Syllabus for Four Year Undergraduate Programme in Statistics

Learning Outcomes based Curriculum Framework (LOCF) following NEP 2020

With effect from the Academic Session 2023-2024

Department of Statistics
Siksha Bhavana (Institute of Science)
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Santiniketan–731235, West Bengal, India

COURSE STRUCTURE OF FOUR-YEAR UNDERGRADUATE PROGRAMME IN STATISTICS

Sem	Major Courses	Minor Courses	Multi Courses	AECC	SEC	CVAC	Research*	Internship	Total Credits	
I	2x4cr=8	MnA 1x4cr=4	1x3cr=3	ENG/MIL1 1x2cr=2	1x3cr=3	TS 1x3cr=3	---		23	B.Sc. Certificate
II	2x4cr=8	MnB 1x4cr=4	1x3cr=3	ENG/MIL2 1x2cr=2	1x3cr=3	ES 1x3cr=3	---		23	
YEAR 1 NCrF level 4.5	2x8=16cr	2x4=8cr	2x3=6cr	2x2=4cr	2x3=6cr	2x3=6cr	---	Sum 4cr	46+4	
After successful completion of ONE YEAR Course (Semesters - I & II) securing 46 credits + 4 credits vocational summer internship, students may exit with B.Sc. Certificate in STATISTICS or continue further.										
III	2x4cr=8	MnA 1x4cr=4	1x3cr=3	MIL/ENG1 1x2cr=2	1x3Cr=3	---	---		20	B.Sc. Diploma
IV	4x4cr=16	MnB 1x4cr=4	---	MIL/ENG2 1x2cr=2	---	---	---		22	
YEAR 2 NCrF level 5.0	10x4=40cr	4x4=16cr	3x3=9cr	4x2=8cr	3x3=9cr	2x3=6cr	---	Sum 4cr	88+4	
After successful completion of TWO YEAR Course (Semesters - I to IV) securing 88 credits + 4 credits vocational summer internship, students may exit with B.Sc. Diploma in STATISTICS or continue further.										
V	3x4cr=12	MnA 1x4cr=4	---	---	---	---	---		16	B.Sc. Degree
VI	3x4cr=12	MnB 1x4cr=4	---	---	---	---	---		16	
YEAR 3 NCrF level 5.5	16x4=64cr	6x4=24cr	3x3=9cr	4x2=8cr	3x3=9cr	2x3=6cr	---	Sum 4cr	120+4	
After successful completion of THREE YEAR COURSE (Semesters - I to VI) securing 120 credits + 4 credits vocational summer internship, students may exit with B.Sc. Degree in STATISTICS or continue further.										
VII	4x4cr=16	MnA 1x4cr=4	---	---	---	---	---		20	B.Sc. Honours Degree
VIII	4x4cr=16	MnB 1x4cr=4	---	---	---	---	---		20	
YEAR 4 NCrF level 6.0	24x4=96cr	8x4=32cr	3x3=9cr	4x2=8cr	3x3=9cr	2x3=6cr	---	Sum 4cr	160+4	
After successful completion of FOUR YEAR COURSE (Semesters - I to VIII) securing 160 credits + 4 credits vocational summer internship, students may obtain B.Sc. Honours in STATISTICS.										
OR										
VII	3x4cr=12	MnA 1x4cr=4	---	---	---	---	1x4cr=4*		20	B.Sc. Honours (with Research)
VIII	2x4cr=8	MnB 1x4cr=4	---	---	---	---	2x4cr=8*		20	
YEAR 4	21x4=84cr	8x4=32cr	3x3=9cr	4x2=8cr	3x3=9cr	2x3=6cr	3x4=12cr	Sum 4cr	160+4	
After successful completion of FOUR YEAR COURSE (Semesters - I to VIII) securing 160 credits + 4 credits vocational summer internship, students may obtain B.Sc. Honours (with Research) in STATISTICS.										

Dissertation can be opted by students who attain at least CGPA 75% in 3 years and desire the Research degree. The students pursuing B.Sc. Honours (with Research) have to secure 12 credits (4 credits in Semester VII and 8 credits in Semester VIII). However, students pursuing only B.Sc. Honours have to study additional three Major Courses in STATISTICS securing 12 credits (4 credits in Semester VII and 8 credits in Semester VIII) in lieu of the Dissertation.

Learning Outcome based Curriculum for
FOUR-YEAR UNDERGRADUATE PROGRAMME in STATISTICS following NEP 2020

MAJOR COURSES in STATISTICS [Discipline-Specific Core Courses]

CourseCode	Course Type	Course Title	Credits	Marks	Hours
SEMESTER I					
MJST01A	Theory	Descriptive Statistics I	3	75	
MJST01B	*Practical*	Descriptive Statistics I	1	25	
MJST02	Theory	Probability and Probability Distributions I	4	100	
		Total	**8 credits**	**200**	
SEMESTER II					
MJST03A	Theory	Descriptive Statistics II	3	75	
MJST03B	*Practical*	Descriptive Statistics II	1	25	
MJST04A	Theory	Probability and Probability Distributions II	3	75	
MJST04B	*Practical*	Probability and Probability Distributions II	1	25	
		Total	**8 credits**	**200**	
ONE-YEARCERTIFICATE PROGRAMME TOTAL 4 MAJOR COURSES			**16 credits**	**400**	
SEMESTER III					
MJST05	Theory	Sampling Distributions	4	100	
MJST06A	Theory	Linear Algebra	3	75	
MJST06B	*Practical*	Linear Algebra	1	25	
		Total	**8 credits**	**200**	
SEMESTER IV					
MJST07	Theory	Mathematical Analysis and Applications	4	100	
MJST08	Theory	Statistical Inference I	4	100	
MJST09A	Theory	Time Series Analysis	3	75	
MJST09B	Practical	Time Series Analysis	1	25	
MJST10A	Theory	Demography	3	75	
MJST10B	*Practical*	Demography	1	25	
		Total	**16 credits**	**400**	
TWO-YEARDIPLOMA PROGRAMMETOTAL 10 MAJOR COURSES			**40 credits**	**1000**	
SEMESTER V					
MJST11A	Theory	Statistical Inference II	3	75	45
MJST11B	*Practical*	Statistical Inference II	1	25	30
MJST12A	Theory	Linear Models	3	75	45
MJST12B	*Practical*	Linear Models	1	25	30
MJST13A	Theory	Sample Survey and Indian Official Statistics	3	75	45
MJST13B	*Practical*	Sample Survey and Indian Official Statistics	1	25	30
		Total	**12 credits**	**300**	
SEMESTER VI					
MJST14A	Theory	Multivariate Analysis	3	75	45

MJST14B	*Practical*	Multivariate Analysis	1	25	30
MJST15A	Theory	Design of Experiments	3	75	45
MJST15B	*Practical*	Design of Experiments	1	25	30
MJST16A	Theory	Statistical Quality Control	3	75	45
MJST16B	*Practical*	Statistical Quality Control	1	25	30
		Total	**12 credits**	**300**	
THREE-YEAR DEGREE PROGRAMME 16 MAJOR COURSES			**64 credits**	**1600**	
SEMESTER VII					
MJST17A	Theory	Statistical Inference III	3	75	45
MJST17B	*Practical*	Statistical Inference III	1	25	30
MJST18	Theory	Distribution Theory	4	100	
MJST19A	Theory	Applied Multivariate Analysis	3	75	45
MJST19B	*Practical*	Applied Multivariate Analysis	1	25	30
		Total	**12 credits**	**300**	
SEMESTER VIII					
MJST21	Theory	Stochastic Process	4	100	
MJST22A	Theory	Statistical Inference IV	3	75	
MJST22B	Practical	Statistical Inference IV	1	25	
		Total	**8 credits**	**200**	
FOUR-YEARHONOURS PROGRAMME 21 COURSES + 3 COURSES* (Optional in lieu of Dissertation for Honours students) FOUR-YEAR HONOURS with RESEARCH PROGRAMME 21 COURSES + DISSERTATION			**84 credits +12 credits**	**2100 + 300**	

MINOR COURSES in STATISTICS [Discipline-Specific Minor Courses]

Course Code	Course Type	Course Title	Credits	Marks	Hours
SEMESTER I					
MNST01A	Theory	Statistical Methods	3	75	45
MNST01B	Practical	Statistical Methods	1	25	30
SEMESTER II					
MNST01A	Theory	Statistical Methods	3	75	45
MNST01B	Practical	Statistical Methods	1	25	30
ONE-YEAR CERTIFICATE PROGRAMME TOTAL 1 MINOR COURSE			**4**	**100**	
SEMESTER III					
MNST02A	Theory	Introductory Probability	3	75	45
MNST02B	Practical	Introductory Probability	1	25	30

SEMESTER IV					
MNST02A	Theory	Introductory Probability	3	75	45
MNST02B	Practical	Introductory Probability	1	25	30
TWO-YEAR DIPLOMA PROGRAMME TOTAL 2 MINOR COURSES			**8**	**200**	
SEMESTER V					
MNST03A	Theory	Basics of Statistical Inference	3	75	45
MNST03B	*Practical*	Basics of Statistical Inference	1	25	30
SEMESTER VI					
MNST03A	Theory	Basics of Statistical Inference	3	75	45
MNST03B	*Practical*	Basics of Statistical Inference	1	25	30
THREE-YEAR DEGREE PROGRAMME TOTAL 3 MINOR COURSES			**12**	**300**	
SEMESTER VII					
MNST04A	Theory	Applied Statistics	3	75	45
MNST04B	*Practical*	Applied Statistics	1	25	30
SEMESTER VIII					
MNST04A	Theory	Applied Statistics	3	75	45
MNST04B	*Practical*	Applied Statistics	1	25	30
FOUR-YEAR HONOURS PROGRAMME TOTAL 4 MINOR COURSES			**16**	**400**	

SKILL ENHANCEMENT COURSES in STATISTICS

CourseCode	CourseType	Course title	Credits	Marks	Hours
SEMESTER I					
SECST01	Theory	Statistical Data Analysis with Excel	3	75	
SEMESTER II					
SECST02	Theory	Introduction to R	3	75	
ONE-YEAR CERTIFICATE PROGRAMME TOTAL 2 COURSES			**6 credits**	**150**	
SEMESTER III					
SECST03	Theory	Introduction to C/C++	3	75	
TWO-YEAR DIPLOMA PROGRAMME TOTAL 3 COURSES			**9 credits**	**225**	

MULTIDISCIPLINARY COURSE in STATISTICS

CourseCode	CourseType	Course title	Credits	Marks	Hours
SEMESTER I /II/III					

RESEARCH/WITHOUT RESEARCH in STATISTICS

CourseCode	CourseType	Course title	Credits	Marks	Hours
SEMESTER VII					
MJRST20/	Theory	Research Methodology (4cr) (With research)	4	100	
MJWRST20A	Theory	Regression Techniques (Without Research)	3	75	
MJWRST20B	Practical	Regression Techniques (Without Research)	1	25	
SEMESTERVIII					
MJRST23/	Project/Theory	Dissertation (With research)	8	200	
MJWRST23	Project/Theory	Project (Without Research)	4	100	
		Any one of the remaining Courses (Without Research)			
MJWRST241A	Theory	Introduction to Operations Research	3	75	
MJWRST241B /	Practical	Introduction to Operations Research	1	25	
MJWRST242A	Theory	Introduction to Data Science with Python	3	75	
MJWRST242B /	Practical	Introduction to Data Science with Python	1	25	
MJWRST243A	Theory	Categorical Data Analysis and Advanced Data Analysis Techniques	3	75	
MJWRST243B /	Practical	Categorical Data Analysis and Advanced Data Analysis Techniques	1	25	
MJWRST244A	Theory	Reliability /Survival Analysis	3	75	
MJWRST244B	Practical	Reliability /Survival Analysis	1	25	

SEMESTER I

Major Courses in Statistics

MJST01A Descriptive Statistics I (Theory) (Credit 3)

Course Objective: *A statistical survey usually consists of collection of data, scrutiny of data and finally the analysis of data. Thus it is necessary for a student of Statistics is to be familiar with these steps at the very beginning. This particular course is designed keeping this in mind. Here the students are first introduced with the different ways of collecting data, followed by different types of data structure, their representation styles and finally different statistical tools and techniques that can be applied on a data set.*

Learning Outcomes: *After completion of this course, the students will be able to*

(1) Scrutinize an arbitrary data set.
(2) Represent the data in tabular and diagrammatic form.
(3) Prepare the frequency distribution for qualitative and quantitative data.
(4) Find the summary measures, viz. the measures of central tendency, measure of dispersion, measures of skewness and kurtosis of a univariate data.

