tailed test.

Tabulated value of t for 9 degrees of freedom at 5% level = 2.262

Since calculated t < tabulated t, we accept the null hypothesis and conclude that the difference between x and p is not significant.

4. Two different types of drugs A and B were tried on certain patients for increasing weight, 5 persons were given drug A and 7 persons were given drug B. The increase in weight (in pounds) is given below

Drug A	**8**	**12**	**13**	**9**	**3**		
Drug B	**10**	**8**	**12**	**15**	**6**	**8**	**11**

Do the drugs differ significantly with regard to their effect in increasing weight ?

Sol :

Let the weights (in kgs) of the patients treated with drugs A and B be denoted by suitable variances X and Y respectively.

We set up the null hypothesis, $H_0 : \mu_x = \mu_y$ i.e., there is no significant difference between the drugs A and B with regard to their effect on increase in patients weight.

Alternative hypothesis, $H_1 : \mu_x \neq \mu_y$

Under H_0, the appropriate test statistic is,

$$t = \frac{\bar{X} - \bar{Y}}{\sqrt{S^2\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

Degree of freedom (d.f) = $t_{n_1+n_2} - 2$

Computation of Sample Means and Standard Deviations

X	**$(X - \bar{X})$ $(X - 9)$**	**$(X - \bar{X})^2$**	**Y**	**$(Y - \bar{Y})$ $(Y - 10)$**	**$(Y - \bar{Y})^2$**
8	–1	1	10	0	0
12	3	9	8	– 2	4
13	4	16	12	2	4
9	0	0	15	5	25
3	– 6	36	6	– 4	16
			8	– 2	4
			11	1	1
$\Sigma X = 45$	**$\Sigma(X - \bar{X}) = 0$**	**$\Sigma(X - \bar{X})^2 = 62$**	**$\Sigma Y = 70$**	**0**	**54**

Here, $n_1 = 5, \Sigma X = 45, \Sigma(X - \bar{X})^2 = 62$

$$\bar{X} = \frac{\Sigma X}{n_1} = \frac{45}{5} = 9$$

$n_2 = 7, \Sigma Y = 70, \Sigma(Y - \bar{Y})^2 = 54$

$$\bar{Y} = \frac{\Sigma Y}{n_2} = \frac{70}{7} = 10$$

and $$S^2 = \frac{1}{n_1 + n_2 - 2}\left[\Sigma (X - \bar{X})^2 + \Sigma(Y - \bar{Y})^2\right.$$

$$= \frac{1}{5 + 7 - 2}[62 + 54]$$

$$= \frac{1}{10}[116]$$

$$S^2 = \frac{116}{10} = 11.6$$

$$t = \frac{\bar{X} - \bar{Y}}{\sqrt{S^2\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}} = \frac{9 - 10}{\sqrt{11.6 \times \frac{12}{35}}}$$

$$= \frac{-1}{\sqrt{3.98}}$$

$$= \frac{-1}{1.99}$$

Degree of freedom (df) = $t_{n_1+n_2-2}$

$= t_{5+7-2}$

$= t_{10}$

Hence, tabulate value of t for 10 df at 5% level of significance for the two tailed test is 2.228. Thus, calculated t = – 0.50, is less than tabulated value of t (i.e., 2.228).

Therefore, null hypothesis H_0 is accepted at 5% level of significance and we may conclude that the drugs A and B do not differ significantly with regard to their effect on increase in patients weights.

Q10. Discuss in detail about Paired t-test.

Ans : **(Imp.)**

Paired observations arise in many practical situations where each homogeneous experimental unit receives both population conditions. As a result, each experimental unit has a pair of observations, one for each population.

For instance, to test the effectiveness of "drug" some 11 persons blood pressure is measured "before" and "after" the intake of certain drug. Here the individual person is the experimental unit and the two populations are blood pressure "before" and "after" the drug is given. Thus for each observation in one sample, there is a corresponding observation in the other sample pertaining to the same character. Hence the two samples are not independent.

Consider another example. Suppose a business concern is interested to know whether a particular media of promoting sales of a product is really effective or not. In this case we have to test whether the average sales before and after the sales promotion are equal.

If $(x_1, y_1), (x_2, y_2),.....,(x_n, y_n)$, be the pairs of sales data before and after the sales production in a business concern, we apply paired t - test to examine the significance of the difference of the two situations.

Let $d_i = x_i - y_i$ (or) $y_j - x_i$ for i = 1,2,3,...., n

Let the Null Hypothesis be $H_0 : \mu_1 = \mu_2$ (i.e., $\mu = 0$), there is no significant difference between the means in two situations.

Then the Alternative Hypothesis is $H_1 : \mu_1 = \mu_2$

Assuming that H_0 is true, the test statistic for n paired observations (which are dependent) by taking the differences $d_1,d_2,.....,d_n$ of the paired data.

$$t = \frac{\bar{d} - \mu}{S/\sqrt{n}} = \frac{\bar{d}}{S/\sqrt{n}} \; (\because \mu = 0)$$

where $t = \bar{d} = \frac{1}{n}\Sigma d_1$ and $S^2 = \frac{1}{n-1}\sum_{i=1}^{n}(d_i - \bar{d})^2$

or $S^2 = \frac{\sum d^2 - n(\bar{d})^2}{n-1}$ or $\frac{1}{n-1}\left[\sum d^2 - \frac{(\sum d)^2}{n}\right]$

are the mean and variance of the differences $d_u d_2,.....,d_n$ respectively and p is the are of the population of differences.

The above statistic follows student's t-distribution with (n – l) degrees of freedom.

PROBLEMS

5. Ten workers were given a training programme with a view to study then assembly time for a certain mechanism. The results of the time and motion studies before and after the training programme are given below.

Workers	1	2	3	4	5	6	7	8	9	10
X_1	15	18	20	17	16	14	21	19	13	22
Y_1	14	16	21	10	15	18	17	16	14	20

x_1 = Time taken for assembling before training,

f_1 = Time taken for assembling after training.

Test whether there is significant difference in assembly times before and after training.

Sol :

From the given paired data, we see that we are to use paired t-test. Let p be the mean of population of differences.

(i) Null Hypothesis H_0 : $\mu_1 = \mu_2$ or $\mu = 0$ i.e., training is not useful.

(ii) Alternative Hypothesis H_1: $\mu_1 \neq \mu_2$ i.e., training is useful in assembly time.

(iii) Level of significance $\alpha = 0.05$

(iv) Computation : Differences d_i's (before and after training) are

x_1	y_1	d_1
15	14	1
18	16	2
20	21	–1
17	10	7
16	15	1
14	18	– 4
21	17	4
19	16	3
13	14	–1
22	20	2

$\bar{d}$ = mean of differences of sample data = $\frac{\sum d}{n} = \frac{14}{10} = 1.4$

$$S^2 = \frac{1}{n-1}\sum_{i=1}^{n}(d_1 - \bar{d})^2$$

$$= \frac{1}{9}[(1 - 1.4)^2 + (2 - 1.4)^2 + (-1 - 1.4)^2 + (7 - 1.4)^2 + (1 - 1.4)^2 + (-4 - 1.4)^2 + (4 - 1.4)^2 + (3 - 1.4)^2 + (-1 - 1.4)^2 + (2 - 1.4)^2]$$

$$= \frac{1}{9}[0.16 + 0.36 + 5.76 + 31.36 + 0.16 + 29{,}16 + 6.76 + 2.56 + 5.76 + 0.36]$$

$$S^2 = \frac{82.4}{9} = 9.1555$$

$\therefore$ $S = 3.026$

(v) The test statistic is $t = \frac{\bar{d} - \mu}{S/\sqrt{n}} = \frac{\bar{d}}{S/\sqrt{n}} = \frac{1.4}{3.026/\sqrt{10}} = \frac{(1.4)(3.163)}{3.026} = 1.46$

$\therefore$ Calculated $|t| = 1.46$

Tabulated $t_{0.05}$ with $10 - 1 = 9$ degrees of freedom is 1.833

Since calculated $t < t_{005}$, we accept the Null Hypothesis H_0 and conclude that there is no significant difference in assembly times before and after training.

2.3 F-TEST

Q11. Explain briefly about F-Test.

Ans : **(Imp.)**

The F-test is named in honour of the great statistician R.A. Fisher. The object of the F-test is to find out whether the two independent estimates of population variance differ significantly, or whether the two samples may be regarded as drawn from the normal populations having the same variance. For carrying out the test of significance, we calculate the ratio F. F is defined as»:

$$F = \frac{S_1^2}{S_2^2}, \text{ where } S_1^2 = \frac{(X_1 - \bar{X}_1)^2}{n_1 - 1}$$

$$\text{and } S_2^2 = \frac{\Sigma(X_2 - \bar{X}_2)^2}{n_2 - 1}$$

It should be noted that S_1^2 is always the larger estimate of variance, i.e., $S_1^2 > S_2^2$

$$F = \frac{\text{Larger estimate of variance}}{\text{Smaller estimate of variance}}$$

$v_1 = n_1 - 1$ and $v_2 = n_2 - 1$

v_1 = degrees of freedom for sample having larger variance.

v_2 = degrees of freedom for sample having smaller variance.

The calculated value of F is compared with the table value for v_1 and v_2 at 5% or 1% level of significance. If calculated value of F is greater than the table value then the F ratio is considered significant and the null hypothesis is rejected. On the other hand, if the calculated value of F is less than the table value the null hypothesis is accepted and it is inferred that both the samples have come from the population having same variance.

Since F test is based on the ratio of two variances, it is also known as the Variance Ratio Test. The ratio of two variances follows a distribution called the F distribution named after the famous statistician R.A. Fisher.

Assumptions in F-Test

The F test is based on the following assumptions :

1. Normality, i.e., the values in each group are normally distributed.
2. Homogeneity, i.e., the variance within each group should be equal for all groups ($\sigma_1^2 = \sigma_2^2 = ... = \sigma_c^2$) This assumption is needed in order to combine or pool the variances within the groups into a single 'within groups source of variation.
3. Independence of error. It states that the error (variation of each value around its own group mean) should be independent for each value.

PROBLEMS

6. Two random samples were drawn from two normal populations and their value are :

A:	**66**	**67**	**75**	**76**	**82**	**84**	**88**	**90**	**92**		
B :	**64**	**66**	**74**	**78**	**82**	**85**	**87**	**92**	**93**	**95**	**97**

Test whether the two populations have the same variance at the 5% level of significance. (F= 3.36) at 5% level for v_1 =10 and v_2 = 8.

Sol :

Let us take the hypothesis that the two populations have the same variance.

Applying F-test :

$$F = \frac{S_1^2}{S_2^2}$$

A X_1	$(X_1 - \bar{X}_1)$ x_1	x_1^2	B X_2	$(X_2 - \bar{X}_2)$ x_2	x_2^2
66	–14	196	64	–19	361
67	–13	169	66	–17	289
75	–5	25	74	–9	81
76	–4	16	78	–5	25
82	+2	4	82	–1	1
84	+4	16	85	+2	4
88	+8	64	87	+4	16
90	+10	100	92	+9	81
92	+12	144	93	+10	100
			95	+12	144
			97	+14	196
$\Sigma X_1 = 720$	**$\Sigma x_1 = 0$**	**$\Sigma x_1^2 = 734$**	**$\Sigma X_2 = 913$**	**$\Sigma x_2 = 0$**	**$\Sigma x_2^2 = 1298$**

$$\bar{X}_1 = \frac{\Sigma X_1}{n_1} = \frac{720}{9} = 80;\ \bar{X}_2 = \frac{\Sigma X_2}{n_2} = \frac{913}{11} = 83$$

$$S_1^2 = \frac{\Sigma x_1^2}{n_1 - 1} = \frac{734}{9-1} = 91.75$$

$$S_2^2 = \frac{\Sigma x_2^2}{n_{12} - 1} = \frac{1298}{11-1} = 129.8$$

$$F = \frac{S_1^2}{S_2^2} = \frac{129.8}{91.75} = 1.415$$

For $v_1 = 10$ and $v_2 = 8$, $F_{0.05} = 3.36$

The calculated value of F is less than the table value. The hypothesis is accepted. Hence it may be calculated that the two populations have the same variance.

7. In a sample of 8 observations, the sum of squared deviations of items from the mean was 84.4. In another sample of 10 observations, the value was found to be 102.6. Test whether the difference is significant at 5% level.

You are given that at 5% level, critical value of F for $v_1 = 7$ and $v_2 = 9$ degrees of freedom is 3.29 and for $v_1 = 8$ and $v_2 = 10$ degrees of freedom, its value is 3.07.

Sol :

Let us take hypothesis that the difference in the variances of the two samples is not significant. We are given :

$n_1 = 8,\ \Sigma(X_1 - \bar{X}_1)^2 = 84.4$

$n_2 = 10,\ \Sigma(X_2 - \bar{X}_2)^2 = 102.6$

$$F = \frac{S_1^2}{S_2^2}$$

$$S_1^2 = \frac{\Sigma(X_2 - \bar{X}_2)^2}{n_2 - 1} = \frac{84.4}{7} = 12.06$$

$$S_2^2 = \frac{\Sigma(X_2 - \bar{X}_2)^2}{n_2 - 1} = \frac{102.6}{9} = 11.4$$

$$F = \frac{12.06}{11.4} = 1.06$$

For $v_1 = 7$ and $v_2 = 9$ $F_{0.05} = 3.29$.

