KARPAGAM ACADEMY OF HIGHER EDUCATION
(Deemed to be University Established Under Section 3 of UGC Act 1956)
Pollachi Main Road, Eachanari (Po),
Coimbatore –641 021
SYLLABUS

		Semester – V			
		L	T	P	C
16MBP304	**BIOSTATISTICS AND RESEARCH METHODOLOGY**	4	0	0	4

Course Objective:
This course has been intended to provide the learner insights into helpful areas of Statistics which plays an essential role in present, future use and applications of Biology.

Course Outcome:
Students get an idea about collection, interpretation and presentation of statistical data.

UNIT-I
Definitions-Scope of Biostatistics- Variables in biology, collection, classification and tabulation of data- Graphical and diagrammatic representation.
Measures of central tendency – Arithmetic mean, median and mode. Measures of dispersion- Range, standard deviation, Coefficient of variation.

UNIT – II
Correlation – Meaning and definition - Scatter diagram –Karl pearson's correlation coefficient. Rank correlation.
Regression: Regression in two variables – Regression coefficient problems – uses of regression.

UNIT – III
Test of significance: Tests based on Means only-Both Large sample and Small sample tests - Chi square test - goodness of fit. Analysis of variance – one way and two way classification. CRD, RBD Designs.

UNIT – IV
Research: Scope and significance – Types of Research – Research Process – Characteristics of good research – Problems in Research – Identifying research problems. Research Designs – Features of good designs.

UNIT – V
Sampling Design: Meaning – Concepts – Steps in sampling – Criteria for good sample design. Scaling measurements – Techniques – Types of scale.

REFERENCES

1. Jerrold H. Zar. (2003). Biostatistical Analysis. (4th ed.). Pearson Education (P) Ltd, New Delhi.
2. Kothari. C.R. (2004). Research Methodology – Methods and Techniques. (2nd ed.). New Age International Pvt. Ltd, New Delhi.
3. IndranilSaha and Bobby Paul. (2016), Essentials of Biostatistics (2nded.).Academic Publishers, Kolkata.

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Department of Microbiology

LECTURE PLAN

Subject: Biostatistics and Research Methodology **Subject Code: 16MBP304**

S.No	Lecture Duration	Topic to be covered	Support Material
Unit – I			
1.	1	Definitions, Scope of Biostatistics, Variables in biology	R1:Chp 1:Pg: 1-2
2.	1	Collection and Classification of data	R4:Chp 1:Pg:2-4 R3:Chp 4:Pg:31
3.	1	Tabulation of data	R3:Chp6:Pg 56-59,73-76
4.	1	Diagrammatic representation of data: Bar diagram and Pie diagram	R3:Chp 7:Pg:84-97
5.	1	Graphical representation of data: Histogram	R3:Chp 8:Pg:101-109
6.	1	Graphical representation of data: Ogives	R3:Chp 8:Pg:109-110
7.	1	Measures of Central tendency : Arithmetic Mean	R3:Chp 9:Pg: 121-128
8.	1	Continuation of Problems on arithmetic mean	R3:Chp 9:Pg: 128-133
9.	1	Problems on Median	R3:Chp 9:Pg: 146-148
10.	1	Problems on Mode	R3:Chp 9:Pg: 151-156
11.	1	Continuation of problems on Median and Mode	R3:Chp 9:Pg: 149-150, 157-158
12.	1	Measures of dispersion: Problems on Range	R3:Chp 9:Pg: 234-239
13.	1	Problems on Standard deviation	R3:Chp 9:Pg: 249-259
14.	1	Coefficient of variation	R3:Chp 10:Pg: 272-282
15.	1	Recapitulation and discussion on possible questions	
Total No. of Lecture hours planned – 15 hours			
R1. Jerrold H. Zar. (2003). Biostatistical analysis.(4th ed.). Pearson Education (P) Ltd, NewDelhi. **R3.**Pillai, R.S.N., &Bagavathi, V.(2002). Statistics. New Delhi: S. Chand & Company Ltd. **R4.**Indranil Saha& Bobby Paul.(2016). Essentials of Biostatistics.Academic publishers, Kolkata.			
Unit – II			
1.	1	Correlation: Meaning and definition	R3:Chp 12:Pg: 359-361
2.	1	Scatter diagram	R3:Chp 12:Pg: 362-364
3.	1	Karl Pearson's correlation coefficient-problems	R3:Chp 12:Pg: 366-370
4.	1	Continuation of problem in Karl Pearson's correlation coefficient	R3:Chp 12:Pg: 371-377
5.	1	Rank correlation-problems	R3:Chp 12:Pg: 385-387
6.	1	Continuation of problems on rank correlation	R3:Chp 12:Pg: 387-389
7.	1	Regression: Uses of regression	R3:Chp 13:Pg: 425-427
8.	1	Regression in two variables	R3:Chp 13:Pg: 431-442
9.	1	Continuation of problems on regression in two	R3:Chp 13:Pg: 432-443

		variables	
10.	1	Regression coefficient problems	R3:Chp 13:Pg: 445-458
11.	1	Continuation on problems in regression coefficient	R3:Chp 13:Pg: 459-470
12.	1	Recapitulation and discussion on possible questions	
Total No. of Lecture hours planned – 12 hours			
R3. Pillai, R.S.N., &Bagavathi, V.(2002). Statistics. New Delhi: S. Chand & Company Ltd.			
Unit – III			
1.	1	Test of significance: Tests based on Means	R2:Chp 9:Pg: 195-202
2.	1	Large sample tests-problems	R2:Chp 9:Pg: 202-204
3.	1	Continuation on problems in large sample test	R2:Chp 9:Pg: 209-211
4.	1	Small sample tests-problems	R2:Chp 9:Pg: 204-207
5.	1	Continuation on problems in small sample tests	R2:Chp 9:Pg: 211-214
6.	1	Chi square test- problems, goodness of fit	R2:Chp 10:Pg: 233-236
7.	1	Analysis of variance- one way classification	R2:Chp 11:Pg: 256-264
8.	1	Analysis of variance- two way classification	R2:Chp 11:Pg: 264-270
9.	1	CRD designs	R2:Chp 3:Pg: 42-44
10.	1	RBD designs	R2:Chp 3:Pg: 44-45
11.	1	Recapitulation and discussion on possible questions	
Total No. of Lecture hours planned – 11 hours			
R2. Kothari.C.R. (2004).Research Methodology – Methods and Techniques.(2thed.). New Age International Pvt. Ltd, New Delhi.			
Unit – IV			
1.	1	Research: Scope and significance	R2:Chp 1:Pg: 1-2
2.	1	Types of Research	R2:Chp 1:Pg: 2-3
3.	1	Research Process	R2:Chp 1:Pg: 10-15
4.	1	Continuation of research process	R2:Chp 1:Pg: 15-19
5.	1	Characteristics of good research	R2:Chp 1:Pg: 20-21
6.	1	Problems in research	R2:Chp 2:Pg: 24-26
7.	1	Continuation of problems in research	R2:Chp 2:Pg: 26-27
8.	1	Identifying research problems	R2:Chp 2:Pg: 27-29
9.	1	Research designs	R2:Chp 3:Pg: 31-32
10.	1	Features of good designs	R2:Chp 3:Pg: 32-33
11.	1	Recapitulation and discussion on possible questions	
Total No. of Lecture hours planned – 11 hours			
R2. Kothari.C.R. (2004).Research Methodology – Methods and Techniques.(2thed.). New Age International Pvt. Ltd, New Delhi.			
Unit – V			
1.	1	Sampling design: Meaning and concepts	R2:Chp 4:Pg: 55-56
2.	1	Steps in sampling	R2:Chp 4:Pg: 56-57
3.	1	Criteria for good sample designs	R2:Chp 4:Pg: 57-58
4.	1	Scaling measurements	R2:Chp 5:Pg: 71-72
5.	1	Techniques	R2:Chp 5:Pg: 75-78
6.	1	Types of scale	R2:Chp 5:Pg: 79-83
7.	1	Continuation of types of scale	R2:Chp 5:Pg: 84-87

8.	1	Recapitulation and discussion on possible questions	
9.	1	Discussion on previous ESE question papers	
10.	1	Discussion on previous ESE question papers	
11.	1	Discussion on previous ESE question papers	
Total No. of Lecture hours planned – 11 hours			
R2. Kothari.C.R. (2004).Research Methodology – Methods and Techniques.(2thed.). New Age International Pvt. Ltd, New Delhi.			

REFERENCES:

R1. Jerrold H. Zar. (2003). Biostatistical analysis.(4thed.). Pearson Education (P) Ltd, New Delhi.

R2. Kothari.C.R. (2004).Research Methodology – Methods and Techniques.(2thed.). New Age International Pvt. Ltd, New Delhi.

R3. Pillai, R.S.N., &Bagavathi, V.(2002). Statistics. New Delhi: S. Chand & Company Ltd.

R4. Indranil Saha& Bobby Paul.(2016). Essentials of Biostatistics.Academic publishers, Kolkata.

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Department of Microbiology

Subject: Biostatistics and Research Methodology Subject Code: 16MBP304 L T P C

Class : II – M.Sc. Microbiology Semester : III 4 0 0 4

UNIT I

Definitions-Scope of Biostatistics- Variables in biology, collection, classification and tabulation of data- Graphical and diagrammatic representation.
Measures of central tendency – Arithmetic mean, median and mode. Measures of dispersion-Range, standard deviation, Coefficient of variation.

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Statistics Meaning and Definition

Statistical tools are found useful in progressively increasing of disciplines. In ancient times the statistics or the data regarding the human force and wealth available in their land had been collected by the rulers. Now-a-days the fundamental concepts of statistics are considered by many to be essential part of their knowledge.

Origin and Growth

The origin of the word ‘statistics’ has been traced to the Latin word ‘status’, the Italian word ‘statista’ , the French word ‘statistique’ and the German word ‘statistik’. All these words mean political state.

Meaning

The word ‘statistics’ is used in two different meanings. As a plural word it means data or numerical statements. As a singular word it means the science of statistics and statistical methods. The word ‘statistics’ is also used currently as singular to mean data.

Definitions

Statistics is “the science of collection, organization, presentation, analysis and interpretation of numerical data”. – DrS.P.Gupta.

"Statistics are numerical statement of facts in any department of enquiry, placed in relation to each other". – Dr.A.L.Bowley.

Population: A population is any entire collection of people, animals, plants or things on which we may collect data. It is the entire group of interest, which we wish to describe or about which we wish to draw conclusions. In the above figure the life of the light bulbs manufactured say by GE, is the concerned population.

Qualitative and Quantitative Variables: Any object or event, which can vary in successive observations either in quantity or quality is called a "variable." Variables are classified accordingly as quantitative or qualitative. A qualitative variable, unlike a quantitative variable does not vary in magnitude in successive observations. The values of quantitative and qualitative variables are called "Variates" and" Attributes", respectively.

Variable: A characteristic or phenomenon, which may takes different values, such as weight, gender since they are different from individual to individual.

Randomness: Randomness means unpredictability. The fascinating fact about inferential statistics is that, although each random observation may not be predictable when taken alone, collectively they follow a predictable pattern called its distribution function. For example, it is a fact that the distribution of a sample average follows a normal distribution for sample size over 30. In other words, an extreme value of the sample mean is less likely than an extreme value of a few raw data.

Sample: A subset of a population or universe.

An Experiment: An experiment is a process whose outcome is not known in advance with certainty.

Statistical Experiment: An experiment in general is an operation in which one chooses the values of some variables and measures the values of other variables, as in physics. A statistical experiment in contrast is an operation in which one takes a random sample from a population and infers the values of some variables. For example, in a survey, we "survey" i.e. "look at" the situation without aiming to change it, such as in a survey of political opinions. A random sample from the relevant population provides information about the voting intentions.

In order to make any generalization about a population, a random sample from the entire population; that is meant to be representative of the population, is often studied. For each population, there are many possible samples. A sample statistic gives information about a corresponding population parameter. For example, the sample mean for a set of data would give information about the overall population mean μ .

It is important that the investigator carefully and completely defines the population before collecting the sample, including a description of the members to be included.

Example: The population for a study of infant health might be all children born in the U.S.A. in the 1980's. The sample might be all babies born on 7th of May in any of the years.

An experiment is any process or study which results in the collection of data, the outcome of which is unknown. In statistics, the term is usually restricted to situations in which the researcher has control over some of the conditions under which the experiment takes place.

Example: Before introducing a new drug treatment to reduce high blood pressure, the manufacturer carries out an experiment to compare the effectiveness of the new drug with that of one currently prescribed. Newly diagnosed subjects are recruited from a group of local general practices. Half of them are chosen at random to receive the new drug, the remainder receives the present one. So, the researcher has control over the subjects recruited and the way in which they are allocated to treatment.

Design of experiments is a key tool for increasing the rate of acquiring new knowledge. Knowledge in turn can be used to gain competitive advantage, shorten the product development cycle, and produce new products and processes which will meet and exceed your customer's expectations.

Primary data and Secondary data sets: If the data are from a planned experiment relevant to the objective(s) of the statistical investigation, collected by the analyst, it is called a Primary Data set. However, if some condensed records are given to the analyst, it is called a Secondary Data set.

Random Variable: A random variable is a real function (yes, it is called" variable", but in reality it is a function) that assigns a numerical value to each simple event. For example, in sampling for quality control an item could be defective or non-defective, therefore, one may assign X=1, and X = 0 for a defective and non-defective item, respectively. You may assign any other two distinct real numbers, as you wish; however, non-negative integer random variables are easy to work with. Random variables are needed since one cannot do arithmetic operations on words; the random variable enables us to compute statistics, such as average and variance. Any random variable has a distribution of probabilities associated with it.

Probability: Probability (i.e., probing for the unknown) is the tool used for anticipating what the distribution of data should look like under a given model. Random phenomena are not haphazard: they display an order that emerges only in the long run and is described by a distribution. The mathematical description of variation is central to statistics. The probability required for statistical inference is not primarily axiomatic or combinatorial, but is oriented toward describing data distributions.

Sampling Unit: A unit is a person, animal, plant or thing which is actually studied by a researcher; the basic objects upon which the study or experiment is executed. For example, a person; a sample of soil; a pot of seedlings; a zip code area; a doctor's practice.

Parameter: A parameter is an unknown value, and therefore it has to be estimated. Parameters are used to represent a certain population characteristic. For example, the population meanμ is a parameter that is often used to indicate the average value of a quantity.

Within a population, a parameter is a fixed value that does not vary. Each sample drawn from the population has its own value of any statistic that is used to estimate this parameter. For example, the mean of the data in a sample is used to give information about the overall mean μin the population from which that sample was drawn.

Statistic: A statistic is a quantity that is calculated from a sample of data. It is used to give information about unknown values in the corresponding population. For example, the average of the data in a sample is used to give information about the overall average in the population from which that sample was drawn.

A statistic is a function of an observable random sample. It is therefore an observable random variable. Notice that, while a statistic is a "function" of observations, unfortunately, it is commonly called a random "variable" not a function.

It is possible to draw more than one sample from the same population, and the value of a statistic will in general vary from sample to sample. For example, the average value in a sample is a statistic. The average values in more than one sample, drawn from the same population, will not necessarily be equal.

Statistics are often assigned Roman letters (e.g. $\bar{x}$and s), whereas the equivalent unknown values in the population (parameters) are assigned Greek letters (e.g., μ, σ).

The word estimate means to esteem, that is giving a value to something. A statistical estimate is an indication of the value of an unknown quantity based on observed data.

More formally, an estimate is the particular value of an estimator that is obtained from a particular sample of data and used to indicate the value of a parameter.

Example: Suppose the manager of a shop wanted to know μ , the mean expenditure of customers in her shop in the last year. She could calculate the average expenditure of the hundreds (or perhaps thousands) of customers who bought goods in her shop; that is, the population mean μ . Instead she could use an estimate of this population mean μ by calculating the mean of a representative sample of customers. If this value were found to be Rs.25, then Rs.25 would be her estimate.

Functions

The following are the important functions of statistics.

* Collection
* Numerical Presentation
* Diagrammatic Presentation
* Condensation

* Comparison
* Forecasting
* Policy Making
* Effect Measuring
* Estimation
* Tests of significance.

Characteristics

* Statistics is a Quantitative Science.
* It never considers a single item.
* The values should be different.
* Inductive logic is applied.
* Statistical results are true on the average.
* Statistics is liable to be misused.

COLLECTION OF DATA

Data constitutes the base. The findings of an investigation depend on correctness and completeness of the relevant data. Sources of data are of two kinds- primary source and secondary source. The term source means origin or place from which data comes or got. A primary source is one that itself collects the data; a secondary source is one that makes available data which were collected by some other agency. Based on source, data are classified under two categories- Primary data and secondary data.

PRIMARY & SECONDARY DATA

Methods of collecting primary data

- Primary data are those which are called as first information.
- There are five types of data.
- 1.Direct personal interview
- 2. Indirect oral interview
- 3. Information through agencies
- 4.Mailed Questionnaire method
- 5. Schedules sent through Enumerators

Secondary Data

- Secondary data can be compiled from published sources and unpublished sources
- Published source:
- The government collect some data's and they publish it .
- Eg: Census of India
- Unpublished Sources:
- All the statistical data are not published.
- Eg:Bank collects certain particulars from the loaner.

Classification

Classification is the process of arranging data into groups or classes according to the common characteristics possessed by the individual items.

Basis

Data can be classified on the basis of one or more of the following:

i) Geographical Classification or Spatial Classification

Some data can be classified area-wise such as states, towns etc.

ii)Chronological or Temporal or Historical Classification

Some data can be classified on the basis of time and arranged chronologically or historically.

iii) Qualitative Classification

Some data can be classified on the basis of attributes or characteristics.

iv)Quantitative Classification

Some data can be classified in terms of magnitudes.

Tabulation

Tabulation is the process of arranging data systematically in rows and columns of a table.

There are two methods or modes in which data can be presented. They are

i) Statistical Tables

ii) Diagrams or Graphs

Parts of a table

A good table has the following parts or components:

* Identification number
* Title
* Prefatory Note or Head note
* Stubs
* Captions
* Body of the table
* Foot note

* Source

Frequency Distribution

The easiest method of organizing data is a frequency distribution, which converts raw data into a meaningful pattern for statistical analysis.

The following are the *steps* of constructing a frequency distribution:
1. Specify the number of class intervals. A class is a group (category) of interest. No totally accepted rule tells us how many intervals are to be used. Between 5 and 15 class intervals are generally recommended. Note that the classes must be both *mutually exclusive and all-inclusive.* Mutually exclusive means that classes must be selected such that an item can't fall into two classes, and all-inclusive classes are classes that together contain all the data.

2. When all intervals are to be the same width, the following rule may be used to find the required class interval width:

W = (L - S) / K

where:

W= class width, **L=** the largest data, **S=** the smallest data, **K=** number of classes

Example

Suppose the age of a sample of 10 students are:
20.9, 18.1, 18.5, 21.3, 19.4, 25.3, 22.0, 23.1, 23.9, and 22.5
We select K=4 and W=(25.3 - 18.1)/4 = 1.8 which is rounded-up to 2. The frequency table is as follows:

Class Interval	**Class Frequency**	**Relative Frequency**
18-20	3	30 %
20-22	2	20 %
22-24	4	40 %
24- 26	1	10 %

Cumulative Frequency Distribution

When the observations are numerical, cumulative frequency is used. It shows the total number of observations which lie above or below certain key values. Cumulative Frequency for a population = frequency of each class interval + frequencies of preceding intervals. For example, the cumulative frequency for the above problem is: 3, 5, 9, and 10.

Diagrams and Graphs

Diagrams

Diagrams are various geometrical shapes such as bars, circles etc . Diagrams are based on scales but are not confirmed to points or lines. They are more attractive and easier to understand than graphs and are widely used in advertisement and publicity.

Rules for construction

* Title
* Proportion between width and height
* Size
* scale
* Index
* Suitable Diagram
* Simplicity
* Neatness
* Foot-Note and source
* Identification numbers.

Graphic Presentation of Data

- Use initial exploratory data-analysis techniques to produce a pictorial representation of the data.
- Resulting displays reveal patterns of behavior of the variable being studied.
- The method used is determined by the type of data and the idea to be presented.
- No single correct answer when constructing a graphic display.

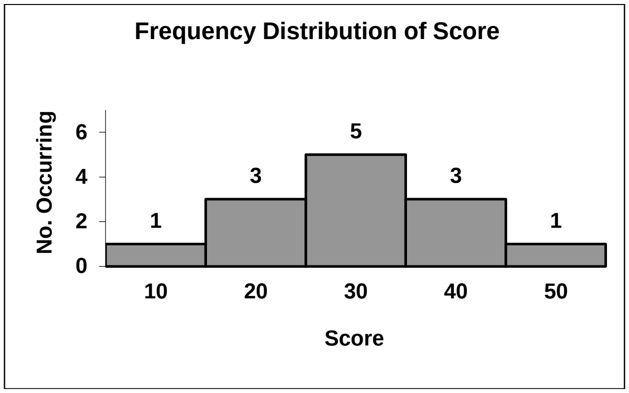
Types of Diagram

The frequently used diagrams are divided into the following four heads:

1. One Dimensional diagram- Bar Diagram
2. Two Dimensional diagram – Pie Diagram, Rectangle, squares and circles
3. Three Dimensional diagram – Cubes
4. Pictograms and Cartograms.

Histograms are used to graph absolute, relative, and cumulative frequencies.

Histograms are typically used to display the frequency distribution of a continuous variable. The Y-axis indicates the frequency of occurance of the value/s specified on the X-axis. The X-axis represents an ordered range of values. E.g.



Notes: From the above histogram we might conclude that a score of 20 occurred three times, however, in most instances the box identified with a score of 20 covers a range of possible scores, in this case those scores being greater than 15 but not greater than 25. It should also be noted that in the case of a histogram there is no gap between the bars.

Ogive is also used to graph cumulative frequency. An ogive is constructed by placing a point corresponding to the *upper end of each class* at a height equal to the cumulative frequency of the class. These points then are connected. An ogive also shows the relative cumulative frequency distribution on the right side axis.