Statistical Methods: Definition and scope of Statistics, concepts of statistical population and sample. Data: quantitative and qualitative, attributes, variables, scales of measurement, nominal, ordinal, interval and ratio. Presentation: tabular and graphical, including histogram and ogives, consistency and independence of data with special reference to attributes.

Measures of Central Tendency: mathematical and positional. Measures of Dispersion: range, quartile deviation, mean deviation, standard deviation, coefficient of variation, Moments, absolute moments, factorial moments, skewness and kurtosis.

SUGGESTED READING:

1. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I & II, 8th Edn. The World Press, Kolkata.
2. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
3. Mood, A.M. Graybill, F.A. and Boes, D.C. (2007): Introduction to the Theory of Statistics, 3rd Edn., (Reprint), Tata McGraw-Hill Pub. Co. Ltd.

MJST01B Descriptive Statistics I (PRACTICAL/LAB. WORK) (Credit 1)

List of Practical

1. Graphical representation of data.
2. Problems based on measures of central tendency.
3. Problems based on measures of dispersion.
4. Problems based on combined mean and variance and coefficient of variation.
5. Problems based on moments, skewness and kurtosis.

MJST02 Probability and Probability Distributions I (Credit 4)

Course Objective: *This is a fundamental course on probability theory. Students must have the knowledge of probability theory, random variables and their distributions to make further progress on statistical analysis.*

Learning Outcomes: *After completion of this course, the students will be able to*

(1) Understand the random experiment, sample space and probability theory.
(2) Know the one / two dimensional random variables and their properties in discrete / continuous framework.

Probability: Introduction, random experiments, sample space, events and algebra of events. Definitions of Probability – classical, statistical, and axiomatic. Conditional Probability, lawsof addition and multiplication, independent events, theorem of total probability, Bayes'theorem and its applications.

Random variables: discrete and continuous random variables, p.m.f., p.d.f. and c.d.f., illustrations and properties of random variables, univariate transformations with illustrations. Mathematical Expectation, Properties and uses of generating Functions.

SUGGESTED READING:

1. Hogg, R.V., Tanis, E.A. and Rao J.M. (2009): Probability and Statistical Inference, Seventh Ed, Pearson Education, New Delhi.
2. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
3. Myer, P.L. (1970): Introductory Probability and Statistical Applications, Oxford & IBH Publishing, New Delhi

Minor Courses in Statistics

MNST01A Statistical Methods (Theory)Credit 3

Course Objectives: *A statistical survey usually consists of collection of data, scrutiny of data and finally the analysis of data. Thus it is necessary for a student of Statistics is to be familiar with these steps at the very beginning. This particular course is designed keeping this in mind. Here the students are first introduced with the different ways of collecting data, followed by different types of data structure, their representation styles and finally different statistical tools and techniques that can be applied on a data set.*

Learning Outcomes: *After completion of this course, the students will be able to*

(1) Scrutinize an arbitrary data set.
(2) Represent the data in tabular and diagrammatic form.
(3) Prepare the frequency distribution for qualitative and quantitative data.
(4) Find the summary measures, viz. the measures of central tendency, measure of dispersion, measures of skewness and kurtosis of a univariate data.

(5) *Find the degree of association/correlation between the two concerned variables in case of a bivariate data.*
(6) *Fit linear and non-linear curves for predicting the value of one variable, given the value of another, in case of bivariate data.*

Introduction: Definition and scope of Statistics, concepts of statistical population and sample. Data: quantitative and qualitative, attributes, variables, scales of measurement - nominal, ordinal, interval and ratio. Presentation: tabular and graphic, including histogram and ogives.

Measures of Central Tendency: mathematical and positional. Measures of Dispersion: range, quartile deviation, mean deviation, standard deviation, coefficient of variation, moments, skewness and kurtosis.

Bivariate data: Definition, scatter diagram, simple, partial and multiple correlation (3 variables only), rank correlation. Simple linear regression, principle of least squares and fitting of polynomials and exponential curves.

Theory of attributes, consistency of data, independence and association of attributes, measures of association and contingency.

SUGGESTED READING:

1. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I & II, 8th Edn. The World Press, Kolkata.
2. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
3. Mood, A.M. Graybill, F.A. and Boes, D.C. (2007): Introduction to the Theory of Statistics, 3rd Edn., (Reprint), Tata McGraw-Hill Pub. Co. Ltd.

MNST01B Statistical Methods (Practical) Credit 1

PRACTICAL/ LAB WORK

List of Practical

1. Graphical representation of data
2. Problems based on measures of central tendency
3. Problems based on measures of dispersion
4. Problems based on combined mean and variance and coefficient of variation
5. Problems based on moments, skewness and kurtosis
6. Fitting of polynomials, exponential curves
7. Karl Pearson correlation coefficient
8. Partial and multiple correlations
9. Spearman rank correlation with and without ties.
10. Correlation coefficient for a bivariate frequency distribution
11. Lines of regression, angle between lines and estimated values of variables.
12. Checking consistency of data and finding association among attributes.

Skill Enhancement Courses in Statistics

SECCST01: Statistical data analysis with EXCEL (Credit 3)

Course Objectives:

- *To build a strong understanding on the Basics of Microsoft Excel*
- *To understand data crunching and data presentation*

Learning Outcomes: *After completion of this course, the students will be able to create dynamic reports by mastering some of the most popular tools in excel.*

Introduction to Excel: About Excel & Microsoft, Uses of Excel, Excel software, Spreadsheet window pane, Title Bar, Menu Bar, Standard Toolbar, Formatting Toolbar, the Ribbon, File Tab and Backstage View, Formula Bar, Workbook Window, Status Bar, Task Pane, Workbook & sheets.

Columns & Rows: Selecting Columns & Rows, Changing Column Width & Row Height, Autofitting Columns & Rows, Hiding/Unhiding Columns & Rows, Inserting & Deleting Columns & Rows, Cell, Addressof a cell, Components of a cell – Format, value, formula, Use of paste and paste special

Creating Formulas: Using Formulas, Formula Functions – Sum, Average, if, Count, max, min, Proper, Upper,Lower, Using AutoSum etc.

Spreadsheet Charts: Constructing various Line, Bar and Pie charts. Using the Pivot chart features of Excel. Understanding and constructing Histograms and Scatterplots, Formatting Chart Objects, Changing the Chart Type, Showing and Hiding the Legend, Showing and Hiding the Data Table

Data Analysis: Sorting, Filter, Text to Column, Data Validation.

Hands-on practical session on different topics.

Weightage: 40% on Theory and 60% on Practical.

References:

1. Jain . R. (2021): A to Z of MS EXCEL: A Book for Learners and Trainers, Amazon Digital Services LLC - KDP Print US
2. Minhas, D.S. (2023): All you wanted to know about: creating worksheets with MS-EXCEL, New Dawn publishing
3. Aggarwal, V.B, Sood, A. and Gupta, S. (2000): A Tutorial on MS-Excel, Pitambar Publishing Company Private Limited.

SEMESTER II

Major Courses in Statistics

MJST03A Descriptive Statistics II (Theory) (Credit 3)

Course Objective: *This course is designed for finding relationship between two or more interdependent variables with changes in one variable being associated with the changes in other. It enables the students to estimate or predict the unknown value of one variable from the known value of the other variable. The course also contains meaning, importance and method of constructing Index numbers, which is a device for measuring changes in a variable or a group of related variables. The index number of industrial activity enables us to study the progress of industrialization in the country.*

Learning Outcomes: *After completion of this course, the students will be able to*

1. *Find the degree of association/correlation between the two concerned variables in case of a bivariate data.*
2. *Fit linear and non-linear curves for predicting the value of one variable, given the value of another, in case of bivariate data.*
3. *Calculate price and quantity index numbers using simple and weighted average of price relatives, the Chain Base index numbers and consumer price index number.*

Bivariate data: Definition, scatter diagram, simple correlation, Simple linear regression, principle of least squares and fitting of polynomials and exponential curves, Correlation index and Correlation ratio, Rank correlation and Intra-class correlation.

Index Numbers: Definition, construction of index numbers and problems thereof for weighted and unweighted index numbers including Laspeyre's, Paasche's, Edgeworth-Marshall and Fisher's. Chain index numbers, conversion of fixed based to chain base index numbers and vice-versa. Consumer price index numbers. Income distribution, Lorenz curve and Gini's coefficient.

SUGGESTED READING:

1. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I & II, 8th Edn. The World Press, Kolkata.
2. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
3. Mood, A.M. Graybill, F.A. and Boes, D.C. (2007): Introduction to the Theory of Statistics, 3rd Edn., (Reprint), Tata McGraw-Hill Pub. Co. Ltd.

MJST03B Descriptive Statistics II (PRACTICAL/LAB. WORK) (Credit 1)

List of Practical

1. Fitting of polynomials, exponential curves.
2. Karl Pearson correlation coefficient.
3. Correlation coefficient for a bivariate frequency distribution.
4. Lines of regression, angle between lines and estimated values of variables.
5. Spearman rank correlation with and without ties.
6. Planes of regression and variances of residuals for given simple correlations.
7. Planes of regression and variances of residuals for raw data.
8. Intra-class Correlation.
9. To calculate price and quantity index numbers using simple and weighted average of price relatives.
10. To calculate chain-base index numbers.
11. To calculate consumer price index numbers
12. To calculate Gini's coefficient

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MJST04A Probability and Probability Distributions II (Theory) (Credit 3)

Course Objective: *In this course, students will have a nice idea about several univariate and bivariate discrete and continuous distributions. The notions of different modes of convergence of a sequence of random variables are also introduced.*

Learning Outcomes: *After completion of this course, the students will be able to*

(1) Recognize various discrete as well as continuous distributions, their properties and applications.
(2) Understand the concepts of law of large numbers and the central limit theorem.