The calculated value of F is less than the table value. Hence we accept the hypothesis and conclude that the difference in the variance of two samples is not significant at 5% level:

8. Two samples are drawn from two normal population. From the following data test whether the two samples have the same variance at 5% level :

Sample 1 :	**60**	**65**	**71**	**74**	**76**	**82**	**85**	**87**		
Sample 2 :	**61**	**66**	**67**	**85**	**78**	**63**	**85**	**86**	**88**	**91**

Sol :

Let us take the hypothesis that the two populations have the same variance.

Applying F-test :

$$F = \frac{S_1^2}{S_2^2}$$

Sample 1 X_1	$(X_1 - \bar{X})_1$ x_1	x_1^2	**Samples 2** X_2	$(X_2 - \bar{X}_2)$ x_2	x_2^2
60	–15	225	61	–16	256
65	–10	100	66	–11	121
71	–4	16	67	–10	100
74	–1	1	85	+8	64
76	+1	1	78	+1	1
82	+7	49	63	–14	196
85	+10	100	85	+8	64
87	+12	144	86	+9	81
			88	+11	121
			91	+14	196
$\Sigma X_1 = 600$	**$\Sigma X_1 = 0$**	**$\Sigma(X_1^2 = 636$**	**$\Sigma X_2 = 770$**	**$\Sigma x_2 = 0$**	**$\Sigma x_2^2 = 1200$**

$$\bar{X}_1 = \frac{600}{8} = 75;\ \bar{X}_2 = \frac{770}{10} = 77$$

$$S_1^2 = \frac{\Sigma x_1^2}{n_1 - 1} = \frac{636}{8-1} = \frac{636}{7} = 90.857$$

$$S_2^2 = \frac{\Sigma x_2^2}{n_2 - 1} = \frac{1200}{10-1} = \frac{1200}{9} = 133.333$$

$$F = \frac{133.333}{90.857} = 1.468$$

For $v_1 = 9$ and $v_2 = 7$, $F_{0.05} = 3.68$. The calculated value of F is less than the table value. The hypothesis holds good and hence we conclude that the two populations have the same variance.

9. The following data present the yields in quintals of common ten subdivisions of equal area of two agricultural plots :

Plot 1 :	**6.2**	**5.7**	**6.5**	**6.0**	**6.3**	**5.8**	**5.7**	**6.0**	**6.0**	**5.8**
Plot 2 :	**5.6**	**5.9**	**5.6**	**5.7**	**5.8**	**5.7**	**6.0**	**5.5**	**5.7**	**5.5**

Test whether two samples taken from two random populations have the same variance. (5% point of F for $v_1 = 9$ and $v_2 = 9$ is 3.18).

Sol :

Let us take the null hypothesis that the samples come from populations having me same variance.

Calculations for Sample Variances

X_1	$(X_1 - \bar{X}_1)$	$(X_1 - \bar{X}_1)^2$	X_2	$(X_2 - \bar{X}_2)$	$(X_2 - \bar{X}_2)^2$
6.2	+0.2	0.04	5.6	–0.1	0.01
5.7	–0.3	0.09	5.9	+0.2	0.04
6.5	+0.5	0.25	5.6	–0.1	0.01
6.0	0	0	5.7	0	0
6.3	+0 3	0.09	5.8	+0.1	0.01
5.8	–0.2	0.04	5.7	0	0
5.7	–0.3	0.09	6.0	+0.3	0.09
6.0	0	0	5.5	–0.2	0.04
6.0	0	0	5.7	0	0
5.8	–0.2	0.04	5.5	–0.2	0.04
$\Sigma X_1 = 60$	**$\Sigma(X_1 - \bar{X}_1) = 0$**	**$\Sigma(X_1 - \bar{X}_1)^2 = 0.64$**	**$\Sigma X_2 = 57$**		**$S(X_2 - \bar{X}_2)^2 = 0.24$**

$$F = \frac{S_1^2}{S_2^2}$$

$$S_1^2 = \frac{\Sigma(X_1 - \bar{X}_1)^2}{n_1 - 1} = \frac{0.64}{9} = 0.071$$

$$S_2^2 = \frac{\Sigma(X_2 - \bar{X}_2)^2}{n_2 - 1} = \frac{0.24}{9} = 0.027$$

$$F = \frac{0.071}{0.027} = 2.63$$

The value of for 9 and 6 at 5% level of significance is 3.18. The calculated value is less than the table value. The hypothesis holds true. Hence the samples come from populations having the same variance.

2.4 CHI SQUARE TEST

Q12. Explain briefly about Chi-Square Test.

Ans : **(Imp.)**

The magnitude of discrepancy between the theory and observation is given by the quantity χ^2 (a Greek letter, pronounced as "chi-square"). If $\chi = 0$, the observed and expected frequencies completely coincide. As the value of χ^2 increases, the discrepancy between the observed and theoretical frequencies increases. Thus, χ^2 affords a measure of the correspondence between theory and observation.

Definition

If a set of events $A_1, A_2,.....,A_n$ are observed to occur with frequencies $O_1, O_2,.....,O_n$ respectively and according to probability rules $A_1, A_2,...., A_n$ are expected to occur with frequencies $E_1, E_2,....,E_n$ respectively with $O_1, O_2,.....,0_n$ are called observed frequencies and $E_1, E_2,....,E_n$ are called expected frequencies.

If O_i (i = 1, 2,...,n) is a set of observed (experimental) frequencies and E_i (i= 1, 2,...,n) is the corresponding set of expected (theoretical) frequencies, then χ^2 is defined as $\chi^2 = \sum_{i=1}^{n} \frac{(O_i - E_i)}{E_i}$ with (n – l) degrees of freedom.

χ^2 is used to test whether differences between observed and expected frequencies are significant.

Note :

If the data is given in a series of 'n' numbers then degrees of freedom = n – 1.

In case of Binomial distribution, d.f. = n – 1.

In case of Poisson distribution, d.f. = n – 2

In case of Normal distribution, d.f. = n – 3

Chi-square Distribution is an important continuous probability distribution and it is used in both large and small tests. In chi-square tests, χ^2 - distribution is mainly used

(i) To test the goodness of fit,

(ii) To test the independence of attributes,

(iii) To test if the population has a specified value of the variance σ^2.

Q13. Explain briefly about Chi Square Test as Test of goodness of fit.

Ans :

One of the very popular applications of χ^2 test is test of goodness of fit. It enables us to ascertain how the theoretical distributions such as Binomial, Poisson, Normal etc. can fit into empirical distributions obtained from sample data. When an ideal frequency curve whether normal or some other type is fitted to the data, we are interested out how well this curve fits with the observed facts.

A test of the concordance (goodness of fit) of the two can be made just by inspection, but such a test is obviously inadequate. Precision can be secured by applying the χ^2 test.

The following are the steps in testing the goodness of fit :

1. Null and alternative hypotheses are established, and a significance level is selected for rejection of the null hypothesis.

2. A random sample of independent observations is drawn from a relevant statistical population.

3. A set of expected or theoretical frequencies is derived under the assumptions that the null hypothesis is true. This generally takes the form of assuming that a particular probability distribution is applicable to the statistical population under consideration.

4. The observed frequencies are compared with the expected, or theoretical frequencies.

5. If the calculated value of χ^2 is less than the table value at a certain level of significance (generally 5% level) and for certain degrees of freedom the fit is considered to be good, i.e., the divergence between the actual and expected frequencies is attributed to random fluctuations of sampling.

On the other hand, if the calculated value of χ^2 is greater than the table value, the fit is considered to be poor, i.e., it cannot be attributed to fluctuations of sampling rather it is due to the inadequacy of the theory to fit the observed facts.

Goodness of Fit

χ^2 test help us to find out how well the assumed theoretical distribution fit to the observed data. When some theoretical distribution is fitted to the given data, the statistician or managers will be interested in knowing as to how this distribution fits with the observed data.

This method of χ^2 test helps in answering this question.

If the calculated value of χ^2 is less than the table value at a certain level of significance, the fit is considered to be good one i.e., divergence between the observed and expected frequencies is attributable to fluctuations of sampling. But if the reverse occurs, the fit is not considered to be a good one. In short,

$\chi^2_{cal} < \chi^2_{table} \Rightarrow$ Good fit

$\chi^2_{cal} < \chi^2_{table} \Rightarrow$ Not a good fit.

If = 1, 2, ... n is a set of observed (experimental) frequencies and E_i (i = 1, ... n) is the corresponding set of theoretical frequencies then $\chi^2 = \sum_{i=1}^{n} \frac{(O_i - E_i)^2}{E_i}$ with the condition that, $\sum_{i=1}^{n} O_i = \sum_{i=1}^{n} E_i$ = N = Total frequency follows, χ^2 - Distribution with (n – 1) d.o.f.

Steps for Test of Goodness of Fit

1. Null hypothesis : Good fit exists between the theoretical distribution and given data.

2. Alternative hypothesis : No good fit.

3. Level of significance is α.

4. Critical region : Reject null hypothesis if $\chi^2 > \chi^2_a$ with v d.o.f. i.e., theoretical distribution is a poor fit.

5. Computations : $\chi^2 = \sum_{i=1}^{k} \frac{(O_i - E_i)^2}{E_i}$

6. **Decision :** Accept null hypothesis, if $\chi^2 < \chi^2_\alpha$. i.e., the theoretical distribution is a good fit to the data.

PROBLEMS

10. The number of automobile accidents per week in a certain community are as follows : 12, 8, 20, 2, 14, 10, 15, 6, 9, 4. Are these frequencies in agreement with the be that accident conditions were the same during this 10 week period.

Sol :

Expected frequency of accidents each week $= \frac{100}{10} = 10$.

Null Hypothesis H_0 : The accident conditions were the same during the 10 week period.

Alternative Hypothesis H_1 : The accidents conditions are different during the 10 week period.

Observed Frequency (O_i)	Expected Frequency (E_i)	$(O_i - E_i)$	$(O_i - E_i)^2$	$\frac{(O_i - E_i)^2}{E_i}$
12	10	2	4	0.4
8	10	–2	4	0.4
20	10	10	100	10.0
2	10	–8	64	6.4
14	10	4	16	1.6
10	10	0	0	0.0
15	10	5	25	2.5
6	10	–4	16	1.6
9	10	–1	1	0.1
4	10	–6	36	3.6
100	100			26.6

Now $\chi^2 = \Sigma \frac{(O_i - E_i)^2}{E_i} = 26.6$ i.e., Calculated $\chi^2 = 26.6$

Here n = 10 observations are given

Degrees of freedom (d.f) = n – 1 = 10 – 1 = 9

Tabulated $\chi^2 = 16.9$

Since Calculated χ^2 > Tabulated χ^2 therefore, the Null Hypothesis is rejected and conclude that the accident conditions were not the same during the 10 week period.

11. A sample analysis of examination results of 500 students was made. It was found that 220 students had failed, 170 had secured a third class, 90 were placed in second class and 20 got a first class. Do these figures commensurate with the general examination result which is in the ratio of 4 : 3 : 2 : 1 for the various categories respectively.

Sol :

Null Hypothesis H_0 : The observed results commensurate with the general examination results.

Alternative Hypothesis H_1 : The observed results are not commensurate with the general examination

Expected frequencies are in the ratio of 4 : 3 : 2 : 1

Total frequency = 500

If we divide the total frequency 500 in the ratio 4 : 3 : 2 : 1, we get the expected frequencies as 200, 150, 100, 50.

Calculations for χ^2

Class	Observed Frequency (O_i)	Expected Frequency (E_i)	$(O_i - E_i)$	$(O_i - E_i)^2$	$\frac{(O_i - E_i)^2}{E_i}$
Failed	220	200	20	400	2.00
Third	170	150	20	400	2.667
Second	90	100	–10	100	1.000
First	20	50	–30	900	18.00
	500	500			23.667

Calculated $\chi^2 = \sum \frac{(O_i - E_i)^2}{E_i} = 23.667$

Degrees of freedom = 4 –1 = 3 i.e., v = 3

For v = 3, $\chi^2_{0.05} = 7.81$

i.e., tabulated value of x^2at 5% level for 3 d.f = 7.81

Since calculated $\chi^2_{0.05}$ > tabulated $\chi^2_{0.05}$, we reject the null hypothesis.

i.e., the observed results are not commensurate with the general examination results.

12. The following figures show the distribution of digits in numbers chosen a random from a telephone directory.

Digits	0	1	2	3	4	5	6	7	8	9
Frequency	1026	1107	997	966	1075	933	1107	972	964	853

Test whether the digits may be taken to occur equally frequently in the director.

Sol :

Null Hypothesis H_0 : The digits occur equally frequently in the directory.

Alternative Hypothesis H_1 : The digits do not occur equally frequently.

Under this null hypothesis the expected frequencies for each of the digits

0,1,2,....,9 is $\frac{10,000}{10}$ = 1000.

