# Practical Manual

# Statistical Methods & Experimental Design

**FBS 148 3(2+1)**

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**Syllabus FBS 148 3(2+1):** Formation of frequency distribution, Diagrammatic and graphic representation. Calculation of different measures of central tendency. Computation of various measures of dispersion. Calculation of coefficient of variation – coefficients of Skewness and kurtosis. Computation of product moment correlation coefficient – rank correlation coefficient – and coefficient of concordance. Fitting of linear regression models for prediction. Simple problems on probability – fitting of binomial distribution. Fitting of Poisson distribution, problems on normal distribution. Selection of simple random sample – estimation of parameters – sample size determination. Selection of stratified random sample – equal, proportional and Neyman's allocation in stratified sampling. Large sample tests. Small sample tests, t and F tests, Chi –square test, test of goodness of fit – test of independence of attributes in a contingency table – computation of mean – square contingency. Analysis of variance – construction of ANOVA table of one-way classified data. Analysis of variance – construction of ANOVA table of two-way classified data. Layout and analysis of CRD, Layout and analysis of RBD. Analysis of data from $2^n$ factorial experiments in RBD. Formation of Yate's table – calculation of main effects and interaction effects. Layout and analysis of split-plot design.

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## CONTENTS

# Practical No. 1

## Objective: To construct frequency table and draw Histogram, Polygon, Frequency Curve, Ogive, bar diagram and pie chart.

**Problem**: The height of 45 sugarcane plants are following 85, 86, 89, 76, 76, 75, 111, 123, 56, 68, 67, 69, 91, 93, 99, 122, 112, 144, 123, 142, 151, 165, 88, 86, 92, 89, 90, 190, 145, 167, 173, 113, 118, 115, 119, 123, 126, 127, 88, 78, 93, 88, 98, 78, 67. Construct a frequency table and draw histogram, polygon, frequency curve, and ogive of the given data.

**Solution:**

Step-I: calculate the range= maximum value –minimum value. =...........................................

Step-II: number of classes = approximate value of k = 1+3.322 $\log_{10}N$ =...............................

.......................................................................................................................................

Step-III: Divide the by number of classes and get width of class interval = $\frac{\text{range}}{\text{number of classes}}$

Step-IV: **Construct a table**

| Class Interval | Tally Marks | Frequency |
|---|---|---|
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**Problem:** The cropping pattern in U.P. in the year 2012-13 was as follows. Draw simple bar diagram for this data is given below.

| Crops | Area In 1,000 hectares |
|---|---|
| Cereals | 6950 |
| Oilseeds | 3165 |
| Pulses | 1660 |
| Others | 2250 |

**Problem:** Draw a multiple bar diagram for the following data which represented agricultural production for the period from 2015-2019

| Year | Food grains (tones) | Vegetable(tones) | others (tones) |
|---|---|---|---|
| 2015 | 120 | 45 | 15 |
| 2016 | 125 | 50 | 25 |
| 2017 | 135 | 60 | 30 |
| 2018 | 140 | 65 | 35 |
| 2019 | 160 | 70 | 40 |

**Problem:** Draw a Component bar diagram for the following data:

| Year | Sales (Rs.) | Gross Profit (Rs.) | Net Profit (Rs.) |
|---|---|---|---|
| 2015 | 110 | 40 | 20 |
| 2016 | 125 | 55 | 25 |
| 2017 | 130 | 60 | 30 |
| 2018 | 145 | 65 | 35 |
| 2019 | 160 | 70 | 40 |

**Problem:** Draw a Component bar diagram and Percentage bar diagram for the following data:

| Year | Sales (Rs.) | Gross Profit (Rs.) | Net Profit (Rs.) |
|---|---|---|---|
| 2015 | 110 | 40 | 20 |
| 2016 | 125 | 55 | 25 |
| 2017 | 130 | 60 | 30 |
| 2018 | 145 | 65 | 35 |
| 2019 | 160 | 70 | 40 |

$$\text{Percentage} = \frac{Actual\ value}{Total\ of\ the\ actual\ value} \times 100$$

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**Problem:** Given the cultivable land area in five Bundelkhand region districts of UP. Construct a pie diagram for the following data.

| Districts | Cultivable area (in hectares) |
|---|---|
| Jhansi | 425 |
| Lalitpur | 300 |
| Banda | 350 |
| Hamirpur | 250 |
| Jalaun | 500 |

$$\text{Angle} = \frac{Actual\ value}{Total\ of\ the\ actual\ value} \times 360^0$$

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**Practical No. 2**

## Objective: To Calculate different measures of central tendency

**Problem:** The following data is related to crop yield in quintals of last 7 years of a farmer. Calculate the arithmetic mean of crop yield per plot in kg?

45, 54, 56, 42, 52, 39, 52, 48, 61, 55, 64

**Solution:** Step –I: count number of observations, n =....................................................................

Step-II: to calculate the total of all of observation = $\sum_{i=1}^{n} x_i$ =.....................................................

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Step-III: Finally, we calculate the arithmetic mean of the following formula,

$\overline{x} = \frac{\sum_{i=1}^{n} x_i}{n}$ = ...........................................................................................................................

**Problem:** The following data is related to marks of 50 students of midterm exam. To find the Arithmetic Mean of the given data.

| Income in Lakh ($x_i$): | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 |
|---|---|---|---|---|---|---|---|---|
| No. of farmer ($f_i$): | 4 | 6 | 10 | 10 | 9 | 8 | 2 | 1 |

**Solution:** Step-I to construct the following table:

| Variable ($x_i$) | frequency($f_i$) | $f_i \times x_i$ |
|---|---|---|
| | | |
| | | |
| | | |
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| | | |
| | | |
| | | |
| | | |
| **Total** | $\sum_{i=1}^{n} f_i$= | $\sum_{i=1}^{n} f_i x_i$= |

Step-II: To calculate the arithmetic mean, $\overline{x} = \frac{\sum_{i=1}^{n} f_i x_i}{N}$ =

**Problem:** The following data is related to milk production in liter of 220 farmers of a village. Calculate average milk production of the given village?

| Milk in liter($x_i$) | 0 - 4 | 4 - 8 | 8 - 12 | 12-16 | 16 - 20 |
|---|---|---|---|---|---|
| No. of farmer ($f_i$): | 20 | 90 | 60 | 40 | 10 |

**Solution:** Step-I: to construct the following table:

| **Class Interval** ($x_i - x_{i+1}$) | **frequency($f_i$)** | **Mid Value of Class Interval** $m_i = \frac{x_i + x_{i+1}}{2}$ | $f_i \times m_i$ |
|---|---|---|---|
| | | | |

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|---|---|---|---|
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| | | | |
| | | | |
| **Total** | N=$\sum_{i=1}^{n} f_i$= | | $\sum_{i=1}^{n} \boldsymbol{f_i} m_i$**=** |

Step-II: To calculate the arithmetic of the following formula, $\overline{x}$ = $\frac{\sum_{i=1}^{n} f_i x_i}{N}$=.................................

**Median**

**Problem:** The following data is related to plant height in cm. To find the median height of the plants?
9, 11, 12, 14, 18, 15, 21, 22, 24, 25, 3, 5

**Solution:**

Step-I: arrange the data in ascending order.....................................................................................

Step –II: count number of observations, n =........................................................................................

Step –III: Since n is odd number so we find median by the following formula:

Median = $(\frac{n+1}{2})^{th}$ $item$ =.....................................................................................................

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**Problem:** The following data is related to marks of 14 students getting from 30 marks Mid-term examination. To find the median marks of the students?
28, 19, 20, 22, 12, 14, 18, 15, 21, 22, 24, 25, 20, 28

**Solution:** Step-I: arrange the data in ascending.......................................................................................

Step –II: count number of observations, n =...........................................................................................

Step –III: Since n is even number so we find median by the following formula:

Median = $\frac{(\frac{n}{2})^{th}\ item + (\frac{n}{2}+1)^{th}\ item}{2}$ =...........................................................................................

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**Problem:** The following data is related to yearly income of 60 farmers of a village which are selected randomly. To find the median income of farmers of the given village?

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Income in Lakh ($x_i$): | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| No. of farmer ($f_i$): | 1 | 3 | 16 | 12 | 18 | 7 | 3 |

**Solution:** Step-I: To construct the following table

| Variable ($x_i$) | frequency($f_i$) | cumulative frequency |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| **Total** | N=$\sum_{i=1}^{n} f_i$= | |

Step-II: To calculate $\frac{N}{2}$=.........................................................................................................

Step-III: To see the value just greater than $\frac{N}{2}$ in cumulative frequency column =.....................

Step-IV: In first column, see the value of x correspond to the value getting in step-III,

Median =.........................................................................................................................