Standard probability distributions: binomial, Poisson, geometric, negative binomial, hypergeometric, uniform, normal, exponential, Cauchy, beta and gamma along with their properties and limiting/approximation cases.

Bivariate Normal Distribution (BVN): p.d.f. of BVN, properties of BVN, marginal and conditional distribution.

Limit laws: convergence in probability and convergence in distribution and their inter relations, Chebyshev's inequality, Weak Law of Large Numbers (W.L.L.N) and its applications, De-Moivre Laplace theorem, Central Limit Theorem (C.L.T.) for i.i.d. variables, applications of C.L.T. and Liapunov Theorem (without proof).

SUGGESTED READING:

1. Hogg, R.V., Tanis, E.A. and Rao J.M. (2009): Probability and Statistical Inference, Seventh Ed, Pearson Education, New Delhi.
2. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
3. Myer, P.L. (1970): Introductory Probability and Statistical Applications, Oxford & IBH Publishing, New Delhi
IBH Publishing, New Delhi

MJST04B Probability and Probability Distributions II (PRACTICAL/LAB. WORK (Credit 1)

List of Practical

1. Fitting of binomial distributions for n and p = q = ½.
2. Fitting of binomial distributions for given n and p.
3. Fitting of binomial distributions after computing mean and variance.
4. Fitting of Poisson distributions for given value of lambda.
5. Fitting of Poisson distributions after computing mean.
6. Fitting of negative binomial.
7. Application problems based on binomial distribution.
8. Application problems based on Poisson distribution.
9. Application problems based on negative binomial distribution.
10. Problems based on area property of normal distribution.
11. To find the ordinate for a given area for normal distribution.
12. Application based problems using normal distribution.
13. Fitting of normal distribution when parameters are given.
14. Fitting of normal distribution when parameters are not given.

Minor Courses in Statistics

MNST01A Statistical Methods (Theory)Credit 3

Course Objectives: *A statistical survey usually consists of collection of data, scrutiny of data and finally the analysis of data. Thus it is necessary for a student of Statistics is to be familiar with these steps at the very beginning. This particular course is designed keeping this in mind. Here the students are first introduced with the different ways of collecting data, followed by different types of data structure, their representation styles and finally different statistical tools and techniques that can be applied on a data set.*

Learning Outcomes: *After completion of this course, the students will be able to*

(7) Scrutinize an arbitrary data set.
(8) Represent the data in tabular and diagrammatic form.
(9) Prepare the frequency distribution for qualitative and quantitative data.
(10) Find the summary measures, viz. the measures of central tendency, measure of dispersion, measures of skewness and kurtosis of a univariate data.
(11) Find the degree of association/correlation between the two concerned variables in case of a bivariate data.
(12) Fit linear and non-linear curves for predicting the value of one variable, given the value of another, in case of bivariate data.

Introduction: Definition and scope of Statistics, concepts of statistical population and sample. Data: quantitative and qualitative, attributes, variables, scales of measurement - nominal, ordinal, interval and ratio. Presentation: tabular and graphic, including histogram and ogives.

Measures of Central Tendency: mathematical and positional. Measures of Dispersion: range, quartile deviation, mean deviation, standard deviation, coefficient of variation, moments, skewness and kurtosis.

Bivariate data: Definition, scatter diagram, simple, partial and multiple correlation (3 variables only), rank correlation. Simple linear regression, principle of least squares and fitting of polynomials and exponential curves.

Theory of attributes, consistency of data, independence and association of attributes, measures of association and contingency.

SUGGESTED READING:

4. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I & II, 8th Edn. The World Press, Kolkata.
5. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
6. Mood, A.M. Graybill, F.A. and Boes, D.C. (2007): Introduction to the Theory of Statistics, 3rd Edn., (Reprint), Tata McGraw-Hill Pub. Co. Ltd.

MNST01B Statistical Methods (Practical) Credit 1

PRACTICAL/ LAB WORK

List of Practical

13. Graphical representation of data
14. Problems based on measures of central tendency
15. Problems based on measures of dispersion
16. Problems based on combined mean and variance and coefficient of variation
17. Problems based on moments, skewness and kurtosis
18. Fitting of polynomials, exponential curves
19. Karl Pearson correlation coefficient
20. Partial and multiple correlations
21. Spearman rank correlation with and without ties.
22. Correlation coefficient for a bivariate frequency distribution
23. Lines of regression, angle between lines and estimated values of variables.
24. Checking consistency of data and finding association among attributes.

Skill Enhancement Courses in Statistics

SECCST02 Introduction to R (Credit 3)

Course Objectives: *1. Explaining the idea and advantages of open-source software*
2. Introducing R as an open-source software
3. Developing the idea of programming and syntaxes of R programming, especially for mathematical computations
4. Demonstrating applications of R in performing fundamental statistical analysis and visualizations.

Learning Outcomes: *After completion of this course, the students will be able to*

1. Understand the cons and advantages of open-source software.
2. Installing and start working in R in different environments
3. Basic programming and solving mathematical problems using R
4. Feeding a dataset in an R environment and carrying out different fundamental statistical analyses and plots in R

Open source software and its advantages, a Very brief history of R, installing R in computers, Different R environments (e.g. Posit, Anaconda etc.), Use of R as a calculator and built-in functions in R, Objects (variables) and their types (scalar, vector, matrix, List, Data Frame etc.) in R, performing different mathematical operations using objects e.g. vectors, matrix etc., Control statement and loop in R, Functions in R and example of their use. Coding examples for solving various mathematical problems (Finding Fibonacci sequence, mean, median, mode, variance, skewness, kurtosis of a set of numbers etc.)

Data input in R environment for statistical analysis and examining different characteristics (dimension, variable names, missing values, no. of missing values, variables nature etc.) of the dataset. Data visualizations (pie-chart, bar-plot, histogram, density plot, box-plot etc.) for variables of a dataset in R, Constructing frequency table and finding descriptive statistics measures of a dataset.

Hands-on practical session on different topics.

Weightage: 40% on Theory and 60% on Practical.

References:

1. https://www.r-project.org/other-docs.html
2. Robert L. Kabacoff: R in Action, 2nd Edition.
3. Norman Matloff: The Art of R Programming: A Tour of Statistical Software Design
4. Roger D. Peng: R Programming for Data Science
5. Roger D. Peng: Exploratory Data Analysis with R

SEMESTER III

Major Courses in Statistics

MJST05 Sampling Distribution (Credit 4)

Course Objective: *The ultimate goal of Statistics is to infer about the population characteristics, based on the corresponding sample analogues. Since the sample quantities are random, it is required to find their exact or asymptotic probability distributions. Understanding of some basic tools and techniques are prerequisite for these. This course is designed keeping focus on these and mandatory for performing any sort of statistical inference.*

Learning Outcomes: *After completion of this course, the students will be able to*

1) *Get an idea about the properties of Central Chi-square, t and F distributions.*
2) *Understand the concept of sampling fluctuation.*
3) *Derive the sampling distribution of different sample entities like the sample mean, sample variance in case of sampling from a Normal population.*
4) *Derive the sampling distribution of sample order statistics*
5) *Understand the concepts of law of large numbers and the central limit theorem.*

Definitions of random sample, parameter and statistic, sampling distribution of a statistic, sample mean, standard errors of sample mean, sample variance and sample proportion.

Exact sampling distribution: Definition and derivation of $\chi 2$ with n degrees of freedom (d.f.) using m.g.f., nature of p.d.f. curve for different degrees of freedom, mean, variance, m.g.f., cumulant generating function, mode, additive property and limiting form of $\chi 2$ distribution.

Exact sampling distributions: Student's and Fishers t-distribution, Derivation of their p.d.f.s, nature of probability curve with different degrees of freedom, mean, variance, moments and limiting form of t distribution. Snedecore's F-distribution: Derivation of p.d.f., nature of p.d.f. curve with different degrees of freedom, mean, variance and mode. Distribution of $1/F(n_1,n_2)$. Relationship between t, F and $\chi 2$ distributions.

Distribution of sample mean and sample variance, Order Statistics: Introduction, distribution of the rth order statistic, smallest and largest order statistics. Joint distribution of r^{th} and s^{th} order statistics, distribution of sample median and sample range.

Sampling from a bivariate normal population, distribution of sample correlation coefficient and sample regression coefficient (for both non-stochastic and stochastic independent variable)

SUGGESTED READING:

1. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2003): *An Outline of Statistical Theory*, Vol. I, 4th Edn. World Press, Kolkata.
2. Rohatgi V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and

Statistics. 2ndEdn. (Reprint) John Wiley and Sons.
3. Hogg, R.V. and Tanis, E.A. (2009): *A Brief Course in Mathematical Statistics*. Pearson Education.
4. Johnson, R.A. and Bhattacharya, G.K. (2001): *Statistics-Principles and Methods*, 4th Edn. John Wiley and Sons.
5. Mood, A.M., Graybill, F.A. and Boes, D.C. (2007): *Introduction to the Theory of Statistics*, 3rd Edn. (Reprint).Tata McGraw-Hill Pub. Co. Ltd.

MJST06A Linear Algebra (Theory) (Credit 3)

Course Objective: *This is also a basic and prerequisite course for the students before studying the courses like multivariate analysis, linear models and stochastic process. The course mainly focuses on vector space, matrix theory, determinant, system of linear equations, rank of a matrix and eigenvalues.*

Learning Outcomes: *After completion of this course, the students will be able to*

(1) Understand the concept of vector space and its dimension.
(2) Classify various types of matrices and their important properties.
(3) Analyze and solve various types of determinants, quadratic forms and system of linear equations.
(4) Interpret the rank related properties of a matrix and its eigenvalues.

Vector spaces, Subspaces, sum of subspaces, Span of a set, Linear dependence and independence, dimension and basis, dimension theorem, orthogonality of vectors.

Algebra of matrices - A review, theorems related to triangular, symmetric and skew symmetric matrices, idempotent matrices, Hermitian and skew Hermitian matrices, orthogonal matrices, singular and non-singular matrices and their properties. Trace of a matrix, unitary, involutory and nilpotent matrices. Adjoint and inverse of a matrix and related properties.

Determinants of Matrices: Definition, properties and applications of determinants for 3rd and higher orders, evaluation of determinants of order 3 and more using transformations. Symmetric and Skew symmetric determinants, Circulant determinants and Vandermonde determinants for nth order, Jacobi's Theorem, product of determinants.

Rank of a matrix, row-rank, column-rank, standard theorems on ranks, rank of the sum and the product of two matrices. Generalized inverse (concept with illustrations).Partitioning of matrices and simple properties.

Solution to the system of linear equations, row reduction and echelon forms, the matrix equations AX=B, solution sets of linear equations, linear independence, Applications of linear equations.
Quadratic forms and related properties, Linear orthogonal transformation and their diagonalization.