Calculations for χ^2

Digits	Observed Frequency (O_i)	Expected Frequency (E_i)	$(O_i - E_i)$	$(O_i - E_i)^2$	$\frac{(O_i - E_i)^2}{E_i}$
0	1026	1000	26	676	0.676
1	1107	1000	107	11449	11.449
2	997	1000	–3	9	0.009
3	966	1000	–34	1156	1.156
4	1075	1000	75	5625	5.625
5	933	1000	–67	4489	4.489
6	1107	1000	107	11449	11.449
7	972	1000	–28	784	0.784
8	964	1000	–36	1296	1.296
9	853	1000	–147	21609	21.609
Total	10000	10,000			58.542

Calculated $\chi^2 = \sum \frac{(O_i - E_i)^2}{E_i} = 58.542$

Degrees of freedom = n - 1 = 10-1 = 9

The tabulated value of for 9 d.f. at 5% level = 16.919

Since calculated χ^2 > tabulated χ^2, we reject the null hypothesis H_0 and conclude :hat the digits do not occur equally frequently in the directory.

13. A die is thrown 264 times with the following results. Show that the die is biased. [Given $\chi^2_{0.05} = 11.07$ for 5 d.f]

No. appeared on the die	1	2	3	4	5	6
Frequency	40	32	28	58	54	52

Sol :

Null Hypothesis H_0: The die is unbiased.

The expected frequency of each of the numbers 1, 2, 3, 4, 5, 6 is

$$\frac{264}{6} = 44$$

Calculations for χ^2

Observed frequency (O_i)	Expected frequency (E_i)	$(O_i - E_i)$	$(O_i - E_i)^2$	$\frac{(O_i - E_i)^2}{E_i}$
40	44	–4	16	0.3636
32	44	–12	144	3.2727
28	44	–16	256	5.8181
58	44	+14	196	4.4545
54	44	+10	100	2.2727
52	44	+8	64	1.4545
264	264			17.6362

$\therefore \quad \chi^2 = \sum \frac{(O_i - E_i)^2}{E_i} = 17.6362$

The number of degrees of freedom = n – 1 = 5

The tabulated value of χ^2 for 5 d.f at 5% level = 11.07

Since calculated χ^2 > tabulated χ^2, we reject the null hypothesis H_0

i.e., we reject the hypothesis that the die is unbiased. Hence the die is biased.

14. The following results are obtained when a dice is thrown 132 times. Test the Hypothesis that the dice is unbiased

No. Turned up	1	2	3	4	5	6
Frequency	16	20	25	14	29	28

Sol :

Chi-Square Test

Step - 1

Null Hypothesis :

H_0 : The dice is unbiased

Alternative Hypothesis :

H_1 : The dice is not unbiased

Expected (E) = $\frac{132}{6}$ = 22 times

Step - 2 : Computing Test Statistics χ^2

S.No.	O	E	O – E	$(O - E)^2$	$\frac{(O-E)^2}{E}$
1	16	22	– 6	36	1.64
2	20	22	– 2	4	0.18
3	25	22	3	9	0.41
4	14	22	– 8	64	2.91
5	29	22	7	49	2.23
6	28	22	6	36	1.64
					$\Sigma\left[\frac{(O-E)^2}{E}\right] = 9.01$

$$c^2 = \Sigma\left[\frac{(O-E)^2}{E}\right]$$

$$= 9.01$$

Step - 3 : Level of Significance :

Level of significance = a = 0.05 (Assumed)

Degree of freedom = n – 1

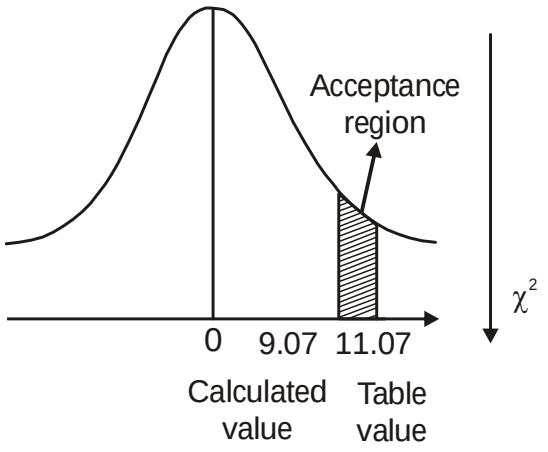
= 6 – 1 = 5

Step - 4 :

Table value of χ^2 for 5 d. at 5% level of significance is 11.07.

Step - 5 :

Table calculated value of χ^2 is 9.01 which is less than the table value i.e., 11.07. Hence, Null hypothesis is accepted, which states that the dice is unbiased.



Figure

Q14. Explain the Chi-Square Test for independence of attributes.

Ans : **(Imp.)**

An attribute means a quality or characteristic. Example of attributes are drinking, smoking, blindness, honesty, beauty etc.

An attribute may be marked by its presence (position) or absence in a number of a given population. Let the observations be classified according to two attribute and the frequencies O_i in the different categories be shown in a two-way table called contingency table. We have to test on the basis of cell frequencies whether the two attributes are independent or not. We take the Null - Hypothesis H_0 that there is no association between the attributes i.e., we assume that the two attributes are independent. The expected frequencies (E_i) of any cell = $\frac{\text{Row total} \times \text{Column total}}{\text{Grand total}}$

The test statistic $\chi^2 = \sum_i \left[\frac{(O_i - E_i)^2}{E_i}\right]$ approximately follows Chi-square distribution with d.f. = (No. of rows – 1) × (No. of columns – 1)

If the calculated value of χ^2 is less than the table value at a specified level (generally 5%) of significance, the hypothesis holds good i.e., the attributes are independent and do not bear any association. On the other hand, if the calculated value of χ^2 is greater than the table value at a specified level of significance, we say that the results of the experiment do not support the hypothesis, in other words, the attributes are associated.

Let us consider two attributes A and B. A is divided into two classes and B is divided into two classes. The various cell frequencies can be expressed in the following table known as 2 × 2 contingency table.

	A	a	b
	B	c	d
a	b		a + b
c	d		c + d
a + c	b + d		N = a + b + c + d

The expected frequencies are given by

$E(a) = \frac{(a+c)(a+b)}{N}$	$E(b) = \frac{(b+d)(a+b)}{N}$	a + b
$E(c) = \frac{(a+c)(c+d)}{N}$	$E(d) = \frac{(b+d)(c+d)}{N}$	c + d
a + c	b + d	N = a + b + c + d

The value of y^2 is given by χ^2 is given $\chi^2 = \frac{N(ad-bc)^2}{(a+b)(c+d)(a+c)(b+d)}$ where

N = a + b + c + d with d.f. = (2 – l)(2 – l) = 1. We use this formula when the expected frequencies are in fractions (or decimals).

PROBLEMS

15. On basis of information given below about the treatment of 200 patients suffering from a disease, state whether the new treatment is comparatively superior to the conventional treatment.

	Favourable	Not favourable	Total
New	60	30	90
Conventional	40	70	110

Sol :

Null Hypothesis H_0 : Difference between new and conventional treatment (or) New and conventional treatment are independent.

Alternative Hypothesis H_1 : No difference between new and conventional treatment.

The number of degrees of freedom is (2 – 1) (2 – 1) =1

Expected frequencies are given in the table :

$$\text{Expected frequency} = \frac{\text{Row total} \times \text{Column total}}{\text{Grand total}}$$

$\frac{90 \times 100}{200} = 45$	$\frac{90 \times 100}{200} = 45$	90
$\frac{100 \times 110}{200} = 55$	$\frac{100 \times 110}{200} = 55$	110
100	100	200

Calculation of χ^2 :

Observed Frequency (O_i)	Expected Frequency (E_1)	$(O_i - E_i)$	$(O_i - E_i)^2$	$\frac{(O_i - E_i)^2}{E_i}$
60	45	+15	225	5
30	45	–15	225	5
40	55	–15	225	4.09
70	55	+15	225	4.09
200	200			18.18

$$\therefore \quad \chi^2 = \sum \frac{(O - E)^2}{E} = 18.18$$

Tabulated χ^2 for 1 d.f. at 5% level of significance is 3.841.

Since calculated χ^2 > tabulated χ^2 we reject the null hypothesis H_0 i.e., new and conventional treatment are not independent. The new treatment is comparatively. Superior to conventional treatment.

16. The following table gives the classification of 100 workers according to sex and nature of work. Test whether the nature of work is independent of the sex of the worker.

	Stable	Unstable	Total
Males	**40**	**20**	**60**
Females	**10**	**30**	**40**
Total	**50**	**50**	**100**

Sol :

Null Hypothesis H_0 : The nature of work is independent of the sex of the workers.

Alternative Hypothesis H_1 : The nature of work are dependent of the sex in the workers.

Expected frequencies are given in the table :

$\frac{50\times60}{100} = 30$	$\frac{50\times60}{100} = 30$	60
$\frac{50\times40}{100} = 20$	$\frac{50\times40}{100} = 20$	40
50	50	100

Calculation of χ^2 :

O_i	E_i	$(O_i - E_i)$	$(O_i - E_i)^2$	$\frac{(O_i - E_i)^2}{E_i}$
40	30	+10	100	3.333
20	30	–10	100	3.333
10	20	–10	100	5.000
30	20	+10	100	5.000
100	100		$\sum\frac{(O_i - E_i)^2}{E_i}$	16.66

$\chi^2 = \sum\frac{(O_i - E_i)^2}{E_i} = 16.66$

$\therefore$ Calculated $\chi^2 = 16.66$

Tabulated value of χ^2 for (2 – 1) (2 – 1) = 1 d.f. at 5% level of significance is 3.84.

Since calculated χ^2 > tabulated χ^2, we reject the null hypothesis H_0, i.e,, the nature of work is not independent of the sex of the workers.

i.e., there is difference in the nature of work on the basis of sex.

17. In an anti malarial campaign in a certain area quinine was administered to 812 persons. Out of a total population of 3248 persons the number of fever cases in shown below :

	Fever	No Fever	Total
Quinine	**20**	**792**	**812**
No Quinine	**220**	**2216**	**2436**
Total	**240**	**3008**	**3248**

Discuss the usefulness of quinine in checking malaria.

Sol :

It is a χ^2 test

Null Hypothesis

H_0 = Quinine is not effective in checking malaria

Alternative Hypothesis

H_1 = Quinine is effective in checking malaria

Computing Test Statistic

$$\chi^2 = \Sigma\left(\frac{(O_{ij} - E_{ij})^2}{E_q}\right)$$

$$E_{ij} = \frac{RT \times CT}{GT}$$

Calculation of Expected Frequencies

Treatment	Fever	No Fever	Total
Quinine	$\frac{812 \times 240}{3.248} = 60$ E_{11}	$\frac{812 \times 3,008}{3,248} = 752$ E_{12}	812
No Quinine	$\frac{2,436 \times 240}{3,248} = 180$ E_{21}	$\frac{2,436 \times 3,008}{3,248} = 2,256$ E_{22}	2,436
Total	**240**		**3,248**

Calculation of x^2

Group	O_{ij} (1)	E_{ij} (2)	$O_{ij} - E_{ij}$ (3) = (1) – (2)	$(O_{ij} - E_{ij})^2$ (4)	$\frac{(O_{ij} - E_{ij})^2}{E_{ij}}$ (5) = $\frac{(4)}{(2)}$
11	20	60	– 40	1,600	26.667
12	792	752	40	1,600	2.128
21	220	180	40	1,600	8.889
22	2,216	2,256	– 40	1,600	0.709
				Total	**38.393**

$$\therefore \chi^2 = \sum\left(\frac{O_{ij} - E_{ij}}{E_{ij}}\right) = 38.393$$

Level of significance, α = 0.05 (Assumed)

Degree of freedom = (c – 1) (r – 1) = (2 – 1) (2 – 1)

= 1 × 1 = 1

Table of χ^2 at 1 d,f and 0.05 is 3.84

Since calculated $\chi^2 \geq \chi^2_{tab}$, we reject null hypothesis. Hence, quinine is effective in checking malaria.

2.5 ANOVA

Q15. Define ANOVA? What are the assumptions of ANOVA?

Ans : **(Imp.)**

Meaning

The analysis of variance, popularly known as ANOVA is very useful statistical technique for testing the equality of more than two means of populations. As discussed in the previous chapter, the significance of the difference between the two means of two samples can be judged through the application of either Z-test or t-test, but the difficulty arises when the researcher has to test the significance of difference among the more than two sample means at the same time. This technique is successfully used by the researchers in the field of economics, commerce, management, education, psychology, sociology and in many other areas. This technique is used where multiple sample cases are involved.

The ANOVA technique is developed by Professor R. A. Fisher in 1920s and later on Professor Snedecor and many others contributed in the development of this technique. The analysis of variance technique consists of classifying and cross classifying statistical results and testing whether the means of a specified classification differ significantly. In other word, ANOVA is a procedure for testing the difference among different groups of data for homogeneity. ANOVA is a technique that separates the total amount of variation in a set of data in two ways, the amount which can be attributed to chance and the amount which can be attributed to the specific causes. There may be variation between samples and also within sample items. The between sample variance represents the effect of treatment or factor and within sample variance describes the deviation of data points within each group from the sample mean which is often called error. It consists of splitting the variance for analytical purpose. Thus, it is a technique of analysing the variance to which a response is subject into its various components corresponding to various sources of variation. ANOVA is also used to test the significance of regression analysis.