A less-than ogiveshows how many items in the distribution have a value less than the upper limit of each class.

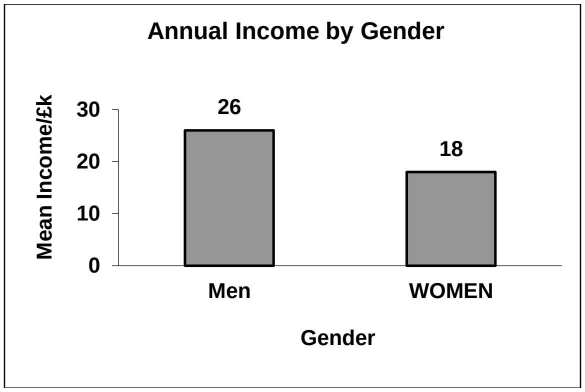
A more-than ogive shows how many items in the distribution have a value greater than or equal to the lower limit of each class.

A less-than cumulative frequency polygon is constructed by using the upper true limits and the cumulative frequencies.
A more-than cumulative frequency polygon is constructed by using the lower true limits and the cumulative frequencies.

Pie chart is often used in newspapers and magazines to depict budgets and other economic information. A complete circle (the pie) represents the total number of measurements. The size of a slice is proportional to the relative frequency of a particular category. For example, since a complete circle is equal to 360 degrees, if the relative frequency for a category is 0.40, the slice assigned to that category is 40% of 360 or (0.40)(360)= 144 degrees.

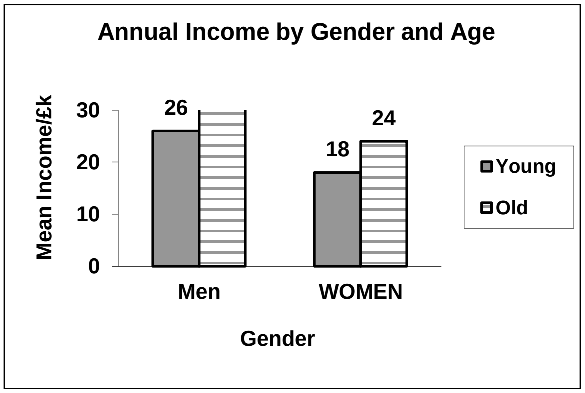
Bar Charts

Simple Bar charts are often used to compare data from two or more groups. The Y-axis is typically interval level data representing one variable or measure, and the X-axis is used to denote different categories or nominal data (for example comparing men and women's average income, or comparing two or more participant's word fluency scores. The height of the bar indicates the 'group's' value on the Y-axis.



Notes: The chart has a title (Annual Income by Gender) indicating that annual income is being 'broken down' by gender. The Y-axis indicates the measure of interest (Mean Income) and the units of measurement (£k). The categorisation variable (Gender) is indicated and the levels of this variable are also indicated (Men & Women). All charts and tables should include a figure or table number to identify them subsequently. Note that the actual values associated with each category have also been added to aid clarity.

Clustered bar charts are typically used to illustrate the distribution of a continuous variable (e.g. income) across two or more categorical variables. E.g.



Measures of central tendency

According to Professor Bowley the measures of central tendency are “statistical constants which enable us to comprehend in a single effort the significance of the whole “

The following are the three measures of central tendency in this chapter we deal with

- Arithmetic Mean or simply Mean
- Median
- Mode

Arithmetic Mean or simply Mean

Arithmetic Mean or simply Mean is the total values of the item divided by their number of the items. It is usually denoted by $\bar{X}$

Individual series

$$\bar{X} = \Sigma X / N$$

Example

The expenditure of ten families are given below .Calculate arithmetic mean.

30 ,70 ,10 ,75 ,500 ,8 ,42 ,250 ,40 ,36 .

Solution

Here N=10

$\Sigma X = 30 +70 +10 +75 +500 +8 +42 +250 +40 +36 = 1061$

$\bar{X} = 1061 / 10 = 106.1$

Discrete series

$\bar{X} = \Sigma f X / \Sigma f$

Example

Calculate the mean number of person per house.

No.ofperson : 2 3 4 5 6

No.of house :10 25 30 25 10

Solution

X	f	f X
2	10	20
3	25	75
4	30	120
5	25	125
6	10	60

Σ f =100   Σ f X= 400

$\bar{X}$ =400 / 100 = 4 .

Continuous series

$\bar{X}$ = Σ f m / Σ f   where m represents the mid value.

Midvalue= (upper boundary + lower boundary)/2.

Example

Calculate the mean for the following.

Marks :	20-30	30-40	40-50	50-60	60-70	70-80
No.of student :	5	8	12	15	6	4

Solution

C.I	f	m	f m
20-30	5	25	125
30-40	8	35	280
40-50	12	45	540
50-60	15	55	825
60-70	6	65	390
70-80	4	75	300

Σ f = 50   Σ f m= 2460

$\bar{X}$ = 2460 / 50 = 49.2.

Median

The median is the value for the middle most item when all the items are in the order of magnitude. It is denoted by M or Me.

Individual series

For odd number of item

Position of the median = (N+1) / 2

For even number of item

Position of the median = [(N / 2)+((N/2)+1)] / 2

Example

Calculate median for the following .

22 ,10, 6, 7 ,12, 8, 5.

Solution

Here N =7

Arrange in ascending order or descending order.5,6,7,8,10,12,22

(N+1) / 2= (7+1) /2

= 4 th item = 8

Discrete series

Position of the median = (N+1) / 2^{th} item.

Example

Find the median for the following.

X : 10 15 17 18 21

F: 4 16 12 5 3

Solution

X	f	c.f
10	4	4
15	16	20
17	12	32
18	5	37
21	$\underline{3}$	40
	N= 40	

(N+1) /2 = (40+1) / 2 = 20.5th item

= (20 th item +21st item) /2 =(15+17) /2

= 16.

Continuous series

$$M = L+\frac{[((N/2) - c.f) \times i]}{f.}$$

Where L- lower boundary, f-frequency, i-size of class interval,

c.f- cumulative frequency.

Example

Calculate the median height given below.

Height :	145-150	150-155	155-160	160-165	165-170	170-175
No.ofstudent :	2	5	10	8	4	1

Solution

Height	No. of student	c.f
145-150	2	2
150-155	5	7
155-160	10	17
160-165	8	25
165-170	4	29
170-175	1	30

Σ f = 30

Position of the median = N/2 thitem = 30 / 2 =15.

$$M = L+\frac{[((N/2) - c.f) \times i]}{f.}$$

$$= 155+ \frac{[(15-7)x5]}{10} = 155+(40/10) = 159.$$

Mode

Mode is the value which has the greatest frequency density . Mode is usually denoted by Z .

Individual series

The value which occur more times are identified as mode.

Example

Determine the mode

32, 35,42, 32, 42,32.

Solution

Unimode = 32.

Discrete series

Determine the mode

Size of dress	no.of set
18	55
20	120
22	108
24	45

Here mode represents highest frequency .

Mode =20

Continuousseries

$Z = L +[i(f_1-f_0) /(2f_1 – f_0 – f_2)]$

Where L- lower boundary , f_1-frequency of the modal class, f_0 – frequency of the preceeding modal class, f_2- frequency of the succeeding modal class, i-size of class interval , c.f- cumulative frequency.

Example

Determine the mode

Marks	:	0-10	10-20	20-30	30-40	40-50
No.of student	:	5	20	35	20	12

Solution

Marks	No. of student
0-10	5
10-20	20
20-30	35
30-40	20
40-50	12

$Z = L +[i(f_1-f_0) /(2f_1 – f_0 – f_2)]$

$= 20+[10(35-20)/(2(35)-20-20)] = 20+5$

$= 25.$

Empirical relation

- Mode= 3 median -2 mean.

Meaure of Dispersion

Measure of dispersion deals mainly with the following three measures

- Range
- Standard deviation
- Coefficient of variation

Range

Range is the difference between the greatest and the smallest value.

- Range = L – S , where L-largest value & S-Smallest value
- Coefficient of range = (L-S) /(L+S)

Individual series

Example

Find the value of range and its coefficient of range for the following data.
8 ,10, 5, 9,12,11

solution

Range = L – S
= 12- 5 =7

coefficient of range = (L-S) /(L+S)
= (12-5) / (12+5)
= 7 /17 = 0.4118

Continuous series

Range = L – S , where L-Midvalue of largest boundary & S-Midvalue of smallest boundary

Example

Calculate the range.

Marks :	20-30	30-40	40-50	50-60	60-70	70-80
No.of student :	5	8	12	15	6	4

Solution

C.I	f	m
20-30	5	25
30-40	8	35
40-50	12	45
50-60	15	55
60-70	6	65
70-80	4	75

Here L=75 & S=25

Range = L – S = 75-25 = 50

Standard deviation

The standard deviation is the root mean square deviation of the values from the arithmetic mean .It is a positive square root of variants. It is also called root mean square deviation. This is usually denoted by σ .

Individual series

$$\sigma \ =\sqrt{(\Sigma x^2 / N) -(\Sigma x / N)^2}$$

Example

Calculate standard deviation for the following data.

40,41,45,49,50,51,55,59,60,60.

Solution

X	X^2
40	1600
41	1681
45	2025
49	2401
50	2500
51	2601
55	3025
59	3481
60	3600
603	600
510	Σx^2= 26504

$$\sigma = \sqrt{(\Sigma x^2 / N) -(\Sigma x / N)^2}$$

$$= \sqrt{(26514/10) - (510/10)^2}$$

$$= 7.09$$

Discrete series

$$\sigma = \sqrt{(\Sigma fx^2 / \Sigma f) -(\Sigma fx / \Sigma f)^2}$$

Example

Calculate standard deviation for the following data.

X : 0 1 2 3 4 5

F : 1 2 4 3 0 2

Solution

X	f	fx	x^2	fx^2
0	1	0	0	0
1	2	2	1	2
2	4	8	4	16
3	3	9	9	27
4	0	0	16	0
5	2	10	25	50
	Σ f = 12	Σ fx= 29		Σ fx^2 =95

$$\sigma = \sqrt{(\Sigma fx^2 / \Sigma f) – (\Sigma fx / \Sigma f)^2}$$

$$= \sqrt{(95/12\ ) – (\ 29 /12\ )^2}$$

$$= 1.44$$

Continuous series

$$\sigma = \sqrt{(\Sigma fm^2 / \Sigma f) – (\Sigma fm / \Sigma f)^2}$$

Example

C.I	0-10	10-20	20-30	30-40	40-50
F	2	5	9	3	1

Solution

C.I	f	m	fm	m^2	fm^2
0-10	2	5	10	25	50
10-20	5	15	75	225	1125
20-30	9	25	225	625	5625
30-40	3	35	105	1225	3675
40-50	1	45	45	2025	2025
	20		460		12500

$$\sigma = \sqrt{(\Sigma fm^2 / \Sigma f) – (\Sigma fm / \Sigma f)^2}$$

$$= \sqrt{(12500/20\ ) – (\ 460 /20\ )^2}$$

$$= 9.79$$

Coefficient of variation

Coefficient of variation = [standard deviation / arithmetic mean] x100

Example

Calculate the coefficient of variation .

Mean= 51, standard deviation = 7.09

Solution

Coefficient of variation = [standard deviation / arithmetic mean] x100

= (7.09 /51) x100

= 13.9

Part B (5x6=30 Marks)

Possible Questions

1. Draw a suitable Pie diagram to represent the following submitted as a part of the budget proposal of the govt. of India for the year 1995 – 96.

Item of Expenditure	Percentage
1. Interest	26
2. Defence	13
3. Subsidies	6
4. Other non plan expenditure	10
5. States share of taxes and duties	15
6. Non-plan assistance to state and UT govt.	6
7. State and UT plan assistance	10
8. Central plan	14
Total	100

2. Explain about the Classification of data
3. Calculate the coefficient of variation for the following data.

X:	6	9	12	15	18
f:	7	12	13	10	8

4. Calculate the standard deviation for the following data.

X :	0-10	10-20	20-30	30-40	40-50
f :	2	5	9	3	1

5. Find median on the basis of the following data.

Marks:	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
No. of students:	7	11	24	32	9	14	2	1

6. Calculate the standard deviation for the following data.

Class Interval:	0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16
Frequency :	45	50	45	70	30	25	20	18

7. Calculate the mean for the following data.

Class Interval:	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
Frequency:	4	14	20	51	32	17	6	4

Part C (1x10=10 Marks)

Possible Questions

1. Draw a Histogram and hence find the modal wage.

Weeklywage(in Rs)
(Midvalue) :
	310	330	350	370	390

No. of labourers :	25	50	75	60	15

2. Explain the methods of collection of data?
3. Calculate the mode.

Marks :	0-19	20-39	40-59	60-79	80-99
No. of students:	5	20	35	20	12

4. Calculate the standard deviation for the following data.

Annual Profit (Rs):	20-40	40-60	60-80	80-100	100-120	120-140	140-160
No. of Banks:	10	14	25	48	33	24	16

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Class : II - M.Sc. Microbiology **Semester : III**

Unit I

Introduction to Statistics and Measure of Central Tendency

Part A (20x1=20 Marks)
(Question Nos. 1 to 20 Online Examinations)

Possible Questions

Question	Choice 1	Choice 2	Choice 3	Choice 4	Answer
The word statistics is used as--------------------	singular word	a plural word	both singular and plural words	neither singular nor plural word	both singular and plural words
In chronological classification data are classified on the basis of---------------	time	attributes	class intervals	location	time
Bar diagrams are -------------- dimensional diagrams	two	three	one	multi	one
Diagrams and graphs are tools of -------------	collection of data	presentation	analysis	summarization	presentation
In a two dimensional diagram -------------------	only height is considered	only width is considered	height,width and thickness are considered	Both height and width are considered	only height is considered
Data are generally obtained from--------------------	Primary sources	Secondary sources	Both primary and secondary sources	neither primary nor secondary sources	Both primary and secondary sources

In geographical classification data are classified on the basis of------------------	area	attributes	time	location	area
In qualitative classification data are classified on the basis of------------------	area	attributes	time	location	attributes
In quantitative classification data are classified on the basis of-----------------	area	attributes	time	magnitude	magnitude
Number of source of data is-------------------	2	3	4	1	2
Squares and rectangles are---------------------------	Two dimensional diagram	One dimensional diagram	Three dimensional diagram	Multi dimensional diagram	Two dimensional diagram
Data originally collected for an investigation is known as------------------------	Tabulation	Primary data	Secondary data	Published data	Primary data
The heading of a row in a statistical table is known as ----------------------	stub	caption	title	heading	stub
Statistics can ----------	prove anything	disprove anything	neither prove nor disprove anything but it is just a tool	none of these	neither prove nor disprove anything but it is just a
Statistics is also a science of----------------	estimates	both a and b	probabilities	neither a nor b	both a and b
Statistics is---------	quantitative science	a qualitative science	both quantitative and qualitative science	neither quantitative nor qualitative	both quantitative and qualitative science
Statistics considers-------------	a single item	a set of item	either a single item or a set of item	neither a single item or a set of item	a set of item

Statistics can be considered as----------------	an art	a science	both an art and science	neither an art nor a science	both an art and science
The other name of cumulative frequency curve is ----------	Ogive	Bars	Histogram	Pie diagram	Ogive
Number of methods of collection of primary data is--------------------	2	3	4	5	5
Number of questions in a questionnaire should be------------------------	5	10	maximum	minimum	minimum
Sources of secondary data are-----------	Published sources	Unpublished sources	Either Published sources or Unpublished	primary source	Either Published sources or Unpublished
Compared with primary data , secondary data are------------	more reliable	less reliable	equally reliable	uniformly reliable	less reliable
----------- are column headings	stub	heading	bar	captions	captions
Mid value= ------	lower boundary/2	upper boundary/2	lower boundary+ upper boundary)/2	lower boundary+ upper boundary	lower boundary+ upper boundary)/2
The origin of the word statistics has been traced to the Latin word -------	statista	status	statistik	statistique	status
Graphs of frequency distribution are-----------------	histogram	pie diagram	bar chart	circle	histogram
cubes are----------------------	Two dimensional diagram	One dimensional diagram	Three dimensional diagram	Multi dimensional diagram	Three dimensional diagram

------------------- is the difference between the value of the smallest item and the valueof the largest item.	class interval	frequency	number of items	range	range
-------------- is one which is used by the individual or agency which collect it.	primary data	secondary data	both		primary data
Exclusive class intervals suit --------------------------	discrete variables	continuous variables	both	neither	continuous variables
A table is a systematic arrangement of statistical data in------------------	columns	rows	both columns and rows	stubs	both columns and rows
The collected data in any statistical investigation are known as -------------	raw data	arranged data	classified data	tabulated data	raw data
Ogives intersect at --------------------	Mean	Median	Mode	Standard deviation	Median
The emitting form of a frequency polygon is called -----------------------	histogram	ogive	bar diagram	frequency curve	frequency curve
Classification is a process of arranging data in------------------	grouping of related facts in different classes	different rows	different columns and rows	different columns grouping of	grouping of related facts in different classes
To represent two or more sets of interrelated data , we use -----------	bar diagram	pie diagram	histogram	multiple bar diagram	multiple bar diagram
Histogram is a graph of ------------------------	Time series	frequency distribution	cumulative frequency distribution	normal distribution	frequency distribution
Univariate data consists of -----------------------	one variable	two variables	three variable	four	one variable

Which one of the following is a measure of central tendency?	Median	range	variation	correlation	Median
The total of the values of the items divided by their number of items is known as	Median	Arithmetic mean	mode	range	Arithmetic mean
In the short-cut method of arithmetic mean, the deviation is taken as	x – A	A – x	(x – A) / c	(A – x) / c	x – A
The sum of the deviations of the values from their arithmetic mean is	– 1	one	two	zero	zero
The formula for the weighted arithmetic mean is	∑wx / ∑w	∑w / ∑wx	∑x / n	∑x / ∑f	∑wx / ∑w
Find the Mean of the following values. 5, 15, 20, 10, 40	5	18	41	20	18
Which of the followings represents median?	First quartile	Third quartile	Second quartile	Q.D	Second quartile
Which of the measure of central tendency is not affected by extreme values?	Mode	Median	sixth deciles	Mean	Median
Sum of square of the deviations about mean is	Maximum	one	zero	Minimum	Minimum
Median is the value of -------------- item when all the items are in order of magnitude.	First	second	Middle most	last	Middle most
Find the Median of the following data 160, 180, 175, 179, 164, 178, 171, 164, 176.	160	175	176	180	175

The position of the median for an individual series is taken as	(N + 1) / 2	(N + 2) / 2	N/2	N/4	(N + 1) / 2
Mode is the value, which has	Average frequency density	less frequency density	greatest frequency density	graetest frequency	greatest frequency density
A frequency distribution having two modes is said to be	unimodal	bimodal	trimodal	modal	bimodal
Mode has --------------- stable than mean.	less	more	same	most	less
Which of the following is not a measure of dispersion?	Range	quartile deviation	standard deviation	median	median
Range of the given values is given by	L- S	L+S	S+L	LS	L- S
Which one of the following is relative measure of dispersion?	Range	Q.D	S.D	coefficient of variation	coefficient of variation
Coefficient of variation is defined as	(AM * 100)/S.D	(S.D* 100)/A.M	S.D/A.M	(1/S.D)*100	(S.D* 100)/A.M
If the values of median and mean are 72 and 78 respectively, then find the mode.	16	60	70	76	60
Find Mean for the following 3, 4, 5.	4.25	2.25	3	2.28	3
The coefficient of range	L-S /L+S	L+S /L-S	L-S	L+S	L-S /L+S

Second quartile is also called as	Mode	mean	median	G.M	median
If A.M = 8, N=12, then find ∑X.	76	80	86	96	96
If the value of mode and mean is 60 and 66 then, find the value of median.	64	46	54	44	64
The formula for median for continuous series is	M = (N+1) / 2	M = L + [(N/2 + cf) / f] * i	M =L - (N/2+cf)/f* i	M = L + [(N/2 - cf) / f] * i	M = L + [(N/2 - cf) / f] * i
Median is	Average point	Midpoint	Most likely point	Most remote point	Midpoint
Mode is the value which	Is a mid point	Occur the most	Average of all	Most remote Likely	Occur the most
. ……………. Is known as positional average	Median	Mean	Mode	Range	Median
The median of marks 55, 60, 50, 40, 57, 45, 58, 65, 57, 48 of 10 students is	55	57	52.5	56	56
The middle most value of a frequency distribution table is known as	Mean	Median	Mode	Range.	Median
The middle most value of a frequency distribution table is known as	Mean	Median	Mode	Range	Median
Which of the following measures of averages divide the observation into two parts	Mean	Median	Mode	Range	Median

Which of the following measures of averages divide the observation into four equal parts	Mean	Median	Mode	Quartile	Quartile
Arithmetic mean of the series 1, 3, 5, 7, 9 is	5	6	5.5	6.5	5
Arithmetic mean of the series 3, 4, 5, 6, 7 is ………	5.5	6	5	6.5	5
The Arithmetic mean for the series 3, 5, 5, 2, 6, 2, 9, 5, 8, 6, is…………….	5	6	5.5	6.5	5
The median value for the series 3, 5, 5, 2, 6, 2, 9, 5, 8, 6 is …	6	5	5.5	6.5	5
The mode for the series 3, 5, 6, 2, 6, 2, 9, 5, 8, 6 is	5	6	5.5	6.5	6
The Arithmetic mean for the series 51.6, 50.3, 48.9, 48.7, 48.5 is……….	49.8	50	48.9	49.6	49.8
The Median for the series 51.6, 50.3, 48.9, 48.7, 49.5, is…………	49.8	50	48.9	49.6	49.6
The Arithmetic mean for the series 51.6, 50.3, 48.9, 48.7, 49.5 is…………..	49.8	50	48.9	49.6	48.9
The Mode for the series 51.6, 50.3, 48.9, 48.7, 49.5 is………….	49.8	50	48.9	49.6	48.9
If standard deviation is 5, then the variance is	5	625	25	2.23068	25

Standard deviation is also called as	Root mean square deviation	mean square deviation	Root deviation	Root median square deviation	Root mean square deviation
Measures of central tendency is also known as	Dispersion	averages	correlation	tendency	correlation
From the given data 35,40,43,32,27 the coefficient of range is	23	0.23	13	0.13	13
If S.D = 6, then find variance.	6	36	42	12	36
Which one of the following shows the relation between variance and standard deviation?	var = square root of S.D	S.D = square root of variance	variance = S.D	variance / S.D = 1	S.D = square root of variance
If variance is 64, then find S.D.	8	13	14	11	8

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Class : II – M.Sc. Microbiology	**Semester : III**	**4 0 0 4**

Unit-II

Correlation – Meaning and definition - Scatter diagram –Karl pearson's correlation coefficient. Rank correlation.
Regression: Regression in two variables – Regression coefficient problems – uses of regression.