Characteristic roots and Characteristic vector, Properties of characteristic roots, Cayley Hamilton theorem.

SUGGESTED READINGS:

1. Lay David C.: Linear Algebra and its Applications, Addison Wesley, 2000.
2. Schaum's Outlines : Linear Algebra, Tata McGraw-Hill Edition, 3rdEdition, 2006.
3. Krishnamurthy V., Mainra V.P. and Arora J.L.: An Introduction to Linear Algebra (II, III, IV, V).
4. Jain P.K. and Khalil Ahmad: Metric Spaces, Narosa Publishing House, New Delhi, 1973
5. Biswas, S. (1997): A Textbook of Matrix Algebra, New Age International, 1997.
6. Gupta S.C.: An Introduction to Matrices (Reprint). Sultan Chand & Sons, 2008.
7. Artin M.: Algebra. Prentice Hall of India, 1994.
8. Datta K.B.: Matrix and Linear Algebra. Prentice Hall of India Pvt. Ltd., 2002.
9. Hadley G.: Linear Algrbra. Narosa Publishing House (Reprint), 2002.
10. Searle S.R.: Matrix Algebra Useful for Statistics. John Wiley &Sons., 1982.

MJST06B Linear Algebra (PRACTICAL/LAB. WORK) (Credit 1)

List of Practical

1. To find basis and dimension of a vector space.
2. Gram-Schmidt's orthogonalization process.
3. Echelon form of a matrix and its rank.
4. To find the determinant of a matrix.
5. To find the inverse of a matrix.
6. To find the solutions of a system of a linear equations.
7. Classification of quadratic forms.
8. To find eigenvalues and eigenvectors of a matrix.

Minor Courses in Statistics

MNST02A Introductory Probability (Theory)Credit 3

Course Objectives: *This is a fundamental course on probability theory. Students must have the knowledge of probability theory, random variables and their distributions to make further progress on statistical analysis. This course is designed into four units, the first units mainly devoted into the basics of probability theory and its applications. Second and third units mainly focused on various types of random variables, expectation, generating functions, convergence and central limit theorems. In the fourth unit students will have a nice idea about several discrete and continuous distributions.*

Learning Outcomes: *After completion of this course, the students will be able to*

(1) Understand the random experiment, sample space and probability theory.

(2) Know the one dimensional random variables and their properties in discrete / continuous framework.
(3) Grasp the idea of convergence in probability and central limit theorem.
(4) Recognize various discrete as well as continuous distributions and their properties.

Probability: Introduction, random experiments, sample space, events and algebra of events. Definitions of Probability – classical, statistical, and axiomatic. Conditional Probability, laws of addition and multiplication, independent events, theorem of total probability, Bayes' theorem and its applications.

Random Variables: Discrete and continuous random variables, p.m.f., p.d.f. ,c.d.f. Illustrations of random variables and its properties. Expectation, variance, moments and moment generating function.

Convergence in probability, almost sure convergence, Chebyshev's inequality, weak law of large numbers, De-Moivre Laplace and Lindeberg-Levy Central Limit Theorem (C.L.T.).

Standard probability distributions: Binomial, Poisson, geometric, negative binomial, hypergeometric, uniform, normal, exponential, beta, gamma.

SUGGESTED READING:

1. Hogg, R.V., Tanis, E.A. and Rao J.M. (2009): Probability and Statistical Inference, Seventh Ed, Pearson Education, New Delhi.
2. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
3. Myer, P.L. (1970): Introductory Probability and Statistical Applications, Oxford & IBH Publishing, New Delhi

MNST02B Introductory Probability (Practical) Credit 1

PRACTICAL/ LAB WORK

List of Practical

1. Fitting of binomial distributions
2. Fitting of Poisson distributions
3. Application problems based on binomial distribution
4. Application problems based on Poisson distribution
5. Problems based on area property of normal distribution
6. To find the ordinate for a given area for normal distribution
7. Application based problems using normal distribution
8. Fitting of normal distribution when parameters are not given

Skill Enhancement Courses in Statistics

SECST03: Introduction to C/C++ (Credit 3)

Course Objective: *Now a day's programming has become the key of statistical learning. In order to flourish the theoretical knowledge, the popular computational problems should be illustrated using a programming language. In this course, the most popular programming language C is offered to the students.*

Learning Outcomes: *After completion of this course, the students will be able to*

(1) Execute basic programs in C / C++.
(2) Implement the application of control structures in program.
(3) Write program using loop structure and functions.
(4) Read data from a file and store the outputs in a file.
(5) Get idea about pointers, structure and preprocessor macro.
(6) Write various programs on statistical and numerical computation.

History and importance of C, Keywords, Execution of a C/C++ program; Declaration and assignment of variables, use of numeric constants; Arithmetic, relational, logical, assignment, increment/decrement, operators, use of operators in arithmetic, relational and logical expression; Various interactions through user input; Basic idea of for loop, while loop, if statement, break statement, etc.

Use of library functions (including rand()); create user defined functions, nested functions; Calling functions, multiple input multiple output functions; Introduction to array (1 and 2 dimension), various mathematical operations on array, matrix addition, multiplication; Roots of a quadratic equation; Swapping and Bubble sort; Find mean, median, mode, variance, sd, skewness, kurtosis, Pearson and spearman correlation from user defined values; Box-Muller transformation.

Applications: 1.Print first n even/odd numbers; 2. Find $1 + 2 + \ldots + n$; 3. Find n such that $1 + 2 + \ldots + n < 10^5$; 4. For integer k, find $1^k + 2^k + \cdots + n^k$; 5. Check for prime numbers; 6. Find prime numbers in an interval; 7. Using loop and functions find factorial, combination; 8. Find $\binom{n}{1} + \binom{n}{2} + \cdots + \binom{n}{k}$; 9. Factors of a number; 10. Generate n samples from Ber(p),Bin(n, p),Poi(λ); 11. Generate n samples from $U[0,1], U[a, b]$, N(0,1), N(a,b), χ^2_n; 12. Print first n Fibonacci numbers; 13. Exponential and Logarithmic series without using function; 14. Rolling 3/4 dice and prints the all possible outcome; 15. Gcd and lcm of 2 and more than two numbers.

Hands-on practical session on different topics.

Weightage: 40% on Theory and 60% on Practical.

SUGGESTED READING:

1. Kernighan, B.W. and Ritchie, D. (1988): C Programming Language, 2nd Edition,Prentice Hall.
2. Balagurusamy, E. (2011): Programming in ANSI C, 6th Edition, Tata McGraw Hill.
3. Gottfried, B.S. (1998): Schaum's Outlines: Programming with C, 2nd Edition, Tata

McGraw Hill

SEMESTER IV

Major Courses in Statistics

MJST07 Mathematical Analysis and Applications (Credit 4)

Course Objective: *This is also an intermediate level mathematical course for the students. Since the analytical parts of statistics mostly rely upon mathematical analysis, so students must know the theory of mathematical analysis. Numerical analysis also helps on various fields of statistics. This course is mainly devoted into real number system, sequence and series of real numbers. the idea of Rolle's theorem, mean value theorem, Taylor's theorem and their applications. It also focused on numerical analysis and its application.*

Learning Outcomes: *After completion of this course, the students will be able to*

(1) Understand the concept of sequence, series and their convergence.
(2) Expand functions using Taylor's series and their various properties.
(3) Analyze and solve various problems regarding Rolle's and Mean Value Theorem.
(4) Understand various numerical techniques to compute integration, interpolation etc.

Real Analysis: Representation of real numbers as points on the line and the set of real numbers as complete ordered field. Bounded and unbounded sets, neighborhoods and limit points, Superimum and infimum, derived sets, open and closed sets, sequences and their convergence, limits of some special sequences such as and Cauchy's general principle of convergence, Cauchy's first theorem on limits, monotonic sequences, limit superior and limit inferior of a bounded sequence.

Infinite series, positive termed series and their convergence, Comparison test, D'Alembert's ratio test, Cauchy's n_{th} root test, Raabe's test. Gauss test, Cauchy's condensation test and integral test (Statements and Examples only). Absolute convergence of series, Leibnitz's test for the convergence of alternating series, Conditional convergence. Indeterminate form, L' Hospital's rule.

Review of limit, continuity and differentiability, uniform Continuity and boundedness of a function. Rolle's and Lagrange's Mean Value theorems. Taylor's theorem with lagrange's and Cauchy's form of remainder(without proof). Taylor's and Maclaurin's series expansions of sinx, cosx, log (1+x).

Numerical Analysis: Factorial, finite differences and interpolation. Operators, E and divided difference. Newton's forward, backward and divided differences interpolation formulae. Lagrange's interpolation formulae. Central differences, Gauss and Stirling interpolation formulae. Numerical integration. Trapezoidal rule, Simpson's one-third rule, three-eights

rule, Weddle's rule with error terms. Stirling's approximation to factorial n. Solution of difference equations of first order.

SUGGESTED READINGS

1. Malik S.C. and Savita Arora: Mathematical Analysis, Second Edition, Wiley Eastern Limited, New Age International Limited, New Delhi, 1994.
2. Somasundram D. and Chaudhary B.: A First Course in Mathematical Analysis, Narosa Publishing House, New Delhi, 1987.
3. Gupta S.L. and Nisha Rani: Principles of Real Analysis, Vikas Publ. House Pvt. Ltd., New Delhi, 1995.
4. Appostol T.M.: Mathematical Analysis, Second Edition, Narosa Publishing House, NewDelhi, 1987.
5. Shanti Narayan: A course of Mathematical Analysis, 12th revised Edition, S. Chand & Co. (Pvt.) Ltd., New Delhi, 1987.
6. Singal M.K. and Singal A.R.: A First Course in Real Analysis, 24th Edition, R. Chand & Co., New Delhi, 2003.
7. Bartle, R. G. and Sherbert, D. R. (2002): Introduction to Real Analysis(3rd Edition), John Wiley and Sons (Asia) Pte. Ltd., Singapore.
8. Ghorpade, Sudhir R. and Limaye, Balmohan V. (2006): A Course in Calculus and Real Analysis,Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint.
9. Jain,M. K., Iyengar, S. R. K. and Jain, R. K. (2003): Numerical methods for scientific and engineering computation, New age International Publisher, India.
10. Mukherjee, Kr. Kalyan (1990): Numerical Analysis. New Central Book Agency.
11. Sastry, S.S. (2000): Introductory Methods of Numerical Analysis, 3rd edition, Prentice Hall of India Pvt. Ltd., New Del

MJST08 Statistical Inference I (Credit 4)

Course Objectives:

The main objective of the course is to draw statistically valid conclusions about a population on the basis of a sample in a scientific manner. This course deals with fundamental concepts and techniques of statistical inference including point and interval estimation. Parametric estimation methods are to be explained. Students will be accustomed with theory as well as methods of estimation in this course.