**Problem:** The following data is related to height of tree in feet of 250 trees of a forest. To calculate median height of tree of the given forest?

| Height of tree ($x_i$) | 35-40 | 40-45 | 45-50 | 50-55 | 55-60 |
|---|---|---|---|---|---|
| No. of tree ($f_i$): | 30 | 70 | 90 | 40 | 20 |

**Solution:** Step-I to construct the following table:

| Class Interval | Frequency ($f_i$) | cumulative frequency |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |
| **Total** | N=$\sum_{i=1}^{n} f_i$= | |

Step-II: To calculate $\frac{N}{2}$=.........................

Step-III: To see the value just greater than $\frac{N}{2}$ in cumulative frequency column =....................

Step-IV: corresponding class of step-III is called middle class

Step-V: Median, $M_d$ = L + [h ($\frac{\frac{N}{2}-C}{f}$)] Where L is lower limit of middle class, h is magnitude value of class interval, f is frequency of middle class and C is cumulative frequency of preceding middle class.

Median, $M_d$=...........................................................................................................................

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**Mode**

**Problem:** Suppose that 18 student's shoes size number are following:

6, 7, 8, 7, 6, 7, 10, 7, 8, 9, 9, 7, 7, 7, 8, 7, 7, 7

Find average (mode) size of shoes?

**Solution:** Mode =.........................................................................................................................

**Problem:** Following table gives the category of 250 trees in a forest.

| Tree's Name | A | B | C | D | E |
|---|---|---|---|---|---|
| No. of trees | 12 | 150 | 50 | 20 | 18 |

Find the measure of central tendency (mode) category of trees.

**Solution:** Mode =.........................................................................................................................

**Problem:** The following data is related to milk production in liter of 225 farmers of a village which are selected randomly. To calculate average (mode) milk production of the given village?

| Milk in liter($x_i$) | 0 - 4 | 4 - 8 | 8 - 12 | 12-16 | 16 - 20 | 20-24 | 24-28 |
|---|---|---|---|---|---|---|---|
| No. of farmer ($f_i$): | 30 | 90 | 60 | 12 | 8 | 4 | 1 |

**Solution:** Step-I: See the maximum frequency. Correspond class to maximum frequency is called model class.,$f_1$=.............

Step-II: Mode = L + $[\frac{h(f_1-f_0)}{2f_1-f_0-f_2}]$ where $f_1$ is frequency of model class, $f_0$ is frequency of preceding model class, $f_2$ is frequency of succeeding model class, L is lower limit of model class and h is magnitude value of class interval.

Mode

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**Geometric Mean**

**Problem:** The following data are related to dog population in a city every fifth year.

| No. of fifth year | First | Second | Third | Fourth | Fifth | Six |
|---|---|---|---|---|---|---|
| Population | 4 | 7 | 15 | 28 | 50 | 82 |

Find the geometric mean population of dog?

**Solution:** Step-I

| $x_i$ | log $x_i$ |
|---|---|
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| | |
| | $\sum_{i=1}^{n} log x_i$= |

Step-II: Geometric mean, G= Antilog [$\frac{\sum_{i=1}^{n} log x_i}{n}$] =.............................................................................................

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**Problem:** Find the Geometric mean of the given data:

| $x_i$ | 2 | 4 | 8 | 16 | 32 | 64 |
|---|---|---|---|---|---|---|
| $f_i$ | 4 | 5 | 7 | 6 | 3 | 2 |

**Solution:** Step-I:

| $x_i$ | $f_i$ | log $x_i$ | $f_i$ log $x_i$ |
|---|---|---|---|
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| | | | |
| | N=$\sum_{i=1}^{n} f_i$= | | $\sum_{i=1}^{n} f_i log x_i$= |

Step-II:

Geometric mean, G= Antilog [$\frac{\sum_{i=1}^{n} f_i log x_i}{N}$] =.............................................................................................

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**Problem:** Find the Geometric mean of the given data:

| $x_i$ | 0 - 4 | 4 – 8 | 8 - 12 | 12-16 | 16 - 20 | 20-24 | 24-28 |
|---|---|---|---|---|---|---|---|
| $f_i$ | 3 | 5 | 12 | 15 | 11 | 8 | 2 |

**Solution:**

Step-I: To construct table:

| Class Interval ($x_i$ – $x_{i+1}$) | frequency ($f_i$) | Mid-Value $m_i$=$\frac{x_i+x_{i+1}}{2}$ | log $m_i$ | $f_i$ log $m_i$ |
|---|---|---|---|---|

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| | $N=\sum_{i=1}^{n} f_i=$ | | | $\sum_{i=1}^{n} f_i log m_i=$ |

Step-II: Geometric mean, G= Antilog $[\frac{\sum_{i=1}^{n} f_i log m_i}{N}]$ =...................................................................

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**Harmonic Mean:**

**Problem:** Find Harmonic mean of the given data

1/3, 1/4, 1/5, 1/6, 1/7, 1/8, 1/9

**Solution:** Step-I:

| $x_i$ | $\frac{1}{x_i}$ |
|---|---|
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| | |
| | $\sum_{i=1}^{n} \frac{1}{x_i}=$ |

Step-II: Harmonic mean, H = $\frac{n}{\sum_{i=1}^{n} \frac{1}{x_i}}$ =.......................................................................................................

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**Problem:** A person went from City-A to City-B by different transport mode which speed and cover distance are given below:

| transport mode | by foot | Taxi | train | Airplane | taxi |
|---|---|---|---|---|---|
| Speeds in km/h($x_i$) | 5 | 30 | 60 | 700 | 40 |
| distances in km ($f_i$) | 2 | 15 | 430 | 1100 | 50 |

Find the average speed (Harmonic Mean) of the complete journey.

**Solution:** Step-I:

| $x_i$ | $f_i$ | $\frac{1}{x_i}$ | $\frac{f_i}{x_i}$ |
|---|---|---|---|
| | | | |
| | | | |
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| | | | |
| | | | |
| | N=$\sum_{i=1}^{n} f_i$= | | $\sum_{i=1}^{n} \frac{f_i}{x_i}$= |

Step-II: Harmonic mean, H =$\frac{\sum_{i=1}^{n} \frac{f_i}{x_i}}{N}$ =......................................................................................................

.......................................................................................................................................................

**Problem:** Find the Harmonic mean of the given data:

| $x_i$ | 10-20 | 20-30 | 30-40 | 40-50 | 50-60 | 60-70 | 70-80 |
|---|---|---|---|---|---|---|---|
| $f_i$ | 3 | 3 | 4 | 8 | 11 | 4 | 5 |

**Solution:**

Step-I:

| Class Interval ($x_i - x_{i+1}$) | frequency ($f_i$) | Mid-Value $m_i$=$\frac{x_i+x_{i+1}}{2}$ | $\frac{1}{m_i}$ | $\frac{f_i}{m_i}$ |
|---|---|---|---|---|
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| | | | | |
| | N=$\sum_{i=1}^{n} f_i$= | | | $\sum_{i=1}^{n} \frac{f_i}{x_i}$ = |

Step-II: Harmonic mean, H =$\frac{\sum_{i=1}^{n} \frac{f_i}{m_i}}{N}$ =....................................................................................................

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**Practical No. 3**

## Objective: To calculate measure of dispersion and coefficient of dispersion.

**Range:**

**Problem:** Find the range and its coefficient of the given data set:

4, 8, 12, 11, 34, 22, 5, 10, 35, 28, 35, 39

**Solution:**

Range, R = L – S =..........................................................................................................................

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

**Problem:** Find the range and its coefficient of the given data set:

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| x | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 |
| f | 4 | 8 | 12 | 10 | 21 | 17 | 19 | 7 | 3 |

**Solution:**

Range, R = L – S =..........................................................................................................................

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

**Problem:** Find the range and its coefficient of the given data set:

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| x | 5-10 | 10-15 | 15-20 | 20-25 | 25-30 | 30-35 | 35-40 | 40-45 | 45-50 |
| f | 2 | 5 | 6 | 9 | 13 | 14 | 6 | 4 | 2 |

**Solution:**

Range, R = L – S =..........................................................................................................................

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

**Problem**: Find the Quartile Deviation of the given data:

4, 8, 12, 11, 34, 22, 5, 10, 35, 28, 30, 35, 26, 27

Also find coefficient of quartile deviation.

**Solution: Step-I**: Arrange the data in ascending order....................................................................

**Step-II**: Calculate the value of $\frac{n+1}{4}$ =..........................................................................................

**Step-III**: Lower Quartile ($Q_1$) = $(\frac{n+1}{4})^{th}$ item =.............................................................................

**Step-IV**: To calculate the value of $\frac{3(n+1)}{4}$ =...........................................................................

**Step-V**: Upper Quartile ($Q_3$) = $(\frac{3(n+1)}{4})^{th}$ item =......................................................................

Now, Quartile Deviation, Q = $\frac{Q_3-Q_1}{2}$ =........................................................................................