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Simple Linear Correlation:

The term Correlation refers to the relationship between the variables. Simple correlation refers to the relationship between two variables. Various types of correlation are considered.

Positive or negative : when the values of two variables change in the same direction, their positive correlation between the two variables.

Example :

X	50	60	70	95	100	105
Y	23	32	37	41	46	50

Example :

X	34	25	18	10	7
Y	51	49	42	33	19

Simple or partial or Multiple :

When only two variables are considered as under positive or negative correlation above the correlation between them is called Simple correlation. When more than two variables as considered the correlation between two of them when all other variables are held constant, i.e., when the linear effects of all other variables on them are removed is called partial correlation. When more than two variables are considered the correlation between one of them and its estimate based on the group consisting of the other variables is called multiple correlation.

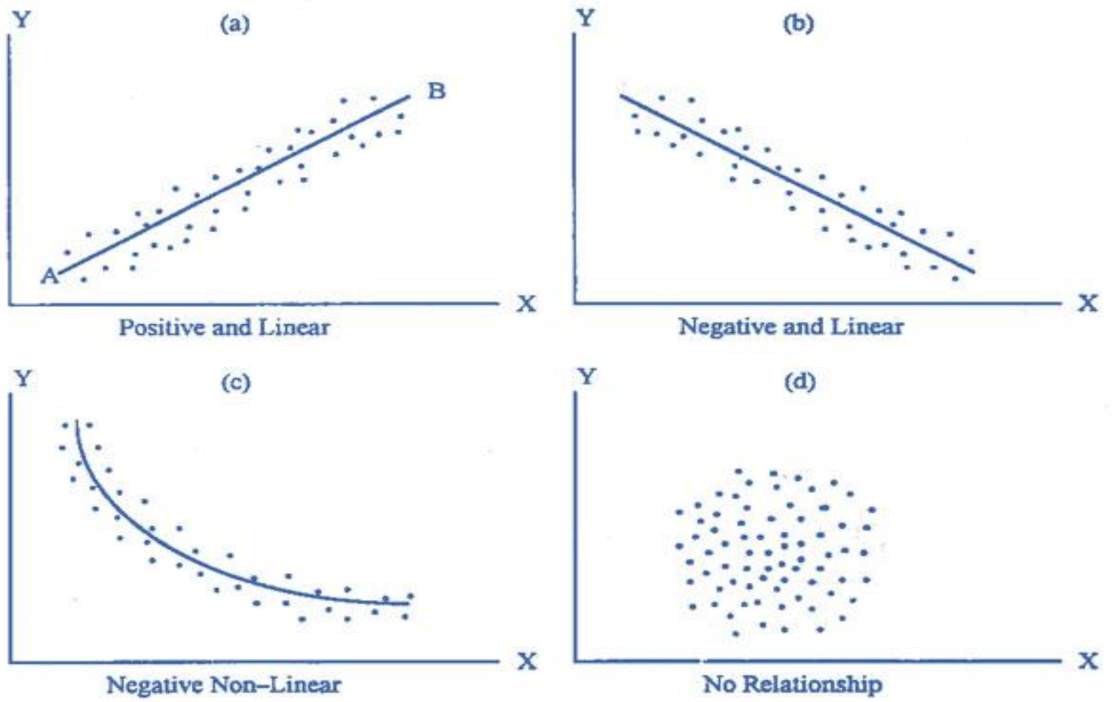
Methods :

The following four methods are available under simple linear correlation and among them , product moment method is the best one.

- Scatter Diagram
- Karl Pearson's correlation coefficient or product moment correlation coefficient (r)
- Spearman's rank correlation coefficient (ρ)
- Correlation coefficient by concurrent deviation method (r_c).

Scatter Diagram :

Scatter diagram is a graphic picture of the sample data. Suppose a random sample of n pairs of observations has the values $(X_1, Y_1), (X_2, Y_2), (X_3, Y_3), \ldots, (X_n, Y_n)$. These points are plotted on a rectangular co-ordinate system taking independent variable on *X*-axis and the dependent variable on *Y*-axis. Whatever be the name of the independent variable, it is to be taken on *X*-axis. Suppose the plotted points are as shown in figure (a). Such a diagram is called scatter diagram. In this figure, we see that when *X* has a small value, *Y* is also small and when *X* takes a large value, *Y* also takes a large value. This is called direct or positive relationship between *X* and *Y*. The plotted points cluster around a straight line. It appears that if a straight line is drawn passing through the points, the line will be a good approximation for representing the original data. Suppose we draw a line ***AB*** to represent the scattered points. The line ***AB*** rises from left to the right and has positive slope. This line can be used to establish an approximate relation between the random variable *Y* and the independent variable *X*. It is nonmathematical method in the sense that different persons may draw different lines. This line is called the regression line obtained by inspection or judgment.



Making a scatter diagram and drawing a line or curve is the primary investigation to assess the type of relationship between the variables. The knowledge gained from the scatter diagram can be used for further analysis of the data. In most of the cases the diagrams are not as simple as in figure (a). There are quite complicated diagrams and it is difficult to choose a proper mathematical model for representing the original data. The scatter diagram gives an indication of the appropriate model which should be used for further analysis with the help of method of least squares. Figure (b) shows that the points in the scatter diagram are falling from the top left corner to the right. This is a relation called inverse or indirect. The points are in the neighborhood of a certain line called the regression line.

As long as the scattered points show closeness to a straight line of some direction, we draw a straight line to represent the sample data. But when the points do not lie around a straight line, we do not draw the regression line. Figure (c) shows that the plotted points have a tendency to fall from left to right in the form of a curve. This is a relation called non-linear or curvilinear. Figure (d) shows the points which apparently do not follow any pattern. If X takes a small value, Y may take a small or large value. There seems to be no sympathy between X and Y. Such a diagram suggests that there is no relationship between the two variables.

Karl Pearson's Coefficient :

Karl Pearson's Product-Moment Correlation Coefficient or simply Pearson's Correlation Coefficient for short, is one of the important methods used in Statistics to measure Correlation between two variables.

A few words about Karl Pearson. Karl Pearson was a British mathematician, statistician, lawyer and a eugenicist. He established the discipline of mathematical statistics. He founded the world's first statistics department In the University of London in the year 1911. He along with his colleagues Weldon and Galton founded the journal "Biometrika" whose object was the development of statistical theory.

The Correlation between two variables X and Y, which are measured using Pearson's Coefficient, give the values between +1 and -1. When measured in population the Pearson's Coefficient is designated the value of Greek letter rho (ρ). But, when studying a sample, it is designated the letter r. It is therefore sometimes called Pearson's r. Pearson's coefficient reflects the linear relationship between two variables. As mentioned above if the correlation coefficient is +1 then there is a perfect positive linear relationship between variables, and if it is -1 then there is a perfect negative linear relationship between the variables. And 0 denotes that there is no relationship between the two variables.

The degrees -1, +1 and 0 are theoretical results and are not generally found in normal circumstances. That means the results cannot be more than -1, +1. These are the upper and the lower limits.

Pearson's Coefficient computational formula

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

Sample question: compute the value of the correlation coefficient from the following table:

Subject	Age x	Weight Level y
1	43	99
2	21	65
3	25	79
4	42	75

5	57	87
6	59	81

Step 1: Make a chart. Use the given data, and add three more columns: xy, x2, and y2.

.

Subject	Age x	Weight Level y	xy	x^2	y^2
1	43	99			
2	21	65			
3	25	79			
4	42	75			
5	57	87			
6	59	81			

Step 2: Multiply x and y together to fill the xy column. For example, row 1 would be 43 × 99 = 4,257

Step 3: Take the square of the numbers in the x column, and put the result in the x^2 column.

Subject	Age x	Weight Level y	xy	x^2	y^2
1	43	99	4257	1849	
2	21	65	1365	441	
3	25	79	1975	625	
4	42	75	3150	1764	
5	57	87	4959	3249	
6	59	81	4779	3481	

Step 4: Take the square of the numbers in the y column, and put the result in the y^2 column.

Step 5: Add up all of the numbers in the columns and put the result at the bottom.2 column. The Greek letter sigma (Σ) is a short way of saying "sum of."

Subject	Age x	Weight Level y	xy	x^2	y^2
1	43	99	4257	1849	9801
2	21	65	1365	441	4225
3	25	79	1975	625	6241
4	42	75	3150	1764	5625
5	57	87	4959	3249	7569
6	59	81	4779	3481	6561
Σ	247	486	20485	11409	40022

Step 6: Use the following formula to work out the correlation coefficient. The answer is: 1.3787 × 10-4 the range of the correlation coefficient is from -1 to 1. Since our result is 1.3787 × 10-4, a tiny positive amount, we can’t draw any conclusions one way or another.

Spearman’s Rank Correlation Coefficient :

The Spearman correlation coefficient is often thought of as being the Pearson correlation coefficient between the ranked variables. In practice, however, a simpler procedure is normally used to calculate ρ. The $n$raw scoresX_i, Y_i are converted to ranks x_i, y_i, and the differences $d_i = x_i - y_i$ between the ranks of each observation on the two variables are calculated.

If there are no tied ranks, then ρ is given by:

$$\rho = \left(1 - \frac{6 \sum d^2}{N(N^2 - 1)}\right)$$

If tied ranks exist, Pearson's correlation coefficients between ranks should be used for the calculation:

One has to assign the same rank to each of the equal values. It is an average of their positions in the ascending order of the values.

Example :

X : 21 36 42 37 25

Y : 47 40 37 42 43. For the data given above , calculate the rank correlation coefficient.

Solution :

		RANK			
X	Y	X	Y	d	D^2
21	47	5	1	4	16
36	40	3	4	-1	1
42	37	1	5	-4	16
37	42	2	3	-1	1
25	43	4	2	2	4
Total				$\sum d = 0$	$\sum d^2 = 38$

$$\rho = 1 - \left(\frac{6 \sum d^2}{N(N^2 - 1)}\right)$$

$$= 1 - \left(\frac{6 \text{ x } 38}{5\,(5^2 - 1)}\right)$$

$= 1- 1.9$

$= -0.9$

Tied Ranks :

When one or more values are repeated the two aspects- ranks of the repeated values and changes in the formula are to be considered.

Example:

Find the rank correlation coefficient for the percentage of marks secured by a group of 8 students in Economics and Statistics.

Marks in Economics:	50	60	65	70	75	40	70	80
Marks in Statistics:	80	71	60	75	90	82	70	50

Solution:

Let X - Marks in Economics

Y - Marks in Statistics

		RANK			
X	Y	X	Y	d	D^2
50	80	7	3	4	16
60	71	6	5	1	1
65	60	5	7	-2	4
70	75	3.5	4	-0.5	0.25
75	90	2	1	1	1
40	82	8	2	6	36
70	70	3.5	6	-2.5	6.25
80	50	1	8	-7	49
		Total		$\sum d = 0$	$\sum d^2 = 113.5$

$$\rho = 1 - \left(\frac{6\{\sum d^2 + m(m^2-1)/12\}}{N(N^2-1)}\right)$$

When m=2 , $m(m^2-1)/12 = 0.5$

Therefore$\rho = 1- \left(6\{113.5+0.5\}/8(8^2-1)\}\right)$

$= 1- 1.3571 = -0.3571$

Simple Linear Regression:

The line which gives the average relationship between the two variables is known as the regression equation. The regression equation is also called estimating equation.

Uses:

1. Regression analysis is used in statistics and other displines.
2. Regression analysis is of practical use in determining demand curve, supply curve, consumption function, etc from market survey.
3. In Economics and Business, there are many groups of interrelated variables.
4. In social resarch, the relation between variables may not known; the relation may differ from place to place.
5. The value of dependent variable is estimated corresponding to any value of the independent variable using the appropriate regression equation.

Method of Least Squares

from a scatter diagram, there is virtually no limit as to the number of lines that can be drawn to make a linear relationship between the 2 variables

- the objective is to create a BEST FIT line to the data concerned
- the criterion is the called the method of least squares
- i.e. the sum of squares of the vertical deviations from the points to the line be a minimum (based on the fact that the dependent variable is drawn on the vertical axis)
- the linear relationship between the dependent variable (Y) and the independent variable(x) can be written as Y = a + bX , where a and b are parameters describing the vertical intercept and the slope of the regression.
- Similarly the linear relationship between the dependent variable (XY) and the independent variable(Y) can be written as X = a' + b'Y , where a and b are parameters describing the vertical intercept and the slope of the regression.
-

Calculating a and b:

The values of a and b for the given pairs of values of (xi,yi) i=1,2,3…..are determined,

Using the normal equations as ,

$\sum y = Na + b\sum x$

$\sum xy = a\sum x + b\sum x^2$

Similarly, the values of a' and b' for the given pairs of values of (xi,yi) i=1,2,3…..are determined,

Using the normal equations as ,

$\sum x = Na' + b'\sum y$

$\sum xy = a'\sum y + b'\sum y^2$

Methods of forming the regression equations

- Regression equations on the basis of normal equations.
- Regression equations on the basis of X and Y and $b_{YX}$and b_{XY}.

Problem

From the following data, obtain the two regression equations.

X	6	2	10	4	8
Y	9	11	5	8	7 use normal equations.

Solution

X	**Y**	**XY**	**X^2**	**Y^2**
6	9	54	36	81
2	11	22	4	121
10	5	50	100	25
4	8	32	16	64
8	7	56	64	49
$\sum x=0$	$\sum y=0$	$\sum xy=214$	$\sum x^2=220$	$\sum y^2=340$

Let the regression equation Y on X is Y = a + bX

The normal equations are ,

$\sum y = Na + b\sum x$

$\sum xy = a\sum x + b\sum x^2$

By substituting the values from the table, we get

5a+30b = 40 -------1

30a + 180b = 214 --------2

Solving these two equations we get,

a=11.90 and b= -0.65

Therefore the regression Y on X is Y = 11.90-0.65X.

Let the regression equation X on Y is X = a' + b'Y

The normal equations are,

$\sum x = Na + b\sum y$

$\sum xy = a\sum y + b\sum y^2$

By substituting the values from the table, we get

5a'+40'b = 30 -------3

40a' + 340b' = 214 --------4

Solving these two equations we get,

a' = 16.40 and b= -1.30

Therefore the regression equation X on Y is X = 16.40-1.30Y

Example From the data given below, find

(i) the two regression equations

(ii) The correlation coefficient between the variables X and y

(iii) The value of Y when X= 30

X :	25	28	35	32	31	36	29	38	34	32
Y :	43	46	49	41	36	32	31	30	33	39

Solution

X	Y	x= X- X`	Y= Y-Y`	xy	x^2	y^2
25	43	-7	5	-35	49	25
28	46	-4	8	-32	16	64
35	49	3	11	33	9	121
32	41	0	3	0	0	9
31	36	-1	-2	2	1	4
36	32	4	-6	-24	16	36
29	31	-3	-7	21	9	49
38	30	6	-8	-48	36	64
34	33	2	-5	-10	4	25
32	39	0	1	0	0	1
320	380	0	0	-93	140	398

X` = 32, Y`= 38, $b_{xy} = \sum xy / \sum y^2 = -0.2337$, $b_{yx} = \sum xy / x^2 = -0.6643$

iv) Regression equation of Y on X ,(Y - Y` )= $b_{yx}$ (X-X`)

(Y – 38) = -0.6643(X-32) $\Rightarrow$ Y = 59.26-0.6643X

(ii) Regression equation of X on Y , (X - X` )= $b_{xy}$ (Y-Y`)

(X – 32) = -0.2337Y +8.88 $\Rightarrow$ X = 40.88 - 0.233 Y

(iii) r = + $\sqrt{b_{yx}b_{xy}}$= -0.3940

(iv) Y = 59.26-0.6643x30= 39

Properties of Regression coefficients

1. The two regression equations are generally different and are not to be interchanged in their usage. ` `
2. The two regression lines intersect at (X, Y).
3. Correlation coefficient is the geometric mean of two regression coefficients.
4. The two regression coefficients and the correlation coefficient have the same sign.
5. Both the regression coefficients and the correlation coefficient cannot be greater than one numerically and simultaneously.
6. Regression coefficients are independent of change of origin but are affected by the change of scale.
7. Each regression coefficient is in the unit of the measurement of the dependent variable.
8. Each regression coefficient indicates the quantum of change in the dependent variable corresponding to unit increase in the independent variable.

Part B (5x6=30 Marks)

Possible Questions

1. Calculate the correlation coefficient from the following data.

X:	57	58	59	59	60	61	62	64
Y:	67	68	65	68	72	72	69	71

2. Find the Karl Pearson’s coefficient of correlation from the marks secured by 10 students in Accountancy and statistics.

Marks in Accountancy (X):	45	70	65	30	90	40	50	75	85	60
Marks in statistics (Y):	35	90	70	40	95	40	60	80	80	50

3. Marks obtained by 8 students in Accountancy (x) and statistics(y) are given below. Compute rank correlation.

X	: 15	20	28	12	40	60	20	80
Y	: 40	30	50	30	20	10	30	60

4. The heights of Fathers (X) and those of their Sons(Y) are given below. Calculate Spearman’s rank correlation coefficient.

X : 180	155	170	174	160	172	166	172	172
Y : 170	165	180	180	164	169	170	170	174

5. From the data given below find the two regression lines.

X:	10	12	13	12	16	15
Y:	40	38	43	45	37	43.

i) Estimate Y when X = 20.

ii) Estimate X when Y = 25.

6. You are given the following data

	X	Y
Standard deviation	5	25
Correlation co-efficients between	X&Y	0.8

Find the regression co-efficients

7. You are given the following data:

	X	Y
Arithmetic mean	20	20
Standard deviation	5	25

Correlation coefficient between X and Y = 0.66

Find the two regression equations.

Part C (1x10=10 Marks)

Possible Questions

1. Find Karl Pearson s coefficient of correlation from the following data.

Wages :	100	101	102	102	100	99	97	98	96	95
Cost of living :	98	99	99	97	95	92	95	94	90	91

2. Find the rank correlation coefficient for the percentage of marks secured by a group of 8 students in Economics and Statistics.

Marks in Economics:	50	60	65	70	75	40	70	80
Marks in Statistics:	80	71	60	75	90	82	70	50

3. Calculate the two regression equations from the following data.

X :	10	12	13	12	16	15
Y:	40	38	43	45	37	43

4. You are given the following data:

	X	Y
Arithmetic mean	36	85
Standard deviation	11	8

Correlation coefficient between X and Y = 0.66

i) Find the two regression equations.

ii) Find r.