Learning Outcomes: *On completion of the course, students will be able to:*

- *Estimate unknown parameters of a given probability distribution using standard and nonstandard estimation techniques.*
- *Understand how to perform point and interval estimation.*
- *Familiar with the fundamental properties of estimators.*
- *Familiar with the different methods of finding out estimators of parameters.*

Estimation: Concepts of point estimation: unbiasedness, sufficiency, consistency, and efficiency. Neyman-Fisher Factorization theorem, likelihood equivalence, Minimal sufficient statistic, Exponential families and Pitman families, Invariance property of sufficiency under one-one transformation of sample space and parameter space. Fisher information for one and several parameters' models, Complete statistics, Ancillary Statistics, Basu's Theorem.

Cramer-Rao inequality and MVB estimators. Bhattacharya lower bound.

Minimum variance unbiased estimator (MVUE), Rao-Blackwell and Lehmann-Scheffe theorems and their applications.

Methods of estimation: maximum likelihood method, methods of moments and percentiles, solution of likelihood equations, iterative procedures, method of minimum chi-square and modified-minimum chi-square.
Concept of interval estimation, confidence level, confidence band.

SUGGESTED READINGS:

1. Goon A.M., Gupta M.K.: Das Gupta.B. (2005), Fundamentals of Statistics, Vol. I, World Press, Calcutta.
2. Rohatgi V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2nd Edn. (Reprint) John Wiley and Sons.
3. Miller, I. and Miller, M. (2002) : John E. Freund's Mathematical Statistics (6th addition, low price edition), Prentice Hall of India.
4. Dudewicz, E. J., and Mishra, S. N. (1988): Modern Mathematical Statistics. John Wiley & Sons.
5. Mood A.M, Graybill F.A. and Boes D.C,: Introduction to the Theory of Statistics, McGraw Hill.
6. Bhat B.R, Srivenkatramana T and Rao Madhava K.S. (1997) Statistics: A Beginner's Text, Vol. I, New Age International (P) Ltd.
7. Snedecor G.W and Cochran W.G.(1967) Statistical Methods. lowa State University Press.

MJST09A Time Series Analysis (Theory) (Credit 3)

Course Objectives: *Time series data is widespread. The structure and analysis of time series data has been unraveled through this course.*

Learning Outcomes: *On completion of the course, students will be able to:*

1. *Knowledge on different components of time series – extraction of those components.*
2. *Presence of time components through various diagrams*
3. *Basic time series modelling-AR(1), AR(2), MA(1) and MA(2)*
4. *Method of forecasting, exponential smoothing*

Introduction to times series data, application of time series from various fields, Components of a times series, Decomposition of time series. Trend: Estimation of trend by free hand curve method, method of semi averages, fitting a various mathematical curve, and growth curves.

Trend Cont.: Method of moving averages. Detrending. Effect of elimination of trend on other components of the time series. Seasonal Component: Estimation of seasonal component by Method of simple averages, Ratio to Trend,

Seasonal Component cont: Ratio to Moving Averages and Link Relative method, Deseasonalization. Cyclic Component: Harmonic Analysis.

Stationary Time series: Weak stationarity, autocorrelation function and correlogram of moving average.

Some Special Processes: Moving-average (MA) process and Autoregressive (AR) process of orders one and two, Estimation of the parameters of AR (1) and AR (2) – Yule-Walker equations.

Forecasting: Exponential smoothing methods, Short term forecasting methods: Brown's discounted regression, Box-Jenkins method and Bayesian forecasting.

SUGGESTED READING:

1. Kendall M.G. (1976): Time Series, Charles Griffin.
2. Chatfield C. (1980): The Analysis of Time Series –An Introduction, Chapman & Hall.
3. Mukhopadhyay P. (2011): Applied Statistics, 2nd ed. Revised reprint, Books and Allied

MJST09B Time Series Analysis (PRACTICAL/LAB. WORK) (Credit 1)

List of Practical

1. Fitting and plotting of modified exponential curve
2. Fitting and plotting of Gompertz curve
3. Fitting and plotting of logistic curve
4. Fitting of trend by Moving Average Method
5. Measurement of Seasonal indices Ratio-to-Trend method
6. Measurement of Seasonal indices Ratio-to-Moving Average method
7. Measurement of seasonal indices Link Relative method
8. Model fitting using Statistical Software.
9. Forecasting by exponential smoothing using Statistical Software.
10. Forecasting by short term forecasting methods using Statistical Software.

MJST10A Demography (Theory) (Credit 3)

Course Objectives: *The scientific nature of demography proves the following four objectives of demography. These are to achieve knowledge about the size, composition, organization and distribution of the population. To describe the past evolution, present distribution and future changes in the population of an area.*

Learning Outcomes: *On completion of the course, students will be able to understand:*

1. *Coverage and content errors in demographic data*
2. *Measure of fertility, stochastic model for reproduction*
3. *Measures of mortality.*
4. *Life table functions and their applications.*
5. *Population growth and population projection.*

Population Theories: Coverage and content errors in demographic data, use of balancing equations and Chandrasekharan-Deming formula to check completeness of registration data. Adjustment of age data, use of Myer and UN indices, Population composition, dependency ratio.

Introduction and sources of collecting data on vital statistics, errors in census and registration data. Measurement of population, rate and ratio of vital events. Measurements of Mortality: Crude Death Rate (CDR), Specific Death Rate (SDR), Infant Mortality, Rate (IMR) and Standardized Death Rates.

Central Mortality Rates and Force of Mortality. Life (Mortality) Tables: Assumption, description, construction of Life Tables and its uses.

Graduation of mortality curves: Gompertz and Makeham's formula

Abridged Life Tables; Concept and construction of abridged life tables by Reed-Merrell method, Greville's method and King's Method.

Measurements of Fertility: Crude Birth Rate (CBR), General Fertility Rate (GFR), Specific Fertility Rate (SFR) and Total Fertility Rate (TFR). Measurement of Population Growth: Crude rates of natural increase, Pearl's Vital Index, Gross Reproduction Rate (GRR) and Net Reproduction Rate (NRR).

Stationary, Stable and quasi stable populations, intrinsic growth rate. Logistic curve and its fitting using Pearl and Reed's method, Rhode's method and Fisher's method, component method for population projection. Stochastic models for population growth.

SUGGESTED READING:

1. Mukhopadhyay P. (1999): Applied Statistics, Books and Allied (P) Ltd.
2. Gun, A.M., Gupta, M.K. and Dasgupta, B. (2008): Fundamentals of Statistics, Vol. II, 9th Edition, World Press.
3. Biswas, S. (1988): Stochastic Processes in Demography & Application, Wiley Eastern Ltd.
4. Croxton, Fredrick E., Cowden, Dudley J. and Klein, S. (1973): Applied General Statistics, 3rd Edition. Prentice Hall of India Pvt. Ltd.
5. Keyfitz N., Beckman John A.: Demogrphy through Problems S-Verlag New york.

MJST10B Demography (PRACTICAL/LAB. WORK (Credit 1)

List of Practical

1. To calculate CDR and Age Specific death rate for a given set of data
2. To find Standardized death rate by:- (i) Direct method (ii) Indirect method
3. To construct a complete life table
4. To fill in the missing entries in a life table
5. To calculate probabilities of death at pivotal ages and use it construct abridged life table using (i) Reed-Merrell Method, (ii) Greville's Method and (iii) King's Method
6. To calculate CBR, GFR, SFR, TFR for a given set of data
7. To calculate Crude rate of Natural Increase and Pearle's Vital Index for a given set of data
8. Calculate GRR and NRR for a given set of data and compare them

Minor Courses in Statistics

MNST02A Introductory Probability (Theory)Credit 3

Course Objectives: *This is a fundamental course on probability theory. Students must have the knowledge of probability theory, random variables and their distributions to make further progress on statistical analysis. This course is designed into four units, the first units mainly devoted into the basics of probability theory and its applications. Second and third units mainly focused on various types of random variables, expectation, generating functions, convergence and central limit theorems. In the fourth unit students will have a nice idea about several discrete and continuous distributions.*

Learning Outcomes: *After completion of this course, the students will be able to*

(1) Understand the random experiment, sample space and probability theory.
(2) Know the one dimensional random variables and their properties in discrete / continuous framework.
(3) Grasp the idea of convergence in probability and central limit theorem.
(4) Recognize various discrete as well as continuous distributions and their properties.

Probability: Introduction, random experiments, sample space, events and algebra of events. Definitions of Probability – classical, statistical, and axiomatic. Conditional Probability, laws of addition and multiplication, independent events, theorem of total probability, Bayes' theorem and its applications.

Random Variables: Discrete and continuous random variables, p.m.f., p.d.f. ,c.d.f. Illustrations of random variables and its properties. Expectation, variance, moments and moment generating function.

Convergence in probability, almost sure convergence, Chebyshev's inequality, weak law of large numbers, De-Moivre Laplace and Lindeberg-Levy Central Limit Theorem (C.L.T.).

Standard probability distributions: Binomial, Poisson, geometric, negative binomial, hypergeometric, uniform, normal, exponential, beta, gamma.

SUGGESTED READING:

1. Hogg, R.V., Tanis, E.A. and Rao J.M. (2009): Probability and Statistical Inference, Seventh Ed, Pearson Education, New Delhi.
2. Miller, Irwin and Miller, Marylees (2006): John E. Freund's Mathematical Statistics with Applications, (7th Edn.), Pearson Education, Asia.
3. Myer, P.L. (1970): Introductory Probability and Statistical Applications, Oxford & IBH Publishing, New Delhi

MNST02B Introductory Probability (Practical) Credit 1

PRACTICAL/ LAB WORK

List of Practical

1. Fitting of binomial distributions

2. Fitting of Poisson distributions
3. Application problems based on binomial distribution
4. Application problems based on Poisson distribution
5. Problems based on area property of normal distribution
6. To find the ordinate for a given area for normal distribution
7. Application based problems using normal distribution
8. Fitting of normal distribution when parameters are not given

SEMESTER V

Major Courses in Statistics

MJST11A Statistical Inference II (Theory) (Credit 3)

Course Objective: *To impart the concepts and principles of testing of hypothesis, a partof statistical inference. Make the students understand the properties and construction of hypothesis testing procedures.*

Learning Outcomes: *After completing the course students will be able to explain and /or perform:*
1) The need of statistical hypothesis and its different kinds.
2) The different notations and terminologies used in statistical hypothesis.
3) carry outvarious optimum tests for examining a hypothesis regarding a population parameter and apply that idea in research and analysis of real-life problems.

Principles of test of significance: Null and alternative hypotheses (simple and composite), Type-I and Type-II errors, level of significance, critical region, size and power, large sample tests for single proportion, difference of two proportions, single mean, difference of two means, standard deviation and difference of standard deviations by classical and p-value approaches, Confidence interval: Relation between confidence interval and testing of hypothesis, Confidence intervals with shortest expected length. Best critical region, most powerful test, uniformly most powerful test, Neyman-Pearson Lemma and its applications to construct most powerful test. UMP tests for simple null hypothesis against one sided alternatives and for one sided null against one sided alternatives in one parameter exponential family. Extension of these results to Pitman family when only upper and lower end depends on the parameter and to distributions with MLR property, non-existence of UMP test for simple null against two sided alternatives in one parameter exponential family.

Likelihood ratio test, properties of likelihood ratio tests. Applications of likelihood ratio tests for testing equality of means and variances of several independent normal populations. Pearsonian Chi-sqaure and its applications in testing goodness of fit, independence and homogeneity.