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

**Problem**: The following data is related to yearly income of 70 farmers of a village which are selected randomly. Measure the deviation in farmer's incomes using quartile deviation.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Income in Lakh ($x_i$): | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| No. of farmer ($f_i$): | 1 | 3 | 6 | 12 | 18 | 11 | 7 | 6 | 4 | 2 |

**Solution:** Step-I Construct the following table:

| **Variable ($x_i$)** | **Frequency ($f_i$)** | **cumulative frequency** |
|---|---|---|
| | | |
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| | | |
| | | |
| | | |
| | | |
| | | |
| **Total** | N=$\sum_{i=1}^{n} f_i$= | |

Step-II: To calculate $\frac{N}{4}$ =...................................................................................................

Step-III: To see the value just greater than $\frac{N}{4}$ in cumulative frequency column.............................

Step-IV: In first column, see the value of x correspond to getting value in step-III that value is called $Q_1$.
........................................................................................................................

Step-V: To calculate $\frac{3N}{4}$ =.................................................................................................

Step-VI: To see the value just greater than $\frac{3N}{4}$ in cumulative frequency column.........................

Step-VII: In first column, see the value of x correspond to getting value in step-VI that value is called Upper Quartile ($Q_3$)........................................................................................................

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

**Problem**: Find the Quartile Deviation of the following frequency distribution:

| x | 5-10 | 10-15 | 15-20 | 20-25 | 25-30 | 30-35 | 35-40 | 40-45 | 45-50 |
|---|---|---|---|---|---|---|---|---|---|
| f | 2 | 5 | 6 | 9 | 13 | 14 | 6 | 4 | 2 |

**Solution:** Step-I: To construct the following table:

| **Class Interval** | **frequency(fi)** | **cumulative frequency** |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| **Total** | N=$\sum_{i=1}^{n} f_i$= | |

Step-II: To calculate $\frac{N}{4}$ =.......................................................................................................................

Step-III: To see the value just greater than $\frac{N}{4}$ in cumulative frequency column =..............................

Step-IV: In first column, see the value of x correspond to getting value in step-III that class is called lower quartile class..............................................................................................................................

Step-V: Lower Quartile ($Q_1$) = L + [h ($\frac{\frac{N}{4} - C}{f}$)] =..........................................................................................

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Step-VI: To calculate $\frac{3N}{4}$ =.......................................................................................................................

Step-VII: To see the value just greater than $\frac{3N}{4}$ in cumulative frequency column...............................

Step-VIII: In first column, see the value of x correspond to getting value in step-VII that class is called upper quartile class..............................................................................................................................

Step-IX: Upper Quartile ($Q_3$) = L + [h ($\frac{\frac{3N}{4} - C}{f}$)] =..........................................................................................

..........................................................................................................................................................

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

**Mean Deviation:**

**Problem:** The height of 10 mango trees are given below. Find the mean deviation about mean.

22.0, 22.5, 22.9, 23.0, 23.2, 23.1, 23.4, 23.0, 24.1, 23.6 in meter.

**Solution: Step-I**: To calculate Average A = Mean = $\frac{\sum_{i=1}^{n} \text{xi}}{n}$ =........................................................

**Step-II**: Construct a table:

| $x_i$ | $\lvert x_i - A \rvert$ |
|---|---|
| | |
| | |
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| | |
| | |
| | |
| | |
| | |
| $\sum_{i=1}^{n}$ xi = | $\sum_{i=1}^{n} \lvert \text{xi} - A \rvert$ = |

**Step-III**: Mean Deviation, $\eta$ = $\frac{\sum_{i=1}^{n} \lvert x_i - A \rvert}{n}$ =...........................................................................

Coefficient of Mean Deviation = $\frac{\eta}{A}$ =..........................................................................................

**Problem:** The following data is related to yield of wheat of 60 plots in quintal. To find the mean deviation about median and coefficient of mean deviation in yield.

| yield | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|
| frequency | 2 | 5 | 6 | 20 | 10 | 10 | 5 | 2 |

**Solution: Step-I**: To calculate Average A, Median
Step-I(a): To construct the following table

| Variable ($x_i$) | Frequency ($f_i$) | cumulative frequency |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| **Total** | N=$\sum_{i=1}^{n} f_i$= | |

:

Step-I(b): To calculate $\frac{N}{2}$=...........................................................................................................

Step-I(c): To see the value just greater than $\frac{N}{2}$ in cumulative frequency column =.....................

Step-I(d): In first column, see the value of x correspond to the value getting in step-III,

Median =........................................................................................................................

**Step-II**: Construct table

| | Frequency ($f_i$) | $\lvert x_i - A \rvert$ | $f_i \lvert x_i - A \rvert$ |
|---|---|---|---|
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| | | | |
| | $N = \sum_{i=1}^{n} f_i$= | | $\sum_{i=1}^{n} f_i \lvert x_i - A \rvert$= |

**Step-III**: Mean Deviation, $\eta = \frac{\sum_{i=1}^{n} f_i \lvert x_i - A \rvert}{N}$ =..............................................................................

**Problem:** The following data is related to height of 200 plants in cm. To calculate mean deviation about mode in height of the plants.

| Height of tree ($x_i$) | 30-32 | 32-34 | 34-36 | 36-38 | 38-40 |
|---|---|---|---|---|---|
| No. of tree ($f_i$): | 3 | 70 | 90 | 35 | 2 |

**Solution: Step-I**: To calculate Average A (Mode)

Mode = L + $[\frac{h(f_1 - f_0)}{2f_1 - f_0 - f_2}]$ =..............................................................................................................

**Step-II**: Construct table

| Class Interval | frequency($f_i$) | Mid value ($m_i$) | $\lvert m_i - A \rvert$ | $f_i \lvert m_i - A \rvert$ |
|---|---|---|---|---|
| | | | | |
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| | | | | |
| | $N = \sum_{i=1}^{n} f_i$= | | | $\sum_{i=1}^{n} f_i \lvert m_i - A \rvert$= |

**Step-III**: Mean Deviation, $\eta = \frac{\sum_{i=1}^{n} f_i \lvert m_i - A \rvert}{N}$ =..............................................................................

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**Problem:** The yield of wheat of 10 plots are given below. Find the standard deviation and Coefficient of Variance (CV) in yield data.
22.0, 22.5, 22.9, 23.0, 23.2, 23.1, 23.4, 23.0, 24.1, 23.6 in quintal.

**Solution:**

**Step-I**: To calculate Arithmetic Mean, $\overline{x} = \frac{\sum_{i=1}^{n} x_i}{n}$ =..........................................................................

**Step-II**: Construct a table:

| $x_i$ | $x_i - \overline{x}$ | $(xi - \overline{x})^2$ |
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| | | |
| $\sum_{i=1}^{n} x_i$= | | $\sum_{i=1}^{n}(xi - \overline{x})^2$= |

**Step-III**: Standard Deviation, $\sigma = \sqrt{\frac{\sum_{i=1}^{n}(xi-\overline{x})^2}{n}}$=........................................................................

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**Step-IV**: Coefficient of Variance (CV) = $\frac{\sigma}{\overline{x}} \times 100$ =...................................................................

**Problem:** The following data is related to income of farmer. Compute the standard deviation and CV of the data.

| Income ('00000') Rs. | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|
| No. of Farmers | 2 | 5 | 16 | 20 | 10 | 10 | 5 | 2 |

**Solution: Step-I**: To calculate Arithmetic Mean, $\overline{x}= \frac{\sum_{i=1}^{n} f_i x_i}{N}$

=.........................................................................

**Step-II**: Construct a table:

| $x_i$ | $f_i$ | $f_i x_i$ | $x_i - \overline{x}$ | $(xi - \overline{x})^2$ | $f_i(xi - \overline{x})^2$ |
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| | | | | | |
| | | $\sum_{i=1}^{n} f_i x_i$= | | | $\sum_{i=1}^{n} f_i(xi - \overline{x})^2$ = |

**Step-III**: Standard Deviation, $\sigma = \sqrt{\frac{\sum_{i=1}^{n} f_i(xi-\overline{x})^2}{N}}$=...............................................................................

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**Step-IV**: Coefficient of Variance (CV) = $\frac{\sigma}{\overline{x}} \times 100$ =.........................................................................

**Problem:** Find the standard deviation, coefficient of standard deviation, variance and CV of the given data.

| Class Interval | 10-20 | 20-30 | 30-40 | 40-50 | 50-60 |
|---|---|---|---|---|---|
| frequency | 8 | 15 | 45 | 20 | 12 |

**Solution: Step-I**: To calculate Arithmetic Mean, $\overline{x} = \frac{\sum_{i=1}^{n} f_i m_i}{N}$ =......................................................