Definitions

The definitions of analysis of variance are given as under :

(i) **According to R. A. Fisher,** "The analysis of variance is defined as the separation of the variance ascribable to one group of causes from the variance ascribable to other groups".

(ii) **According to H. T. Hayslett,** "The analysis of variance is a technique that separates the variation that is present into independent components, then these components are analysed in order to test certain hypothesis".

Assumptions

1. **Normality:** The population is normally distributed.

2. **Homogeneity:** The variance within each group should be equal for all groups. This assumption ensure that all variances within the group are clubbed into single "within group" source of variation.

3. **Randomness:** The samples under study have been drawn at random from the population.

4. **Independence of Error:** This implies that variation of each item around the group mean should be independent for each item value.

2.5.1 One-Way Anova

Q16. Explain in detail about One-Way ANOVA.

Ans : **(Imp.)**

In one way classification (or single factor ANOVA), only one factor is considered and its effect on elementary units is observed, i.e., data classified according to only one criterion.

Example: Yield of crops is affected by type of seed only.

Steps

The steps involved in conducting one-way ANOVA test using short-cut method are as follows:

Step-1

Set null hypothesis (H_0) and alternative hypothesis (H_1)

Null hypothesis states that arithmetic mean of populations from which samples are taken are same/ equal.

$$H_o : \mu_1 = \mu_2 = \mu_3 ..... \mu_k$$

Alternative hypothesis states that arithmetic means of populations from which samples are taken are not equal.

$$H_1 : \mu_1 \neq \mu_2 \neq \mu_3 ..... \mu_k$$

Step-2

Calculate the sum of all the items of all samples.

$$GT = \Sigma x_1 + \Sigma x_2 + \Sigma x_2 ..... \Sigma_k$$

Where,

T = Sum of all the items of all samples

Step-3

Calculate Correction Factor (C.F)

$$CF = \frac{(GT)^2}{N}$$

N = Sum of number of items in each sample (or total number of observations)

Step-4

Calculate Total Sum of Squares (TSS)

$$TSS = \sum_i \sum_j X_{ij}^2 - C.F$$

Step-5

Calculate Sum of Squares Between Samples (SSB)

$$SSB = \frac{\Sigma T_j^2}{n_j} - \frac{GT^2}{N}$$

or

$$SSB = \left[\frac{(\Sigma X_1)^2}{n_1} + \frac{(\Sigma X_2)^2}{n_2} ..... \frac{(\Sigma X_k)^2}{n_k}\right] - \frac{GT^2}{N}$$

Step-6

Calculate sum of squares within samples (SSW).

$$SSW = TSS - SSB$$

Step-7

Calculate mean sum of squares between samples, within samples and variance ratio (F). Use the following ANOVA table.

ANOVA Table for One-way Classification

Source of Variation	Sum of Squares	d.f.	Mean Sum of Squares	Variance Ratio (F)
Between Samples	S_1^2	$k - 1$	$S_1^2 = \frac{S_1^2}{(k-1)}$	$F = \frac{S_1^2}{S_e^2} = F(k-1, n-k)$
Within Samples	S_e^2	$n - k$	$S_e^2 = \frac{S_e^2}{(n-k)}$	
Total	$\mathbf{S_T^2}$	**n – 1**		

Step-8:

Compare the calculated value of F ratio with table value of F for degrees of freedom for between and within samples.

If calculated value of F < table value of F, the difference is taken as insignificant and we accept null hypothesis. If calculated value of F > table value of F, the difference is taken as significant and we reject null hypothesis.

PROBLEMS

18. To assess the significance of possible variation in performance in a certain test between the grammar schools of a city, a common test was given to a number of students taken at random. From the following results, make out an analysis of variance.

Schools			
A	**B**	**C**	**D**
8	**12**	**18**	**13**
10	**11**	**12**	**9**
12	**9**	**16**	**12**
8	**14**	**6**	**16**
7	**4**	**8**	**15**

Sol :

Step-1:

Null Hypothesis (H_0) : There is no significant variation in the performance of students in certain test i.e., $H_0 \neq \mu_1 \neq \mu_2 \neq \mu_3 \neq \mu_4$

Alternative Hypothesis (H_1) : There is a significant variation in the performance of students in certain test i.e., $H_1 \neq \mu_1 \neq \mu_2 \neq \mu_3 \neq \mu_4$

Schools							
School-A		School-B		School-C		School-D	
x_1	x_1^2	x_2	x_2^2	x_3	x_3^2	x_4	x_4^2
8	64	12	144	18	324	13	169
10	100	11	121	12	144	9	81
12	144	9	81	16	256	12	144
8	64	14	196	6	36	16	256
7	49	4	16	8	64	15	225
45	**421**	**50**	**558**	**60**	**824**	**65**	**875**

Step -2: Calculation of Grand Total (GT)

G T = 45 + 50 + 60 + 65 = 220

Step -3: Calculation of Correction Factor

$$\text{Correction Factor} = \frac{(GT)^2}{N}$$

$n_1 = 5, n_2 = 5, n_3 = 5$ and $n_4 = 5$

$N = n_1 + n_1 + n_2 + n_4$

$N = 5 + 5 + 5 + 5 = 20$

$$\text{C.F.} = \frac{(220)^2}{20} = 2{,}420$$

Step-4: Calculation of Total Sum of Squares (TSS)

$$TSS = \sum_i \sum_j X_{ij}^2 - \text{C.F}$$

TSS = (421 + 558 + 824 + 875) – 2420

TSS = 2678 – 2420 = 258

Step-5: Calculation of Sum of Squares Between Samples (SSB)

$$SSB = \frac{\Sigma T_j^2}{n_j} \frac{GT^2}{N} = \left[\frac{45^2}{5} + \frac{50^2}{5} + \frac{60^2}{5} + \frac{65^2}{5}\right] - \frac{(220)^2}{20}$$

$$SSB = \left[\frac{2025}{5} + \frac{2500}{3} + \frac{3600}{5} + \frac{4225}{5}\right] - \frac{48400}{20}$$

SSB = [405 + 500 + 720 + 845] - 2420

SSB = 2470 – 2420 = 50

Step -6: Calculation of Sum of Squares within Samples

SSW = TSS – SSB

SSW = 258 – 50 = 208

Step -7: Anova Table

Sources of Variation	Sum of Squares	Degrees of Freedom	Mean Squares	F-ratio
Between samples	50	(k – 1) = (4 – l) = 3	$\frac{50}{3}$ = 16.67	$\frac{16.67}{13}$ = 1.28
Within samples	208	(N – k) = (20 – 4) = 16	$\frac{208}{16}$ = 13	
Total	**258**	**(N – 1) = (20 – 1) = 19**		

Step -8:

F-ratio calculated = 1.28

F-ratio from table when V_1 = 3 and V_2 = 16 is 3.24 at 5% level of significance.

[**Note:** Assuming level of significance as 5%].

Since, $F_{cal} < F_{table}$, we accept null hypothesis, i.e., there is no significant variation in the performance of students in a certain common test conducted between the different grammar schools of a city.

19. A manufacturing company wishes to test the average life of the four brands of electric bulbs. The company uses ail brands in a randomly selected production plants. The records showing the lives (in "00" hours) of bulbs are as given in the table below:

Brand 1	Brand 2	Brand 3	Brand 4
22	21	23	17
25	17	21	19
20	19	22	18
19	22	19	20
	18	18	

Test the hypothesis that the average life for each brand of bulbs is the same. Assume alpha 1 %.

Sol :

Step -1

Null Hypothesis (H_0): There is no significant difference in the average life of four brands of bulbs.

$H_0 = \mu_1 = \mu_2 = \mu_3 = \mu_4$

Alternative Hypothesis (H_1): There is a significant difference in the average life of four brands of bulbs.

$H_1 = \mu_1 \neq \mu_2 \neq \mu_3 \neq \mu_4$

Brand-1		Brand-2		Brand-3		Brand-4	
x_1	x_1^2	x_2	x_2^2	x_3	x_3^2	x_4	x_4^2
22	484	21	441	23	529	17	289
25	625	17	289	21	441	19	361
20	400	19	361	22	484	18	324
19	361	22	484	19	361	20	400
–	–	18	324	18	324	–	–
86	**1870**	**97**	**1899**	**103**	**2139**	**97**	**1374**

Step -2: Calculation of Grand Total (GT)

GT = 86 + 97+ 103 + 7.4 = 360

Step -3: Calculation of Correction Factor (C.F)

$$\text{Correction Factor} = \frac{(GT)^2}{N}$$

$n_1 = 4, n_2 = 5, n_3 = 5$ and $n_4 = 4$

$N = n_1 + n_2 + n_2 + n_4$

$N = 4 + 5 + 5 + 4 = 18$

$$C.F. = \frac{(360)^2}{18} = 7{,}200$$

Step -4: Calculation of Total Sum of Squares (TSS)

$$TSS = \Sigma_i \Sigma_j x_{ij}^2 - C.F$$

TSS = (1870 + 1899 + 2139+ 1374) – 7200

TSS = 7282 – 7200

TSS = 82

Step-5: Calculation of Sum of Squares Between Samples (SSB)

$$SSB = \frac{\Sigma T_j^2}{n_j} - C.F$$

$$SSB = \left[\frac{(86)^2}{4} + \frac{(97)^2}{5} + \frac{(103)^3}{5} + \frac{(74)^2}{5}\right] - 72O0$$

$$SSB = \left[\frac{7396}{4} + \frac{9409}{5} + \frac{10609}{5} + \frac{5476}{4}\right] - 72O0$$

SSB = [1849 + 1881.8 + 2121.8 + 1369] – 7200

SSB =7221.6 – 7200

SSB = 21.6

Step-6: Calculation of Sum of Squares within Samples

SSW = TSS – SSB

SSW = 82 – 21.6 = 60.4

Step -7: Anova Table

Sources of Variation	Sum of Squares	Degrees of Freedom	Mean Squares	F-ratio
Between samples	21.6	(k – 1) = (4 – 1) = 3	$\frac{21.6}{3}$ = 7.2	$\frac{7.2}{4.31}$ = 1-67
Within samples	60.4	(n – k) = (18 – 4) = 14	$\frac{60.4}{14}$ = 4.31	
Total	**82**	**(n – 1) = (18 – 1) = 17**		

F-ratio calculated = 1.67

Value of F from table when F_1 = 3 and V_2 = 14 is 5.56 at 1% level of significance.

Since $F_{cal} < F_{table}$, we accept null hypothesis (H_0), which means there is no significant difference in the average life of four brands of bulbs.

2.5.2 Two-Way Anova

Q17. Explain in detail about Two-Way ANOVA.

(OR)

Write about Two-Way Classification of ANOVA.

Ans : **(Imp.)**

In Two way classification (or two factor ANOVA), two independent factors are considered and their effect on the response variable of interest is observed.

Example:

Yield of crops is affected by type of seed as well as type of fertilizer.

Steps

The steps involved in conducting two-way ANOVA test using short-cut method are as follows:

Step-1:

Set null hypothesis and alternative hypothesis for the two factors.

Say A and B

$H_{0A} : \mu_1 = \mu_2 ..... \mu_k$

$H_{0B} : \mu_1 = \mu_2 ..... \mu_k$

Null hypothesis states that arithmetic mean of populations from which samples are taken are equal.

$H_{1A} : \mu_1 \neq \mu_2 ..... \mu_k$

$H_{1B} : \mu_1 \neq \mu_2 ..... \mu_k$

Alternative hypothesis states that arithmetic means of populations from which samples are taken are not equal.

Step -2:

Calculate the sum of all the items of all.

$$GT = \Sigma\Sigma x_{ij} = \sum_i R_i = \Sigma_i C_j$$

Where,

R = Row

C = Column

Step -3:

Calculate Correction Factor (C.F)

$$C.F. = \frac{(GT)^2}{N}$$

Step -4:

Calculate Total Sum of Squares (TSS)

TSS = RSS – C.F

$$\Rightarrow RSS = \sum_i \sum_j X_{ij}^2$$

Where,

R = Raw sum of squares

Step -5:

Calculate Sum of Squares Between Rows (SSR)

$$SSR = \frac{R_1^2}{n} + \frac{R_2^2}{n} + \frac{R_3^2}{n} + ... - C.F$$

Where,

n = Number of samples

Step -6:

Calculate Sum of Squares Between Columns (SSC).

$$SSC = \frac{C_1^2}{n} + \frac{C_2^2}{n} + \frac{C_3^2}{n} + ... \frac{C_k^2}{n} - C.F$$

Step -7:

Calculate Sum of Squares due to Error (SSE).

SSE = TSS – SSR – SSC

ANOVA Table for Two-way Classification

Sources of Variation	Sum of Squares	d.f.	Mean Squares Squares	Ratio of F
Between Samples	SSC	(C – l)	$MSC = \frac{SSC}{(C-1)}$	F = MSC
Between Rows	SSR	(r – 1)	$SSR = \frac{SSR}{(r-1)}$	F = MSR/MSE
Residual or Error	SSE	(C –1) (r – 1)	$MSE = \frac{SSE}{(r-1)(C-1)}$	
Total	**SST**	**N – 1**		

Where,

MSC = Mean sum of squares of columns

MSR = Mean sum of squares of rows

MSE = Mean sum of squares of errors

Step -8:

Compare the calculated value of F ratio with table value of F for degrees of freedom for between and within samples.