Sequential Analysis: Sequential probability ratio test (SPRT) for simple vs simple hypotheses. Fundamental relations among α, β, A and B, determination of A and B in practice. Wald's fundamental identity and the derivation of operating characteristics (OC) and average sample number (ASN) functions, examples based on normal, Poisson, binomial and exponential distributions.

SUGGESTED READINGS:

1. Goon A.M., Gupta M.K.: Das Gupta.B. (2005), Fundamentals of Statistics, Vol. I, World Press, Calcutta.
2. Rohatgi V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2ndEdn. (Reprint) John Wiley and Sons.
3. Miller, I. and Miller, M. (2002) : John E. Freund's Mathematical Statistics (6th addition, low price edition), Prentice Hall of India.
4. Dudewicz, E. J., and Mishra, S. N. (1988): Modern Mathematical Statistics. John Wiley & Sons.
5. Mood A.M, Graybill F.A. and BoesD.C,: Introduction to the Theory of Statistics, McGraw Hill.
6. Bhat B.R, Srivenkatramana T and Rao Madhava K.S. (1997) Statistics: A Beginner's Text, Vol. I, New Age International (P) Ltd.
7. Snedecor G.W and Cochran W.G.(1967) Statistical Methods. Iowa State University Press.
8. Goon A.M., Gupta M.K.: Das Gupta.B. (2005), An Outline of Statistical Theory, Vol. II, World Press, Calcutta.

MJST11B Statistical Inference II (PRACTICAL/LAB. WORK) (Credit 1)

List of Practical

1. Testing of significance and confidence intervals for single proportion and difference of two proportions
2. Testing of significance and confidence intervals for single mean and difference of two means and paired tests.
3. Testing of significance and confidence intervals for difference of two standard deviations.
4. Exact Sample Tests based on Chi-Square Distribution.
5. Testing if the population variance has a specific value and its confidence intervals.
6. Testing of goodness of fit.
7. Testing of independence of attributes.
8. Testing based on 2 X 2 contingency table without and with Yates' corrections.
9. Testing of significance and confidence intervals of an observed sample correlation coefficient.
10. Testing and confidence intervals of equality of two population variances
11. Type I and Type II errors
12. Most powerful critical region (NP Lemma)
13. Uniformly most powerful critical region
14. Unbiased critical region
15. Power curves
16. Likelihood ratio tests for simple null hypothesis against simple alternative hypothesis
17. Likelihood ratio tests for simple null hypothesis against composite alternative hypothesis
18. Asymptotic properties of LR tests
19. SPRT procedure
19. OC function and OC curve
20. ASN function and ASN curve

MJST12A Linear Models (Theory) (Credit 3)

Course Objective: *To make them understand what a linear model is and how various reallife problems can be expressed and analyzed using linear models.*

Learning Outcomes: *After completion of this course, the students will be able to*
1) Understand and be proficient at theoretical developments in the analysis of linear models, including linear and quadratic forms, least squares, linear hypothesis testing, analysis of variance, etc.
2) Apply the results from linear model theory in further advanced topics, such as nonparametric models, multivariate analysis, high-dimensional inference, etc.

Gauss-Markov set-up: Theory of linear estimation, Estimability of linear parametric functions, Method of least squares, Gauss-Markov theorem, Estimation of error variance.

Regression analysis: Simple regression analysis, Estimation and hypothesis testing in case of simple and multiple regression models, Concept of model matrix and its use in estimation.

Analysis of variance: Definitions of fixed, random and mixed effect models, analysis of variance and covariance in one-way classified data for fixed effect models, analysis of variance and covariance in two-way classified data with one or equal number of observation per cell for fixed, random and mixed effect models, Analysis of covariance in two-way layout.

Model checking: Prediction from a fitted model, Violation of usual assumptions concerning normality, Homoscedasticity and collinearity, Diagnostics using quantile-quantile plots

SUGGESTED READINGS:
1. Weisberg, S. (2005). Applied Linear Regression (Third edition). Wiley.
2. Wu, C. F. J. And Hamada, M. (2009). Experiments, Analysis, and Parameter Design Optimization (Second edition), John Wiley.
3. Renchner, A. C. And Schaalje, G. B. (2008). Linear Models in Statistics (Second edition), John Wiley and Sons.

MJST12B Linear Models (PRACTICAL/LAB. WORK) (Credit 1)

List of Practical

1. Estimability when X is a full rank matrix and not a full rank matrix
2. Distribution of Quadratic forms
3. Simple Linear Regression
4. Multiple Regression
5. Tests for Linear Hypothesis
6. Bias in regression estimates
7. Lack of fit
8. Orthogonal Polynomials
9. Analysis of Variance of a one way classified data
10. Analysis of Variance of a two way classified data with one observation per cell
11. Analysis of Covariance of a one way classified data
12. Analysis of Covariance of a two way classified data

MJST13A Sample Survey and Indian Official Statistics (Theory) (Credit 3)

Course Objective: *This is an applied course and it has a huge impact in our society. Sampling techniques is a powerful tool mainly used in real-life situations to get an idea about the whole population. This course is designed into four units first three units mainly aims for the concept of sample and various sampling techniques. The fourth unit focused on the statistical system and their functions in India.*

Learning Outcomes: *After completion of this course, the students will be able to*
(1) Understand the concept of population, sample, non-probability, probability sampling and basic principle of sample survey.
(2) Apply various sampling techniques in real-life studies as well as in different research field.
(3) Realize the present official statistical system in India.
(4) Understand role of Ministry of Statistics & Program Implementation.

Concept of population and sample, complete enumeration versus sampling, sampling and non-sampling errors. Types of sampling: non-probability and probability sampling, basic principle of sample survey, simple random sampling with and without replacement, definition and procedure of selecting a sample, estimates of: population mean, total and proportion, variances of these estimates, estimates of their variances and sample size determination.

Stratified random sampling: Technique, estimates of population mean and total, variances Of these estimates, proportional and optimum allocations and their comparison with SRS.Practical difficulties in allocation, estimation of gain in precision, post stratification And its performance. Systematic Sampling: Technique, estimates of population mean and total, variances of these estimates ($N=n\times k$). Comparison of systematic sampling with SRS and stratified sampling in the presence of linear trend and corrections.

Introduction to Ratio and regression methods of estimation, first approximation to the population mean and total (for SRS of large size), Bias and MSE of these estimates and estimates of them, variances in terms of correlation coefficient for regression method of estimation and their comparison with SRS.

Cluster sampling (equal clusters only) estimation of population mean and its variance, comparison (with and without randomly formed clusters). Relative efficiency of cluster sampling with SRS in terms of intra class correlation. Concept of sub sampling. Two-stage sampling (equal size case) estimation of population mean, variance of the estimator and optimum allocation problem. Double sampling method for ratio and regression methods of estimation.

Present official statistical system in India, Methods of collection of official statistics, their reliability and limitations. Role of Ministry of Statistics & Program Implementation (MoSPI), Central Statistical Office (CSO), National Sample Survey Office (NSSO), and National Statistical Commission. Government of India's Principal publications containing data on the topics such as population, industry and finance.

SUGGESTED READING:

1. Cochran W.G. (1984):Sampling Techniques(3rd Ed.), Wiley Eastern.
2. Sukhatme,P.V., Sukhatme,B.V. Sukhatme,S. Asok,C.(1984). Sampling Theories of Survey With Application, IOWA State University Press and Indian Society of Agricultural Statistics
3. Murthy M.N. (1977): Sampling Theory & Statistical Methods, Statistical Pub. Society, Calcutta.
4. Des Raj and Chandhok P. (1998): Sample Survey Theory, Narosa Publishing House.
5. Goon A.M., Gupta M.K. and Dasgupta B. (2001): Fundamentals of Statistics (Vol.2), World Press.
6. Guide to current Indian Official Statistics, Central Statistical Office, GOI, New Delhi.

7. http://mospi.nic.in/

MJST13B Sample Survey and Indian Official Statistics (PRACTICAL/LAB. WORK) (Credit 1)

List of Practical

1. To select a SRS with and without replacement.
2. For a population of size 5, estimate population mean, population mean square and population variance. Enumerate all possible samples of size 2 by WR and WOR and establish all properties relative to SRS.
3. For SRSWOR, estimate mean, standard error, the sample size
4. Stratified Sampling: allocation of sample to strata by proportional and Neyman's methods Compare the efficiencies of above two methods relative to SRS
5. Estimation of gain in precision in stratified sampling.
6. Comparison of systematic sampling with stratified sampling and SRS in the presence of a linear trend.
7. Ratio and Regression estimation: Calculate the population mean or total of the population. Calculate mean squares. Compare the efficiencies of ratio and regression estimators relative to SRS.
8. Cluster sampling: estimation of mean or total, variance of the estimate, estimate of intra-class correlation coefficient, efficiency as compared to SRS.
9. Two-stage sampling: estimation of mean or total.\
10. Double sampling for ratio and regression methods of estimation of population mean/total: finding the estimated bias and MSE of the estimators

Minor Courses in Statistics

MNST03A Basics of Statistical Inference (Theory)Credit 3

Course Objectives: *This is a fundamental course on statistical inference. Students must have the knowledge of probability theory, random variables and their distributions to make further progress on statistical analysis. This course is designed into four units, the first units mainly devoted into the basics of estimation theory and testing of hypothesis. Second unit focused on categorical data and its associated testing. Third unit contains various nonparametric testing procedures. In the fourth unit students will have a nice idea about analysis of variance and design of experiment.*

Learning Outcomes: *After completion of this course, the students will be able to*
(1) Understand the estimation theory and hypothesis testing.
(2) Analyze the categorical data and its associated testing.
(3) Grasp the idea of non-parametric testing procedures such as Sign test, Wilcoxon test, etc .
(4) Perform the analysis of variance technique and application of design of experiment.

Estimation of population mean, confidence intervals for the parameters of a normal distribution (one sample and two sample problems).
The basic idea of significance test. Null and alternative hypothesis. Type I & Type II errors, level of significance, concept of p-value. Tests of hypotheses for the parameters of a normal distribution (one sample and two sample problems).

Categorical data: Tests of proportions, tests of association and goodness-of-fit using Chisquare test, Yates' correction.

Tests for the significance of correlation coefficient. Sign test for median, Sign test for symmetry, Wilcoxon two-sample test.

Analysis of variance, one-way and two-way classification. Brief exposure of three basic principles of design of experiments, treatment, plot and block. Analysis of completely randomized design, randomized complete block design. Bioassay.

SUGGESTED READING:

1. Daniel, Wayne W., Bio-statistics: A Foundation for Analysis in the Health Sciences. John Wiley (2005).
2. Goon, A.M., Gupta M.K. & Das Gupta, Fundamentals of statistics, Vol.-I & II (2005).
3. Dass, M. N. & Giri, N. C.: Design and analysis of experiments. John Wiley.
4. Dunn, O.J Basic Statistics: A primer for the Biomedical Sciences .(1964, 1977) by John Wiley.
5. Bancroft, Holdon Introduction to Bio-Statistics (1962) P.B. Hoebar New York.
6. Goldstein, A Biostatistics-An introductory text (1971). The Macmillion New York.