**Step-II**: Construct a table:

| **Class Interval** | **$f_i$** | **Mid-Value ($m_i$)** | $\boldsymbol{f_i m_i}$ | **$m_i - \overline{x}$** | $(\boldsymbol{m_i - \overline{x}})^2$ | **$f_i(m_i - \overline{x})^2$** |
|---|---|---|---|---|---|---|
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| | | | $\sum_{i=1}^{n} f_i m_i$= | | | $\sum_{i=1}^{n} f_i(m_i - \overline{x})^2$= |

**Step-III**: Standard Deviation, $\sigma = \sqrt{\frac{\sum_{i=1}^{n} f_i(m_i - \overline{x})^2}{N}}$=.........................................................................

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**Coefficient of Standard Deviation** = $\frac{\sigma}{\overline{x}}$ =..............................................................................................

**Variance = (**Standard Deviation)$^2$ = $\sigma^2$ =..............................................................................................

**Coefficient of Variance (CV)** = $\frac{\sigma}{\overline{x}} \times 100$ ...........................................................................................

## Practical No. 4

**Objective: To calculate first four central moments, coefficient of Skewness ($\boldsymbol{\beta_1}$) and Kurtosis ($\boldsymbol{\beta_2}$). Comment on nature of the data.**

**Problem:** Compute first four central moments and the Karl Pearson's coefficient of skewness ($\beta_1$) and Kurtosis ($\beta_2$) from the following data: 8, 10, 11, 15, 16, 18, 21, 25, 28, 32, 35, 39, 41 and 42

**Solution:**

| x | (x-$\bar{x}$) | (x-$\bar{x}$)$^2$ | (x-$\bar{x}$)$^3$ | (x-$\bar{x}$)$^4$ |
|---|---|---|---|---|
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| $\sum x =$..... | | $\sum$(x-$\bar{x}$)$^2$=...... | $\sum$(x-$\bar{x}$)$^3$=....... | $\sum$(x-$\bar{x}$)$^4$=..... |

Arithmetic Mean, $\bar{x} = \frac{\sum x}{n}$ =.........................................................................................................

First central moment, $\mu_1 = \frac{\sum(x-\bar{x})}{n} = 0$

Second central moment, $\mu_2 = \frac{\sum(x-\bar{x})^2}{n}$ =..........................................................................................

Third central moment, $\mu_3 = \frac{\sum(x-\bar{x})^3}{n}$ =..............................................................................................

Fourth central moment, $\mu_4 = \frac{\sum(x-\bar{x})^4}{N}$ =.........................................................................................

Coefficient of Skewness $\beta_1 = \frac{\mu_3^2}{\mu_2^3}$ =...................................................................................................

Coefficient of Kurtosis $\beta_2 = \frac{\mu_4}{\mu_2^2}$ =.........................................................................................................

**Problem:** Compute first four central moments and the Karl Pearson's coefficient of skewness ($\beta_1$) and Kurtosis ($\beta_2$) from the following data:

| Height of tree (x) | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
|---|---|---|---|---|---|---|---|---|---|
| No of trees (f) | 3 | 5 | 8 | 11 | 19 | 23 | 40 | 28 | 14 |

**Solution:**

| x | f | f. x | (x-$\overline{x}$) | f. (x-$\overline{x}$) | f. (x-$\overline{x}$)$^2$ | f. (x-$\overline{x}$)$^3$ | f. (x-$\overline{x}$)$^4$ |
|---|---|---|---|---|---|---|---|
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| **Total** | $N = \sum f$ =........ | $\sum f.x = \cdots$ | | $\sum$f. (x-$\overline{x}$)=0 | $\sum$f. (x-$\overline{x}$)$^2$ =......... | $\sum$f. (x-$\overline{x}$)$^3$ =........ | $\sum$f. (x-$\overline{x}$)$^4$ =....... |

Arithmetic Mean, $\overline{x} = \frac{\sum f.x}{N}$ =.........................................................................................................

First central moment, $\mu_1 = \frac{\sum f.(x-\overline{x})}{N} = 0$

Second central moment, $\mu_2 = \frac{\sum f.(x-\overline{x})^2}{N}$ =.....................................................................................

Third central moment, $\mu_3 = \frac{\sum f.(x-\overline{x})^3}{N}$ =.......................................................................................

Fourth central moment, $\mu_4 = \frac{\sum f.(x-\overline{x})^4}{N}$ =.....................................................................................

Coefficient of Skewness $\beta_1 = \frac{\mu_3^2}{\mu_2^3}$ =............................................................................................

Coefficient of Kurtosis $\beta_2 = \frac{\mu_4}{\mu_2^2}$ =...............................................................................................

**Practical No. 5**

## Objective: To calculate correlation co-efficient between two variables.

**Problem:** Find the correlation coefficient between height and weight of yield of the plants. Data are given below:

| | | | | | |
|---|---|---|---|---|---|
| Height in cm | 6 | 7 | 8 | 9 | 10 |
| weight in gm | 20 | 23 | 24 | 26 | 26 |

**Solution:** Step-I: To construct table:

| x | y | $x^2$ | $y^2$ | xy |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| $\sum_{i=1}^{n} x_i$= | $\sum_{i=1}^{n} y_i$= | $\sum_{i=1}^{n} x_i^2 =$ | $\sum_{i=1}^{n} y_i^2 =$ | $\sum_{i=1}^{n} x_i y_i =$ |

Step-II: (a) n= number of paired observations =

(b)$\overline{x} = \frac{\sum_{i=1}^{n} x_i}{n}$ =.......................................................................................................................

(c) $\overline{y} = \frac{\sum_{i=1}^{n} y_i}{n}$ =.......................................................................................................................

Step-III: (a) $\sigma_x = \sqrt{\frac{1}{n}\sum_{i=1}^{n} x_i^2 - \overline{x}^2}$ =...................................................................................................

(b) $\sigma_y = \sqrt{\frac{1}{n}\sum_{i=1}^{n} y_i^2 - \overline{y}^2}$ =...................................................................................................

(c) Cov(x, y) = $\frac{1}{n}\sum_{i=1}^{n} x_i y_i - \overline{x} \times \overline{y}$ =...................................................................................

Step-IV: Karl Pearson correlation coefficient, $r_{xy} = \frac{Cov(x,y)}{\sigma_x \sigma_y}$=.......................................................

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**Problem:** Find the rank correlation coefficient between height and biomass of the plants. Data are given below:

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Rank in Height | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Rank in biomass | 1 | 2 | 3 | 5 | 6 | 4 | 7 | 8 |

**Solution:** Step-I: Count number of paired observations, n =..........................................................

Step-II: To construct table

| $R_x$ | $R_y$ | $d_i = R_y - R_x$ | $d_i^2$ |
|---|---|---|---|
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| | | | $\sum_{i=1}^{n} d_i^2$= |

Step-III: Rank correlation coefficient, $\rho = 1 - \frac{6\sum_{i=1}^{n} d_i^2}{n(n^2-1)}$ =...........................................................

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**Problem:** let's ask three people to rank order ten popular movies. 1 being the least favorite and 10 being the favorite of the list. Here's the data from evaluator's A, B, and C:

| A | B | C |
|---|---|---|
| 1 | 7 | 6 |
| 5 | 6 | 4 |
| 6 | 2 | 8 |
| 7 | 5 | 5 |
| 10 | 9 | 10 |
| 4 | 3 | 1 |
| 8 | 1 | 3 |
| 3 | 10 | 9 |
| 9 | 4 | 7 |
| 2 | 8 | 2 |

Compute Kendall coefficient Test whether they tend to like the same movies or not?

**Solution:**

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**Practical No. 6**

## Objective: To fit linear regression equation on the given data.

**Problem**: Fit the regression equation of y (yield in kg) on x (number of root fibers) of turmeric crop from the following data.

| No. of roots | 8 | 7 | 5 | 10 | 11 | 9 | 12 | 14 | 13 |
|---|---|---|---|---|---|---|---|---|---|
| Yield (in kg) | 1.2 | 1.1 | 0.7 | 1.3 | 1.3 | 1.0 | 1.4 | 1.3 | 1.4 |

**Solution:** Step-I: To construct table:

| x | y | $x^2$ | $y^2$ | xy |
|---|---|---|---|---|
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| $\sum_{i=1}^{n} x_i$= | $\sum_{i=1}^{n} y_i$= | $\sum_{i=1}^{n} x_i^2 =$ | $\sum_{i=1}^{n} y_i^2 =$ | $\sum_{i=1}^{n} x_i y_i =$ |

Step-II: (a) n= number of paired observations =.............................................................................

(b) $\overline{x} = \frac{\sum_{i=1}^{n} x_i}{n}$ =...........................................................................................................................

(c) $\overline{y} = \frac{\sum_{i=1}^{n} y_i}{n}$ =...........................................................................................................................

Step-III: (a) $\sigma_x = \sqrt{\frac{1}{n}\sum_{i=1}^{n} x_i^2 - \overline{x}^2}$ =..........................................................................................