If calculated value of F < table value of F, the difference is taken as insignificant and we accept null hypothesis. If calculated value of F > table value of F, the difference is taken as significant and we reject null hypothesis.

PROBLEMS

20. Four technicians analyzed three samples each for the moisture content in the sample. The results are given below:

Samples	Technicians			
	A	B	C	D
X	9	12	10	11
Y	12	11	15	12
Z	9	10	12	14

Analyze the data and comment. Use 5% significance level.

Sol :

A two-way ANOVA technique will enable us to analyses the data and comment.

Here, the two factors are, Technicians (T) and Samples (S).

Step-1: Null Hypothesis

$H_{OT} = \mu_A = \mu_B = \mu_C = \mu_D$ i.e., the mean moisture content is same according to all technicians.

$H_{OS} = \mu_X = \mu_Y = \mu_Z$ i.e., the mean moisture content is same in all the samples.

Alternative Hypothesis

H_{IT} = Atleast two of μ_A, μ_B, μ_C and μ_D are different.

H_{IS} = Atleast two of μ_X, μ_Y, μ_Z are different.

Samples	Technicians					
	A	B	C	D	Row Totals(R)	R^2
X	9	12	10	11	$R_1 = 42$	$R_1^2 = 1764$
Y	12	11	15	12	$R_2 = 50$	$R_2^2 = 2500$
Z	9	10	12	14	$R_3 = 45$	$R_3^2 = 2025$
Column Totals(C)	$C_1 = 30$	$C_2 = 33$	$C_3 = 37$	$C_4 = 37$	$G = 137$	
C^2	$C_1^2 = 900$	$C_2^2 = 1089$	$C_3^2 = 1369$	$C_4^3 = 1369$		

Step -2: Calculation Sum of Items of all Samples

$GT = \Sigma\Sigma x_{ij} = \Sigma_i R_i = \Sigma_j C_j$

$GT = 30 + 33 + 37 + 37 = 137$

or

$GT = 42 + 50 + 45 = 137$

Step -3: Calculation of Correction Factor (C.F)

Here, $GT = 137$, $N = 12$,

$$C.F = \frac{(GT)^2}{N} = \frac{(137)^2}{12} = \frac{18769}{12} = 1564.08$$

Step -4: Calculation of Total Sum of Squares (TSS)

$TSS = \Sigma_i \Sigma_j X_{ij}^2 - C.F$

$TSS = (9^2 + 12^2 + 10^2 + 11^2 + 12^2 + 11^2 + 15^2 + 12^2 + 9^2 + 10^2 + 12^2 + 14^2) - 1564.08$

$TSS = (81 + 144 + 100 + 121 + 144 + 121 + 225 + 144 + 81 + 100 + 144 + 196) - 564.08$

$TSS = 1601 - 1564.08 = 36.92$

Step -5: Calculation of Sum of Squares Between Rows (i.e., Between Samples)

$$SSR \frac{R_1^2}{n} \frac{R_2^2}{n} \frac{R_3^2}{n} \frac{R_k^2}{n} = + ... - C.F$$

$$SSR = \left[\frac{(42)^2}{4} + \frac{(50)^2}{4} + \frac{(45)^2}{4}\right] - 1564.08$$

$SSR = (441 + 625 + 506.25) - 1564.08$

$SSR = 1572.25 - 1564.08$

$SSR = 8.17$

Step -6: Calculation of Sum of Squares Between Columns (i.e., Between Technicians)

$$SSC = \frac{C_1^2}{n} + \frac{C_2^2}{n} + \frac{C_3^2}{n} + ... + \frac{C_k^2}{n} - C.F$$

$$SSC = \left(\frac{30^2}{3} + \frac{33^2}{3} + \frac{37^2}{3} + \frac{37^2}{3}\right) - 1564.08$$

$SSC = (300 + 363 + 456.33 + 456.33) - 1564.08$

$SSC = 1575.66 - 1564.08 = 11.58$

Step -7: Calculation of Sum of Squares of Residual or Error (SSE)

$SSE = TSS - SSR - SSC$

$= 36.92 - 8.17 - 11.58 = 17.17$

ANOVA Table

Sources of Variation	Sum of Squares	Degree of Freedom	Mean Sum of Squares	F-ratio	F-ratio (Table)
Between Technicians	11.58	(c – 1) = (4 – 1) = 3	$\frac{11.58}{3}$ = 3.86	$\frac{3.86}{2.86}$ = 1.35	4.76
Between samples	8.17	(r – k) = (r – 1) = (3–1) = 2	$\frac{8.17}{2}$ = 4.09	$\frac{4.09}{2.86}$ = 1.43	5.14
Residual or Error	17.17	(c – 1) (r – 1) = 3 × 2 = 6	$\frac{17.17}{6}$ = 2.86		
Total	**36.92**	**(n – 1) = 12–1 = 11**			

Step-8:

Table values of F-ratio at 5% level of significance.

$F_{(6,3)}$ = 4.76

$F_{(6,2)}$ = 5.14

(i) Calculated $F_{(6,3)}$ < Table $F_{(6,3)}$

Hence null hypothesis is accepted i.e., there is no significant difference between technicians opinion about mean moisture content in the sample.

(ii) Calculated $F_{(6\,2)}$ < Table $F_{(6\,2)}$

Hence, null hypothesis is accepted i.e., there is no significant difference between samples. Mean moisture content is same in all the samples.

21. The following are the defective pieces produced by four operators working, in turn, on four different machines.

	Operator			
Machine	**A**	**B**	**C**	**D**
A_1	34	28	33	29
A_2	31	24	35	22
A_3	27	20	43	72
A_4	28	29	29	26

Perform analysis of variance of 0.05 level of significance to ascertain whether variability in production is due to variability in operator's performance or variability in machines performance.

Sol :

Two variable factors are,

A : Machine (Rows of the given table).

B : Operators (Columns of the given table)

Step -1:

Null Hypothesis

H_{0_A} = Variability in production is not due to variability in machines performance.

$$\mu_{A_1} = \mu_{A_2} = \mu_{A_3} = \mu_{A_4}$$

H_{0_B} = Variability in production is not due to variability in operators performance.

$$\mu_{B_1} = \mu_{B_2} = \mu_{B_3} = \mu_{B_4}$$

Alternative Hypothesis

H_{IB} = Variability in production due to variability in operators performance i.e., $\mu_{B1} \neq \mu_{B2} \neq \mu_{B3} \neq \mu_{B4}$

H_{IA} = Variability in production due to variability in machine performance i.e., $\mu_{A1} \neq \mu_{A2} \neq \mu_{A3} \neq \mu_{A4}$

Coding of Data

To simplify calculations, let us deduct 28 from each value.

– 28 / Machine	Operator B_1	B_2	B_3	B_4	Row Totals (R)
A_1	6	0	5	1	12
A_2	3	– 4	7	-6	0
A_3	– 1	– 8	15	44	50
A.	0	1	1	– 2	0
Column Total (2)	**8**	**–11**	**28**	**37**	**Grand Total = 62**

Step -2: Calculation of Sum of Items of all Samples

$GT = \Sigma\Sigma x_{ij} = \Sigma_i \Sigma_i = \Sigma_j C_j$

GT = 8 + (– 11) + 28 + 37 = 62

or

GT = 12 + 0 + 50 + 0 = 62

Step -3: Calculation of Correction Factor (C.F)

$$C.F = \frac{(GT)^2}{N}$$

$$= \frac{(62)^2}{16} = 240.25$$

Step -4: Calculation of Total Sum of Squares

$$TSS = \Sigma_i \Sigma_j x_{ij}^2$$

$$TSS = [(6)^2 + (0)^2 + (5)^2 + (1)^2 + (3)^2 + (-4)^2 + (7)^2 + (-6)^2 + (-1)^2 + (-8)^2 + (15)^2 + (44)^2 + (0)^2 + (1)^2 + (1)^2 + (-2)^2] - C.F$$

$$TSS = 2404 - 240.25$$

$$\therefore \quad TSS = 2163.75$$

Step -5: Calculation of Sum of Squares Between Machines (Rows)

$$SSR = \frac{R_1^2}{n} + \frac{R_2^2}{n} + \frac{R_3^2}{n} + ... + \frac{R_k^2}{n} - C.F$$

$$SSR = \left(\frac{(12)^2}{4} + \frac{(0)^2}{4} + \frac{(50)^2}{4} + \frac{(0)^2}{4} \right) - C.F$$

$$SSR = [36 + 0 + 625 + 0] - 240.25$$

$$SSR = 661 - 240.25$$

$$\therefore SSR = 420.75$$

Step -6: Calculation of Sum of Squares Between Operators (Columns)

$$SSC = \frac{C_1^2}{n} + \frac{C_2^2}{n} + \frac{C_3^2}{n} + ... + \frac{C_k^2}{n} - C.F$$

$$SSC = \frac{(8)^2}{4} + \frac{(-11)^2}{4} + \frac{(28)^2}{4} + \frac{(37)^2}{4} - C.F$$

$$SSC = [16 + 30.25 + 196 + 342.25] - 240.25 = 584.5 - 240.25$$

$$\therefore SSC = 344.25$$

Step -7: Calculation of Sum of Squares of Residual or Error (SSE)

$$SSE = TSS - SSR - SSC$$

$$= 2163.75 - 420.75 - 344.25 = 1398.75$$

ANOVA Table

Sources of Variation	Sum of Squares	Degree of Freedom	Mean Sum of Squares	F-ratio
Between Operators	420.75	$(c - 1) = (4 - 1) = 3$	$\frac{344.25}{3} = 114.75$	$\frac{114.75}{155.42} = 0.738$
Between Machines	420.75	$(r - 1) = (4 - 1) = 3$	$\frac{420.75}{3} = 140.25$	$\frac{140.25}{155.42} = 0.902$
Residual or Error	1398.75	$(c - 1)(r - 1) = 3 \times 3 = 9$	$\frac{1398.75}{9} = 155.42$	
Total	**2163.75**	**$(n - 1) = 16 - 1 = 15$**		

Step-8

Critical Value of F_{005}	Computed Value of F
Operators (9, 3) = 3.86	0.738
Machines (9, 3) = 3.86	0.902

Decision

(i) Operators

Since the calculated value of F(0.738) is less than table values (3.86) null hypothesis is accepted.

∴ Variability in production is not due to variability in operators performance.

(ii) Machines

Since the calculated value of F(0.902) is less than table value (3.86) null hypothesis is accepted.

∴ Variability in production is not due to variability in machines performance.

2.6 U-TEST

Q18. Discuss the test procedure of U-Test.

Ans :

The sign test for comparing two population distributions ignores the actual H lagnitude of the paired observations and thereby discards information that would be useful in detecting a departure from the null hypothesis. A statistical test that partially circumvents this loss by utilizing the relative magnitudes of the observations was proposed by Mann and is equivalent to a test proposed independently by Wilcoxon.

Rank sum test is a whole family of tests. Here we shall discuss the types, the Mann-Whitney U test. With this test we can test the null hypothesis $\mu_1 = \mu_2$ without assuming whether the populations sampled have roughly the shape of normal distribution.

This test helps us to determine whether two samples have come from identical populations. If it is true that the samples have come form the same populations it is reasonable to assume that the means of the ranks assigned to the values of the two samples are more or less the same. The alternative hypothesis is that the means of the population are not equal and if this is the case, most of the smaller rank will go to the values of one sample, while most of the higher ranks will go to those of the other sample.

The test of the null hypothesis that the two samples come from identical populations may either be based on R\, the sum of the ranks of the values of first sample, or on R2, the sum of the ranks of the values of the second sample. It may be noted that in practice it does not matter which sample we call sample 1 and which we call sample 2.

If the sample sizes are nj and n_2 the sum of R\ and R2 is simply the sum of first n 1 + n2 positive integers, which is known to be

$$\frac{(n_1 + n_2)(n_1 + n_2 + 1)}{2}$$

This formula enables us to find R_2 if we know R_1 and vice versa.

When the use of the rank sums was first proposed as a non-parametric alternative to the two-sample t-test, the decision was based on R_1 or R_2 , but now the decision is usually based on either of the related statistics :

$$U_1 = n_1 n_2 + \frac{n_1(n_1+1)}{2} - R_1$$

$$U_2 = n_1 n_2 + \frac{n_2(n_2+1)}{2} - R_2$$

where n_1 and n_2 are the size of the samples and R_1 and R_2 are the rank sums of the corresponding samples. For small samples, if both n_1 and n_2 are less than 10 (some statisticians say 8) special tables must be used, and if U is smaller than the critical value, Ho can be related to the standard normal curve by the statistic.

$$Z = \frac{U - n_1 n_2 / 2}{\sqrt{n_1 n_2 (n_1 + n_2)/12}}$$

In using this statistic, it is unimportant whether the larger or smaller value obtained from the formulae is used. The values for Z will be numerically equal, but opposite in sign. Note that tied observations are again given the mean of the common ranks.

2.7 KRUSKAL'S WALLIS TEST / H-TEST

Q19. Discuss the test procedure of Kruskal's Wallis Test / H-Test.