MNST03B Basics of Statistical Inference (Practical) Credit 1

PRACTICAL/ LAB WORK

List of Practical

1. Estimators of population mean.
2. Confidence interval for the parameters of a normal distribution (one sample and two sample problems).
3. Tests of hypotheses for the parameters of a normal distribution (one sample and two sample problems).
4. Chi-square test of proportions.
5. Chi-square tests of association.
6. Chi-square test of goodness-of-fit.
7. Test for correlation coefficient.
8. Sign test for median.
9. Sign test for symmetry.
10. Wilcoxon two-sample test.
11. Analysis of Variance of a one way classified data
12. Analysis of Variance of a two way classified data.
13. Analysis of a CRD.
14. Analysis of an RBD.

SEMESTER VI

Major Courses in Statistics

MJST14A Multivariate Analysis (Theory) (Credit 3)

Course Objective: *Modern real-world datasets are becoming increasingly complex, with observations recorded on several variables, leading to the abundance of 'multivariate data'. Understanding the core of these kind of datasets and subsequent analyses has become extremely important in this present scenario. This course will introduce the concept of multivariate data and multiple random variables, and aims to serve as the foundation course for introducing several techniques for multivariate data analysis. The course will be a mix of theory and applications.*

Learning Outcomes: *After completion of this course, the students will be able to*

1. Understand different measures of associations valid for multivariate data-multiple correlation, partial correlation, multiple regression
2. Understand the characteristics of different Multivariate distributions-both discrete and continuous.
3. Understand the notion of concentration ellipsoid.

Multivariate Data: Multiple regression, multiple and partial correlation coefficient and their properties.

Random Vector: Probability mass/density functions, Distribution function, Mean vector & Dispersion matrix, Marginal & Conditional distributions.

Multinomial and Multivariate Normal distribution and their properties. Ellipsoid of concentration.

SUGGESTED READING:

1. Anderson, T.W. (2003): An Introduction to Multivariate Statistical Analysis, 3rd Edn., John Wiley
2. Muirhead, R.J. (1982): Aspects of Multivariate Statistical Theory, John Wiley.
3. Kshirsagar, A.M. (1972) :Multivariate Analysis, 1st Edn. Marcel Dekker.
4. Johnson, R.A. and Wichern, D.W. (2007): Applied Multivariate Analysis, 6th Edn., Pearson & Prentice Hall
5. Mukhopadhyay, P. :Mathematical Statistics.

MJST14B Multivariate Analysis (PRACTICAL/LAB. WORK) (Credit 1)

List of Practical

1. Multiple Regression
2. Multiple and Partial Correlation
3. Bivariate Normal Distribution,

4. Multivariate Normal Distribution

MJST15A Design of Experiments (Theory) (Credit 3)

Course Objective:. *The objective of the course is to develop a systematic method to determine the relationship between factors affecting a process and the output of that process. It is used to find cause and effect relationships. This information is needed to manage process inputs in order to optimize the output.*

Learning Outcomes: *On completion of the course, students will be able to:*

1. Understand the general idea of experiments and hence planning/layout of conducting experiments.
2. Understand basic principles of experiment and some basic designs like, CRD, RBD and LSD.
3. Familiar with incomplete block designs and their applications.
4. Familiar with factorial experiments for industrial and other uses.

Experimental designs: Role, historical perspective, terminology, experimental error, basic principles, uniformity trials, fertility contour maps, choice of size and shape of plots and blocks.

Basic designs: Completely Randomized Design (CRD), Randomized Block Design (RBD), Latin Square Design (LSD) – layout, model and statistical analysis, relative efficiency, analysis with missing observations. Analysis of covariance. Split-plot and Strip-plot design.

Factorial experiments: advantages, notations and concepts, 2^2, 2^3 and 2^n factorial experiments, design and analysis, Total and Partial confounding for 2^n ($n \leq 5$) factorial experiments in a single replicate.

SUGGESTED READINGS:

1. Cochran, W.G. and Cox, G.M. (1959): Experimental Design. Asia Publishing House.
2. Das, M.N. and Giri, N.C. (1986): Design and Analysis of Experiments. Wiley Eastern Ltd.
3. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2005): Fundamentals of Statistics. Vol. II, 8thEdn. World Press, Kolkata.
4. Kempthorne, O. (1965): The Design and Analysis of Experiments. John Wiley.
5. Montgomery, D. C. (2008): Design and Analysis of Experiments, John Wiley.

MJST15B Design of Experiments (PRACTICAL/LAB. WORK) (Credit 1)

List of Practical

1. Analysis of a CRD
2. Analysis of an RBD
3. Analysis of an LSD
4. Analysis of an RBD with one missing observation
5. Analysis of an LSD with one missing observation
6. Analysis of 2^2 and2^3 factorial in CRD and RBD
7. Analysis of 2^2 and2^3 factorial in LSD
8. Analysis of a completely confounded two level factorial design in 2 blocks
9. Analysis of a completely confounded two level factorial design in 4 blocks
10. Analysis of a partially confounded two level factorial design
11. Analysis of a single replicate of a 2^n design

MJST16A Statistical Quality Control (Theory) (Credit 3)

Course Objectives: *The main objectives of the quality control module are to control of material reception, internal rejections, clients, claims, providers and evaluations of the same corrective actions are related to their follow-up. These systems and methods guide all quality activities. It is used to establish a controlled manufacturing process by the use of statistical techniques to reduce process variation. A decrease in variation will lead to: better quality; lower costs (waste, scrap, rework, claims, etc.); more insight into the capability of the process.*

Learning Outcomes: *On completion of the course, students will be able to:*
1. Understand the general idea of quality and monitoring of industrial experiments.
2. Understand basic difference between process control and product control
3. Familiar with control chart techniques and acceptance sampling plan.
4. Familiar with six-sigma methodology.

Quality: Definition, dimensions of quality, historical perspective of quality control and improvements starting from World War II, historical perspective of Quality Gurus and Quality Hall of Fame. Quality system and standards: Introduction to ISO quality standards, Quality registration. Statistical Process Control - Seven tools of SPC, chance and assignable Causes of quality variation. Statistical Control Charts- Construction and Statistical basis of 3-σ Control charts, Rational Sub-grouping.

Control charts for variables: X-bar & R-chart, X-bar & s-chart. Control charts for attributes: np-chart, p-chart, c-chart and u-chart. Comparison between control charts for variables and control charts for attributes. Analysis of patterns on control chart, estimation of process capability.

Acceptance sampling plan: Principle of acceptance sampling plans. Single, Double and sequential sampling plan their OC, AQL, LTPD, AOQ, AOQL, ASN, ATI functions with graphicalinterpretation, use and interpretation of Dodge and Romig's sampling inspection plan tables.

Introduction to Six-Sigma: Overview of Six Sigma, Lean Manufacturing and Total Quality Management (TQM). Organizational Structure and Six Sigma training plans- Selection Criteria for Six-Sigma roles and training plans. Voice of customers (VOC): Importance and VOC data collection. Critical to Quality (CTQ).Introduction to DMAIC using one case study:Define Phase, Measure Phase, Analyse Phase, Improve Phase and Control Phase.

SUGGESTED READING:

1. Montogomery, D. C. (2009): Introduction to Statistical Quality Control, 6th Edition, Wiley India Pvt. Ltd.
2. Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. I & II, 8th Edn. The World Press, Kolkata.
3. Mukhopadhyay, P (2011):Applied Statistics, 2nd edition revised reprint, Books and Allied(P) Ltd.
4. Montogomery, D. C. and Runger, G.C. (2008): Applied Statistics and Probability for Engineers, 3rd Edition reprint, Wiley India Pvt. Ltd.
5. Ehrlich, B. Harris (2002): Transactional Six Sigma and Lean Servicing, 2nd Edition, St. Lucie Press.
6. Hoyle, David (1995): ISO Quality Systems Handbook, 2nd Edition, Butterworth Heinemann Publication.

MJST16B Statistical Quality Control (PRACTICAL/LAB. WORK) (Credit 1)

List of Practical

1. Construction and interpretation of statistical control charts
X-bar & R-chart
X-bar & s-chart
np-chart
p-chart
c-chart
u-chart
2. Single sample inspection plan: Construction and interpretation of OC, AQL, LTPD, ASN, ATI, AOQ, AOQL curves
3. Calculation of process capability and comparison of 3-sigma control limits with specification limits.
4. Use a case study to apply the concept of six sigma application in DMAIC: practical application.

Minor Courses in Statistics

MNST03A Basics of Statistical Inference (Theory)Credit 3

Course Objectives: *This is a fundamental course on statistical inference. Students must have the knowledge of probability theory, random variables and their distributions to make further progress on statistical analysis. This course is designed into four units, the first units mainly devoted into the basics of estimation theory and testing of hypothesis. Second unit focused on categorical data and its associated testing. Third unit contains various nonparametric testing procedures. In the fourth unit students will have a nice idea about analysis of variance and design of experiment.*

Learning Outcomes: *After completion of this course, the students will be able to*
(1) Understand the estimation theory and hypothesis testing.
(2) Analyze the categorical data and its associated testing.
(3) Grasp the idea of non-parametric testing procedures such as Sign test, Wilcoxon test, etc .
(4) Perform the analysis of variance technique and application of design of experiment.

Estimation of population mean, confidence intervals for the parameters of a normal distribution (one sample and two sample problems).
The basic idea of significance test. Null and alternative hypothesis. Type I & Type II errors, level of significance, concept of p-value. Tests of hypotheses for the parameters of a normal distribution (one sample and two sample problems).

Categorical data: Tests of proportions, tests of association and goodness-of-fit using Chisquare test, Yates' correction.

Tests for the significance of correlation coefficient. Sign test for median, Sign test for symmetry, Wilcoxon two-sample test.

Analysis of variance, one-way and two-way classification. Brief exposure of three basic principles of design of experiments, treatment, plot and block. Analysis of completely randomized design, randomized complete block design. Bioassay.

SUGGESTED READING:

1. Daniel, Wayne W., Bio-statistics: A Foundation for Analysis in the Health Sciences.

John Wiley (2005).
2. Goon, A.M., Gupta M.K. & Das Gupta, Fundamentals of statistics, Vol.-I & II (2005).
3. Dass, M. N. &Giri, N. C.: Design and analysis of experiments. John Wiley.
4. Dunn, O.J Basic Statistics: A primer for the Biomedical Sciences .(1964, 1977) by John Wiley.
5. Bancroft, Holdon Introduction to Bio-Statistics (1962) P.B. Hoebar New York.
6. Goldstein, A Biostatistics-An introductory text (1971). The Macmillion New York.