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Class : II - M.Sc. Microbiology **Semester : III**

Unit II

Correlation and Regresion

Part A (20x1=20 Marks)

(Question Nos. 1 to 20 Online Examinations)

Possible Questions

Question	Choice 1	Choice 2	Choice 3	Choice 4	Answer
Which one of the following refers the term Correlation?	Relationship between two values	Relationship between two variables	Average relationship between two	Relationship between two things	Relationship between two variables
If r = +1, then the relationship between the given two variables is	perfectly positive	perfectly negative	no correlation	high positive	perfectly positive
If r = - 1, then the relationship between the given two variables is	perfectly positive	perfectly negative	no correlation	low Positive	perfectly negative
If r = 0, then the relationship between the given two variables is	Perfectly positive	perfectly negative	no correlation	both positive and negative	no correlation
Coefficient of correlation value lies between	1 and –1	0 and 1	0 and ∞	0 and –1.	1 and –1
While drawing a scatter diagram if all points appear to form a straight line getting Downward from left to right, then it is inferred that there is	Perfect positive correlation	simple positive correlation	Perfect negative correlation	no correlation	Perfect negative correlation

The range of the rank correlation coefficient is	0 to 1	–1 to 1	0 to ∞	– ∞ to ∞	–1 to 1
If r =1, then the angle between two lines of regression is	Zero degree	sixty degree	ninety degree	thirty degree	ninety degree
Regression coefficient is independent of	Origin	scale	both origin and scale	neither origin nor scale.	Origin
If the correlation coefficient between two variables X and Y is negative, then the Regression coefficient of Y on X is	Positive	negative	not certain	zero	negative
If the correlation coefficient between two variables X and Y is positive, then the Regression coefficient of X on Y is	Positive	negative	not certain	zero	Positive
There will be only one regression line in case of two variables if	r =0	r = +1	r = –1	r is either +1 or –1	r =0
The regression line cut each other at the point of	Average of X only	Average of Y only	Average of X and Y	the median of X on Y	Average of X and Y
If b_{xy} and b_{yx} represent regression coefficients and if $b_{yx} > 1$ then b_{xy} is	Less than one	greater than one	equal to one	equal to zero	Less than one
Rank correlation was discovered by	R.A.Fisher	Sir Francis Galton	Karl Pearson	Spearman	Spearman
Formula for Rank correlation is	1- ($6\Sigma d^2$ /(n(n2-1)))	1- ($6\Sigma d^2$ /(n(n2+1)))	1+ ($6\Sigma d^2$ /(n(n2+1)))	1 /(n(n2-1))	1- ($6\Sigma d^2$ /(n(n2-1)))
With b_{xy}=0.5, r = 0.8 and the variance of Y=16, the standard deviation of X=	6.4	2.5	10	25.6	2.5

The coefficient of correlation r =	$(b_{xy.} b_{yx})^{1/4}$	$(b_{xy\,.}b_{yx})^{-1/2}$	$(b_{xy\,.}b_{yx})^{1/3}$	$(b_{xy.} b_{yx})^{1/2}$	$(b_{xy.} b_{yx})^{1/2}$
If two regression coefficients are positive then the coefficient of correlation must be	Zero	negative	positive	one	positive
If two-regression coefficients are negative then the coefficient of correlation must be	Positive	negative	zero	one	Positive
The regression equation of X on Y is	X = a + bY	X = a + bX	X= a - bY	Y= a + bX	X = a + bY
The regression equation of Y on X is	X = a + bY	X = a + bX	X= a - bY	Y= a + bX	Y= a + bX
The given two variables are perfectly positive, if	r = +1	r = -1	r = 0	r ≠ +1	r = +1
The relationship between two variables by plotting the values on a chart, known as-	coefficient of correlation	Scatter diagram	Correlogram	rank correlation	Scatter diagram
If x and y are independent variables then,	cov(x,y)≠ 0	cov(x,y)= 1	cov(x,y)= 0	cov(x,y) >1	cov(x,y)= 0
Correlation coefficient is the ----------- of the two regression coefficients.	Mode	Geometric mean	Arithmetic mean	median	Geometric mean
b_{xy} = 0.4, b_{yx} = 0.9 then r =	0.6	0.3	0.1	-0.6	0.6
b_{xy}=1/5, r=8/15, s_x = 5 then s_y=	40/13	13/40	40/3	3	40/3

The geometric mean of the two regression coefficients.	Correlation coefficient	regression coefficients	coefficient of range	coefficient of variation	Correlation coefficient
If two variables are uncorrelated, then the lines of regression	Do not exist	coincide	Parallel to each other	perpendicular to each other	perpendicular to each other
If the given two variables are correlated perfectly negative, then	$r = +1$	$r = -1$	$r = 0$	$r \neq +1$	$r = -1$
If the given two variables have no correlation, then	$r = +1$	$r = -1$	$r = 0$	$r \neq +1$	$r = 0$
If the correlation coefficient between two variables X and Y is ---------, the Regression coefficient of Y on X is positive	Negative	positive	not certain	zero	positive
If the correlation coefficient between two variables X and Y is ---------, the Regression coefficient of Y on X is negative	Negative	positive	not certain	zero	Negative
------------ is independent of origin and scale.	Correlation coefficient	regression coefficients	coefficient of range	coefficient of variation	Correlation coefficient
The angle between two lines of regression is ninety degree, if -------------	$r = 2$	$r = 0$	$r = 1$	$r = -1$	$r = 1$
--------- is used to measure closeness of relationship between variables.	Regression	mean	Rank correlation	correlation	correlation
If r is either +1 or –1, then there will be only one -------- line in case of two variables	Correlation	regression	rank correlation	mean	regression
When b_{xy}=0.85 and b_{yx}= 0.89, then correlation coefficient r =	0.98	0.5	0.68	0.87	0.87

If b_{xy} and b_{yx} represent regression coefficients and if $b_{xy} < 1$, then b_{yx} is	less than 1	greater than one	equal to one	equal to zero	greater than one
While drawing a scatter diagram if all points appear to form a straight line getting Downward from left to right, then it is inferred that there	Perfect positive correlation	simple positive correlation	Perfect negative correlation	no correlation	Perfect negative correlation
If r =1, the angle between two lines of regression is----------	Zero degree	sixty degree	ninety degree	thirty degree	ninety degree
Regression coefficient is independent of--------	Origin	scale	both origin and scale	neither origin nor scale.	Origin
There will be only one regression line in case of two variables if------------	r =0	r = +1	r = –1	r is either +1 or –1	r =0
The regression line cut each other at the point of----------	Average of X only	Average of Y only	Average of X and Y	d) the median of X on Y	Average of X and Y
Given the coefficient of correlation being 0.8, the coefficient of determination will be	0.98	0.64	0.66	0.54	0.64
Given the coefficient of correlation being 0.9, the coefficient of determination will be	0.98	0.81	0.66	0.54	0.81
If the coefficient of determination being 0.49, what is the coefficient of correlation	0.7	0.8	0.9	0.6	0.7
Given the coefficient of determination being 0.36, the coefficient of correlation will be	0.3	0.4	0.6	0.5	0.6

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Class : II – M.Sc. Microbiology	**Semester : III**	**4 0 0 4**

UNIT III

Test of significance: Tests based on Means only-Both Large sample and Small sample tests - Chi square test - goodness of fit. Analysis of variance – one way and two way classification. CRD, RBD Designs.

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2. Kothari. C.R. (2004). Research Methodology – Methods and Techniques. (2nd ed.). New Age International Pvt. Ltd, New Delhi.
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Hypothesis :

A hypothesis a statement about the population parameter. In other words a hypothesis is a conclusion which is usually drawn on a logical bases.

Statistical hypothesis:

It is an idea which may or may not be true about a population or about the probability distribution which we want to test on the basis of random sample.

Testing of Hypothesis:

It is a procedure that helps us to claim the likelihood of hypothesis population parameter, being correct by making use of the sample statistics.

Test of Significance:

The testing of hypothesis discloses the fact that whether the different between sample statistics and the corresponding population parameter is significant or not.

Procedure for testing a Hypothesis:

1. **Setting up a Hypothesis:**

Hypothesis testing is a scientific method of choosing between two claims H_0 and H_a

a) **Null Hypothesis:**

The null hypothesis asserts that there is no different between sample statistic and the population parameter. H_0 is called the null hypothesis. It says that the educated earn no better than others.

$H_0 : \mu = \mu_0$

b) **Alternative Hypothesis:**

The negation of Null hypothesis is called alternative hypothesis.$H_a$is called the alternative hypothesis, which says that the educated earn more.

Example:
In this example, the alternative is one-sided. If the claim were that the educated earn less than others, then the alternative would be set up as $H_a\mu < 30000$.

Some principles:
1) H_0 is presumed true unless overwhelming evidence rejects it. *E.g.*, H_0: defendant is not guilty!
2)Sample data give test statistics for μ, p or σ^2
3)We reject the Null H_0 if statistic falls in Rejection Region
4) Null is usually a zero value (hence the name null).
5) Instead of saying ACCEPT one says FAILS TO REJECT.
6) Absolute certainty does not exist.

If there is a standard value for μ the null is $H_0\mu$ =std value (or true value). e.g. $H_0\mu = 10$ and two-sided alternative is $H_a\mu \neq 10$, where it could be larger than 10 or smaller than 10.

Need Skill to decide (1) appropriate statistical parameter μ, p, etc. (2) appropriate Null (3) One-sided or two-sided.When one of the alternatives is selected, there can be error.
Type I (α) and Type II (β) errors

Definition
Statistics is the science of collecting, organizing, analyzing, and interpreting data in order to make decisions.

Data Sets

There are two types of data sets you will use when studying statistics. These data sets are called *populations* and *samples.*

Definition

A **population** is the collection of *all* outcomes, responses, measurements, or counts that are of interest.

A **sample** is a subset of a population.

Definition: Type I error:

Selecting H_a when H_0 should be selected.H_0 DOGS are dead, H_a DOGS are alive
Truth is DOGS are dead, still selecting H_a is Type I error

Type II error:
Selecting H_0 when H_a should be selected.H_0 DOGS are dead, H_a DOGS are alive.Truth is DOGS are alive, still selecting H_0 means Type II error.

Definition:
αdenotes the probability of Type I error = This is also called the "Level of test."

Definition:
βdenotes the probability of Type II error. This is usually hard to determine since it depends on unknown parameter μ itself.
It is desirable to formulate the hypothesis so that α is the most serious consequence. The two types of errors are inversely related. There is a trade-off between $\alpha$and β. The smaller we make α the larger the β we have to accept. Hence one usually chooses α largest tolerable !

Steps in the Test of Hypothesis:

- Define the hyp. to be tested in plain English.
- Select the appropriate statistical measure (such as μ p, σ^2) to rephrase the hypothesis.
- Determine whether hyp. should be 1 or 2-sided.
- .State the hypothesis using the statistical measure selected in step 2..Specifyα, the "level" of the test.
- .Select the appropriate test statistic, based on the information at hand and the assumptions you are willing to make.
- .Determine the critical value of the test statistic. Three factors for critical value:

a. the type of alternative hypothesis,
(1) Two-sided (2) 1-sided left (3) 1-sided Right
b. the specification of a, the level of the test,
c. the distribution of the test statistic.

- Collect sample data and compute the value of the test statistic.
- .Make the decision. Is the value of the test statistic in the rejection region?

a. If yes, reject the nullhypothesis in favor of the alternative.
b.If no, do not reject the nullhypothesis.

Z - Test for a Mean (Large Samples) Single mean:
The sample size n has to be greater than or equal to 30, or the population standard deviation is givenThe given population mean μ and a sample mean $\overline{x}$.. The result of the test will be a conclusion in which we state that the population mean is, or is not significantly different from, or is less than or more than what is stated.

The test statistic for this type of hypothesis testing is $z = \frac{\overline{X} - \mu}{\frac{s}{\sqrt{n}}}$, the critical value z_c is to be found from the normal distribution table.

Example 1:

The Public Health Service publishes the "*Annual Data Tabulations, Continuous Air Monitoring Projects*", which some years ago indicated that a large Midwestern city had an annual mean level of sulfur dioxide of 0.12 (concentration in parts per million). To change this concentration, many steel mills and other manufacturers installed antipollution equipment. In order to study the effects of these efforts to reduce pollution 36 random checks were made throughout the year. It was found that the sample mean pollution sulfur dioxide level was 0.115 with a sample standard deviation of 0.03.
At the 0.05 level of significance, does this evidence suggest that there has been a change in the sulfur dioxide level in this city?

Solution 1:

We will follow the four step procedure as outlined in "*Hypothesis Testing, An Overview*". The word "change" in the last sentence of the problem tells us to perform a two tailed test.

Step 1 : The Null Hypothesis

The sulfur dioxide concentration in this city is not significantly different from the reported level of 0.12 parts per million.

Step 2 : The Decision Rule

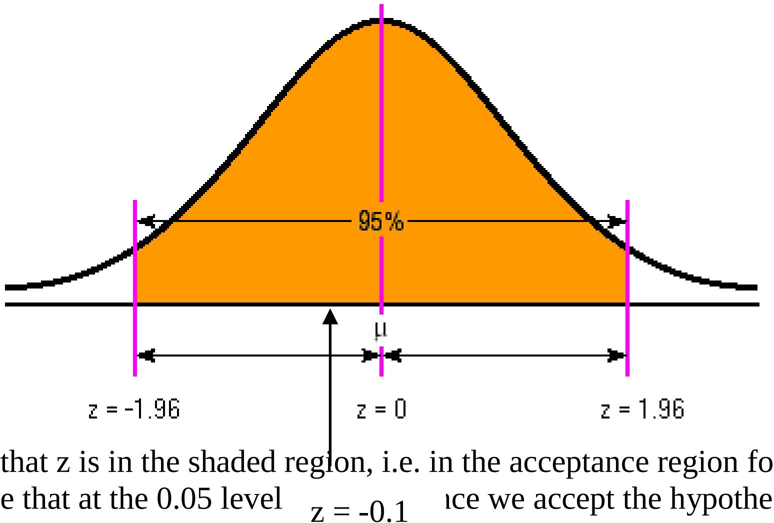
We accept the null hypothesis if $-1.96 < z < 1.96$

Step 3 : The Test Statistic

Using $z = \frac{\overline{X} - \mu}{\frac{s}{\sqrt{n}}}$ we find $z = \frac{0.115 - 0.12}{\frac{0.03}{\sqrt{36}}} = -1$.

Step 4 : The Conclusion

Combining the info from steps 2 and 3 in a picture with a normal curve we get:



We see that z is in the shaded region, i.e. in the acceptance region formulated in step 2. Thus we conclude that at the 0.05 level of significance we accept the hypothesis that the sulfur dioxide level in this city is not significantly different from the reported level. In other words, the efforts of industry to change the sulfur dioxide level from the reported level of 0.12 per million parts have not been successful.

Example 2:

A machine is set to fire 30.00 decigrams of chocolate pellets into a box of cake mix as it moves along the production line. Of course, there is some variation in the weight of the pellets. A sample of 36 boxes of mix revealed that the average weight of the chocolate pellets was 30.18 decigrams with a sample standard deviation of 0.50 decigrams. At the 0.05 level of significance, is the sampled weight of the chocolate pellets of 30.18 decigrams suggesting that the mean weight of the chocolate pellets in all cake mix boxes is higher than the set 30.00 decigrams?

Solution 2:

The words "higher than" in the last sentence of the problem tells us to perform a right tailed test.

Step 1 : The Null Hypothesis

The mean weight of the chocolate pellets in the boxes of cake mix is not significantly higher than 30.00 decigrams.

Step 2 : The Decision Rule

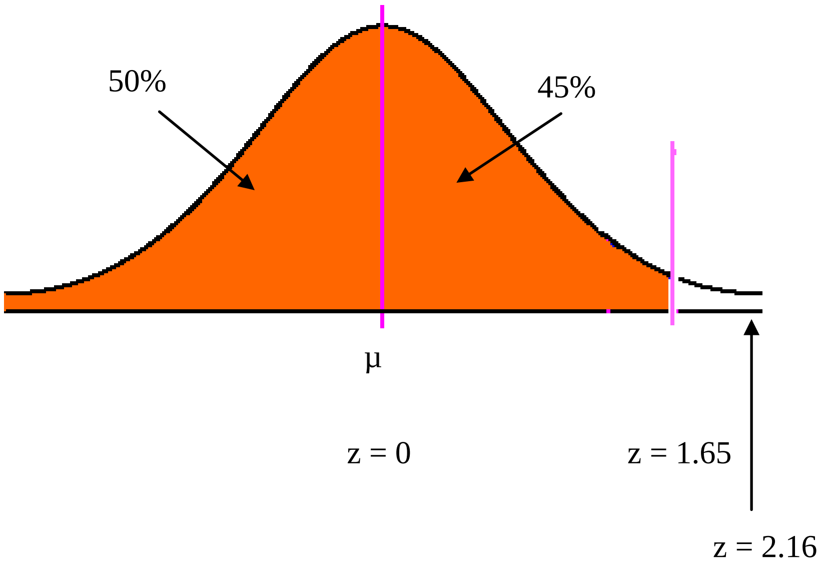
We accept the null hypothesis if $z < 1.65$

Step 3 : The Test Statistic

Using $z = \dfrac{\overline{X} - \mu}{\dfrac{s}{\sqrt{n}}}$ we find $z = \dfrac{30.18 - 30.00}{\dfrac{0.5}{\sqrt{36}}} = 2.16$.

Step 4 : The Conclusion

Combining the info from steps 2 and 3 in a picture with a normal curve we get:



We see that z is outside of the shaded region, i.e. outside of the acceptance region formulated in step 2. Thus we conclude that at the 0.05 level of significance there seems to be sufficient evidence to suggest that the mean weight of the chocolate pellets in all cake mix boxes is higher than the set 30.00 decigrams. In other words, the machine firing the chocolate pellets into the boxes of cake mix is not functioning correctly.

Z- test Difference between two Mean:

$$z = \frac{\bar{x}_1 - \bar{x}_2 - \Delta}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}}$$

wherex_1 and x_2 are the means of the two samples, Δ is the hypothesized difference between the population means (0 if testing for equal means), σ_1 and σ_2 are the standard deviations of the two populations, and n_1 and n_2 are the sizes of the two samples.

Example 1 (two-tailed test): The amount of a certain trace element in blood is known to vary with a standard deviation of 14.1 ppm (parts per million) for male blood donors and 9.5 ppm for female donors. Random samples of 75 male and 50 female donors yield concentration means of 28 and 33 ppm, respectively. What is the likelihood that the population means of concentrations of the element are the same for men and women?

Null hypothesis:H_0: $\mu_1 = \mu_2$

orH_0: $\mu_1 – \mu_2 = 0$

alternative hypothesis:H_a: $\mu_1 - \mu_2$

or: H_a: $\mu_1 - \mu_2 \neq 0$

$$z = \frac{28 - 33 - 0}{\sqrt{\frac{14.1^2}{75} + \frac{9.5^2}{50}}} = \frac{-5}{\sqrt{2.65 + 1.81}} = -2.37$$

The computed *z*-value is negative because the (larger) mean for females was subtracted from the (smaller) mean for males. But because the hypothesized difference between the populations is 0, the order of the samples in this computation is arbitrary— *x* , could just as well have been the female sample mean and *x* , the male sample mean, in which case *z* would be 2.37 instead of –2.37. An extreme *z*-score in either tail of the distribution (plus or minus) will lead to rejection of the null hypothesis of no difference.

The area of the standard normal curve corresponding to a *z*-score of −2.37 is .0089. Because this test is two-tailed, that figure is doubled to yield a probability of .0178 that the population means are the same. If the test had been conducted at a pre-specified significance level of $\alpha < .05$, the null hypothesis of equal means could be rejected. If the specified significance level had been the more conservative (more stringent) $\alpha < .01$, however, the null hypothesis could not be rejected.

In practice, the two-sample *z*-test is not often used because the two population standard deviations σ_1 and σ_2 are usually unknown. Instead, sample standard deviations and the *t*-distribution are used.

t-test Small samples:single mean:

$$t = \frac{\overline{X} - \mu}{\frac{s}{\sqrt{n}}}$$

where*x* is the sample mean,μis a specified value to be tested, *s* is the sample standard deviation, and *n* is the size of the sample. When the standard deviation of the sample is substituted for the standard deviation of the population, the statistic does not have a normal distribution; it has what is called the *t*-distribution. Because there is a different *t*-distribution for each sample size, it is not practical to list a separate area-of-the-curve table for each one. Instead, critical *t*-values for common alpha levels (.05, .01, .001, and so forth) are usually given in a single table for a range of sample sizes. For very large samples, the *t*-distribution approximates the standard normal (*z*) distribution.

Values in the *t*-table are not actually listed by sample size but by degrees of freedom *(df)*. The number of degrees of freedom for a problem involving the *t*-distribution for sample size *n* is simply *n* – 1 for a one-sample mean problem.

Example 1 (one-tailed test): A professor wants to know if her introductory statistics class has a good grasp of basic math. Six students are chosen at random from the class and given a math proficiency test. The professor wants the class to be able to score at least 70 on the test. The six students get scores of 62, 92, 75, 68, 83, and 95. Can the professor be at least 90 percent certain that the mean score for the class on the test would be at least 70?

null hypothesis:H_0: $\mu < 70$

alternative hypothesis:H a: $\mu \geq 70$

First, compute the sample mean and standard deviation.

$$\begin{array}{r} 62 \\ 92 \\ 75 \\ 68 \\ 83 \\ \underline{95} \\ 475 \end{array} \qquad \begin{array}{c} \bar{x} = \dfrac{475}{6} = 79.17 \\ s = 13.17 \end{array}$$

Next, compute the *t*-value:

$$t = \frac{79.17 - 70}{\dfrac{13.17}{\sqrt{6}}} = \frac{9.17}{5.38} = 1.71$$

To test the hypothesis, the computed *t*-value of 1.71 will be compared to the critical value in the *t*-table. But which do you expect to be larger and which smaller? One way to reason about this is to look at the formula and see what effect different means would have on the computation. If the sample mean had been 85 instead of 79.17, the resulting *t*-value would have been larger.

Because the sample mean is in the numerator, the larger it is, the larger the resulting figure will be. At the same time, you know that a higher sample mean will make it more likely that the professor will conclude that the math proficiency of the class is satisfactory and that the null hypothesis of less-than-satisfactory class math knowledge can be rejected. Therefore, it must be true that the larger the computed *t*-value, the greater the chance that the null hypothesis can be rejected. It follows, then, that if the computed *t*-value is larger than the critical *t*-value from the table, the null hypothesis can be rejected.

A 90 percent confidence level is equivalent to an alpha level of .10. Because extreme values in one rather than two directions will lead to rejection of the null hypothesis, this is a one-tailed test, and you do not divide the alpha level by 2. The number of degrees of freedom for the problem is 6 – 1 = 5. The value in the *t*-table for $t_{10,5}$ is 1.476. Because the computed *t*-value of 1.71 is larger than the critical value in the table, the null hypothesis can be rejected, and the professor can be 90 percent certain that the class mean on the math test would be at least 70.

Note that the formula for the one-sample *t*-test for a population mean is the same as the *z*-test, except that the *t*-test substitutes the sample standard deviation *s* for the population standard deviation σ and takes critical values from the *t*-distribution instead of the *z*-distribution. The *t*-distribution is particularly useful for tests with small samples ($n< 30$).

Example 2 (two-tailed test): A Little League baseball coach wants to know if his team is representative of other teams in scoring runs. Nationally, the average number of runs scored by a Little League team in a game is 5.7. He chooses five games at random in which his team scored 5 9, 4, 11, and 8 runs. Is it likely that his team's scores could have come from the national distribution? Assume an alpha level of .05.

Because the team's scoring rate could be either higher than or lower than the national average, the problem calls for a two-tailed test.

First, state the null and alternative hypotheses:

null hypothesis:H_0: $\mu = 5.7$

alternative hypothesis:H_a: $\mu \neq 5.7$

Next compute the sample mean and standard deviation:

$$\begin{array}{r} 5 \\ 9 \\ 4 \\ 11 \\ \underline{8} \\ 37 \end{array} \qquad \begin{array}{l} \bar{x} = \frac{37}{5} = 7.4 \\ s = 2.88 \end{array}$$

Next, the *t*-value:

$$t = \frac{7.4 - 5.7}{\frac{2.88}{\sqrt{5}}} = \frac{1.7}{1.29} = 1.32$$

Now, look up the critical value from the *t*-table. You need to know two things in order to do this: the degrees of freedom and the desired alpha level. The degrees of freedom is 5 – 1 = 4. The overall alpha level is .05, but because this is a two-tailed test, the alpha level must be divided by two, which yields .025. The tabled value for $t_{.025,4}$ is 2.776. The computed *t* of 1.32 is smaller than the *t* from the table, so you cannot reject the null hypothesis that the mean of this team is equal to the population mean. The coach can conclude that his team fits in with the national distribution on runs scored.

Chi-Square test:

$\chi^2 = \sum (E\text{-}O)^2 / E$

Example, “There is no association between the gender of applicants and whether or not their application is accepted”.