Ans : **(Imp.)**

If several independent samples are involved, analysis of variance is the usual procedure. Failure to meet the assumptions needed for analysis of variance makes its value doubtful. An alternative technique was developed called the Kruskal-Wallis one-way analysis of variance or the H-test. This test helps in testing the null hypothesis that k independent random samples come from identical populations against the alternative hypothesis that the means of these samples are not all equal.

As is done in the Mann-Whitney U-test all data are ranked as if they were in one sample, from lowest to highest, the rank sums of each sample are calculated. The H-statistic is calculated form the formula:

$$H = \frac{12}{N(N+1)}\left(\frac{R_1^2}{n_1} + \frac{R_2^2}{n_2} + ... + \frac{R_k^2}{n_k}\right) - 3(n + 1)$$

when n_1, n_2 ,....., rk are the number in each of k samples, $N = n_1 + n_2 + ... + n_k$, and R_1, R_2, R_k are the rank sums of each sample. If there are ties, the usual procedure is followed, but H is fairly sensitive to ties, so if there are very many of them a correction should be made. The effect of the correction is to increase slightly the value of H, so its use is not imperative. For small samples, H is approximately distributed as Chi-Square with k-1 degrees of freedom, and table 6 given in the appendix can be used.

If the null hypothesis is true and each sample has at least five observations, the sampling distribution of H can be approximated closely with a chi-square distribution with K –1 degrees of freedom. Consequently, we can reject the null-hypothesis that $\mu = \mu_2$ = Pic and accept the alternative that the p's are not all equal at the level of significance a(alpha), if $H > \chi a^2$ for k –1 degrees of freedom. If any sample has less than five items, the χ^2 approximation cannot be used, and the test must be based on special tables.

2.8 RESEARCH REPORT

2.8.1 Concept and Contents of a Research Report

Q20. What is interpretation? Explain the techniques of interpretation.

(OR)

"Interpretation is a fundamental component of research process". Explain why.

Ans :

Meaning

Interpretation refers to the task of drawing inferences from the collected facts after an analytical and/or experimental study. In fact, it is a search for broader meaning of research findings. The task of interpretation has two major aspects viz.,

(i) The effort to establish continuity in research through linking the results of a given study with those of another, and

(ii) The establishment of some explanatory concepts.

"In one sense, interpretation is concerned with relationships within the collected data, partially overlapping analysis". Interpretation also extends beyond the data of the study to include the results of other research, theory and hypotheses. Thus, interpretation is the device through which the factors that seem to explain what has been observed by researcher in the course of the study can be better understood and it also provides a theoretical conception which can serve as a guide for further researches.

Technique of Interpretation

The task of interpretation is not an easy job, rather it requires a great skill and dexterity on the part of researcher. Interpretation is an art that one learns through practice and experience. The researcher may, at times, seek the guidance from experts for accomplishing the task of interpretation.

The technique of interpretation often involves the following steps:

(i) Researcher must give reasonable explanations of the relations which he has found and he must interpret the lines of relationship in terms of the underlying processes and must try to find out the thread of uniformity that lies under the surface layer of his diversified research findings. In fact, this is the technique of how generalization should be done and concepts be formulated.

(ii) Extraneous information, if collected during the study, must be considered while interpreting the final results of research study, for it may prove to be a key factor in understanding the problem under consideration.

(iii) It is advisable, before embarking upon final interpretation, to consult someone having insight into the study and who is frank and honest and will not hesitate to point out omissions and errors in logical argumentation. Such a consultation will result in correct interpretation and, thus, will enhance the utility of research results.

(iv) Researcher must accomplish the task of interpretation only after considering all relevant factors affecting the problem to avoid false generalization. He must be in no hurry while interpreting results, for quite often the conclusions, which appear to be all right at the beginning, may not at all be accurate.

Q21. Describe the precaution that the researcher should take while interpreting his findings.

Ans :

Researcher must pay attention to the following points for correct interpretation:

(i) At the outset, researcher must invariably satisfy himself that

  (a) The data are appropriate, trustworthy and adequate for drawing inferences;

  (b) The data reflect good homogeneity; and that

  (c) Proper analysis has been done through statistical methods.

(ii) The researcher must remain cautious about the errors that can possibly arise in the process of interpreting results. Errors can arise due

to false generalization and/or due to wrong interpretation of statistical measures, such as the application of findings beyond the range of observations, identification of correlation with causation and the like. Another major pitfall is the tendency to affirm that definite relationships exist on the basis of confirmation of particular hypotheses. In fact, the positive test results accepting the hypothesis must be interpreted as "being in accord" with the hypothesis, rather than as "confirming the validity of the hypothesis". The researcher must remain vigilant about all such things so that false generalization may not take place. He should be well equipped with and must know the correct use of statistical measures for drawing inferences concerning his study.

(iii) He must always keep in view that the task of interpretation is very much intertwined with analysis and cannot be distinctly separated. As such he must take the task of interpretation as a special aspect of analysis and accordingly must take all those precautions that one usually observes while going through the process of analysis viz., precautions concerning the reliability of data, computational checks, validation and comparison of results.

(iv) He must never lose sight of the fact that his task is not only to make sensitive observations of relevant occurrences, but also to identify and disengage the factors that are initially hidden to the eye. This will enable him to do his job of interpretation on proper lines. Broad generalization should be avoided as most research is not amenable to it because the coverage may be restricted to a particular time, a particular area and particular conditions. Such restrictions, if any, must invariably be specified and the results must be framed within their limits.

(v) The researcher must remember that "ideally in the course of a research study, there should be constant interaction between initial hypothesis, empirical observation and theoretical conceptions. It is exactly in this area of interaction between theoretical orientation and empirical observation that opportunities for originality and creativity lie".

Q22. What is research report? State the significance of research report.

Ans :

Meaning

Research report is a channel to communicate the research findings to the readers of the report. A good research report is that which does its task efficiently and effectively.

Significance

The following points helps us to know the significance of a research report,

1. A research report is a true, accurate and historical message which helps in transferring the information relating to the research results, recommendations, conclusions and other vital information to the clients.
2. The clients makes his or her decisions on the basis of the contents of the report so it is very important for the researchers to provide value to the client in the research report.
3. The researchers should properly and effectively make their research report as, poorly written research report will not be able to communicate effectively and the time and efforts spend in the research process will be wasted.
4. A good research report helps in making effective communication with the readers of the report and also helps in building credibility.
5. The quality of research report and presentation helps in evaluating the quality of marketing research project or work.
6. The usefulness of research report affects the management's decision to carry out research in future or whether to deal with the particular supplier again or not.

Q23. Explain the steps involved in writing a research report.

Ans :

The following steps are involved in writing a research report:

1. Logical Analysis of Subject Matter

This is concerned with the development of the subject. Two ways to develop the subject (a) Logically and (b) Chronologically, on the basis of mental connections and association of one thing with the other by means of analysis. Chronological development is based on a connection or sequence in time or occurrence.

2. Preparation of the Final Outline

Outlines are used as framework for the long written works. They help in logical organization of material and a reminder of the points to be stressed in the report.

3. Preparation of the Rough Draft

Now the researcher sits to write down what he has done in the context of research study. He will write down the procedure adopted for collecting the data, along with the various limitations faced by him, the broad findings and the generalizations.

4. Rewriting and Polishing of the Rough Draft

Researcher will check the report for weaknesses in logical development and presentation including mechanics of writings, grammar, spelling and usage.

5. Preparation of the Final Bibliography

It is a list of books in some way pertinent to research study.

6. Layout of the Research Report

The research report should convey enough about the study, the scientific context and adequacy of the methods to show how serious the findings are to be taken. Therefore, there is a need for the proper layout of the report. The layout of the report should comprise,

(a) Preliminary pages

(b) Main text

(c) End matter.

(a) Preliminary Pages: The report should carry a title and data followed by acknowledgments in the form of preface or foreword. Then there should be table of contents followed by list of tables and illustrations so that, the reader can easily locate the required information in the report.

(b) Main Text: Researcher should provide the complete outline of the research report along with all the details. The main text should have the following details,

(i) Introduction

(ii) Statement of findings and recommendations

(iii) Results

(iv) Implications drawn from the results

(v) Summary.

(c) End Matter: Appendices should be enlisted in respect of techno a! data such as questionnaire, sample information, mathematical derivations, bibliography etc.

Q24. Explain the layout of research report.

(OR)

Describe in brief the layout of a research report, covering all relevant points.

Ans :

Anybody, who is reading the research report, must necessarily be conveyed enough about the study so that he can place it in its general scientific context, judge the adequacy of its methods and thus form an opinion of how seriously the findings are to be taken. For this purpose there is the need of proper layout of the report. The layout of the report means as to what the research report should contain. A comprehensive layout of the research report should comprise

(A) Preliminary pages

(B) The main text

(C) The end matter

Let us deal with them separately.

(A) Preliminary Pages

In its preliminary pages the report should carry a title and date, followed by acknowledge-ments in the form of 'Preface' or 'Foreword'. Then there should be a table of contents followed by list of tables and illustrations so that the decision-maker or anybody interested in reading the report can easily locate the required information in the report.

(B) Main Text

The main text provides the complete outline of the research report along with all details. Title of the research study is repeated at the top of the first page of the main text and then follows the other details on pages numbered consecutively, beginning with the second page. Each main section of the report should begin on a new page. The main text of the report should have the following sections;

(i) Introduction;

(ii) Statement of findings and recommendations;

(iii) The results;

(iv) The implications drawn from the results; and

(v) The summary.

(i) Introduction: The purpose of introduction is to introduce the research project to the readers. It should contain a clear statement of the objectives of research i.e., enough background should be given to make clear to the reader why the problem was considered worth investigating. A brief summary of other relevant research may also be stated so that the present study can be seen in that context. The hypotheses of study, if any, and the definitions of the major concepts employed in the study should be explicitly stated in the introduction of the report.

The methodology adopted in conducting the study must be fully explained. The scientific reader would like to know in detail about such thing: How was the study carried out? What was its basic design? If the study was an experimental one, then what were the experimental manipulations? If the data were collected by means of question-naires or interviews, then exactly what questions were asked (The questionnaire or interview schedule is usually given in an appendix)? If measurements were based on observation, then what instructions were given to the observers? Regarding the sample used in the study the reader should be told: Who were the subjects? How many were there? How were they selected? All these questions are crucial for estimating the probable limits of generalizability of the findings. The statistical analysis adopted must also be clearly stated. In addition to all this, the scope of the study should be stated and the boundary lines be demarcated. The various limitations, under which the research project was completed, must also be narrated.

(ii) Statement of findings and recommen-dations: After introduction, the research report must contain a statement of findings and recommendations in non-technical language so that it can be easily understood by all concerned. If the findings happen to be extensive, at this point they should be put in the summarised form.

(iii) Result: A detailed presentation of the findings of the study, with supporting data in the form of tables and charts together with a validation of results, is the next step in writing the main text of the report. This generally comprises the main body of the report, extending over several chapters. The result section of the report should contain statistical summaries and reductions of the data rather than the raw data. All the results should be presented in logical sequence and splitted into readily identifiable sections. All relevant results must find a place in the report. But how one is to decide about what is relevant is the basic question. Quite often guidance comes primarily from the research problem and from the hypotheses, if any, with which the study was concerned. But ultimately the researcher must rely on his own judgement

in deciding the outline of his report. "Nevertheless, it is still necessary that he states clearly the problem with which he was concerned, the procedure by which he worked on the problem, the conclusions at which he arrived, and the bases for his conclusions."

(iv) Implications of the results: Toward the end of the main text, the researcher should again put down the results of his research clearly and precisely. He should, state the implications that flow from the results of the study, for the general reader is interested in the implications for understanding the human behaviour. Such implications may have three aspects as stated below:

(a) A statement of the inferences drawn from the present study which may be expected to apply in similar circumstances.

(b) The conditions of the present study which may limit the extent of legitimate generalizations of the inferences drawn from the study.

(c) The relevant questions that still remain unanswered or new questions raised by the study along with suggestions for the kind of research that would provide answers for them.

It is considered a good practice to finish the report with a short conclusion which summarises and recapitulates the main points of the study. The conclusion drawn from the study should be clearly related to the hypotheses that were stated in the introductory section. At the same time, a forecast of the probable future of the subject and an indication of the kind of research which needs to be done in that particular field is useful and desirable.

(v) Summary: It has become customary to conclude the research report with a very brief summary, resting in brief the research problem, the methodology, the major findings and the major conclusions drawn from the research results.

(C) End Matter

At the end of the report, appendices should be enlisted in respect of all technical data such as questionnaires, sample information, mathematical derivations and the like ones. Bibliography of sources consulted should also be given. Index (an alphabetical listing of names, places and topics along with the numbers of the pages in a book or report on which they are mentioned or discussed) should invariably be given at the end of the report. The value of index lies in the fact that it works as a guide to the reader for the contents in the report.

Q25. Explain different types of reports.

Ans :

(A) Technical Report

In the technical report the main emphasis is on (i) the methods employed, (it) assumptions made in the course of the study, (iii) the detailed presentation of the findings including their limitations and supporting data.