(b) $\sigma_y = \sqrt{\frac{1}{n}\sum_{i=1}^{n} y_i^2 - \overline{y}^2}$ =..........................................................................................................

(c) Cov (x, y) = $\frac{1}{n}\sum_{i=1}^{n} x_i y_i - \overline{x} \times \overline{y}$ =...........................................................................................

Step-IV: Karl Pearson correlation coefficient, $r_{xy} = \frac{Cov(x,y)}{\sigma_x \sigma_y}$=..........................................................

Step-V: regression coefficient, $b_{yx} = \frac{\sigma_y}{\sigma_x} \times r_{xy}$=..........................................................................

Step-VI: regression equation, $y - \overline{y} = b_{yx} (x - \overline{x})$ =..........................................................................

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# Practical No. 7

**Objective: To solve some basic problems of probability, Additive and Multiplicative laws of Probability**

**Problem:** Suppose a coin toss three times then what is the probability getting:

(a) Three heads (b) one head and two tails

**Solution:**...................................................................................................................................

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**Problem:** Suppose a coin toss two times then what is the probability getting:

(a) Both heads (b) one head and one tail

**Solution:**...................................................................................................................................

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**Problem:** Two dice are rolled simultaneously. What is the probability getting the

(a) Sum of their point is 8

(b) Sum of their point is at least 10

**Solution:**..............................................................................................................................................

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**Problem:** A bag contains 3 red, 4 white and 1black balls. Three balls are drawn at random. What is the probability getting: (a) all white balls (b) one white and two red balls

**Solution:**..............................................................................................................................................

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**Problem:** A bag contains 4 white and 2 black balls. Two balls are drawn at random. What is the probability getting: (a) both white balls (b) one white and one black balls

**Solution:**..............................................................................................................................................

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**Addition Law of Probability**: If A and B are two events. The probability of occurring A or B (at least one) is given by, $P(A\cup B) = P(A) + P(B) - P(A\cap B)$

**Problem:** A card is drawn at random from a pack of 52 cards. What is the probability getting:
(a) king (b) heart (c) king and heart (d) king or heart
**Solution:**……………………………………………………………………………………………………………

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**Problem:** A card is drawn at random from a pack of 52 cards. What is the probability getting (a) Club (b) Ace (c) Club and Ace (d) Club or Ace.

**Solution:**……………………………………………………………………………………………………………

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**Multiplication Law of Probability:** If A and B are two events then

$$P(A\cap B) = P(A).\ P(B|A), \quad P(A) > 0$$

Where P(B|A) is a conditional probability of occurrence of B when A has already occurr.

**Bayes Theorem:** If $E_1, E_2, \ldots, E_n$ are mutually exclusive events, $P(E_i) \neq 0$ and A is any arbitrary event such that A is subset of $\cup_{i=1}^{n} E_i$ then conditional probability,

$$P(E_i|A) = \frac{P(E_i)P(A|E_i)}{\sum_{i=1}^{n} P(E_i)P(A|E_i)}$$

**Problem:** There are three urns, contains some balls following way:

Urn-I 3 red, 2 black and 3 white balls
Urn-II 2 red, 4 black, 2 white
Urn-III 2 red, 3 black, 3 white
A urn is selected randomly and draw two balls getting one red and one white. What is the probability that balls come out to be Urn-II.

**Solution:**..........................................................................................................................................

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**Problem:** There are three urns, contains some balls following way:

Urn-I 4 red, 2 black and 2 white balls
Urn-II 2 red, 2 black, 2 white
Urn-III 2 red, 4 black, 2 white
A urn is selected randomly and draw two balls getting one red and one white. What is the probability that balls come out to be Urn-II.

**Solution:**.........................................................................................................................................

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## Practical No. 8

## Objective: To fit Binominal and Poisson distributions of the given data.

**Problem:** Suppose 6 coins toss simultaneously. What is the probability getting 4 heads?

**Solution:**............................................................................................................................................

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**Problem:** The following data relate to the frequency distribution of number of boys in the first six children in families of U.P.

| **No. of boys/family** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | Total |
|---|---|---|---|---|---|---|---|---|
| **No. of families** | 5 | 58 | 200 | 368 | 365 | 255 | 70 | 1321 |

**Solution:**............................................................................................................................................

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**Problem:** The mean and variance of Binomial Distribution are 6 and 3/2 respectively. Find parameter of binomial distribution.

**Solution:**.............................................................................................................................
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**Problem:** Suppose there is a disease, whose average incidence is 2 per 100000 plants. What is the probability that a plot of 100000 plant has at most 3 the average incidence?

**Solution:**.........................................................................................................................................

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**Problem:** The following data relate to the number of α –particles emitted by a film of polonium in 2600 successive intervals of one-eighth of a minute. Fit Poisson Distribution

| **No. of α- particles** | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Observed frequency** | 55 | 200 | 383 | 525 | 532 | 408 | 273 | 139 | 45 | 26 | 10 | 4 | 0 | 1 | 1 |

**Solution:**.........................................................................................................................................

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**Practical No. 9**

## Objective: To Solve Normal distributions problem.

**Problem: X is a normal variate with mean 25 and standard deviation 5. Find the probabilities that (i) 20 $\leq X \leq 50$ (ii) $X \geq 30$ (iii) $|X-30|>5$**

**Solution:**

**Problem:** The following data relate to the frequency distribution of 1000 population of their intelligence score.

| **Class intervals** | 60-65 | 65-70 | 70-75 | 75-80 | 80-85 | 85-90 | 90-95 | 95-100 | Total |
|---|---|---|---|---|---|---|---|---|---|
| **Observed Freq.** | 2 | 22 | 150 | 335 | 326 | 135 | 25 | 5 | 1000 |

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**Practical No. 10**

## Objective: To draw a simple random sample and estimate population mean and population variance.

**Problem:** Draw a sample of size n=3 using simple random sampling with –out replacement (SRSWOR) from a population unit 1, 2, 3, 4 and 5. Show the sample mean and sample mean square is an unbiased estimate of population mean and population mean square and to determine its variances and S.E.

**Solution:** Step-I: Construct the following table:

| S. N. | Possible Samples | Sample mean $\overline{y_n}$ | Sample Mean Square ($s^2$) | $(\overline{y_n} - \overline{y_N})$ | $(\overline{y_n} - \overline{y_N})^2$ |
|---|---|---|---|---|---|
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| | | | | | |
| | | | | | |
| Total | | | | | |

Step-II: calculate:

Number of all possible samples of size n from N = $\binom{N}{n}$ =…………………………………………………..

Sample Mean, $\overline{y_n} = \frac{\sum y_i}{n}$ =………………………………………………………………………………

Sample Mean Square, $s^2 = \frac{\sum(y_i - \overline{y_n})^2}{n-1}$ =………………………………………………………………….

Population Mean, $\overline{y_N} = \frac{\sum y_i}{N}$ =……………………………………………………………………………..

Population Mean Square, $S^2 = \frac{\sum(y_i - \overline{y_N})^2}{N-1}$ =…………………………………………………………….…

E$(\overline{y_n}) = \frac{\sum \overline{y_n}}{\binom{N}{n}}$ =………………………………………………………………………………………

E$(s^2) = \frac{\sum s_i^2}{\binom{N}{n}}$ =………………………………………………………………………………………

Var $(\overline{y_n}) = \frac{N-n}{Nn} S^2$ =………………………………………………………………………………………

Standard Error = $\sqrt{\text{Var}(\overline{y_n})} = \frac{\sum(\overline{y_n} - \overline{y_N})^2}{\binom{N}{n}}$ = ………………………………………………………………..

Step-III: Now we have to check whether

E$(\overline{y_n}) = \overline{y_N}$ =………………………………………………………………………………………

E$(s^2) = S^2$ =………………………………………………………………………………………

## Practical No. 11

**Objective: To draw samples in stratified random sampling under (equal, proportional and Neyman allocation) along with determination of their variances and standard errors.**

**Problem**: A hypothetical population of N= 5000 is divided into four strata, their sizes of population and standard deviations are given as follows:

| **Strata** | I | II | III | IV | V |
|---|---|---|---|---|---|
| **Size Ni** | 500 | 600 | 1500 | 1300 | 1100 |
| **SD Si** | 3 | 4 | 8 | 6 | 9 |

**Solution:** ......................................................................................................................................

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## Practical No. 12

## Objective: To test significant difference between means & proportions in case of single sample and two samples using z-test (large sample test).

**1. Z - test for Single Mean:**

**Problem:** A sample of 500 trees which mean height is 13.6 meter. Test whether the sample comes from a forest which trees mean height is 14 meter and standard deviation is 2.4 meter.

**Solution:** It is used when we want to test significant difference between sample mean and population mean or testing a sample come from a specific population which mean is specific. Let $x_1$, $x_2$, ... , $x_n$ be a sample of size n from a population which mean is $\mu$ and standard deviation $\sigma$ is known where n is large number. This method has three steps:

Step-I(a): Null Hypothesis $H_0$: Here we set up the null hypothesis that there is no significant difference between sample mean and population mean.