The first step is to put the observed data (what was actually measured/recorded) into a contingency table as shown in Table 1.

Table 1: Observed frequencies

	Application successful	Application not successful	TOTAL
Male	23	40	63
Female	31	39	70
TOTAL	54	79	133

The second step is to calculate the expected frequencies. These are the frequencies that we would have expected to have recorded given the row/column totals. There are several different ways you can do this. The most basic involves calculating what you would observe if there was no association between the two variables. This is done by multiplying the row total by the column total and dividing the result by the table total, for each cell. This is shown in Table 2:

Table 2: Calculation of expected frequencies

	Application successful	Application not successful	TOTAL
Male	(63 * 54) / 133 = 25.58	(63 * 79) / 133 = 37.42	63
Female	(70 * 54) / 133 = 28.42	(70 * 79) / 133 = 41.58	70
TOTAL	54	79	133

Be sure to check that your observed and expected values both sum up to the same total.

The third step is to calculate the chi-square statistic.

The formula for chi-square is: $\chi^2 = \sum (E\text{-}O)^2 / E$

Where E is the expected values and O is the observed values. The sigma sign means that everything that follows is summed. So '(expected – observed)^2 / expected' is calculated for each cell in the contingency table as shown below.

The expected value for this cell

The observed value for this cell

	Application successful	Application not successful
Male	$(25.58 – 23)^2$ / 25.28 = 0.26	$(37.42 - 40)^2$ / *37.42* = 0.18
Female	$(28.42 - 31)^2$ / 28.42 = 0.23	$(41.58 - 39)^2$ / 41.58 =0.16

….. and then the results from each cell are summed:

0.26 + 0.18 + 0.23 + 0.16 = <u>0.83</u>

And that is the χ^2 value.

Calculate the degrees of freedom:

(number of rows – 1) x (number of columns – 1)=(n-1)x(c-1)

Here there are two rows and two columns, so the degrees of freedom is 1.

The final step is to see whether the chi-square value, given the degrees of freedom, is statistically significant. This can be done by comparing the χ^2 value against a table of critical values that have been derived from the chi-square distribution. Alternatively most software packages will tell you the exact p-value so you can see instantly whether it is below the standard threshold of 0.05 or not.

In this example, χ^2 = 0.83 which is greater than 0.0199, the critical value for 5% significance with 1 degree of freedom. Hence the result is not significant and we cannot reject the null hypothesis that there is no association between the gender of applicants and whether or not their application is accepted or not. What this means is that the likelihood that the difference between the observed and expected values is due to chance rather than any genuine affect is greater than 5%.

When presenting results in reports it is usual to give one table and put the expected frequencies in brackets, like this:

	Application successful	Application not successful	TOTAL
Male	23 (25.58)	40 (37.42)	63
Female	31 (28.42)	39 (41.58)	70
TOTAL	54	79	133

The results are then written as χ^2 = 0.08, df = 1, p<0.05 (or p=NS if the result was not significant).

One way ANOVA:

A One-Way Analysis of Variance is a way to test the equality of three or more means at one time by using variances.

Assumptions:

- The populations from which the samples were obtained must be normally or approximately normally distributed.
- The samples must be independent.
- The variances of the populations must be equal.

Hypotheses:

The null hypothesis will be that all population means are equal, the alternative hypothesis is that at least one mean is different.

In the following, lower case letters apply to the individual samples and capital letters apply to the entire set collectively. That is, n is one of many sample sizes, but N is the total sample size.

Grand Mean:

$$\bar{X}_{GM} = \frac{\sum x}{N}$$

$$\bar{X}_{GM} = \frac{\sum n\bar{x}}{\sum n}$$

The grand mean of a set of samples is the total of all the data values divided by the total sample size. This requires that you have all of the sample data available to you, which is usually the case, but not always. It turns out that all that is necessary to find perform a one-way analysis of variance are the number of samples, the sample means, the sample variances, and the sample sizes.

Another way to find the grand mean is to find the weighted average of the sample means. The weight applied is the sample size.

Total Variation:

The total variation (not variance) is comprised the sum of the squares of the differences of each mean with the grand mean.

There is the between group variation and the within group variation. The whole idea behind the analysis of variance is to compare the ratio of between group variance to within group variance. If the variance caused by the interaction between the samples is much larger when compared to the variance that appears within each group, then it is because the means aren't the same.

$$SS(T) = \sum (x - \bar{X}_{GM})^2$$

Between Group Variation:

The variation due to the interaction between the samples is denoted SS(B) for Sum of Squares Between groups. If the sample means are close to each other (and therefore the Grand Mean) this will be small. There are k samples involved with one data value for each sample (the sample mean), so there are k-1 degrees of freedom.

The variance due to the interaction between the samples is denoted MS(B) for Mean Square Between groups. This is the between group variation divided by its degrees of freedom. It is also denoted by s_b^2.

$$SS(B) = \sum n(\bar{x} - \bar{X}_{GM})^2$$

Within Group Variation:

The variation due to differences within individual samples, denoted SS(W) for Sum of Squares Within groups. Each sample is considered independently, no interaction between samples is involved. The degrees of freedom is equal to the sum of the individual degrees of freedom for each sample. Since each sample has degrees of freedom equal to one less than their sample sizes, and there are k samples, the total degrees of freedom is k less than the total sample size: df = N - k.

$$SS(W) = \sum df \cdot s^2$$

Mean Square Within groups:

The variance due to the differences within individual samples is denoted MS(W) for Mean Square Within groups. This is the within group variation divided by its degrees of freedom. It is also denoted by s_w^2. It is the weighted average of the variances (weighted with the degrees of freedom).

F test statistic:

A F variable is the ratio of two independent chi-square variables divided by their respective degrees of freedom.

$$\boxed{F = \frac{s_b^2}{s_w^2}}$$

Also recall that the F test statistic is the ratio of two sample variances, well, it turns out that's exactly what we have here. The F test statistic is found by dividing the between group variance by the within group variance. The degrees of freedom for the numerator are the degrees of freedom for the between group (k-1) and the degrees of freedom for the denominator are the degrees of freedom for the within group (N-k).

Summary Table:

	SS	**df**	**MS**	**F**

Between	SS(B)	k-1	SS(B)
			----------- 	
			k-1
				MS(B)
				-------------- 	
				MS(W)

Within	SS(W)	N-k	SS(W) ----------- N-k	
Total	SS(W) + SS(B)	N-1		

Each Mean Square is just the Sum of Squares divided by its degrees of freedom, and the F value is the ratio of the mean squares. Do not put the largest variance in the numerator, always divide the between variance by the within variance. If the between variance is smaller than the within variance, then the means are really close to each other and you will fail to reject the claim that they are all equal. The degrees of freedom of the F-test are in the same order they appear in the table.

Decision Rule:

The decision will be to reject the null hypothesis if the test statistic from the table is greater than the F critical value with k-1 numerator and N-k denominator degrees of freedom.

OnewayAnova Example:

Consider an experiment to study the effect of three different levels of some factor on a response (e.g. three types of fertilizer on plant growth). If we had 6 observations for each level, we could write the outcome of the experiment in a table like this, where a_1, a_2, and a_3 are the three levels of the factor being studied.

$\boldsymbol{a_1}$	$\boldsymbol{a_2}$	$\boldsymbol{a_3}$
6	8	13
8	12	9
4	9	11
5	11	8
3	6	7
4	8	12

The null hypothesis, denoted H_0, for the overall F-test for this experiment would be that all three levels of the factor produce the same response, on average. To calculate the F-ratio:

Step 1: Calculate the mean within each group:

$$\overline{Y}_1 = \frac{1}{6}\sum Y_{1i} = \frac{6+8+4+5+3+4}{6} = 5$$
$$\overline{Y}_2 = \frac{1}{6}\sum Y_{2i} = \frac{8+12+9+11+6+8}{6} = 9$$
$$\overline{Y}_3 = \frac{1}{6}\sum Y_{3i} = \frac{13+9+11+8+7+12}{6} = 10$$

Step 2: Calculate the overall mean:

$$\overline{Y} = \frac{\sum_i \overline{Y}_i}{a} = \frac{\overline{Y}_1 + \overline{Y}_2 + \overline{Y}_3}{a} = \frac{5+9+10}{3} = 8$$

where$a$ is the number of groups.

Step 3: Calculate the "between-group" sum of squares:

$$S_B = n(\overline{Y}_1 - \overline{Y})^2 + n(\overline{Y}_2 - \overline{Y})^2 + n(\overline{Y}_3 - \overline{Y})^2$$
$$= 6(5-8)^2 + 6(9-8)^2 + 6(10-8)^2 = 84$$

where$n$ is the number of data values per group.

The between-group degrees of freedom is one less than the number of groups

$$f_b = 3 - 1 = 2$$

so the between-group mean square value is

$$MS_B = 84 / 2 = 42$$

Step 4: Calculate the "within-group" sum of squares. Begin by centering the data in each group

a_1	a_2	a_3
6 − 5 = 1	8 − 9 = -1	13 − 10 = 3
8 − 5 = 3	12 − 9 = 3	9 − 10 = -1
4 − 5 = -1	9 − 9 = 0	11 − 10 = 1
5 − 5 = 0	11 − 9 = 2	8 − 10 = -2
3 − 5 = -2	6 − 9 = -3	7 − 10 = -3
4 − 5 = -1	8 − 9 = -1	12 − 10 = 2

The within-group sum of squares is the sum of squares of all 18 values in this table

$$S_W = 1 + 9 + 1 + 0 + 4 + 1 + 1 + 9 + 0 + 4 + 9 + 1 + 9 + 1 + 1 + 4 + 9 + 4 = 68$$

The within-group degrees of freedom is

$$f_W = a(n - 1) = 3(6 - 1) = 15$$

Thus the within-group mean square value is

$$MS_W = S_W / f_W = 68/15 \approx 4.5$$

Step 5: The F-ratio is

$$F = \frac{MS_B}{MS_W} \approx 42/4.5 \approx 9.3$$

The critical value is the number that the test statistic must exceed to reject the test. In this case, $F_{\text{crit}}(2,15) = 3.68$ at $\alpha = 0.05$. Since $F = 9.3 > 3.68$, the results are significant at the 5% significance level. One would reject the null hypothesis, concluding that there is strong evidence that the expected values in the three groups differ. The p-value for this test is 0.002.

After performing the F-test, it is common to carry out some "post-hoc" analysis of the group means. In this case, the first two group means differ by 4 units, the first and third group means differ by 5 units, and the second and third group means differ by only 1 unit. The standard error of each of these differences is $\sqrt{4.5/6 + 4.5/6 = 1.2}$. Thus the first group is strongly different from the other groups, as the mean difference is more times the standard error, so we can be highly confident that the population mean of the first group differs from the population means of the other groups. However there is no evidence that the second and third groups have different population means from each other, as their mean difference of one unit is comparable to the standard error.

Two-Way ANOVA:

The two-way analysis of variance is an extension to the one-way analysis of variance. There are two independent variables (hence the name two-way).

Assumptions:

- The populations from which the samples were obtained must be normally or approximately normally distributed.
- The samples must be independent.
- The variances of the populations must be equal.
- The groups must have the same sample size.

Hypotheses:

There are three sets of hypothesis with the two-way ANOVA.

The null hypotheses for each of the sets are given below.

1. The population means of the first factor are equal. This is like the one-way ANOVA for the row factor.
2. The population means of the second factor are equal. This is like the one-way ANOVA for the column factor.
3. There is no interaction between the two factors. This is similar to performing a test for independence with contingency tables.

Factors:

The two independent variables in a two-way ANOVA are called factors. The idea is that there are two variables, factors, which affect the dependent variable. Each factor will have two or more levels within it, and the degrees of freedom for each factor is one less than the number of levels.

Treatment Groups

Treatement Groups are formed by making all possible combinations of the two factors. For example, if the first factor has 3 levels and the second factor has 2 levels, then there will be 3x2=6 different treatment groups.

As an example, let's assume we're planting corn. The type of seed and type of fertilizer are the two factors we're considering in this example. This example has 15 treatment groups. There are 3-1=2 degrees of freedom for the type of seed, and 5-1=4 degrees of freedom for the type of fertilizer. There are 2*4 = 8 degrees of freedom for the interaction between the type of seed and type of fertilizer.

The data that actually appears in the table are samples. In this case, 2 samples from each treatment group were taken.

	Fert I	Fert II	Fert III	Fert IV	Fert V
Seed A-402	106, 110	95, 100	94, 107	103, 104	100, 102
Seed B-894	110, 112	98, 99	100, 101	108, 112	105, 107
Seed C-952	94, 97	86, 87	98, 99	99, 101	94, 98

Main Effect:

The main effect involves the independent variables one at a time. The interaction is ignored for this part. Just the rows or just the columns are used, not mixed. This is the part which is similar to the one-way analysis of variance. Each of the variances calculated to analyze the main effects are like the between variances

Interaction Effect:

The interaction effect is the effect that one factor has on the other factor. The degrees of freedom here is the product of the two degrees of freedom for each factor.

Within Variation

The Within variation is the sum of squares within each treatment group. You have one less than the sample size (remember all treatment groups must have the same sample size for a two-way ANOVA) for each treatment group. The total number of treatment groups is the product of the number of levels for each factor. The within variance is the within variation divided by its degrees of freedom. The within group is also called the error.

F-Tests

There is an F-test for each of the hypotheses, and the F-test is the mean square for each main effect and the interaction effect divided by the within variance. The numerator degrees of freedom come from each effect, and the denominator degrees of freedom is the degrees of freedom for the within variance in each case.

Two-Way ANOVA Table

It is assumed that main effect A has a levels (and A = a-1 df), main effect B has b levels (and B = b-1 df), n is the sample size of each treatment, and N = abn is the total sample size. Notice the overall degrees of freedom is once again one less than the total sample size.

Source	**SS**	**df**	**MS**	**F**
Main Effect A	*given*	A, a-1	SS / df	MS(A) / MS(W)
Main Effect B	*given*	B, b-1	SS / df	MS(B) / MS(W)
Interaction Effect	*given*	A*B, (a-1)(b-1)	SS / df	MS(A*B) / MS(W)
Within	*given*	N - ab, ab(n-1)	SS / df	
Total	sum of others	N - 1, abn - 1		

Summary

The following results are calculated using the Quattro Pro spreadsheet. It provides the p-value and the critical values are for alpha = 0.05.

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F-crit*
Seed	512.8667	2	256.4333	28.283	0.000008	3.682
Fertilizer	449.4667	4	112.3667	12.393	0.000119	3.056
Interaction	143.1333	8	17.8917	1.973	0.122090	2.641
Within	136.0000	15	9.0667			
Total	**1241.4667**	**29**				

From the above results, we can see that the main effects are both significant, but the interaction between them isn't. That is, the types of seed aren't all equal, and the types of fertilizer aren't all equal, but the type of seed doesn't interact with the type of fertilizer.

Here is the correct table:

Source of Variation	*SS*	*df*	*MS*	*F*
Sample	3.920	1	3.920	4.752
Column	9.680	1	9.680	11.733
Interaction	54.080	1	54.080	65.552
Within	3.300	4	0.825	
Total	70.980	7		

Blocking:

The analysis of experiment is used to eliminate one source of variability is discussed in completely randomized block design.The analysis of experiment is used to eliminate two or three source of variability is discussed in randomized block design.

Completely Randomised Block Design:

Consider the statistical analysis of the the completely randomized design or onewayclassification.Suppose the experiment has available the results of k independent random samples from k different populatios. Testing the hypothesis that the mean of these k populations are all equal. We complete the completely randomized design by One-Way Analysis of Variance.

Randomised Block Design:

The analysis of experiment in a two way classification. This kind of arrangement is also called a randomized block design, provided the treatment are allocated at random within each block.

Part B (5x6=30 Marks)

Possible Questions

1. Two types of batteries are tested for their length of life and the following data are obtained.

	Type I	Type II
Sample size	9	8
Mean	600 hrs	640 hrs
Variance	121	144

Use the 5% level of significance to test whether the mean values differ significantly? (Table value is $t_{0.025, 15} = 2.131$).

2. A survey of 320 families with 5 children each revealed the following distributions.

No. of Boys :	5	4	3	2	1	0
No. of Girls :	0	1	2	3	4	5
No. of Families:	14	56	110	88	40	12

Is the result consistent with the hypothesis that male and female births are equally probable? (Table value is $\chi^2_{0.05, 5} = 11.0705$).

3. Write the procedure of classification of two – way ANOVA
4. Below are given the gain in weights in Kg. of cows fed on 2 diets X and Y.

Diet X: 25	32	30	32	24	14	32			
Diet Y: 24	34	22	30	42	31	40	30	32	35

Test at 5% level whether the two diets differ in their effect on mean weights. (Table value is $t_{0.025, 15} = 2.131$).

5. Random samples are drawn from 2 populations and their results were obtained.

Sample X:	16	17	18	19	20	21	22	24	26	27		
Sample Y:	19	22	23	25	26	28	29	30	31	32	35	36

Find variance and test whether the 2 samples have same variance. (Table value is $F_{0.05, 9, 11} = 3.105$).

6. Samples of two types of electric bulbs were tested for length of life and the following data were obtained.

	Type I	Type II
Sample size	8	7
Mean	1134 hrs	1024 hrs
SD	35	40

Use the 5% level of significance to test whether the mean values differ significantly? (Table value is $t_{0.025, 13} = 2.160$).

7. The theory predicts that proportion of beans in the four groups A, B, C and D should be 9,3,3,1. In an experiment with 1600 beans, the numbers in the 4 types were 882, 313, 287 and 118. Does the experiment result support the theory? (Table value is $\chi^2_{0.05, 3}$=7.181).

Part C (1x10=10 Marks)

Possible Questions

1. The systolic pressure of 10 persons in the age of 45 – 50 is given below.
   148, 128, 147, 127, 150, 145, 124, 140, 142, 149. From the data at 5% level discuss the suggestion that the average systolic pressure of the population is 150.
   (Table value is $t_{0.025, 9} = 3.17$).
2. Write the steps in testing the hypothesis.
3. 300 digits were chosen at random from a set of table, the frequency of the digits was as follows.

Digits:	0	1	2	3	4	5	6	7	8	9
Frequency:	28	29	33	31	26	35	32	30	31	25

   Using χ^2 test assess the hypothesis that the digits were distributed uniformly in the table. (Table value is $\chi^2_{0.05, 9} = 16.9190$).
4. The height of 10 children selected at random from a given locality had a mean 63.2 cm and variance 6.25 cm. Test at 5% level of significance, the hypothesis that the children of the given locality are on the average less than 65 cm. (Table value is $t_{0.05, 9} = 2.16$).

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Subject: Biostatistics and Research Methodology **Subject Code: 16MBP304**

Class : II - M.Sc. Microbiology **Semester : III**

Unit III

Test of significance

Part A (20x1=20 Marks)
(Question Nos. 1 to 20 Online Examinations)

Possible Questions

Question	Choice 1	Choice 2	Choice 3	Choice 4	Answer
The word ---------------- is used to indicate various statistical measures like mean, standard deviation, correlation etc, in the universe.	Statistic	parameter	hypothesis	none of these	parameter
The term STATISTIC refers to the statistical measures relating to the -----------.	Population	hypothesis	sample	universe	sample
A hypothesis may be classified as -----------------.	Simple	Composite	null	all the above	all the above
Level of significance is the probability of--------------.	Type I error	Type II error	Not committing error	any of the above	any of the above
Degrees of freedom are related to -------------------.	No. of observations in a set	hypothesis under test	No. of independent observations in a	No. of dependent observations in a set	No. of independent observations in a set
A critical function provides the basis for ----------------.	Accepting H_0	rejecting H_0	no decision about H_0	all the above	all the above

Student's t-test is applicable in case of -------------------.	Small samples	for sample of size between 5 and 30	Large samples	none of the above	Small samples
Student's t-test is applicable only when ---------------------.	The variate values are independent	the variable is distributed normally	The sample is not large	all the above	all the above
If the calculated value is less than the table value then we accept the --------------- hypothesis.	Alternative	null	both	sample	null
Small sample test is also known as -------------------.	Exact test	t – test	normal test	F-test	t – test
The formula for χ^2 is -------------	$\sum(O–E)^2/E$	$\sum(E+O)^2/E$	$\sum(O-E)/E$	$\sum(O-E)^2/O$	$\sum(O–E)^2/E$
If a statistic 't' follows student's t distribution with n degrees of freedom then t^2 follows ------	χ^2distribution with (n-1) degrees of freedom	χ^2distribution with n degrees of freedom	χ^2distribution with n^2 degrees of	χ^2distribution with (n+1) degrees of	χ^2distribution with (n-1) degrees of freedom
The distribution used to test goodness of fit is------------	F distribution	χ^2distribution	t distribution	Z distribution	χ^2distribution
Degree of freedom for statistic chi-square incase of contingency table of order 2x2 is----------	3	4	2	1	1
Larger group from which the sample is drawn is called ------------.	Sample	sampling	universe	parameter	universe
Any hypothesis concerning a population is called a ----------------.	Sample	population	statistical measure	statistical hypothesis	statistical hypothesis
Rejecting Ho when it is true leads -----------.	Type I error	Type II error	correct decision	either (a) or (b)	Type I error

Accept Ho when it is true leads -----------.	Type I error	Type II error	correct decision	either (a) or (b)	correct decision
Type II error occurs only if ----------.	Reject Ho when it is true	Accept Ho when it is false	Accept Ho when it is true	reject Ho when it is false	Accept Ho when it is false
The correct decision is ---------------.	Reject Ho when it is true	Accept Ho when it is false	Reject Ho when it is false	none of these	Reject Ho when it is false
The maximum probability of committing type I error, which we specified in a test is known as -----------------.	Null hypothesis	alternative hypothesis	DOF	level of significance	level of significance
If the computed value is less than the critical value, then ---------------.	Null hypothesis is accepted	Null hypothesis is rejected	Alternative hypothesis is accepted	population	Null hypothesis is accepted
If the computed value is greater than the critical value, then ---------------.	Null hypothesis is accepted	Null hypothesis is rejected	Alternative hypothesis is accepted	small sample	Null hypothesis is rejected
In sampling distribution the standard error is ----------------.	np	pq	npq	sqrt(npq)	sqrt(npq)
If the sample size is greater than 30, then the sample is called --------------.	Large sample	small sample	population	Null hypothesis	Large sample
If the sample size is less than 30, then the sample is called --------------.	Large sample	small sample	population	alternative hypothesis	small sample
Z – test is applicable only when the sample size is -----------.	zero	one	small	large	large
The degrees of freedom for two samples in t – test is ---------.	$n_1 + n_2 + 1$	$n_1 + n_2 – 2$	$n_1 + n_2 + 2$	$n_1 + n_2 – 1$	$n_1 + n_2 – 2$