A general outline of a technical report can be as follows:

1. **Summary of results:** A brief review of the main findings just in two or three pages.
2. **Nature of the study:** Description of the general objectives of study, formulation of the problem in operational terms, the working hypothesis, the type of analysis and data required, etc.
3. **Methods employed:** Specific methods used in the study and their limitations. For instance, in sampling studies we should give details of sample design viz., sample size, sample selection, etc.
4. **Date:** Discussion of data collected, their sources, characteristics and limitations. If secondary data are used, their suitability to the problem at hand be fully assessed. In case of a survey, the manner in which data were collected should be fully described.
5. **Analysis of data and presentation of findings:** The analysis of data and presentation of the findings of the study with

supporting data in the form of tables and charts be fully narrated. This, in fact, happens to be the main body of the report usually extending over several chapters.

6. **Conclusions:** A detailed summary of the findings and the policy implications drawn from the results be explained.

7. **Bibliography:** Bibliography of various sources consulted be prepared and attached.

8. **Technical appendices:** Appendices be given for all technical matters relating to questionnaire, mathematical derivations, elaboration on particular technique of analysis and the like ones.

9. **Index:** Index must be prepared and be given invariably in the report at the end.

The order presented above only gives a general idea of the nature of a technical report; the order of presentation may not necessarily be the same in all the technical reports. This, in other words, means that the presentation may vary in different reports; even the different sections outlined above will not always be the same, nor will all these sections appear in any particular report.

It should, however, be remembered that even in a technical report, simple presentation and ready availability of the findings remain an important consideration and as such the liberal use of charts and diagrams is considered desirable.

(B) Popular Report

The popular report is one which gives emphasis on simplicity and attractiveness. The simplification should be sought through clear writing, minimization of technical, particularly mathematical, details and liberal use of charts and diagrams. Attractive layout along with large print, many subheadings, even an occasional cartoon now and then is another characteristic feature of the popular report. Besides, in such a report emphasis is given on practical aspects and policy implications.

We give below a general outline of a popular report.

1. **The findings and their implications:** Emphasis in the report is given on the findings of most practical interest and on the implications of these findings.

2. **Recommendations for action:** Recommendations for action on the basis of the findings of the study is made in this section of the report.

3. **Objective of the study:** A general review of how the problem arise is presented along with the specific objectives of the project under study.

4. **Methods employed:** A brief and non-technical description of the methods and techniques used, including a short review of the data on which the study is based, is given in this part of the report.

5. **Results:** This section constitutes the main body of the report wherein the results of the study are presented in clear and non-technical terms with liberal use of all sorts of illustrations such as charts, diagrams and the like ones.

6. **Technical appendices:** More detailed information on methods used, forms, etc. is presented in the form of appendices. But the appendices are often not detailed if the report is entirely meant for general public.

Q26. Explain the mechanics of writing a research report.

Ans :

The following points deserve mention so far as the mechanics of writing a report are concerned:

1. **Size and physical design:** The manuscript should be written on unruled paper 8 1/2 x 11 in size. If it is to be written by hand, then black or blue-black ink should be used. A margin of at least one and one-half inches should be allowed at the left hand and of at least half an inch at the right hand of the paper. There should also be one-inch margins, top and bottom. The paper should be neat and legible. If the manuscript is to be typed, then all typing should be double-spaced on one side of the page only except for the insertion of the long quotations.

2. **Procedure:** Various steps in writing the report should be strictly adhered.

3. **Layout:** Keeping in view the objective and nature of the problem, the layout of the report should be thought of and decided and accordingly adopted. The layout of the research report and various types of reports have been described in this chapter earlier which should be taken as a guide for report-writing in case of a particular problem.

4. **Treatment of quotations:** Quotations should be placed in quotation marks and double spaced, forming an immediate part of the text. But if a quotation is of a considerable length (more than four or five type written lines) then it should be single-spaced and indented at least half an inch to the right of the normal text margin.

5. **The footnotes:** Regarding footnotes one should keep in view the followings:

   (a) The footnotes serve two purposes viz., the identification of materials used in quotations in the report and the notice of materials not immediately necessary to the body of the research text but still of supplemental value. In other words, footnotes are meant for cross references, citation of authorities and sources, acknowledgement and elucidation or explanation of a point of view. It should always be kept in view that footnote is not an end nor a means of the display of scholarship. The modem tendency is to make the minimum use of footnotes for scholarship does not need to be displayed.

   (b) Footnotes are placed at the bottom of the page on which the reference or quotation which they identify or supplement ends. Footnotes are customarily separated from the textual material by a space of half an inch and a line about one and a half inches long.

   (c) Footnotes should be numbered consecutively, usually beginning with 1 in each chapter separately. The number should be put slightly above the line, say at the end of a quotation. At the foot of the page, again, the footnote number should be indented and typed a little above the line. Thus, consecutive numbers must be used to correlate the reference in the text with its corres ponding note at the bottom of the page, except in case of statistical tables and other numerical material, where symbols such as the asterisk (*) or the like one may be used to prevent confusion.

   (d) Footnotes are always typed in single space though they are divided from one another by double space.

6. **Documentation style:** Regarding documentation, the first footnote reference to any given work should be complete in its documentation, giving all the essential facts about the edition used. Such documentary footnotes follow a general sequence. The common order may be described as under:

   (i) Regarding the single-volume reference

   1. Author's name in normal order (and not beginning with the last name as in a bibliography) followed by a comma;
   2. Title of work, underlined to indicate italics;
   3. Place and date of publication;
   4. Pagination references

   (ii) Regarding multivalumed reference

   1. Author's name in the annual order.
   2. Title of work, underlined to indicate italics;
   3. Place and date of publication;
   4. Number of volume;
   5. Pagination references (The page number).

   (iii) Regarding works arranged alphabetically

   For works arranged alphabetically such as encyclopedias and dictionaries, no pagination reference is usually needed.

(iv) Regarding periodicals reference

1. Name of the author in normal order;
2. Title of article, in quotation marks;
3. Name of periodical, underlined to indicate italics;
4. Volume number;
5. Date of issuance;
6. Pagination.

(v) Regarding anthologies and collections reference

Quotations from anthologies or collections of literary works must be acknowledged not only by author, but also by the name of the collector.

(vi) Regarding second-hand quotations reference

In such cases the documentation should be handled as follows:

1. Original author and title;
2. "quoted or cited in,";
3. Second author and work.

(vii) Case of multiple authorship

If there are more than two authors or editors, then in the documentation the name of only the first is given and the multiple authorship is indicated by "et al." or "and others".

Subsequent references to the same work need not be so detailed as stated above. If the work is cited again without any other work intervening, it may be indicated as *ibid,* followed by a comma and the page number.

7. **Punctuation and abbreviations in footnotes:** The first item after the number in the footnote is the author's name, given in the normal signature order. This is followed by a comma. After the comma, the title of the book is given: the article (such as "A", "An", "The" etc.) is omitted and only the first word and proper nouns and adjectives are capitalized. The title is followed by a comma. Information concerning the edition is given next.

8. **Use of statistics, charts and graphs:** A judicious use of statistics in research reports is often considered a virtue for it contributes a great deal towards the clarification and simplification of the material and research results. One may well remember that a good picture is often worth more than a thousand words. Statistics are usually presented in the form of tables, charts, bars and line-graphs and pictograms. Such presentation should be self explanatory and complete in itself. It should be suitable and appropriate looking to the problem at hand. Finally, statistical presentation should be neat and attractive.

9. **The final draft:** Revising and rewriting the rough draft of the report should be done with great care before writing the final draft.

10. **Bibliography:** Bibliography should be prepared and appended to the research report.

11. **Preparation of the index:** At the end of the report, an index should invariably be given, the value of which lies in the fact that it acts as a good guide, to the reader. Index may be prepared both as subject index and as author index. The former gives the names of the subject-topics or concepts along with the number of pages on which they have appeared or discussed in the report, whereas the latter gives the similar information regarding the names of authors. The index should always be arranged alphabetically. Some people prefer to prepare only one index common for names of authors, subject-topics, concepts and the like ones.

Q27. What are the precautions for writing research report?

Ans : **(Imp.)**

1. While determining the length of the report (since research reports vary greatly in length), one should keep in view the fact that it should be long enough to cover the subject but short

enough to maintain interest. In fact, report-writing should not be a means to learning more and more about less and less.

2. A research report should not, if this can be avoided, be dull; it should be such as to sustain reader's interest.

3. Abstract terminology and technical jargon should be avoided in a research report. The report should be able to convey the matter as simply as possible. This, in other words, means that report should be written in an objective style in simple language, avoiding expressions such as "it seems," "there may be" and the like.

4. Readers are often interested in acquiring a quick knowledge of the main findings and as such the report must provide a ready availability of the findings. For this purpose, charts, graphs and the statistical tables may be used for the various results in the main report in addition to the summary of important findings.

5. The layout of the report should be well thought out and must be appropriate and in accordance with the objective of the research problem.

6. The reports should be free from grammatical mistakes and must be prepared strictly in accordance with the techniques of composition of report-writing such as the use of quotations, footnotes, documentation, proper punctuation and use of abbreviations in footnotes and the like.

7. The report must present the logical analysis of the subject matter. It must reflect a structure wherein the different pieces of analysis relating to the research problem fit well.

8. A research report should show originality and should necessarily be an attempt to solve some intellectual problem. It must contribute to the solution of a problem and must add to the store of knowledge.

9. Towards the end, the report must also state the policy implications relating to the problem under consideration. It is usually considered desirable if the report makes a forecast of the probable future of the subject concerned and indicates the kinds of research still needs to be done in that particular field.

10. Appendices should be enlisted in respect of all the technical data in the report.

11. Bibliography of sources consulted is a must for a good report and must necessarily be given.

12. Index is also considered an essential part of a good report and as such must be prepared and appended at the end.

13. Report must be attractive in appearance, neat and clean, whether typed or printed.

14. Calculated confidence limits must be mentioned and the various constraints experienced in conducting the research study may also be stated in the report.

15. Objective of the study, the nature of the problem, the methods employed and the analysis techniques adopted must all be clearly stated in the beginning of the report in the form of introduction.

Short Question and Answers

1. Population

Ans :

The term population refers to information of group of observations about which inferences are to be made. Population size denoted as 'N' which represents the number of objects or observations in the population. Population may be finite or infinite depending upon N being finite or infinite.

2. Sampling

Ans :

Sampling may be defined as the selection of some part of an aggregate or totality on the basis of which a judgement or inference about the aggregate or totality is made. In other words, it is the process of obtaining information about an entire population by examining only a part of it.

Need

The following is the need for sampling,

i) It can save time and money. A sample study is usually less expensive than a census study and produces results at a relatively faster speed.

ii) It is the only way when population contains infinitely many members.

iii) It may enable more accurate measurements for a sample study. It is generally conducted by trained and experienced investigators.

iv) It remains the only choice when a test involves the destruction of the items under study.

v) It usually enables to estimate the sampling error and thus, assists in obtaining information concerning some characteristics of the population.

3. Systematic Sampling

Ans :

Systematic sampling involves the selection of sample units at equal intervals, after all the units in the population are arranged in some systematic order such as alphabetical, chronological, geographical order etc. systematic sampling is also called 'quasi-random sampling'. In systematic sampling, the sample size is usually taken in such a way that it completely divides the population size. Let us suppose that N sampling units in the population are arranged in some systematic order and serially numbered 1 to N. Our sample size 'n' should be such that it completely divides N. $\frac{N}{n} = K$ this K is called that sample interval. If K is in fraction then it is to be rounded off to get an integral value e.g., if we want to have a sample of size 5 from a population of size 100. Then K will be $K = \frac{100}{5} = 20$.

In this case the subsequent items are selected by taking every K^{th} items i.e. 20^{th} items, refers to sample interval or sample ratio. The ratio of population size to the size of the sample.

4. Cluster Sampling

Ans :

This sampling implies dividing population into clusters and drawing random sample either from all clusters or selected clusters. Cluster Sampling is similar to stratified sampling. In the cluster sampling the universe is divided into number of relatively small subdivisions or clusters and then some of these clusters are randomly selected for inclusion in the overall sample. The element within cluster should be heterogeneous as possible, but cluster themselves should be as homogeneous as possible. The common form of cluster sampling is area or geographical sampling.

For example, if we are interested in obtaining the income or opinion data in a city, the whole city may be divided into N different blocks or localities (which determine the clusters) and a simple random sample of n blocks is drawn. The individuals in the selected blocks determine the cluster sample. The difference between cluster sampling and stratified sampling is that in case of cluster sampling only a

sample of subgroups or clusters is chosen, whereas in stratified sampling all subpopulations or strata are selected for further sampling. The objectives of the both methods are also different. The objective of cluster sampling is to increase the efficiency by decreasing the costs, whereas the objective of stratified sampling is to increase the precision.

5. Parametric Test

Ans :

These tests are based on some assumptions about the parent population from which the sample has been drawn. These assumptions can be with respect to sample size, type of distribution or on population parameters like mean, standard deviation etc. The most commonly used parametric tests are Z-test, t-test and χ^2 test (however when y is used as a test of good of fit or as a test of independence, it is termed as a nonparametric test). Parametric tests are more powerful than nonparametric tests as they use interval and ratio data.

Parametric tests are based on certain assumptions.

- The observations being tested should be independent so that inclusion of one set of observation does not affect the subsequent observations.
- Parametric tests assume normality of distribution.
- Parametric tests require interval or ratio measurement scales, so that arithmetic operations can be applied on them.