(b): Alternative hypothesis $H_1$: we set up the alternative hypothesis that there is significant difference between sample mean and population mean.

Step-II: to calculate test statistic

z = $\frac{\overline{x}-\mu}{\sigma/\sqrt{n}}$ =

……………………………………………………………………………………………………

……………………………………………………………………………………………………...

Where $\overline{x}$ → sample mean, $\mu$ → Population Mean and $\sigma$ → Population standard deviation

Step-III: **Conclusion:** If calculated value of |z| is less than tabulated value of $z_\alpha$ at $\alpha$ % level of significance then null hypothesis is accepted otherwise rejected.

**2. Z - test for difference Mean:**

**Problem:** Suppose two varieties of Wheat A & B are sowing in 400 and 450 plots respectively. Their yield means are 35 and 42 respectively and standard deviation are 4 and 5 respectively. Test whether there is any significant difference between mean yields of A and B or not?

**Solution:** Step-I:(a) Null Hypothesis $H_0$: Here we set up the null hypothesis that there is no significant difference between two sample means.

(b) Alternative hypothesis $H_1$: we set up the alternative hypothesis that there is significant difference between two sample means.

Step-II: to calculate test statistic

z = $\frac{\overline{x}-\overline{y}}{\sqrt{[\frac{\sigma_1^2}{n_1}+\frac{\sigma_2^2}{n_2}]}}$ =……………………………………………………………………………………………

……………………………………………………………………………………………………

Where $\overline{x}$ → mean of first sample, $\overline{y}$ → mean of second sample and $\sigma_1$ and $\sigma_2$ are standard deviation of first and second population respectively.

Step-III: Conclusion: If calculated value of |z| is ................than tabulated value of $z$ at 5 % level of significance then null hypothesis is.......................................................................................................

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**3. Z - test for single Proportion:**

**Problem:** Forty plants were attacked by a disease and only 36 survived. Will you reject the hypothesis that the survival rate, if attacked by this disease, is 85%.

**Solution:** Step-I (a): Null Hypothesis $H_0$: Here we set up the null hypothesis that there is no significant difference between sample proportion and population proportion.

(b): Alternative hypothesis $H_1$: we set up the alternative hypothesis that there is significant difference between sample proportion and population proportion.

Step-II: to calculate test statistic

$$z = \frac{p-P}{\sqrt{(PQ/n)}} =$$ ……………………………………………………………………………………………………..

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Where $p$ → sample proportion, $P$ → Population proportion and Q=1-P

Step-III: **Conclusion:** If calculated value of |z| is less than tabulated value of $z_\alpha$ at $\alpha$ % level of significance then null hypothesis is accepted otherwise rejected.

**4. Z - test for difference of Proportion:**

**Problem:** Random samples of 450 farmers from UP and 500 farmers from MP were asked whether they would like to have showing RR21 wheat in your field. 200 farmers from UP and 250 farmers from MP were in favor of the proposal. Test the hypothesis that proportions of farmers from UP and MP in favor of the proposal, are same or not.

**Solution:** Step-I: (a) Null Hypothesis $H_0$: Here we set up the null hypothesis that there is no significant difference between two sample proportion.

(b) Alternative hypothesis $H_1$: we set up the alternative hypothesis that there is significant difference between two sample proportions.

Step-II: to calculate test statistic

$$z = \frac{p_1 - p_2}{\sqrt{PQ[\frac{1}{n_1}+\frac{1}{n_2}]}} =$$ ..........................................................................................................................

Where $p_1$ → proportion of first sample, $p_2$ → proportion of second sample. P→ Population Proportion and Q = 1- P

Step-III: Conclusion: If calculated value of |z| is less than tabulated value of $t_\alpha$ at $\alpha$ % level of significance then null hypothesis is accepted otherwise rejected.

**Practical No. 13**

## Objective: To test significant difference between sample mean and population, two sample means for independent samples and paired samples using t-test

**Problem:** A sample of 10 trees which height are 10.5, 10.4, 10.8, 11.3, 12.5, 12.7, 11.5, 11.8, 12.1 and 11.5 meter. Test whether the sample comes from a forest which trees mean height is 11.

**Solution:** Step-I (a): Null Hypothesis $H_0$: Here we set up the null hypothesis that there is no significant difference between sample mean and population mean.

**(b): Alternative hypothesis $H_1$:** we set up the alternative hypothesis that there is significant difference between sample mean and population mean.

Step-II: to calculate test statistic t

| $x_i$ | $x_i - \overline{x}$ | $(x_i - \overline{x})^2$ |
|---|---|---|
| | | |
| | | |
| | | |
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| | | |
| | | |
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| | | |
| | | |
| $\sum_{i=1}^{n_1} x_i$= | | $\sum_{i=1}^{n_1}(x_i - \overline{x})^2$= |

Sample mean, $\overline{x} = \frac{\sum_{i=1}^{n} x_i}{n}$ =..........................................................................................................................

S = $\sqrt{\frac{\sum_{i=1}^{n}(x_i - \overline{x})^2}{n-1}}$ =..........................................................................................................................

t = $\frac{\overline{x} - \mu}{S/\sqrt{n}}$ =..........................................................................................................................

Step-III: Conclusion: Since calculated value of |t| is ............ tabulated value of $t$ at $\alpha$ % level of significance then null hypothesis is..........................................................................................

**Problem:** A sample of 10 trees from forest A which height are 11.5, 11.4, 11.8, 12.3, 12.5, 13.3, 12.5, 12.8, 13.1 and 11.5 meter and second sample of 8 trees from forest B which height are 12.8, 12.3, 12.5, 13.8, 12.5, 12.8, 13.1 and 14.1 meter. Test whether forest A and B have same average height trees or not?

**Solution:** Step-I:(a) Null Hypothesis $H_0$: Here we set up the null hypothesis that there is no significant difference between two sample means.

(b) Alternative hypothesis $H_1$: we set up the alternative hypothesis that there is significant difference between two sample means.

Step-II: to calculate test statistic t

| $x_i$ | $x_i - \overline{x}$ | $(x_i - \overline{x})^2$ |
|---|---|---|
| | | |
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| | | |
| $\sum_{i=1}^{n_1} x_i$= | | $\sum_{i=1}^{n_1} (x_i - \overline{x})^2$= |

Sample mean, $\overline{x} = \frac{\sum_{i=1}^{n_1} x_i}{n_1}$ =.......................................................................................................................

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| $y_i$ | $y_i - \overline{y}$ | $(y_i - \overline{y})^2$ |
|---|---|---|
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|---|---|---|
| | | |
| $\sum_{i=1}^{n_2} y_i$= | | $\sum_{i=1}^{n_2}(y_i - \overline{y})^2$= |

Sample mean, $\overline{y} = \frac{\sum_{i=1}^{n_2} y_i}{n_2}$ =...................................................................................................................

S = $\sqrt{\frac{\sum_{i=1}^{n_1}(x_i - \overline{x})^2 + \sum_{i=1}^{n_2}(y_i - \overline{y})^2}{n_1 + n_2 - 2}}$ =..........................................................................................................

t = $\frac{\overline{x} - \overline{y}}{S\sqrt{[\frac{1}{n_1} + \frac{1}{n_2}]}}$ =.......................................................................................................................................

..................................................................................................................................................................

Step-III: **Conclusion:** Since calculated value of |t| is ............ tabulated value of $t$ at $\alpha$ % level of significance then null hypothesis is.........................................................................................................

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**Problem:** The following given yield data is related to before and after applying a soil treatment

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Before treatment | 7.9 | 8.5 | 7.3 | 9.7 | 10.3 | 10.2 | 11.1 | 8.9 | 8.5 |
| After treatment | 9.6 | 10.1 | 8.9 | 10.8 | 12.1 | 11.5 | 11.0 | 10.1 | 8.9 |

Test whether there is any significant effect of the soil treatment on the yield or not?

**Solution:** Step-I: (a) Null Hypothesis $H_0$: Here we set up the null hypothesis that there is no significant difference between two sample means.

(b) **Alternative hypothesis $H_1$:** we set up the alternative hypothesis that there is significant difference between two sample means.

Step-II: to calculate test statistic t

| $x_i$ | $y_i$ | $d_i = y_i - x_i$ | $d_i - \overline{d}$ | $(d_i - \overline{d})^2$ |
|---|---|---|---|---|
| | | | | |
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| | | | | |
| | | | | |
| | | $\sum_{i=1}^{n} d_i$= | | $\sum_{i=1}^{n}(d_i - \overline{d})^2$= |

Sample mean, $\overline{d} = \frac{\sum_{i=1}^{n} d_i}{n}$ =...........................................................................................................