An assumption of t – test is population of the sample is -----------.	Binomial	Poisson	normal	exponential	normal
The degrees of freedom of chi – square test is ------------.	(r – 1)(c – 1)	(r + 1)(c + 1)	(r + 1)(c – 1)	(r – 1)(c + 1)	(r – 1)(c – 1)
In chi – square test, if the values of expected frequency are less than 5, then they are combined together with the neighbouring	Goodness of fit	DOF	LOS	pooling	pooling
The expected frequency of chi – square test can be calculated as ----------.	(RT + CT) / GT	(RT – CT) / GT	(RT * CT) / GT	(RT*CT)	(RT * CT) / GT
In F – test, the variance of population from which samples are drawn are ----------.	equal	not equal	small	large	equal
If the data is given in the form of a series of variables, then the DOF is ---------.	n	n-1	n+1	(r – 1)(c – 1)	n-1
The characteristic of the chi–square test is -------------.	DOF	LOS	ANOVA	independence of attributes	independence of attributes
If $S_1^2 > S_2^2$, then the F – statistic is -----------.	S_1 / S_2	S_2 / S_1	S_1^2 / S_2^2	S_1^3 / S_2^3	S_1^2 / S_2^2
The value of Z test at 5% level of significance is ------------.	3.96	2.96	1.96	0.96	1.96
In -------, the variance of population from which samples are drawn are equal	t-test	Chi-Square test	Z-test	F-test	F-test
F – statistics is ---------------------.	Variance between the samples / variance within the	Variance within the samples / variance between	Variance between the rows / variance between	Variance within the rows / variance within	Variance between the samples / variance within the

Analysis of variance utilizes:	t-test	Chi-Square test	Z-test	F-test	F-test
F – test whish is also known as ------	Chi-Square test	Z-test	varience ratio test	t-test	varience ratio test
The technique of analysis of variance refered to as ------	ANOVA	F – test	Z – test	Chi- square test	ANOVA
The two variations, variation within the samples and variations between the samples are tested for their significance by -------	Chi- square test	F – test	t-test	Z – test	F – test
Under ------- classification , the influence of only one attribute or factor is considered.	two way	three way	one way	many	one way
Under --------- classification , the influence of two attribute or factors is considered	two way	three way	one way	many	two way
Completely randomized design is similar to ----------	three way	one way	two way	t test	one way
Randomized block design is similar to ----------	two way	three way	one way	many	two way
ANOVA is the technique of analysis of ------	standard deviation	variance	mean	range	variance
Under one way classification , the influence of only ----- attribute or factor is considered	two	three	one	many	one
Under two way classification , the influence of only ----- attribute or factor is considered	four	two	three	one	two

KARPAGAM ACADEMY OF HIGHER EDUCATION

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Subject: Biostatistics and Research Methodology	**Subject Code: 16MBP304**	**L T P C**
Class : II – M.Sc. Microbiology	**Semester : III**	**4 0 0 4**

UNIT-IV

Research: Scope and significance – Types of Research – Research Process – Characteristics of good research – Problems in Research – Identifying research problems. Research Designs – Features of good designs.

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Introduction:

Research in common refers to a search for knowledge. We can define research as a scientific and systematic search for pertinent information on a specific topic. Research is thus an original contribution to the existing stock of knowledge making for its advancement. It is the persuit of truth with the help of study, observation, comparison and experiment.

Meaning of research:

Research is an academic activity and as such the term should be used in a technical sense. According to “Clifford Wooody” research comprises defining and redefining problem ,formulating hypothesis or suggested solutions; collecting, organizing and evaluating data, making deductions and reaching conclusion and atlast carefully testing the conclusion to determine whether they fit the formulating hypothesis.

OBJECTIVES OF RESEARCH

The purpose of research is to discover answers to questions through the application of scientific procedures. The main aim of research is to find out the truth which is hidden and which has not been discovered as yet. Though each research study has its own specific purpose, we may think of research objectives as falling into a number of following broad groupings:

1. To gain familiarity with a phenomenon or to achieve new insights into it (studies with this object in view are termed as exploratory or **formulative research** studies);

2. To portray accurately the characteristics of a particular individual, situation or a group (studies with this object in view are known as **descriptive research** studies);

3. To determine the frequency with which something occurs or with which it is associated with something else (studies with this object in view are known as **diagnostic research** studies);

4. To test a hypothesis of a causal relationship between variables (such studies are known as **hypothesis-testing research** studies).

Types of research:

i)Descriptive (Vs) Analytical:

Descriptive research includes surveys and fact-finding enquiries of different kinds. The major purpose of descriptive research is description of the state of affairs as it exist at present. The main characteristics of this method is that the researcher of this method is that the researcher has no control over the variables.

ii)Applied (Vs) Fundamental:

Research can either be applied (or action) research or fundamental (to basic or pure) research. Applied research aims at finding a solution for an immediate problem facing a society or an industrial, business organization, where as fundamental research is mainly concerned with generalization and with the formulation of a theory.

iii)Quantitative (Vs) Qualitative:

Quantitative research is based on the measurement of quantity or amount. It is applicable to phenomena that can be expressed in terms of quantity. Qualitative research, on the other hand is concerned with qualitative phenomenon. Qualitative research is specially important in the behavioural science where the aimto discover the underlying motives of human behaviour.

iv)Conceptual (Vs) Empirical :

Conceptual research is that related to some abstract idea(s) or theory. It is generally used by philosophers and thinkers to develop a new concepts to reinterpret existing one. Empirical research is appropriate when proof is sought that certain variables affect other variables in some way.

v) Some other types of research :

All other types of research are variations of one or more of the above stated approach, based on either the purpose of research, or the time required to accomplish research, on the environment in which research is done, or on the basis of some other similar factors.

Research Process:

Research process consist of series of actions or steps necessary to effectively carry out research and the desired sequencing of these steps.

- **Formulating the research problem.**
- **Extensive literature survey.**
- **Developig the hypothesis.**
- **Preparing the research design.**
- **Determining the sample design.**
- **Collecting the data.**
- **Execution of the project.**
- **Analysis of data.**
- **Hypothesis testing.**
- **Generalisation and interpretation.**
- **Preparation of the report and the presentation of the result.**

1. Formulating the research problem:

There are two types of research problems, viz., those which relate to states of nature and those which relate to relationships between variables. At the very outset the researcher must single out the problem he wants to study, i.e., he must decide the general area of interest or aspect of a subject-matter that he would like to inquire into. Initially the problem may be stated in a broad general way and then the ambiguities, if any, relating to the problem be resolved. Then, the feasibility of a particular solution has to be considered before a working formulation of the problem can be set up. The formulation of a general topic into a specific research problem, thus, constitutes the first step in a scientific enquiry. Essentially two steps are involved in formulating the research problem, viz., understanding the problem thoroughly, and rephrasing the same into meaningful terms from an analytical point of view.

The best way of understanding the problem is to discuss it with one's own colleagues or with those having some expertise in the matter. In an academic institution the researcher can seek the help from a guide who is usually an experienced man and has several research problems in mind. Often, the guide puts forth the problem in general terms and it is up to the researcher to narrow it down and phrase the problem in operational terms. In private business units or in governmental organisations, the problem is usually earmarked by the administrative agencies with whom the researcher can discuss as to how the problem originally came about and what considerations are involved in its possible solutions. The researcher must at the same time examine all available literature to get himself acquainted with the selected problem. He may review two types of literature—the conceptual literature concerning the concepts and theories, and the empirical literature consisting of studies made earlier which are similar to the one proposed. The basic outcome of this review will be the knowledge as to what data and other materials are available for operational purposes which will enable the researcher to specify his own research problem in a meaningful context. After this the researcher rephrases the problem into analytical or operational terms i.e., to put the problem in as specific terms as possible. This task of formulating, or defining, a research problem is a step of greatest importance in the entire research process. The problem to be investigated must be defined unambiguously for that will help discriminating relevant data from irrelevant ones. Care must, however, be taken to verify the objectivity and validity of the background facts concerning the problem. Professor W.A. Neiswanger correctly states that the statement of the objective is of basic importance because it determines the data which are to be collected, the characteristics of the data which are relevant, relations which are to be explored, the choice of techniques to be used in these explorations and the form of the final report. If there are certain pertinent terms, the same should be clearly defined along with the task of formulating the problem. In fact, formulation of the problem often follows a sequential pattern where a number of formulations are set up, each formulation more specific than the preceeding one, each one phrased in more analytical terms, and each more realistic in terms of the available data and resources.

2. Extensive literature survey:

Once the problem is formulated, a brief summary of it should be written down. It is compulsory for a research worker writing a thesis for a Ph.D. degree to write a synopsis of the topic and submit it to the necessary Committee or the Research Board for approval. At this juncture the researcher should undertake extensive literature survey connected with the problem. For this purpose, the abstracting and indexing journals and published or unpublished bibliographies are the first place to go to. Academic journals, conference proceedings, government reports, books etc., must be tapped depending on the nature of the problem. In this process, it should be remembered that one source will lead to another. The earlier studies, if any, which are similar to the study in hand should be carefully studied. A good library will be a great help to the researcher at this stage.

3. Development of working hypotheses:

After extensive literature survey, researcher should state in clear terms the working hypothesis or hypotheses. Working hypothesis is tentative assumption made in order to draw out and test its logical or empirical consequences. As such the manner in which research hypotheses are developed is particularly important since they provide the focal point for research. They also affect the manner in which tests must be conducted in the analysis of data and indirectly the quality of data which is required for the analysis. In most types of research, the development of working hypothesis plays an important role. Hypothesis should be very specific and limited to the piece of research in hand because it has to be tested. The role of the hypothesis is to guide the researcher by delimiting the area of research and to keep him on the right track. It sharpens his thinking and focuses attention on the more important facets of the problem. It also indicates the type of data required and the type of methods of data analysis to be used.

How does one go about developing working hypotheses? The answer is by using the following approach:

(a) Discussions with colleagues and experts about the problem, its origin and the objectives in seeking a solution;
(b) Examination of data and records, if available, concerning the problem for possible trends, peculiarities and other clues;
(c) Review of similar studies in the area or of the studies on similar problems; and
(d) Exploratory personal investigation which involves original field interviews on a limited scale with interested parties and individuals with a view to secure greater insight into the practical aspects of the problem.

Thus, working hypotheses arise as a result of a-priori thinking about the subject, examination of the available data and material including related studies and the counsel of experts and interested parties. Working hypotheses are more useful when stated in precise and clearly defined terms. It may as well be remembered that occasionally we may encounter a problem where we do not need working hypotheses, specially in the case of exploratory or formulative researches which do not aim at testing the hypothesis. But as a general rule, specification of working hypotheses in another basic step of the research process in most research problems.

4. Preparing the research design:

The research problem having been formulated in clear cut terms, the researcher will be required to prepare a research design, i.e., he will have to state the conceptual structure within which research would be conducted. The preparation of such a design facilitates research to be as efficient as possible yielding maximal information. In other words, the function of research design is to provide for the collection of relevant evidence with minimal expenditure of effort, time and money. But how all these can be achieved depends mainly on the research purpose. Research purposes may be grouped into four categories, viz., (i) Exploration, (ii) Description, (iii) Diagnosis, and (iv) Experimentation. A flexible research design which provides opportunity for considering many different aspects of a problem is considered appropriate if the purpose of the research study is that of exploration. But when the purpose happens to be an accurate description of a situation or of an association between variables, the suitable design will be one that minimises bias and maximises the reliability of the data collected and analysed.

There are several research designs, such as, experimental and non-experimental hypothesis testing. Experimental designs can be either informal designs (such as before-and-after without control, after-only with control, before-and-after with control) or formal designs (such as completely randomized design, randomized block design, Latin square design, simple and complex factorial designs), out of which the researcher must select one for his own project.
The preparation of the research design, appropriate for a particular research problem, involves usually the consideration of the following:

(i) the means of obtaining the information;
(ii) the availability and skills of the researcher and his staff (if any);
(iii) explanation of the way in which selected means of obtaining information will be organised and the reasoning leading to the selection;
(iv) the time available for research; and
(v) the cost factor relating to research, i.e., the finance available for the purpose.

5. Determining sample design:

All the items under consideration in any field of inquiry constitute a ‘universe’ or ‘population’. A complete enumeration of all the items in the ‘population’ is known as a census inquiry. It can be presumed that in such an inquiry when all the items are covered no element of chance is left and highest accuracy is obtained. But in practice this may not be true. Even the slightest element of bias in such an inquiry will get larger and larger as the number of observationsincreases. Moreover, there is no way of checking the element of bias or its extent except through aresurvey or use of sample checks. Besides, this type of inquiry involves a great deal of time, moneyand energy. Not only this, census inquiry is not possible in practice under many circumstances. Forinstance, blood testing is done only on sample basis. Hence, quite often we select only a few itemsfrom the universe for our study purposes. The items so selected constitute what is technically calleda sample.

The researcher must decide the way of selecting a sample or what is popularly known as thesample design. In other words, a sample design is a definite plan determined before any data areactually collected for obtaining a sample from a given population. Thus, the plan to select 12 of acity's 200 drugstores in a certain way constitutes a sample design. Samples can be either probabilitysamples or non-probability samples. With probability samples each element has a known probabilityof being included in the sample but the non-probability samples do not allow the researcher to determinethis probability. Probability samples are those based on simple random sampling, systematic sampling,stratified sampling, cluster/area sampling whereas non-probability samples are those based onconvenience sampling, judgement sampling and quota sampling techniques.

6. Collecting the data:

In dealing with any real life problem it is often found that data at hand areinadequate, and hence, it becomes necessary to collect data that are appropriate. There are severalways of collecting the appropriate data which differ considerably in context of money costs, time andother resources at the disposal of the researcher.Primary data can be collected either through experiment or through survey. If the researcherconducts an experiment, he observes some quantitative measurements, or the data, with the help ofwhich he examines the truth contained in his hypothesis.

7. Execution of the project:

Execution of the project is a very important step in the researchprocess. If the execution of the project proceeds on correct lines, the data to be collected would beadequate and dependable. The researcher should see that the project is executed in a systematicmanner and in time. If the survey is to be conducted by means of structured questionnaires, data canbe readily machine-processed. In such a situation, questions as well as the possible answers may becoded. If the data are to be collected through interviewers, arrangements should be made for properselection and training of the interviewers. The training may be given with the help of instructionmanuals which explain clearly the job of the interviewers at each step. Occasional field checksshould be made to ensure that the interviewers are doing their assigned job sincerely and efficiently.A careful watch should be kept for unanticipated factors in order to keep the survey as muchrealistic as possible. This, in other words, means that steps should be taken to ensure that the surveyis under statistical control so that the collected information is in accordance with the pre-definedstandard of accuracy. If some of the respondents do not cooperate, some suitable methods should bedesigned to tackle this problem. One method of dealing with the non-response problem is to make alist of the non-respondents and take a small sub-sample of them, and then with the help of expertsvigorous efforts can be made for securing response.

8. Analysis of data:

After the data have been collected, the researcher turns to the task of analyzing them. The analysis of data requires a number of closely related operations such as establishment ofcategories, the application of these categories to raw data through coding, tabulation and then drawingstatistical inferences. The unwieldy data should necessarily be condensed into a few manageablegroups and tables for further analysis. Thus, researcher should classify the raw data into somepurposeful and usable categories. Coding operation is usually done at this stage through which thecategories of data are transformed into symbols that may be tabulated and counted. Editing is theprocedure that improves the quality of the data for coding. With coding the stage is ready for tabulation.Tabulation is a part of the technical procedure wherein the classified data are put in the form oftables. The mechanical devices can be made use of at this juncture. A great deal of data, specially inlarge inquiries, is tabulated by computers. Computers not only save time but also make it possible tostudy large number of variables affecting a problem simultaneously.Analysis work after tabulation is generally based on the computation of various percentages,coefficients, etc., by applying various well defined statistical formulae.

In the process of analysis,relationships or differences supporting or conflicting with original or new hypotheses should be subjectedto tests of significance to determine with what validity data can be said to indicate any conclusion(s).For instance, if there are two samples of weekly wages, each sample being drawn from factories indifferent parts of the same city, giving two different mean values, then our problem may be whetherthe two mean values are significantly different or the difference is just a matter of chance. Throughthe use of statistical tests we can establish whether such a difference is a real one or is the result ofrandom fluctuations. If the difference happens to be real, the inference will be that the two samplescome from different universes and if the difference is due to chance, the conclusion would be thatthe two samples belong to the same universe. Similarly, the technique of analysis of variance canhelp us in analysing whether three or more varieties of seeds grown on certain fields yield significantlydifferent results or not. In brief, the researcher can analyse the collected data with the help ofvarious statistical measures.

9. Hypothesis-testing:

After analysing the data as stated above, the researcher is in a position totest the hypotheses, if any, he had formulated earlier. Do the facts support the hypotheses or theyhappen to be contrary? This is the usual question which should be answered while testing hypotheses.Various tests, such as Chi square test, t-test, F-test, have been developed by statisticians for the

purpose. The hypotheses may be tested through the use of one or more of such tests, depending uponthe nature and object of research inquiry. Hypothesis-testing will result in either accepting the hypothesisor in rejecting it. If the researcher had no hypotheses to start with, generalisations established on thebasis of data may be stated as hypotheses to be tested by subsequent researches in times to come.

10. Generalisations and interpretation:

If a hypothesis is tested and upheld several times, it maybe possible for the researcher to arrive at generalisation, i.e., to build a theory. As a matter of fact,the real value of research lies in its ability to arrive at certain generalisations. If the researcher had nohypothesis to start with, he might seek to explain his findings on the basis of some theory. It is knownas interpretation. The process of interpretation may quite often trigger off new questions which inturn may lead to further researches.

11. Preparation of the report or the thesis:

Finally, the researcher has to prepare the report ofwhat has been done by him. Writing of report must be done with great care keeping in view thefollowing:

1. The layout of the report should be as follows: (i) the preliminary pages; (ii) the main text,
and (iii) the end matter.

In its preliminary pages the report should carry title and date followed by acknowledgementsand foreword. Then there should be a table of contents followed by a list of tables and listof graphs and charts, if any, given in the report.

The main text of the report should have the following parts:
(a) Introduction: It should contain a clear statement of the objective of the research andan explanation of the methodology adopted in accomplishing the research. The scopeof the study along with various limitations should as well be stated in this part.
(b) Summary of findings: After introduction there would appear a statement of findingsand recommendations in non-technical language. If the findings are extensive, theyshould be summarised.
(c) Main report: The main body of the report should be presented in logical sequence andbroken-down into readily identifiable sections.
(d) Conclusion: Towards the end of the main text, researcher should again put down theresults of his research clearly and precisely. In fact, it is the final summing up.

At the end of the report, appendices should be enlisted in respect of all technical data. Bibliography,i.e., list of books, journals, reports, etc., consulted, should also be given in the end. Index should alsobe given specially in a published research report.

2. Report should be written in a concise and objective style in simple language avoiding vague expressions such as 'it seems,' 'there may be', and the like.

3. Charts and illustrations in the main report should be used only if they present the information more clearly and forcibly.
4. Calculated 'confidence limits' must be mentioned and the various constraints experienced in conducting research operations may as well be stated.

Criteria of good research :

1. The purpose of the research should be clearly defined and common concepts be used.

2. The research procedure used should be described in sufficient detail to permit another researcher to repeat the research for further advancement.

3. The procedural design of the research should be carefully planned to yield results.

4. The researcher should report with complete frankness.

5. The analysis of data should be sufficiently adequate to reveal its significance and the method of analysis used should be appropriate.

6. Greater confidence in research is warranted.

Qualities of good research :

- Good Research is systematic
- Good Research is logical
- Good Research is Empirical
- Good Research is Replicable

Problems Encountered by Researchers in India :

- The lack of a scientific training in the methodology of research**.**
- There is insufficient interaction between the university department.
- Most of the business units in our country do not have the confidence that the material supplied by them to the researcher will not be misused.
- Research studies overlapping one another are undertaken quite often for want of adequate information.
- There does not exist a code of conduct.
- Many researcher in our country also face the difficulty of adequate and timely secretarial assistance.
- There is also the difficulty of timely availability of published data.
- Library management and functioning is not satisfactory.
- There is also the difficulty of timely availability of published data from various government and other agencies.
- There may be at a time, take place the problem of conceptualization.

Research problem:

A research problem, in general refers to some difficulty which a researcher experiences in the context of either a theoretical or practical situation and wants to obtain a situation for the same. Usually we say that a research problem exist if one researcher find out the best solution for the research problem.

Selecting the problem:

- Subject which is overdone should not be normally chosen, for it will be a difficult task to throw any new light in such a case.
- Controversial subject should not become the choice of averager.

- Too narrow or two vague problem should be avoided.
- The subject selected for research should be familiar and feasible.
- The importance of the subject , the qualifications and the training of a researcher, the costs involved.
- The selection of a problem must be proceeded by a preliminary study.

Technique involved in defining a problem:

The techniques for the purpose involves the undertakimg of the following step one another:

i) Statement of the problem in a general way .

ii) Understanding the nature of the problem.

iii) Surveying the available literature.

iv) Developing the ideas through discussion.

v) Rephrasing the research problem.

Research Design:

A research design is the arrangement of condition for collection and analysis of data in a manner that aims to combine relevance to the research process with economy in procedure .In fact, the research design is the conceptual structure within which research is conducted; it constitutes the blue print for the collection, measurement and analysis of the data.

Different research design:

- Research design in case of exploratory research studies.
- Research design in case of descriptive and diagnostic research studies.
- Research design in case of hypothesis testing research studies.