6. Non-Parametric Test

Ans :

Non-parametric tests are the study of statistical tests but it does not relate to parameter estimation or precise distributional assumptions. The type of test which non-parametric tests include are chi-square test, sign test, S-median test, Wilcoxon signed rank test etc. Assumptions of normal population are not considered under non-parametric test. Under these tests, inverse hypothesis is created and the inferences are made by testing variables. These tests are also called as "Distribution free tests". In case of non- parametric tests, the population distribution are same for null hypothesis and the power of non-parametric tests are low. These tests use Mann-Whitney U-test and Wilcoxon signed ranks test. Non-parametric tests also use Kruskal Wallis test and Friedman test. Nature of Non-Parametric

Non parametric test is a statistical test in which,

i) Parameter such as mean, variance is not involved.

ii) Frequency function of sample is unknown.

iii) Specific distribution of data is not followed.

iv) No assumption about population is made.

7. What is Small sample test ?

Ans :

Small sample size referred to size of sample which is less than 30. In case of small sample size the z-test is not appropriate test statistic as the assumptions on which it is based do not hold good in case of small sample. The theoretical work on t-distribution was done by W.S. Gosset (1876-1937) under the pen name "student' as he was the employee of the company Guinness & Sons, a Dublin bravery, Ireland, which did not allowed it employees to publish research findings under their own names. The t-distribution is used when sample size is less than 30 and the population standard deviation is not known.

8. State the applications of the t-distribution.

Ans :

The t - distribution has a wide number of applications in Statistics, some of them are given below :

1. To test the significance of the sample mean, when population variance is not given
2. To test the significance of the mean of the sample i.e., to test if the sample mean differs significantly from the population mean.
3. To test the significance of the difference between two sample means or to compare two samples.

4. To test the significance of an observed sample correlation coefficient and sample regression coefficient.

9. Chi-Square Test.

Ans :

The magnitude of discrepancy between the theory and observation is given by the quantity χ^2 (a Greek letter, pronounced as "chi-square"). If $\chi = 0$, the observed and expected frequencies completely coincide. As the value of χ^2 increases, the discrepancy between the observed and theoretical frequencies increases. Thus, χ^2 affords a measure of the correspondence between theory and observation.

Definition

If a set of events $A_1, A_2,.....,A_n$ are observed to occur with frequencies $O_1, O_2,.....,O_n$ respectively and according to probability rules $A_1, A_2,...., A_n$ are expected to occur with frequencies $E_1, E_2,....,E_n$ respectively with $O_1, O_2,.....,0_n$ are called observed frequencies and $E_1, E_2,....,E_n$ are called expected frequencies.

If O_i (i = 1, 2,...,n) is a set of observed (experimental) frequencies and E_i (i= 1, 2,...,n) is the corresponding set of expected (theoretical) frequencies, then χ^2 is defined as $\chi^2 = \sum_{i=1}^{n} \frac{(O_i - E_i)}{E_i}$ with (n – 1) degrees of freedom.

χ^2 is used to test whether differences between observed and expected frequencies are significant.

Note :

If the data is given in a series of 'n' numbers then degrees of freedom = n – 1.

In case of Binomial distribution, d.f. = n – 1.

In case of Poisson distribution, d.f. = n – 2

In case of Normal distribution, d.f. = n – 3

10. Define ANOVA.

Ans :

Meaning

The analysis of variance, popularly known as ANOVA is very useful statistical technique for testing the equality of more than two means of populations. As discussed in the previous chapter, the significance of the difference between the two means of two samples can be judged through the application of either Z-test or t-test, but the difficulty arises when the researcher has to test the significance of difference among the more than two sample means at the same time. This technique is successfully used by the researchers in the field of economics, commerce, management, education, psychology, sociology and in many other areas. This technique is used where multiple sample cases are involved.

The ANOVA technique is developed by Professor R. A. Fisher in 1920s and later on Professor Snedecor and many others contributed in the development of this technique. The analysis of variance technique consists of classifying and cross classifying statistical results and testing whether the means of a specified classification differ significantly. In other word, ANOVA is a procedure for testing the difference among different groups of data for homogeneity. ANOVA is a technique that separates the total amount of variation in a set of data in two ways, the amount which can be attributed to chance and the amount which can be attributed to the specific causes. There may be variation between samples and also within sample items. The between sample variance represents the effect of treatment or factor and within sample variance describes the deviation of data points within each group from the sample mean which is often called error. It consists of splitting the variance for analytical purpose. Thus, it is a technique of analysing the variance to which a response is subject into its various components corresponding to various sources of variation. ANOVA is also used to test the significance of regression analysis.

11. U-Test.

Ans :

The sign test for comparing two population distributions ignores the actual H lagnitude of the paired observations and thereby discards information that would be useful in detecting a departure from the null hypothesis. A statistical test that partially circumvents this loss by utilizing the relative magnitudes of the observations was proposed by Mann and is equivalent to a test proposed independently by Wilcoxon.

Rank sum test is a whole family of tests. Here we shall discuss the types, the Mann-Whitney U test. With this test we can test the null hypothesis $\mu_1 = \mu_2$ without assuming whether the populations sampled have roughly the shape of normal distribution.

This test helps us to determine whether two samples have come from identical populations. If it is true that the samples have come form the same populations it is reasonable to assume that the means of the ranks assigned to the values of the two samples are more or less the same. The alternative hypothesis is that the means of the population are not equal and if this is the case, most of the smaller rank will go to the values of one sample, while most of the higher ranks will go to those of the other sample.

The test of the null hypothesis that the two samples come from identical populations may either be based on R\, the sum of the ranks of the values of first sample, or on R2, the sum of the ranks of the values of the second sample. It may be noted that in practice it does not matter which sample we call sample 1 and which we call sample 2.

If the sample sizes are nj and n_2 the sum of R\ and R2 is simply the sum of first n 1 + n2 positive integers, which is known to be

$$\frac{(n_1 + n_2)(n_1 + n_2 + 1)}{2}$$

This formula enables us to find R_2 if we know R_1 and vice versa.

12. What is interpretation?

Ans :

Meaning

Interpretation refers to the task of drawing inferences from the collected facts after an analytical and/or experimental study. In fact, it is a search for broader meaning of research findings. The task of interpretation has two major aspects viz.,

(i) The effort to establish continuity in research through linking the results of a given study with those of another, and

(ii) The establishment of some explanatory concepts.

"In one sense, interpretation is concerned with relationships within the collected data, partially overlapping analysis". Interpretation also extends beyond the data of the study to include the results of other research, theory and hypotheses. Thus, interpretation is the device through which the factors that seem to explain what has been observed by researcher in the course of the study can be better understood and it also provides a theoretical conception which can serve as a guide for further researches.

13. What is research report?

Ans :

Meaning

Research report is a channel to communicate the research findings to the readers of the report. A good research report is that which does its task efficiently and effectively.

Significance

The following points helps us to know the significance of a research report,

1. A research report is a true, accurate and historical message which helps in transferring the information relating to the research results, recommendations, conclusions and other vital information to the clients.
2. The clients makes his or her decisions on the basis of the contents of the report so it is very important for the researchers to provide value to the client in the research report.
3. The researchers should properly and effectively make their research report as, poorly written research report will not be able to communicate effectively and the time and efforts spend in the research process will be wasted.

Choose the Correct Answers

1. A hypothesis is true, but is rejected, this is an error of type [a]
   (a) I (b) II
   (c) I and II (d) None
2. A hypothesis is false, but accepted, this is an error of type [b]
   (a) I (b) II
   (c) I and II (d) None
3. A random sample of 400 products contains 52 defective items. Standard error of proportion is [b]
   (a) 0.168 (b) 0.0168
   (c) 0.0016 (d) 1.68
4. 500 eggs are taken from a large consignment and 50 are found to be bad. Standard error of proportion is [c]
   (a) 1.3 (b) 0.13
   (c) 0.013 (d) None
5. Among 900 people in a state 90 are found to be chapati eaters. The 99% confidence interval for the true proportion is [c]
   (a) (0.08,0.12) (b) (0.8,1.2)
   (c) (0.07,0.13) (d) None
6. If n = 40,0 = 2.06 then the maximum error with 99% confidence is [b]
   (a) 0.7377 (b) 0.8387
   (c) 0.6387 (d) 0.536
7. If n = 100,CT = 5 then the maximum error with 95% confidence is [a]
   (a) 0.98 (b) 1.2875
   (c) 3.92 (d) 1.16
8. If the size of the sample is 25 and the maximum error with 95% confidence is 0.1 then the standard deviation of the sample is [c]
   (a) 2.55 (b) 2.12
   (c) 0.255 (d) 0.025
9. If the maximum error with probability 0.95 is 1.2 and the standard deviation 0 population is 10, then sample size is [c]
   (a) 26 (b) 266
   (c) 267 (d) 269
10. A sample of size n is taken from a population whose variance is 9. The maximum error of estimate for p with 95% confidence is 0.5. Then n= [d]
   (a) 12 (b) 68
   (c) 128 (d) 139

Fill in the blanks

1. _____ is a process of selecting some items that are considered by researcher as true representative of the population.
2. _____ statistics are the distribution free statistics used for testing hypothesis.
3. Level of significance is denoted by _____ .
4. _____ is an "educated guess" about the outcome of an empirical test designed to answer a research question.
5. Essential of sampling _____.
6. ANOVA stands for _____.
7. t-test was developed by _____.
8. χ^2 test of goodness of fit is a powerful test given by _____.
9. χ^2 test of homogeneity is an extension of the _____ test.
10. _____ is the most effective and commonly used method of selecting a sample.

ANSWERS

1. Sampling
2. Non-parametric
3. '$\propto$'
4. Hypothesis
5. Optimization
6. Analysis of variance
7. W.W. Gosset
8. Karl Pearson
9. Chi-square
10. Random sampling

FACULTY OF COMMERCE

B.Com. III Year VI Semester (CBCS) Examination

Model Paper - I

RESEARCH METHODOLOGY AND PROJECT REPORT

Time: 1½ Hours | Max. Marks: 40

PART – A (2 × 5 = 10 Marks)

[Short Answer Type]

Note: Answer any TWO of the following questions not exceeding one page each.

ANSWERS

1. (a) Define Research. **(Unit-I, SQA. 1)**

   (b) Research Design **(Unit-I, SQA. 8)**

   (c) U-Test. **(Unit-II, SQA. 11)**

   (d) State the applications of the t-distribution. **(Unit-II, SQA. 8)**

PART – B (2 × 15 = 30 Marks)

[Essay Answer Type]

Note: Answer all the questions.

2. (a) Describe briefly the research process and its stages. **(Unit-I, Q.No. 6)**

(OR)

   (b) Write about itemized rating scales? Explain them with an examples. **(Unit-I, Q.No. 29)**

3. (c) Explain in detail about Two-Way ANOVA. **(Unit-II, Q.No. 17)**

(OR)

   (d) Write briefly about the various sampling techniques. **(Unit-II, Q.No. 2)**

FACULTY OF COMMERCE

B.Com. III Year VI Semester (CBCS) Examination

Model Paper - II

RESEARCH METHODOLOGY AND PROJECT REPORT

Time: 1½ Hours Max. Marks: 40

PART – A (2 × 5 = 10 Marks)

[Short Answer Type]

Note: Answer any TWO of the following questions not exceeding one page each.

ANSWERS

1. (a) What is research methodology? **(Unit-I, SQA. 7)**

   (b) Define Scaling. **(Unit-I, SQA. 10)**

   (c) Define ANOVA. **(Unit-II, SQA. 10)**

   (d) What is interpretation? **(Unit-II, SQA. 12)**

PART – B (2 × 15 = 30 Marks)

[Essay Answer Type]

Note: Answer all the questions.

2. (a) Discuss the four categories of measure-ment scales. **(Unit-I, Q.No. 18)**

   (OR)

   (b) Explain different types of hypothesis tests. **(Unit-I, Q.No. 34)**

3. (c) What are the precautions for writing research report? **(Unit-II, Q.No. 27)**

   (OR)

   (d) Compare and contrast Parametric Test and Non-Parametric Test. **(Unit-II, Q.No. 4)**

FACULTY OF COMMERCE

B.Com. III Year VI Semester (CBCS) Examination

Model Paper - III

RESEARCH METHODOLOGY AND PROJECT REPORT

Time: 1½ Hours Max. Marks: 40

PART – A (2 × 5 = 10 Marks)

[Short Answer Type]

Note: Answer any TWO of the following questions not exceeding one page each.

ANSWERS

1. (a) Describe the objectives of research. **(Unit-I, SQA. 2)**

   (b) Empirical research **(Unit-I, SQA. 6)**

   (c) What is research report? **(Unit-II, SQA. 13)**

   (d) Non-Parametric Test **(Unit-II, SQA. 6)**

PART – B (2 × 15 = 30 Marks)

[Essay Answer Type]

Note: Answer all the questions.

2. (a) Explain in detail the procedure of testing a hypothesis. **(Unit-I, Q.No. 35)**

   (OR)

   (b) Explain the major types of research design. **(Unit-I, Q.No. 13)**

3. (c) Explain briefly about F-Test. **(Unit-II, Q.No. 11)**

   (OR)

   (d) What is research report? State the significance of research report. **(Unit-II, Q.No. 22)**