S = $\sqrt{\frac{\sum_{i=1}^{n}(d_i - \overline{d})^2}{n-1}}$ =..........................................................................................................................

t = $\frac{\overline{d}}{S/\sqrt{n}}$ =..................................................................................................................................

Step-III: Conclusion: Since calculated value of |t| is ............ tabulated value of $t$ at $\alpha$ % level of significance then null hypothesis is.....................................................................................................

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## Practical No. 14

**Objective: To test goodness of fit of the distribution and association between attributes using chi Square test.**

**Problem:** The no. of deaths due to covid-19 over the days of week is following:

| Day's | Sun | Mon | Tue | Wed | Fri | Sat | Sun |
|---|---|---|---|---|---|---|---|
| No. of death | 14 | 11 | 13 | 10 | 12 | 9 | 15 |

Test whether death due to covid-19 is distributed uniformly over the days of week or not?

**Solution:** Step-I: (a) Null Hypothesis $H_0$: Here we set up the null hypothesis that there is no significant difference between observed frequencies and expected frequencies.

(b) Alternative hypothesis $H_1$: we set up the alternative hypothesis that there is significant difference between observed frequencies and expected frequencies.

Step-II: Calculate test statistic, $\chi^2$

| $O_i$ | $E_i$ | $O_i - E_i$ | $(O_i - E_i)^2$ | $\frac{(O_i - E_i)^2}{E_i}$ |
|---|---|---|---|---|
| | | | | |
| | | | | |
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| | | | | |
| | | | | |
| | | | | $\chi^2 = \sum_{i=1}^{n} \frac{(O_i - E_i)^2}{E_i}$= ........... |

Step-III: **Conclusion:** Since calculated value of $\chi^2$is ...........than tabulated value of $\chi^2$at 5 % level of significance then null hypothesis is..............................................................................................................

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**Problem:** The following data is related to eye colour father and their son.

| | | Father's eye colour | | |
|---|---|---|---|---|
| | | *Blue* | Black | Total |

| | | | | |
|---|---|---|---|---|
| Son's eye colour | $Blue$ | 70 | 30 | 100 |
| | Black | 20 | 8o | 100 |
| | Total | 90 | 110 | 200 |

Test whether there is any association between father's eye colour and son's eye colour or not?

**Solution:**

Step-I:(a) Null Hypothesis $H_0$: Here we set up the null hypothesis that there is no association between two attributes.

(b) Alternative hypothesis $H_1$: we set up the alternative hypothesis that there is any association between two attributes.

Step-II: calculate expected frequencies:

| | | Attribute A | | |
|---|---|---|---|---|
| | | $\alpha$ | A | Total |
| Attribute B | $\beta$ | $(\alpha\beta)$ | $(A\beta)$ | $(\beta)$ |
| | B | $(\alpha B)$ | $(AB)$ | $(B)$ |
| | Total | $(\alpha)$ | $(A)$ | N |

Expected frequencies,

E$(\alpha\beta)$ = $\frac{(\beta)(\alpha)}{N}$ =..........................................................................................................................

E$(A\beta)$ = $\frac{(\beta)(A)}{N}$ =..........................................................................................................................

E$(\alpha B)$ = $\frac{(B)(\alpha)}{N}$ =.........................................................................................................................

E$(AB)$ = $\frac{(B)(A)}{N}$ =..........................................................................................................................

Step-III: to calculate test statistic, $\chi^2$

| $O_i$ | $E_i$ | $O_i - E_i$ | $(O_i - E_i)^2$ | $\frac{(O_i - E_i)^2}{E_i}$ |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | $\chi^2 = \sum_{i=1}^{n} \frac{(O_i-E_i)^2}{E_i}$= |

Step-IV: **Conclusion:** Since calculated value of $\chi^2$is ...........than tabulated value of $\chi^2$at 5 % level of significance then null hypothesis is...........................................................................................................

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**Practical No. 15**

## Objective: To construct Completely Randomized Design (CRD) and analyze the data.

**Problem:** Draw the layout of CRD for 4 treatments A, B, C and D with replication 4, 4, 3 and 3

**Problem:** The data relate to the five varieties of fertilizers using CRD conducted in a field with four plots per variety.

| **Varieties** | Seed yield of sesame (gm/plot) | | | |
|---|---|---|---|---|
| V1 | 6 | 7 | 7 | 6 |
| V2 | 8 | 9 | 10 | 8 |
| V3 | 5 | 6 | 6 | |
| V4 | 6 | 6 | 7 | |

Test whether the varieties are differed significantly or not?

**Solution:**

| **Varieties** | Seed yield of sesame (gm/plot) | | | | Total | Mean |
|---|---|---|---|---|---|---|
| V1 | 6 | 7 | 7 | 6 | | |
| V2 | 8 | 9 | 10 | 8 | | |
| V3 | 5 | 6 | 6 | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| V4 | 6 | 6 | 7 | | | |
| Total | | | | | | |

**Null Hypothesis:** Here we set up the null hypothesis that the treatments are not differ significantly.

**Alternative Hypothesis:** At least one of the treatments differs significantly.

1. No. of treatment = k =...............................................................................................
2. No. of observation, N =...............................................................................................
3. Grand total, G=$\sum_1^k \sum_1^{n_i} x_{ij}$ =...............................................................................................
4. Correction Factor, C.F.=$\frac{G^2}{N}$ =...............................................................................................
5. Raw of Sum Squares, RSS =...............................................................................................
6. Total Sum of Squares, TSS= RSS – C. F. =....................................................................
7. Sum of squares due to treatment, SST =.........................................................................
8. Sum of Squares due to Error, SSE= TSS – SST =..........................................................

**Table: Analysis of Variance**

| **Source of variation** | **Degree of freedom** | **Sum of Square** | **Mean sum of square** | **Fcal** | **$F_{tab\ (.05)}$** |
|---|---|---|---|---|---|
| due to treatment | | | | | |
| Within varieties (Error) | | | | | |
| Total | | | | | |

Since calculated value of F is ............... than tabulated of $F_{.05}$ So the null hypothesis is .............................. at 5% level of significance.

**Standard error** of difference between two treatments = $\sqrt{\left(\frac{1}{n_i}+\frac{1}{n_2}\right) * MSSE}$

=.........................................

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Critical Difference =CD= $(S.E.)_{diff} \times t_{.05}$ (error d.f.) =.........................................................................

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**Practical No. 16**

## Objective: To construct the layout of RBD and analyse the data.

**Problem:** Draw RBD layout for the 4 treatments A, B, C and D with 5 replications.

**Solution:**

**Problem:** Four varieties of Onion were compared as regard yields within four blocks in RBD. The data pertaining to yield in kg per plot are given below:

| Varieties | Block | | | |
|---|---|---|---|---|
| | **1** | **2** | **3** | **4** |
| **A** | 4 | 5 | 3 | 4 |
| **B** | 6 | 8 | 4 | 6 |
| **C** | 4 | 6 | 5 | 5 |
| **D** | 6 | 7 | 6 | 7 |

Analyze the data and give conclusion?

**Solution: Null hypothesis $H_0$:** There is no significant difference between treatments as well as blocks as regard yield.

**Alternative hypothesis $H_1$:** At least two treatments as well as blocks are differing significantly.

**1.** Number of treatment = k =..........................................................................................

**2.** Number of replication = r =........................................................................................

**3.** Total number of observation = rk =.............................................................................

**4.** Grand Total (G) = $\sum_{i=1}^{k}\sum_{j=1}^{r} y_{ij}$ =...........................................................................

**5.** Correction factor = $\frac{G^2}{rk}$ =.........................................................................................

**6.** Raw sum of Squares (RSS) =.......................................................................................

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**7.** Total sum of squares (TSS) = RSS – C. F =.......................................................................

**8.** Sum of Squares due to treatment (SST) =$\frac{T_1^2+T_2^2+\cdots+T_k^2}{r}$ – C.F =................................................

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**9.** Sum of Squares due to Block (SSB) = $\frac{B_1^2+B_2^2+\cdots+B_k^2}{k}$ - CF =....................................................

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**10.** Error sum of square (SSE) = TSS – SST – SSB =.................................................................

## ANOVA TABLE

| Sources of variation | D.F | S.S | M.S S | F- cal value | F- table value At 5% Level of significance |
|---|---|---|---|---|---|
| Treatments | | | | | |
| Blocks (replications) | | | | | |
| Error | | | | | |
| Total | | | | | |

Since calculated value of F is ................. than tabulated of $F_{.05}$ so null hypothesis is ................. at 5% level of significance.

Since null hypothesis is rejected so we calculate Critical difference (C.D)

Standard Error of difference between two treatment means = $\sqrt{\frac{2\,MSSE}{r}}$ =....................................

Standard Error of difference between two Block means = $\sqrt{\frac{2\,MSSE}{k}}$ =..........................................