Important Experimental Designs

Experimental design refers to the framework or structure of an experiment and as such there are several experimental designs. We can classify experimental designs into two broad categories, viz.,informal experimental designs and formal experimental designs. Informal experimental designs arethose designs that normally use a less sophisticated form of analysis based on differences in magnitudes,whereas formal experimental designs offer relatively more control and use precise statisticalprocedures for analysis.

Important experiment designs are as follows:
(a) Informal experimental designs:
(i) Before-and-after without control design.
(ii) After-only with control design.
(iii) Before-and-after with control design.
(b) Formal experimental designs:
(i) Completely randomized design (C.R. Design).
(ii) Randomized block design (R.B. Design).

We may briefly deal with each of the above stated informal as well as formal experimental designs.

1. Before-and-after without control design: In such a design a single test group or area isselected and the dependent variable is measured before the introduction of the treatment. The treatmentis then introduced and the dependent variable is measured again after the treatment has beenintroduced. The effect of the treatment would be equal to the level of the phenomenon after thetreatment minus the level of the phenomenon before the treatment.

2. After-only with control design: In this design two groups or areas (test area and control area)are selected and the treatment is introduced into the test area only. The dependent variable is then
measured in both the areas at the same time. Treatment impact is assessed by subtracting the value of the dependent variable in the control area from its value in the test area.

3. Before-and-after with control design: In this design two areas are selected and the dependent variable is measured in both the areas for an identical time-period before the treatment. The treatmentis then introduced into the test area only, and the dependent variable is measured in both for anidentical time-period after the introduction of the treatment. The treatment effect is determined bysubtracting the change in the dependent variable in the control area from the change in the dependentvariable in test area.

4. Completely randomized design (C.R. design): Involves only two principles viz., the principle of replication and the principle of randomization of experimental designs. It is the simplest possibledesign and its procedure of analysis is also easier. The essential characteristic of the design is thatsubjects are randomly assigned to experimental treatments (or vice-versa). For instance, if we have10 subjects and if we wish to test 5 under treatment A and 5 under treatment B, the randomizationprocess gives every possible group of 5 subjects selected from a set of 10 an equal opportunity ofbeing assigned to treatment A and treatment B. One-way analysis of variance (or one-way ANOVA)*is used to analyse such a design. Even unequal replications can also work in this design. It providesmaximum number of degrees of freedom to the error. Such a design is generally used whenexperimental areas happen to be homogeneous.

i) **Two-group simple randomized design:** In a two-group simple randomized design, firstof all the population is defined and then from the population a sample is selected randomly.Further, requirement of this design is that items, after being selected randomly from thepopulation, be randomly assigned to the experimental and control groups (Such randomassignment of items to two groups is technically described as principle of randomization).Thus, this design yields two groups as representatives of the population.

(ii) Random replications design: The limitation of the two-group randomized design is usuallyeliminated within the random replications design. In the illustration just cited above, theteacher differences on the dependent variable were ignored, i.e., the extraneous variablewas not controlled. But in a random replications design, the effect of such differences areminimised (or reduced) by providing a number of repetitions for each treatment. Eachrepetition is technically called a ‘replication’. Random replication design serves two purposesviz., it provides controls for the differential effects of the extraneous independent variablesand secondly, it randomizes any individual differences among those conducting the treatments.

5. Randomized block design (R.B. design) is an improvement over the C.R. design. In the R.B design the principle of local control can be applied along with the other two principles of experimentaldesigns. In the R.B. design, subjects are first divided into groups, known as blocks, such that withineach group the subjects are relatively homogeneous in respect to some selected variable. The variableselected for grouping the subjects is one that is believed to be related to the measures to be obtainedin respect of the dependent variable. The number of subjects in a given block would be equal to thenumber of treatments and one subject in each block would be randomly assigned to each treatment.In general, blocks are the levels at which we hold the extraneous factor fixed, so that its contributionto the total variability of data can be measured. The main feature of the R.B. design is that in thiseach treatment appears the same number of times in each block. The R.B. design is analysed by the two-way analysis of variance (two-way ANOVA)* technique.

Part B (5x6=30 Marks)

Possible Questions

1. Briefly describe the different steps involved in a research process..
2. What is the objective of doing a research?
3. Write the important concept relating research design
4. Explain about identifying the research problems.
5. What are the problems occurring in doing a research?
6. Explain the data processing and analysis.
7. Write about the types of research.

Part C (1x10=10 Marks)

Possible Questions

1. Explain the research process in detail.
2. Explain the meaning and significance of a research design.
3. What are the features of a good design?
4. What are the techniques involved in defining a problem?

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Class : II - M.Sc. Microbiology **Semester : III**

Unit IV

Research

Part A (20x1=20 Marks)
(Question Nos. 1 to 20 Online Examinations)

Possible Questions

Question	Choice 1	Choice 2	Choice 3	Choice 4	Answer
Number of source of data is	2	3	4	1	2
Number of methods of collection of primary data is	2	3	4	5	5
Number of questions in a questionnaire should be	5	10	maximum	minimum	minimum
Sources of secondary data are	Published sources	Unpublished sources	Both Publishedand Unpublished sources	secondary	Both Publishedand Unpublished
Compared with primary data, secondary data are	More reliable	less reliable	equally reliable	Published sources	less reliable
A ------- source is one that itself collects the data.	Primary	secondary	published	Unpublished	secondary

The data which is compiled from the records of others is called-----data	Primary	secondary	published	Unpublished	published
Which one is considered a major component of the research study	Interpretation	research report	finding	draft	research report
Research task remains incomplete till the ___________ has been presented.	Report	objective	finding	objective and finding	Report
What is the last step in a research study	Writing report	writing finding	writing limitations	research report	Writing report
Which is the final step in report writing………..	Writing report	writing finding	writing drafts	writing limitations	writing drafts
What is usually appended to the research work	Editing	bibliography	coding	research report	bibliography
The ___________ is one which gives emphasis on simplicity and attractiveness	popular report	research report	article report	writing limitations	popular report
Which should be avoided in a research report	Abstract terminology	technical jargon	both (a) and (b)	Writing report	both (a) and (b)
___________ should slow originality and should necessarily be on attempt to solve some intellectual problem	Interpretation	research report	finding	draft	research report
The researcher must remain caution about the ________ that can possibly arise in the process of interpreting results	Analysis	conclusions	findings	error	error
Which one should be considered while interpreting a given data	Validity	reliability	both (a) and (b)	technical jargon	reliability

_________ is asking questions face to face	Indirect method	mailed questionnaire	through post	personal interview	personal interview
Journals, books, magazines etc are useful sources of collecting----------	Primary data	secondary data	both (a) and (b)	objective	secondary data
The collected raw data to detect errors and are called,	Editing	coding	classification	all the above	Editing
Questionnaire should contain --------------	Simple	straight forward	easy understanding	all the above	all the above
The formal, systematic and intensive process of carrying on a scientific method of analysis is _______________	Research Design	research	interpretation	research analysis	research
------ Refers to the process of assigning numerals or symbols to answers of response	Coding	editing	classification	all the above	Coding
The research study, which is based on describing the characteristic of a particular individual or group	Experience survey	Descriptive	Diagnostic	Exploratory	Descriptive
Research is a_____________	Finding	assumption	statement	all the above	all the above
The research, which has the purpose of improving a product or a process testing theoretical concepts in actual problem situations is-------research.	Statistical	Applied	Domestic	Biological	Applied
The chart of research process indicates that the process consists of a number of ---.	Closely related activities	unrelated activities	Closely unrelated activities	moderately related activities	Closely related activities
The objective of a good design is --------------.	Maximize the bias andmaximize the reliability of	Minimize the bias and minimize the reliability of	Minimize the bias and maximize the reliability of	Maximize the bias and maximize the reliability of	Maximize the bias and maximize the reliability of

A ---------- is used whenever a full written report of the study is required.	Popular report	Technical report	article	monograph	Technical report
The ----------- is one which gives emphasis on simplicity and attractiveness.	Popular report	Technical report	article	monograph	Popular report
Which of the following are measurements of scale?	Nominal	ordinal	interval	all the above	all the above
____Scale is a system of assigning numbers, symbols to events in order to label them.	Interval	ordinal	Nominal	ratio	Nominal
The qualitative phenomena are considered in the -------------- scale.	Ordinal	Nominal	interval	ratio	Ordinal
---------- Scales can have an arbitrary zero, but it is not possible to determine the absolute zero.	Ordinal	Nominal	interval	ratio	interval
--------- Scales have an absolute or true zero of measurement	Ordinal	Nominal	interval	ratio	ratio
The section of ---------- constitutes the main body of the report where in the results of the study are presented in clear.	Appendix	results	methods	Ordinal	results
Study to portray accurately characteristics of a particular individual, situation or a group is called ------------ research	Exploratory	Diagnostic	Descriptive	Hypothesis testing	Descriptive
Critical evaluation made by the researcher with the facts and information already available is called ----------- research.	Analytical	Exploratory	Diagnostic	Hypothesis testing	Analytical
Research to find reason, why people think or do certain things is an example of -----------	Quantitative Research	Applied Research	Qualitative research	Fundamental research	Qualitative research

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Class : II – M.Sc. Microbiology Semester : III 4 0 0 4

UNIT-V

Sampling Design: Meaning – Concepts – Steps in sampling – Criteria for good sample design. Scaling measurements – Techniques – Types of scale.

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Introduction:

The researcher should select a representative of the total population as possible in order to produce a miniature cross-section.The selected respondents constitute what is technically called a sample and the selection process is called sampling techniques.The survey so conducted is called a sample survey.

Sample design:

A sample design is a definite plan for obtaining a sample from a given population.It refers to the technique or the procedure the researcher would adopt in selecting items from the sample.Sample design is determined before the data collected.

STEPS IN SAMPLE DESIGN

While developing a sampling design, the researcher must pay attention to the following points:

(i) **Type of universe:** The first step in developing any sample design is to clearly define the set of objects, technically called the Universe, to be studied. The universe can be finite or infinite. In finite universe the number of items is certain, but in case of an infinite universe the number of items is infinite, i.e., we cannot have any idea about the total number of items. The population of a city, the number of workers in a factory and the like are examples of finite universes, whereas the number of stars in the sky, listeners of a specific radio programme, throwing of a dice etc. are examples of infinite universes.

(ii) **Sampling unit:** A decision has to be taken concerning a sampling unit before selecting sample. Sampling unit may be a geographical one such as state, district, village, etc., or a construction unit such as house, flat, etc., or it may be a social unit such as family, club, school, etc., or it may be an individual. The researcher will have to decide one or more of such units that he has to select for his study.

(iii) **Source list:** It is also known as 'sampling frame' from which sample is to be drawn. It contains the names of all items of a universe (in case of finite universe only). If source list is not available, researcher has to prepare it. Such a list should be comprehensive, correct, reliable and appropriate. It is extremely important for the source list to be as representative of the population as possible.

(iv) **Size of sample:** This refers to the number of items to be selected from the universe to constitute a sample. This a major problem before a researcher. The size of sample should neither be excessively large, nor too small. It should be optimum. An optimum sample is one which fulfills the requirements of efficiency, representativeness, reliability and flexibility. While deciding the size of sample, researcher must determine the desired precision as also an acceptable confidence level for the estimate. The size of population variance needs to be considered as in case of larger variance usually a bigger sample is needed. The size of population must be kept in view for this also limits the sample size. The parameters of interest in a research study must be kept in view, while deciding the size of the sample. Costs too dictate the size of sample that we can draw. As such, budgetary constraint must invariably be taken into consideration when we decide the sample size.

(v) **Parameters of interest:** In determining the sample design, one must consider the question of the specific population parameters which are of interest. For instance, we may be interested in estimating the proportion of persons with some characteristic in the population, or we may be interested in knowing some average or the other measure concerning the population. There may also be important sub-groups in the population about whom we would like to make estimates. All this has a strong impact upon the sample design we would accept.

(vi) **Budgetary constraint:** Cost considerations, from practical point of view, have a major impact upon decisions relating to not only the size of the sample but also to the type of sample. This fact can even lead to the use of a non-probability sample.

(vii) **Sampling procedure:** Finally, the researcher must decide the type of sample he will use i.e., he must decide about the technique to be used in selecting the items for the sample. In fact, this technique or procedure stands for the sample design itself. There are several sample designs (explained in the pages that follow) out of which the researcher must choose one for his study. Obviously, he must select that design which, for a given sample size and for a given cost, has a smaller sampling error.

Criteria of Selecting A Sampling Procedure:

- Inappropriate Sampling Frame
- Defective Measuring Device
- Non-respondents
- Indeterminacy Principle
- Natural basis in the Reporting of Data.

CharacteresticsOf a Good Sample Design:

- Sample Design must result in truly representative sample.
- Sample design must be such which results in a small sampling error.
- Sample Design must be viable in the context of funds available for the research study.
- Sample design must be such so that systematic bias can be controlled in a better way.
- Sample should be such that the results of the sample study can be applied.

Complex Random Sampling Designs:

i) Systematic Sampling:

The most practical way of sampling is to select every ith item on a list.Sampling of this type is known as systematic sampling.Systematic sampling has a certain plus point.It can be taken as an improvement over asimple random sample in as much as the systematic sample is spread more evenly over the entire populations.it is an Easier and less costlier method of sampling and can be conveniently used in even in case of large population.But there are certain dangers too in using this type of sampling.

ii) Stratified sampling:

If a population from which a sample is to be drawn does not constitute a homogenous group, stratified sampling is generally applied in order to obatin a representative sample.Under stratified sampling the population isdivided into several sub-populations that are individually more homogeneous than the population and then we select item from each stratum to constitute a sample.

iii) Cluster Sampling:

A sample can be taken into a number of smaller non-overlapping areas andthen to randomly select a number of these smaller areas with the ultimate sample consisting of all units in these small areas or clusters.Thus in cluter sampling the total population is divide into the number of relatively small subdivisions which arethem clusters of still smaller units and then some of these clusters are randomly selected for inclusion in the overall sample.

iv) Area Sampling:

If cluster happen to be some geographic subdivisions, in that case cluster sampling is better known as area sampling.In other words, cluster designs, where the primary sampling unit represents acluster of units based on geographic area, are distinguished as area sampling.

v) Multi-Stage Sampling:

Multi-stage sampling is a further development of the principle of clutersampling.Ordinarily multi-stage sampling is applied in big inquiries extending to a considerable large geographical area.

vi) Sampling with probability proportion to size :

In case the cluster sampling units do not have the same number or approximately of elements, it is considered appropriate to use a random selection process wherethe probability of each cluster being included in the sample is proportional to the size of the clusters.

vii) Sequential Sampling:

This sampling design is some what complex sample design . The ultimate size of the sample under this technique is not fixed in advance, but is determined according to mathematical decision rules on the basis of information yielded as survey progresses. This is usually adopted in case of statistical quality control.

TECHNIQUE OF DEVELOPING MEASUREMENT TOOLS

The technique of developing measurement tools involves a four-stage process, consisting of the following:
(a) Concept development;
(b) Specification of concept dimensions;
(c) Selection of indicators; and
(d) Formation of index.

The first and foremost step is that of concept development which means that the researchershould arrive at an understanding of the major concepts pertaining to his study. This step of conceptdevelopment is more apparent in theoretical studies than in the more pragmatic research, where thefundamental concepts are often already established.

The second step requires the researcher to specify the dimensions of the concepts that hedeveloped in the first stage. This task may either be accomplished by deduction i.e., by adopting amore or less intuitive approach or by empirical correlation of the individual dimensions with the totalconcept and/or the other concepts. For instance, one may think of several dimensions such as productreputation, customer treatment, corporate leadership, concern for individuals, sense of socialresponsibility and so forth when one is thinking about the image of a certain company.

Once the dimensions of a concept have been specified, the researcher must develop indicatorsfor measuring each concept element. Indicators are specific questions, scales, or other devices bywhich respondent’s knowledge, opinion, expectation, etc., are measured. As there is seldom a perfectmeasure of a concept, the researcher should consider several alternatives for the purpose. The useof more than one indicator gives stability to the scores and it also improves their validity.

The last step is that of combining the various indicators into an index, i.e., formation of anindex. When we have several dimensions of a concept or different measurements of a dimension,
we may need to combine them into a single index. One simple way for getting an overall index is toprovide scale values to the responses and then sum up the corresponding scores. Such an overallindex would provide a better measurement tool than a single indicator because of the fact that an“individual indicator has only a probability relation to what we really want to know.This way wemust obtain an overall index for the various concepts concerning the research study.

Scaling

In research we quite often face measurement problem (since we want a valid measurement but maynot obtain it), specially when the concepts to be measured are complex and abstract and we do notpossess the standardised measurement tools. Alternatively, we can say that while measuring attitudesand opinions, we face the problem of their valid measurement. Similar problem may be faced by aresearcher, of course in a lesser degree, while measuring physical or institutional concepts. As suchwe should study some procedures which may enable us to measure abstract concepts more accurately.This brings us to the study of scaling techniques.

Meaning of Scaling

Scaling describes the procedures of assigning numbers to various degrees of opinion, attitude andother concepts. This can be done in two ways viz., (i) making a judgement about some characteristicof an individual and then placing him directly on a scale that has been defined in terms of thatcharacteristic and (ii) constructing questionnaires in such a way that the score of individual's responsesassigns him a place on a scale. It may be stated here that a scale is a continuum, consisting of thehighest point (in terms of some characteristic e.g., preference, favourableness, etc.) and the lowestpoint along with several intermediate points between these two extreme points. These scale-pointpositions are so related to each other that when the first point happens to be the highest point, thesecond point indicates a higher degree in terms of a given characteristic as compared to the thirdpoint and the third point indicates a higher degree as compared to the fourth and so on. Numbers formeasuring the distinctions of degree in the attitudes/opinions are, thus, assigned to individualscorresponding to their scale-positions. All this is better understood when we talk about scalingtechnique(s). Hence the term 'scaling' is applied to the procedures for attempting to determinequantitative measures of subjective abstract concepts. Scaling has been defined as a "procedure forthe assignment of numbers (or other symbols) to a property of objects in order to impart some of thecharacteristics of numbers to the properties in question.

Scale Classification Bases

The number assigning procedures or the scaling procedures may be broadly classified on one or more of the following bases: (a) subject orientation; (b) response form; (c) degree of subjectivity; (d) scale properties; (e) number of dimensions and (f) scale construction techniques. We take up each of these separately.

(a) Subject orientation: Under it a scale may be designed to measure characteristics of the respondentwho completes it or to judge the stimulus object which is presented to the respondent. In respect ofthe former, we presume that the stimuli presented are sufficiently homogeneous so that the betweenstimulivariation is small as compared to the variation among respondents. In the latter approach, weask the respondent to judge some specific object in terms of one or more dimensions and we presumethat the between-respondent variation will be small as compared to the variation among the differentstimuli presented to respondents for judging.

(b) Response form: Under this we may classify the scales as categorical and comparative.Categorical scales are also known as rating scales. These scales are used when a respondent scoressome object without direct reference to other objects. Under comparative scales, which are alsoknown as ranking scales, the respondent is asked to compare two or more objects. In this sense therespondent may state that one object is superior to the other or that three models of pen rank in order1, 2 and 3. The essence of ranking is, in fact, a relative comparison of a certain property of two ormore objects.

(c) Degree of subjectivity: With this basis the scale data may be based on whether we measuresubjective personal preferences or simply make non-preference judgements. In the former case, therespondent is asked to choose which person he favours or which solution he would like to see

employed, whereas in the latter case he is simply asked to judge which person is more effective insome aspect or which solution will take fewer resources without reflecting any personal preference.

(d) Scale properties: Considering scale properties, one may classify the scales as nominal, ordinal,interval and ratio scales. Nominal scales merely classify without indicating order, distance or uniqueorigin. Ordinal scales indicate magnitude relationships of 'more than' or 'less than', but indicate nodistance or unique origin. Interval scales have both order and distance values, but no unique origin.Ratio scales possess all these features.

(e) Number of dimensions: In respect of this basis, scales can be classified as 'unidimensional' and 'multidimensional' scales. Under the former we measure only one attribute of the respondent orobject, whereas multidimensional scaling recognizes that an object might be described better by usingthe concept of an attribute space of 'n' dimensions, rather than a single-dimension continuum

.

(f) Scale construction techniques: Following are the five main techniques by which scales canbe developed.

(i) Arbitrary approach: It is an approach where scale is developed on ad hoc basis. This isthemost widely used approach. It is presumed that such scales measure the concepts forwhich they have been designed, although there is little evidence to support such an assumption.

(ii) Consensus approach: Here a panel of judges evaluate the items chosen for inclusion inthe instrument in terms of whether they are relevant to the topic area and unambiguous inimplication.

(iii) Item analysis approach: Under it a number of individual items are developed into a testwhich is given to a group of respondents. After administering the test, the total scores arecalculated for every one. Individual items are then analysed to determine which itemsdiscriminate between persons or objects with high total scores and those with low scores.

(iv) Cumulative scales are chosen on the basis of their conforming to some ranking of itemswith ascending and descending discriminating power. For instance, in such a scale theendorsement of an item representing an extreme position should also result in theendorsement of all items indicating a less extreme position.

(v) Factor scales may be constructed on the basis of intercorrelations of items which indicatethat a common factor accounts for the relationship between items. This relationship istypically measured through factor analysis method.

Important Scaling Techniques

We now take up some of the important scaling techniques often used in the context of researchspecially in context of social or business research.

Rating scales: The rating scale involves qualitative description of a limited number of aspects of athing or of traits of a person. When we use rating scales (or categorical scales), we judge an objectin absolute terms against some specified criteria i.e., we judge properties of objects without referenceto other similar objects.

These ratings may be in such forms as “like-dislike”, “above average, average,below average”, or other classifications with more categories such as “like very much—like somewhat—neutral—dislike somewhat—dislike very much”; “excellent—good—average—belowaverage—poor”, “always—often—occasionally—rarely—never”, and so on. There is no specificrule whether to use a two-points scale, three-points scale or scale with still more points. In practice,three to seven points scales are generally used for the simple reason that more points on a scaleprovide an opportunity for greater sensitivity of measurement.Rating scale may be either a graphic rating scale or an itemized rating scale.