Critical Difference (C.D) = $(S.E.)_{diff} \times t_{.05}$ (error d.f) =....................................................................

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## Practical No. 17

## Objective: To construct layout of Latin Square Design (LSD) and analyse the data.

**Problem:** Draw LSD layout for 4 treatments A, B, C and D.

**Solution:**

**Problem-** A Latin square experiment is conducted to compare five compositions of feeds for producing honey in five bees. The feed composition are A, B, C, D and E. The experimental units are bees and the bees types will be used as columns and the way how to feed the bees (methods) were used as rows:

| Method | B1 | B2 | B3 | B4 | B5 |
|---|---|---|---|---|---|
| **M1** | A<br>6 | B<br>8 | C<br>6 | D<br>6 | E<br>9 |
| **M2** | B<br>8 | C<br>7 | D<br>6 | E<br>7 | A<br>8 |
| **M3** | C<br>6 | D<br>7 | E<br>7 | A<br>8 | B<br>10 |
| **M4** | D<br>6 | E<br>8 | A<br>7 | B<br>9 | C<br>6 |
| **M5** | E | A | B | C | D |

| | 8 | 7 | 9 | 6 | 6 |
|---|---|---|---|---|---|

Test whether the feed have any effect on honey gain or not?

**Solution: Null Hypothesis**.........................................................................................................

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1. Number of treatments = Number of rows = number of columns = k =..................................
2. Grand total = sum of all observations =.....................................................................................
3. Correction factor (C.F) = (Grand total)$^2$/(Treatment)$^2$ =......................................................
4. Raw sum of squares (R.S.S) =..........................................................................................
5. Total sum of squares (T.S.S) = R.S.S – C.F =.........................................................................
6. Sum of squares due to treatments (S.S.T) = $\frac{T_1^2}{k} + \frac{T_2^2}{k} + \ldots + \frac{T_k^2}{k}$ - C. F =...............................

   ..........................................................................................................................................

7. Sum of squares due to rows (S.S.R) = $\frac{R_1^2}{k} + \frac{R_2^2}{k} + \ldots + \frac{R_k^2}{k}$ - C. F =..........................................

   ..........................................................................................................................................

8. Sum of squares due to columns (S.S.C) = $\frac{C_1^2}{k} + \frac{C_2^2}{k} + \ldots + \frac{C_k^2}{k}$ - C. F =....................................

   ..........................................................................................................................................

9. Sum of squares due to error (S.S.E) =T.S.S – S.S.T – S.S.R – S.S.C =...............................

   ..........................................................................................

**Table: ANOVA**

| Source of variation | Degree of freedom | Sum of squares | Mean sum of square | F ratio |
|---|---|---|---|---|
| Treatment | | | | |
| Rows | | | | |
| Column | | | | |
| Error | | | | |
| Total | | | | |

Since calculated value is................than tabulated value so Null hypothesis is.........................

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In this case, we calculate the value of Standard error of difference between two treatment means by using the following formula:

S.E = $\sqrt{\frac{2\ \text{MSSE}}{k}}$ =...........................................................................................................................

Critical Difference: C.D = (S.E) × ($t_{0.05}$ at error d.f) =..................................................................

**Practical No. 18**

## Object: To construct the Split Plot Design and analyse the data.

**Problem:** Draw layout of Split plot design for the two factors A (allot in main plot) with 4 levels ($A_1$, $A_2$, $A_3$, $A_4$) and B (allot in subplot) with 3 levels ($B_1$, $B_2$, $B_3$) with 3 replications.

**Solution:**

**Problem:** An experiment was laid out in Sprit Plot Design with three farm to study the effect of three sowing dates $D_1$, $D_2$ and $D_3$ with three varieties of wheat A, B and C. The following yields in quintal per acre were found.

| varieties | **Farm 1** | | | **Farm 2** | | | **Farm 3** | | |
|---|---|---|---|---|---|---|---|---|---|
| | **D1** | **D2** | **D3** | **D1** | **D2** | **D3** | **D1** | **D2** | **D3** |
| **A** | 10.6 | 10.9 | 10.1 | 11.6 | 10.8 | 10.1 | 8.1 | 8.2 | 7.9 |
| **B** | 11.4 | 11.7 | 10.8 | 11.9 | 11.5 | 11.1 | 8.7 | 9.3 | 9.1 |
| **C** | 11.8 | 12.4 | 11.3 | 12.6 | 12.1 | 11.8 | 9.5 | 9.8 | 9.5 |

Analyse the data and calculate critical difference for different comparisons. State your conclusions.

**Solution: Null Hypothesis**..........................................................................................................

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**Table-1**

| **Factor A** / Factor B | **Farm 1** | | | | **Farm 2** | | | | **Farm 3** | | | | **Grand Total** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Levels** | | | **Total** | **Levels** | | | **Total** | **Levels** | | | **Total** | |
| | **A** | **B** | **C** | | **A** | **B** | **C** | | **A** | **B** | **C** | | |
| **D1**<br>**D2**<br>**D3** | | | | | | | | | | | | | |
| **Total** | | | | | | | | | | | | | |

From table-1, we calculate

C.F = $\frac{G^2}{rmn}$

$(TSS)_1 = \Sigma\Sigma\Sigma(a_i b_j B_k)^2 - C.F \qquad i=1,2, ..., m; \; j=1,2, ..., n; \; k=1,2, ..., r$

**Table-2**

| Blocks | Levels of factor A | | | Total |
|---|---|---|---|---|
| | **D1** | **D2** | **D3** | |
| **Farm1** | | | | |
| **Farm2** | | | | |
| **Farm3** | | | | |
| Total | | | | |

From table-2, we calculate

$(TSS)_2 = \sum_{i=1}^{m} \sum_{k=1}^{r} \frac{(a_i B_k)^2}{n} - C.F$

Sum of Squares due to blocks (SSB) = $\sum_{k=1}^{r} \frac{B_k^2}{mn}$ – C.F

Sum of Squares due to factor A (SS(A))= $\sum_{i=1}^{m} \frac{a_i^2}{nr}$ – C.F

Sum of Squares due to Error(a) [SSE(a)] = $(TSS)_2$ – SSB – SSA

**Table-3**

| Levels of factor B | Levels of factor A | | | Total |
|---|---|---|---|---|
| | **D1** | **D2** | **D3** | |
| A | | | | |
| B | | | | |
| C | | | | |
| Total | | | | |

From table-3, we calculate

$(TSS)_3 = \sum_{i=1}^{m} \sum_{j=1}^{n} \frac{(a_i b_j)^2}{r}$ – C.F =.............................................................................................

Sum of Squares due to factor B (SS(B))= $\sum_{j=1}^{n} \frac{b_j^2}{rm}$ – C.F =.................................................................

Sum of Squares due toAB[SS(AB)] = $(TSS)_3$ – SS(B) – SS(A) =....................................................

Sum of Squares due to Error(b) [SSE(b)] = $(TSS)_1$ - $(TSS)_2$ – $(TSS)_3$ + SS(A) =.............................

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**Table: Analysis of Variance**

| **Source of variation** | **Degrees of freedom** | **Sum of Square** | **Mean sum of square** | **Fcal** | **$F_{tab}$(5 %)** |
|---|---|---|---|---|---|
| Replication (Block) | r-1 | SSB | | | |
| Factor A (Main Plot) | m-1 | SS(A) | | | |
| Error (a) | (m-1)(r-1) | SSE(a) | | | |
| Factor B (Sub Plot) | n-1 | SS(B) | | | |
| Interaction | (m-1)(n-1) | SS(AB) | | | |
| Error (b) | m(n-1)(r-1) | SSE(b) | | | |
| Total | mnr-1 | | | | |

If calculated value of F is ..................... than tabulated of $F_{.05}$ then null hypothesis is .....................at 5% level of significance. .............................................................................................................................

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Since null hypothesis is rejected then we calculate Critical difference (C.D)

Standard Error of difference between two A means = $\sqrt{\frac{2\ MSSE(a)}{rn}}$ =……………………………………………

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Standard Error of difference between two B means = $\sqrt{\frac{2\ MSSE(b)}{rm}}$ =……………………………………………

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Standard Error of difference between two B means at the same level of A = $\sqrt{\frac{2\ MSSE(b)}{r}}$ =…………

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Critical Difference (C.D) = $(S.E.)_{diff} \times t_{.05}$ (error d.f) =………………………………………………………………

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Standard Error of difference between two A means at the same level of B

= $\sqrt{\frac{2\ [MSSE(a)+(n-1)MSE(b)]}{rn}}$

=………………………………………………………………………………………………………

and $t_w = \frac{t(a)MSSE(a)+t(b)(n-1)MSE(b)}{MSSE(a)+(n-1)MSE(b)}$

=………………………………………………………………………………………

Critical Difference (C.D) = $(S.E.)_{diff} \times t_w$

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