(i) The graphic rating scale is quite simple and is commonly used in practice. Under it thevarious points are usually put along the line to form a continuum and the rater indicates hisrating by simply making a mark (such as ü) at the appropriate point on a line that runs fromone extreme to the other. Scale-points with brief descriptions may be indicated along theline, their function being to assist the rater in performing his job. The following is an exampleof five-points graphic rating scale when we wish to ascertain people’s liking or disliking anyproduct:position along the line which fact may increase the difficulty of analysis. The meanings ofthe terms like “very much” and “some what” may depend upon respondent’s frame ofreference so much so that the statement might be challenged in terms of its equivalency.Several other rating scale variants (e.g., boxes replacing line) may also be used.

(ii) The itemized rating scale (also known as numerical scale) presents a series of statementsfrom which a respondent selects one as best reflecting his evaluation. These statementsare ordered progressively in terms of more or less of some property. An example of itemizedscale can be given to illustrate it.Suppose we wish to inquire as to how well does a worker get along with his fellow workers? Insuch a situation we may ask the respondent to select one, to express his opinion, from the following:

- He is almost always involved in some friction with a fellow worker.
- He is often at odds with one or more of his fellow workers.
- He sometimes gets involved in friction.
- He infrequently becomes involved in friction with others.
- He almost never gets involved in friction with fellow workers.

The chief merit of this type of scale is that it provides more information and meaning to the rater,and thereby increases reliability. This form is relatively difficult to develop and the statements maynot say exactly what the respondent would like to express.Rating scales have certain good points. The results obtained from their use compare favourablywith alternative methods. They require less time, are interesting to use and have a wide range ofapplications. Besides, they may also be used with a large number of properties or variables. But theirvalue for measurement purposes depends upon the assumption that the respondents can and domake good judgements. If the respondents are not very careful while rating, errors may occur. Threetypes of errors are common viz., the error of leniency, the error of central tendency and the error ofhallo effect. The error of leniency occurs when certain respondents are either easy raters or hardraters. When raters are reluctant to give extreme judgements, the result is the error of centraltendency. The error of hallo effect or the systematic bias occurs when the rater carries over ageneralised impression of the subject from one rating to another. This sort of error takes place whenwe conclude for example, that a particular report is good because we like its form or that someone isintelligent because he agrees with us or has a pleasing personality. In other words, hallo effect is
likely to appear when the rater is asked to rate many factors, on a number of which he has noevidence for judgement.

Measurement and scaling:

Measurement is a process of mapping aspects of a domain onto the other aspects of a range according to some rule of correspondence.Inmeasuring, we devise some form of the scale in the range and then transfer or map the properties of object from the domain on to this scale.

Measurement Scale:
The most widely used classification of measurement scales are

a)Nominal Scale:

Nominal scale is simply a system of assigning number symbols to events in order to label them.The usual example of this is the assignment of numbers of basket ball players in order to identify them such numbers cannot be considered to be associated with an ordered scale for their order is of no consequence.The numbers are just convenient labels for the particular class of events and as such have no quantitative value.Nominal scales provide convenient ways of keeping track of people, object and events. Nominal scale is the least powerful scale of measurement.

b)Ordinal scale:

The lowest level of the ordered scale that is commonly used is the ordinal scale. The ordinal scales places event in order, but there is no attempt to make the intervals of the scale equal in terms of some rule.

c) Interval scale:

In the case of interval scale, the scales are adjusted in terms of some rule that has been established as a bazsis for making the units equal.The units are equal only in so far as one accepts the assumption on which the rule is based. Interval scales can have an arbitrary zero, but is not possible to determine for them what may be called an absolute zero or the unique origin.

d) Ratio scale:

Ratio scales have an absolute true zero of measurement.The absolute zero is not as precise as it was once believed to be ratio scazles represents the actual amounts of variables.

Sources of error in measurement:

Measurement should be precise and unambiguous in an ideal research study.The type of error in measurements are

i) Respondent:

At times the respondent may be reluctant to express strong or negative feelings or it is just possible that he may have very little knowledge but may not admit his ignorance.

ii) Situation:

Situational factors may also care in the way of correct measurement.Any condition which places a strain or interview can have serious effects on the interview-respondent rapport.

iii) Measurer:

The interviewer can distort responses by rewording or reordering questions.Hisbehaviour, style and looks may encourage or discourage certain replies from respondents.

iv) Instrument:

Error may arise because of the defective measuring instrument.

Test of Sound Measurement:

i) **Test of validity:**

Validity is the most critical criterion and indicates the degree to which an instrument measure what it is suppose to measure. Validity can also be thought as utility.

ii) Test of Reliability:

The test of reliability is another important tests of sound measurement. A measuring instrument is reliable if it provides consistent results.

iii) Test of practicality:

The practicality characterestics of a measuring instrument can be judged in terms of economy, convenience and interpretability.

Meaning of scaling:

Scaling describes the procedures of assigning numbers to various degree of opinion, attitude and other concepts.This can be done in two ways

i) Making a judgement about some characteristics of an individual and then placing him directly on a scale that has been defined in terms of that characteristics.

ii) Constructing Questionnaires in such a way that the score of individuals responses assigns him a place on a scale.

Scale classification Bases:

- **Subject orientation**
- **Response form**
- **Degree of subjectivity**
- **Scale properties**
- **Number of Dimension**
- **Scale Construction Techniques**

Important Scaling techniques:

- **Rating scales**
- **Method of paired comparison**
- **Method of rank order.**

Part B (5x6=30 Marks)

Possible Questions

1. Explain the criteria of good research.
2. Explain about the types of scaling and rating.
3. Describe the criteria for good sample design.
4. Write about the measurements in research.
5. Explain the scale construction technique.
6. What are the different types of sample designs?
7. Explain the tests of sound measurement.

Part C (1x10=10 Marks)

Possible Questions

1. What are the features of good research design?
2. Explain the steps in sampling.
3. Explain sources of errors in measurement.
4. Explain about scaling techniques.

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Unit V

Sampling Design

Part A (20x1=20 Marks)
(Question Nos. 1 to 20 Online Examinations)

Possible Questions

Question	Choice 1	Choice 2	Choice 3	Choice 4	Answer
A complete enumeration of all items in the population is known as ____________	sampling unit	sample design	census inquiry	all the above	census inquiry
The selected respondents constitute_____________	population	sample	sample size	population size	sample
The selection process of respondents is called____________	survey	sampling technique	sample survey	census inquiry	sampling technique
The survey conducted to select the respondents is called_____________	sampling technique	sample survey	census inquiry	population size	sample survey
A sample design is a definite plan for obtaining a sample from a given____________	universe	sample design	population	sample survey	population
The number of items in universe can be________________	finite	infinite	both	zero	both

The population of a city, number of workers in a company is_______________	infinite	finite	both	zero	finite
Source list is also known as___________	sampling size	sampling size	sampling frame	population size	sampling frame
The size of the sample should be _____________	large	optimum	small	all the above	optimum
Inappropriateness in sampling frame will result in _______________________	systematic bias	optimum	problems	sampling error	systematic bias
Sampling error ____________ with increase in size of sample	decrease	increase	both	optimum	decrease
Sampling error can be measured from_______________	sample design	sample size	population	sample design and sample size	sample design and sample size
On the representation basis samples may be_____________________	probability sampling	non-probability sampling	both	restricted	both
On element selection basis the samples may be_______________	restricted	unrestricted	both	probability sampling	both
Non-probability sampling is also known as____________________	quota sampling	purposive sampling	deliberate sampling	all the three	all the three
Quota sampling is an example of_____________________	probability sampling	non-probability sampling	both	purposive sampling	non-probability sampling
Probability sampling is also known as_____________________	random sampling	choice sampling	random and choice sampling	multistage sampling	random and choice sampling

Lottery method of selecting data is an example of_________________	random sampling	choice sampling	purposive sampling	quota sampling	random sampling
Systematic sampling is an improved version of______________________	quota sampling	simple random sampling	choice sampling	purposive sampling	simple random sampling
If population is not drawn from homogeneous group_________________ technique is applied	simple random sampling	quota sampling	choice sampling	stratified sampling	stratified sampling
In______________________ total population is divided into number of relatively small sub divisions	cluster sampling	choice sampling	stratified sampling	quota sampling	cluster sampling
When a particular lot is to be accepted or rejected on the basis of single sampling it is known as_____________________	double sampling	single sampling	area sampling	purposive sampling	single sampling
Survey designed to determine attitude of students toward new teaching plan is known as____________________________-	cross stratification sampling	stratification sampling	cluster sampling	multi stage sampling	cross stratification sampling
Sample design is determined_______________ datas are collected	before	after	both	based on the survey	before
Indeterminary principle step comes in_________________	step in sample design	criteria to select sample procedure	both	step doesnot occur	criteria to select sample procedure
The measurement of sampling error is called as_____________________	precision of sampling plan	sampling survey	sampling plan	representation basis	precision of sampling plan
The different sub populations divided to constitute a sample is known as__________________	stratified sampling	survey	population	strata	strata
Every nth item is selected in____________________	stratified sampling	systematic sampling	judgement sampling	all the above	systematic sampling

________________is conducted for determining a more appropriate and efficient stratification plan	survey	sample	pilot study	sample plan	pilot study
_____________________is considered more appropriate when universe happens to be small	purposive sampling	area sampling	cluster sampling	simple random sampling	purposive sampling
When we use rating scales we judge an object in ________terms against some specified criteria.	real	absolute	imaginary	perfect	absolute
Rating scale is also known as______________	Categorical scale	arbitrary scale	cumulative scales	all the above	Categorical scale
The graphical scale is ________and is commonly used in practice.	Problematic	critical	simple	real	simple
_______________is also known as numerical scale	Itemized rating scale	graphical rating scale	cumulative scale	likert scale	Itemized rating scale
The chief merit of itemized rating scale is it provides__________ information	more	deep	critical	all the above	more
_______________occurs when the respondents are either easy raters or hard raters	error of hallo effect	error of leniency	error of central tendency	cumulative scales	error of leniency
______________ occurs when the rater carries a generalized impression of the subject from one rating to another.	error of hallo effect	error of leniency	error of central tendency	graphical rating scale	error of hallo effect
When the raters are reluctant to give extreme judgments, the result is___________	error of hallo effect	error of leniency	error of central tendency	cluster sampling	error of central tendency
Systematic bias is also known as__________________	Error of hallo effect	error of leniency	error of central tendency	cumulative scales	Error of hallo effect

_____________occurs when the rater is asked to rate more factors, which has no evidence for judgment.	error of hallo effect	error of leniency	error of central tendency	cluster sampling	error of hallo effect
_______________ is also known as ranking scale	rating scale	comparative scale	likert scale	graphical rating scale	comparative scale
We make relative judgments against similar objects in _______________	comparative scale	likert scale	differential scale	rating scale	comparative scale
Paired comparisions provide_______________ data.	nominal	ordinal	ratios	interval	ordinal
Ordinal data can be converted to ____________ data through Law of comparative judgment.	nominal	ordinal	ratio	interval	interval
Law of comparative judgment is developed by_______________	J.P.Guilford	Likert	L.L.Thurstone	all the three	L.L.Thurstone
Psychometric Methods book is written by________________	J.P.Guilford	Likert	L.L.Thurstone	Louis Guttman	J.P.Guilford
Respondents are asked to rank their choices in________________	Comparative scaling	arbitrary scaling	rating scale	differential scale	Comparative scaling
_________ is developed on ad-hoc basis	Differential scale	arbitrary scale	rating scale	ranking scale	arbitrary scale
_______________scale is developed by utilizing item analysis approach	Comparative scale	likert scale	differential scale	rating scale	likert scale
Scalogram analysis is developed by______________	J.P.Guilford	Likert	L.L.Thurstone	Louis Guttman	Louis Guttman

Reg No ……………….

(16MBP304)

KARPAGAM ACADEMY OF HIGHER EDUCATION
Karpagam University
Coimbatorev - 641021
DEPARTMENT OF MATHEMATICS
Third Semester
I Internal – July'2017
Biostatistics and Research Methodology

Date : .07.2017( ) **Time: 2 Hours**
Class: II M.Sc Microbiology **Maximum: 50 Marks**

PART – A (20 x 1 = 20 Marks)

Answer all the questions

1. Statistics can be considered as ----------------
a) an art b) a science
c) **both an art and science** d) neither an art nor a science

2. Mid value = ------
a) lower boundary/2
b) upper boundary/2
c) **(lower boundary+ upper boundary)/2**
d) (lower boundary+ upper boundary)

3. Range of the given values is given by ----------------
a) **L- S** b) L+S c) S+L d) LS

4. Which one of the following refers the term Correlation?
a) relationship between two values
b) **relationship between two variables**
c) average relationship between two variables
d) relationship between two things

5. The regression line cut each other at the point of ----------------
a) average of X only b) average of Y only
c) **average of X and Y** d) the median of X on Y

6. If b_{xy} = 0.4, b_{yx} = 0.9 then r = -----------------
a) **0.6** b) 0.3 c) 0.1 d) -0.6

7. If the correlation coefficient between two variables X and Y is ---------, the Regression coefficient of Y on X is negative
a) **negative** b) positive c) not certain d) zero

8. Arithmetic mean of the series 3, 4, 5, 6, 7 is ………
a) 5.5 b) 6 c) **5** d) 6.5

9. Standard deviation is also called as
a) **root mean square deviation** b) mean square deviation
c) Root deviation d) root median square deviation

10. Data originally collected for an investigation is known as---------------
a) tabulation b) **primary data** c) secondary data d) published data

11. If r is either +1 or –1, then there will be only one -------- line in case of two variables.
a) correlation b) **regression** c) rank correlation d) mean

12. Rank correlation was discovered by -------------------
a) R.A.Fisher b) Sir Francis Galton c) Karl Pearson d) **Spearman**

13. Cubes are-----------------------
a) dimensional diagram b) one dimensional diagram
c) **three dimensional diagram** d) multi dimensional diagram

14. The range of the rank correlation coefficient is -----------------
a) 0 to 1 b) **–1 to 1** c) 0 to ∞ d) – ∞ to ∞

15. If r = 0, then the relationship between the given two variables is
a) perfectly positive b) perfectly negative
c) **no correlation** d) both positive and negative

16. The relationship between two variables by plotting the values on a chart, known as------------
a) coefficient of correlation b) **scatter diagram**
c) correlogram d) rank correlation

17. Formula for Rank correlation is --------------------
a) **1- ($6\Sigma d^2$ /(n(n2-1)))** b) 1- ($6\Sigma d^2$ /(n(n2+1)))
c) 1+ ($6\Sigma d^2$ /(n(n2+1))) d) 1 /(n(n2-1))

18. Mode is the value which -------------------------------
a) is a mid point b) **occur the most** c) average of all d) Most remote Likely

19. If S.D = 6, then find variance.
a) 6 b) **36** c) 42 d) 12

20. The ------------- is independent of origin and scale.

a) **correlation coefficient** b) regression coefficients

c) coefficient of range d) coefficient of variation

PART – B (3 x 2 = 6 Marks)

Answer all the questions

21. Name the parts of the table.

22. Define mean deviation.

23. What are the methods used for studying correlation?

PART – C (3 x 8 = 24 Marks)

Answer all the questions

24. a) Explain about the Classification of data.

(OR)

b) Calculation the mode from the following:

Size	10	11	12	13	14	15	16	17	18
Frequency	10	12	15	19	20	8	4	3	2

25. a) Calculate the standard deviation for the following data:

X :	0-10	10-20	20-30	30-40	40-50
f :	2	5	9	3	1

(OR)

b) Find Karl Pearsons coefficient of correlation from the following data:

Wages	:100	101	102	102	100	99	97	98	96	95
Cost of living:	98	99	99	97	95	92	95	94	90	91

26. a) From the data given below find the two regression lines.

X:	10	12	13	12	16	15
Y:	40	38	43	45	37	43.

i) Estimate Y when X = 20.

ii) Estimate X when Y = 25.

(OR)

b) Write the steps in testing the hypothesis.

Reg No ……………

(16MBP304)

KARPAGAM UNIVERSITY
Karpagam Academy of Higher Education
Coimbatore-21
DEPARTMENT OF MICROBIOLOGY
Third Semester
II Internal Test – September'2017
Biostatistics and Research Methodology

Date: .09.2017( ) **Time: 2 Hours**
Class: II M.Sc Microbiology **Maximum: 50 Marks**

PART – A (20 x 1 = 20 Marks)

Answer all the questions

1. Small sample test is also known as ___________
a) exact test b) t-test c) normal test d) F-test

2. Under ________ classification, the influence of two attribute or factors is considered.
a) two way b) three way c)one way d) many way

3. The term Statistic refers to the statistical measures relating to ----.
a) Population b) hypothesis c) sample d) universe

4. If the computed value is less than the critical value, then -----------
a) Null hypothesis is accepted
b) Null hypothesis is rejected
c) Alternative hypothesis is accepted
d) Alternative hypothesis is rejected

5. ANOVA is the technique of analysis of ------
a) standard deviation b) variance c)mean d) range

6. The section of ---------- constitutes the main body of the report where in the results of the study are presented in clear.
a) Appendix b) results c) methods d) error

7. Critical evaluation made by the researcher with the facts and information already available is called ---------- research.
a)analytical b)Exploratory c) Diagnostic d) Hypothesis testing

8. Questionnaire should contain --------------
a) Simple b) straight forward
c) easy understanding d) all the above

9. Scalogram analysis is developed by------------------
a) J.P.Guilford b) Likert c) L.L.Thurstone d) Louis Guttman

10. Systematic sampling is an improved version of----------------------
a) quota sampling b) simple random sampling
c) choice sampling d) purposive sampling

11. The survey conducted to select the respondents is called-----------
a) sampling technique b) sample survey
c) census inquiry d) population size

12. The different sub populations divided to constitute a sample is known as------------------------
a) stratified sampling b) survey c) population d)strata

13. The --------- scales have an absolute or true zero of measurement
a) Ordinal b) Nominal c) interval d) ratio

14. Research to find reason, why people think or do certain things is an example of -----------
a) Quantitative Research b) Applied Research
c) Qualitative research d) Fundamental research

15. Source list is also known as-----------------------
a) sampling size b) sampling size
c) sampling frame d) population size

16.The researcher must remain caution about the --------------- that can possibly arise in the process of interpreting results

a) analysis b) conclusions c) findings d) error

17. A ---------- is used whenever a full written report of the study is required.

a) Popular report b) Technical report c) article d) monograph

18. Sampling error ------------------with increase in size of sample

a) decrease b) increase c) both d) constant

19. In------------------total population is divided into number of relatively small sub divisions

a) cluster sampling b)choice sampling

c) stratified sampling d) quota sampling

20. The research study, which is based on describing the characteristic of a particular individual or group------------------

a) Experience survey b) descriptive c)diagnostic d)exploratory

PART-B (3 x 2 = 6 Marks)

Answer All the Questions:

21. Define critical region.

22. Write about Stratified sampling.

23. What are the characteristics of a good sample design?

PART-C (3 x 8 = 24 Marks)

Answer All the Questions:

24. a) Two types of batteries are tested for their length of life and the following data are obtained.

	Type I	Type II
Sample size	9	8
Mean	600 hrs	640 hrs
Variance	121	144

Use the 5% level of significance to test whether the mean values differ significantly?(Table value is $t_{0.025, 15} = 2.131$).

(OR)

b) 300 digits were chosen at random from a set of table, the frequency of the digits was as follows.

Digits:	0	1	2	3	4	5	6	7	8	9
Frequency:	28	29	33	31	26	35	32	30	31	25

Using χ^2 test assess the hypothesis that the digits were distributed uniformly in the table. (Table value is $\chi^2_{0.05, 9} = 16.9190$).

25. a) Explain the types of research.

(OR)

b) Write the important concept relating research design.

26. a) Describe the criteria for good sample design.

(OR)

b) Explain errors in measurement.

Reg. No..................................

[15MBP304]

KARPAGAM UNIVERSITY

Karpagam Academy of Higher Education
(Established Under Section 3 of UGC Act 1956)
COIMBATORE – 641 021
(For the candidates admitted from 2015 onwards)

M.Sc., DEGREE EXAMINATION, NOVEMBER 2016

Third Semester

MICROBIOLOGY

BIOSTATISTICS AND RESEARCH METHODOLOGY

Time: 3 hours Maximum : 60 marks

PART – A (20 x 1 = 20 Marks) (30 Minutes)
(Question Nos. 1 to 20 Online Examinations)

(Part - B & C 2 ½ Hours)

PART B (5 x 6 = 30 Marks)
Answer ALL the Questions

21. a. Explain about the Classification of data

Or

b. Calculate the median for the following data.

Class Interval	0 - 2	2 - 4	4 - 6	6 - 8	8 - 10	10 - 12	12 - 14	14 - 16
Frequency	45	50	45	70	30	25	20	18

22. a. The heights of Fathers (X) and those of their Sons(Y) are given below. Calculate Spearman's rank correlation coefficient .

X	180	155	170	174	160	172	166	172	172
Y	170	165	180	180	164	169	170	170	174

Or

b. You are given the following data:

	X	Y
Arithmetic mean	20	20
Standard deviation	5	25

Correlation coefficient between X and Y = 0.66
Find the two regression equations.

23. a. Random samples are drawn from 2 populations and their results were obtained.

Sample X	16	17	18	19	20	21	22	24	26	27		
Sample Y	19	22	23	25	26	28	29	30	31	32	35	36

Find variance and test whether the 2 samples have same variance. (Table value is $F_{0.05, 9, 11} = 3.105$).

Or

b. Write the procedure of classification of two – way ANOVA

24. a. What are the problems occurring in doing a research?

Or

b. Write the important concept relating research design

25. a. What are the features of good research design?

Or

b. Explain the steps in sampling.

PART C (1 x 10 = 10 Marks)
(Compulsory)

26. Find the Karl Pearson's coefficient of correlation from the marks secured by 10 students in Accountancy and statistics.

Marks in Accountancy (X)	45	70	65	30	90	40	50	75	85	60
Marks in Statistics (Y)	35	90	70	40	95	40	60	80	80	50