MNST03B Basics of Statistical Inference (Practical) Credit 1

PRACTICAL/ LAB WORK

List of Practical

1. Estimators of population mean.
2. Confidence interval for the parameters of a normal distribution (one sample and two sample problems).
3. Tests of hypotheses for the parameters of a normal distribution (one sample and two sample problems).
4. Chi-square test of proportions.
5. Chi-square tests of association.
6. Chi-square test of goodness-of-fit.
7. Test for correlation coefficient.
8. Sign test for median.
9. Sign test for symmetry.
10. Wilcoxon two-sample test.
11. Analysis of Variance of a one way classified data
12. Analysis of Variance of a two way classified data.
13. Analysis of a CRD.
14. Analysis of an RBD.

SEMESTER VII

Major Courses in Statistics

MJST17A Statistical Inference III (Theory) (Credit 3)

Course Objective: *This course comprises the fundamental concepts of nonparametric methods. It covers a broad range of methods and their applications and is expected to enhance students' abilities in data analysis.*

Learning Outcomes: *On completion of the course, students will be able to:*

1. *Be familiar with nonparametric estimates on abstract space and their properties.*
2. *Construct various nonparametric test statistics, understand their exact and large sample distributions and apply them to analyze different datasets.*

One sample U-statistics, Kernel and symmetric kernel, Two sample U-statistics, Asymptotic distribution of U-statistics. UMVUE property of U-statistics.

Linear rank statistics and their distributional properties, Rank tests, Locally most powerful rank tests.

One sample location problem, sign test and signed rank test, two sample Kolmogorov-Smirnov tests. Two sample location and scale problems. Wilcoxon-Mann-Whitney test, median test, run test, normal score test, ARE of various tests based on linear rank statistics. Kruskal-Wallis k-sample test, Friedman's test.

SUGGESTED READINGS:

1. Rao, C. R. (1973): Linear Statistical Inference.
2. Rohatgi, V. (1988): An Introduction to probability and Mathematical Statistics, Wiley Eastern Ltd., New Delhi (Student Edition).
3. Lehmann, E. L. (1986): Theory of Point Estimation (Student Edition).
4. Lehmann, E. L. (1986): Testing Statistical Hypothesis (Student Edition).
5. Gibbons, J.D. (1985): Nonparametric statistical inference, 2nd ed., Marcel Dekker, Inc.

MJST17B Statistical Inference III (PRACTICAL/LAB. WORK) (Credit 1)

List of Practical

1. Sign test: one sample, two samples, large samples.
2. Run test: Test for randomness based on total number of runs.
3. Wilcoxon-Mann-Whitney U-test
4. Kolmogrov Smirnov test for one sample and two samples.
5. Kruskal-Wallis test

6. Friedman's test

MJST18 Distribution Theory (Credit 4)

Course Objective: *This is a basic and prerequisite course for the students before studying the courses like applied multivariate analysis. It covers a vast area of advanced mathematical statistics-stretching to different multivariate inferential problems.*

Learning Outcomes: *On completion of the course, students will be able to:*

1. *Understand the sampling distributions under multivariate set-up—distribution of sample mean vector, sample variance covariance matrix, sample multiple and partial correlation coefficients etc.*
2. *Understand the concept of Mahalanobis' distance and its distribution.*

Non-central χ^2, t and F distributions. Distributions of quadratic forms under normality, Fisher-Cochran Theorem and related results.

Random Sampling from $N_p(\mu, \Sigma)$ distribution, MLE's of μ and Σ and their Stochastic independence. Central Wishart distribution (without derivation) and its properties (with proof).

Distribution of Hotelling's T^2 and Mahalanobis's D^2 with applications.

Distribution of sample multiple correlation coefficients, partial correlation coefficient and regression coefficient vector.

Multivariate Analysis of Variance (MANOVA): one way and two-way classified data with one observation per cell.

SUGGESTED READINGS:

1. Johnson, S. and Kotz, N. L. (1972): Distributions in Statistics, Vol. I, II and III, Houghton and Miffin.
2. Anderson, T. W. (1983): An Introduction to Multivariate Statistical Analysis, 2nd Ed., Wiley.
3. Johnson, R. and Wichern (1992): Applied Multivariate Statistical Analysis, prentice-Hall, 3rd Ed.
4. Mardia, K.V., Kent, J.T. and Bibby, J.M. (1979):Multivariate Analysis. Academic Press, London.

MJST19A Applied Multivariate Analysis (Theory) (Credit 3)

Course Objective: *To impart the concepts and applications of various multivariate statistical techniques. To make the students understand how to analyze multivariate data using statistical theories.*

Learning Outcomes: *After this course students should be able to*

1. formulate analysis of real-life multivariate data using statistical principles along with softwares.
2. model and forecast various continuous and or discrete dependent variables depending on more than one independent variables.
3. apply various supervised and unsupervised learning methods for real-life applications.

Principal Component Analysis and Canonical Correlation Analysis: Concepts, Computation and Large sample inferences.

Factor Analysis: Concept, Factor model, estimation of factor loadings, Factor rotation, estimation of factor scores, Model fit.

Multivariate Analysis of Variance (MANOVA): one way and two-way classified data with one

observation per cell.

Cluster Analysis: Concept, Proximity measures, Hierarchical and Non-hierarchical clustering techniques

Developing discriminant function considering cost factor. Fisher's method for discriminating two multivariate populations with common dispersion matrix, sample discriminant function, extension for several populations, applications of discriminant analysis.

SUGGESTED READING:

1. Giri, N. C. (1977): Multivariate Statistical Inference, Academic Press.
2. Seber, G. A. F. (1984): Multivariate Observations, Wiley.
3. Anderson, T. W. (1983): An Introduction to Multivariate Statistical Analysis, 2nd Ed., Wiley.
4. Johnson, R. and Wichern (1992): Applied Multivariate Statistical Analysis, prentice-Hall, 3rd Ed.
5. Mardia, K.V., Kent, J.T. and Bibby, J.M. (1979):Multivariate Analysis. Academic Press, London.

MJST19B Applied Multivariate Analysis (PRACTICAL/LAB. WORK) (Credit 1)

List of Practical

1. Principal component analysis
2. Factor analysis
3. Cluster analysis
4. Linear discriminant analysis
5. Multivariate analysis of variance.

Minor Courses in Statistics

MNST04A Applied Statistics (Theory)Credit 3

Course Objectives: *This course is designed for students who will come from other disciplines.*

Learning Outcomes: *This course is designed in such a way that after the completion of this course, students from other disciplines can start doing some elementary analysis of data.*

Economic Time Series: Components of time series, Decomposition of time series- Additive and multiplicative model with their merits and demerits, Illustrations of time series. Measurement of trend by method of free-hand curve, method of semi-averages and method of least squares (linear, quadratic and modified exponential).Measurement of seasonal variations by method of ratio to trend.

Index numbers: Definition, Criteria for a good index number, different types of index numbers. Construction of index numbers of prices and quantities, consumer price index number. Uses and limitations of index numbers.

Statistical Quality Control: Importance of statistical methods in industrial research and practice. Determination of tolerance limits. Causes of variations in quality: chance and assignable. General theory of control charts, process & product control, Control charts for

variables: X- bar and R-charts. Control charts for attributes: p and c-charts.

Demographic Methods: Introduction, measurement of population, rates and ratios of vital events. Measurement of mortality: CDR, SDR (w.r.t. Age and sex), IMR, Standardized death rates.

Life (mortality) tables: definition of its main functions and uses. Measurement of fertility and reproduction: CBR, GFR, and TFR. Measurement of population growth: GRR, NRR.

SUGGESTED READING:

1. Mukhopadhyay, P. (1999): Applied Statistics, New Central Book Agency, Calcutta.
2. Gun, A.M., Gupta, M.K. and Dasgupta, B. (2008): Fundamentals of Statistics, Vol. II, 9th Edition World Press, Kolkata.
3. Gupta, S. C. and Kapoor, V.K. (2008): Fundamentals Of Applied Statistics, 4th Edition(Reprint), Sultan Chand & Sons
4. Montogomery, D. C. (2009): Introduction to Statistical Quality Control, 6th Edition, Wiley India Pvt. Ltd.

MNST04B Applied Statistics (Practical) Credit 1

PRACTICAL/ LAB WORK

List of Practical

1. Measurement of trend: Fitting of linear, quadratic trend, exponential curve and plotting of trend values and comparing with given data graphically.
2. Measurement of seasonal indices by Ratio-to-trend method and plotting of trend values and comparing with given data graphically.
3. Construction of price and quantity index numbers by Laspeyre's formula, Paasche's formula, Marshall-Edgeworth's formula, Fisher's Formula. Comparison and interpretation.
4. Construction of wholesale price index number, fixed base index number and consumer price index number with interpretation
5. Construction and interpretation of X bar & R-chart
6. Construction and interpretation p-chart (fixed sample size) and c-chart
7. Computation of measures of mortality
8. Completion of life table
9. Computation of measures of fertility and population growth

Research Courses in Statistics

MJRST20 Research Methodology Credit 4

Course Objectives: *This course addresses the issues inherent in selecting a research problem and discuss the techniques and tools to be employed in completing a research project. This will also enable the students to prepare report writing and framing Research proposals.*

Learning Outcomes: *After this course students should be able to:*

1. *understand and comprehend the basics in research methodology and applying them in research/ project work.*

2. *select an appropriate research design.*
3. *take up and implement a research project/ study.*
4. *collect the data, edit it properly and analyze it accordingly.*
5. *demonstrate the ability to choose methods appropriate to research objectives.*

Importance of research in decision making, defining research problem and formulation of hypothesis, experimental designs, methods and techniques of data collection. , data processing, statistical analysis and interpretation of data.

Sampling and sampling designs.

Multivariate analysis of data.

Technical aspects of thesis writing.

Knowledge of Computer Software e.g. R, Python, etc. Introduction to LATEX.

SUGGESTED READING:

1. Kothari, C.R.(1985): Research Methodology – Methods and Techniques (Wiley Eastern)
2. Montgomery, D. C. (1976): Design and Analysis of Experiments (Wiley)
3. Johnson, R. & Wichern (1992): Applied Multivariate Statistical Analysis (Prentice-Hall)
4. Cochran, W. G. (1984): Sampling Techniques (Wiley**)**

Without Research Courses in Statistics

MJWRST20A Regression Techniques (Theory) (Credit 3)

Course Objective: *Regression Analysis is the most common statistical modeling approach used in data analysis. In this course students will learn various statistical methods for investigating functional relationships among variables. This is an applied topic that is used in various sectors like academic, company, forecasting etc. The objective is to provide the basic and advanced idea of regression analysis, so that students can be applied this modeling to solve various real life problems and draw inferences from the data.*

Learning Outcomes: *After completing the course the students will be able to:*

1. *Analyze and fit linear, polynomial and multiple linear regression models using data.*
2. *Detect and overcome the issues like model adequacy, multicollinearity and influential points.*
3. *Perform various statistical inferences related to regression analysis.*
4. *Fit the nonlinear, logistic, poisson regression model and their inferences.*

Multiple linear regression.
Model Adequacy Checking: Residual Analysis.
Diagnostics of Leverage and influence, Variable selection and Model Building.
Multicollinearity, Robust Regression.
Introduction to Nonlinear Regression: Parameter estimation, Statistical Inference.
Introduction to Generalized Linear Models: Logistic and Poisson Regression.
Nonparametric Regression.
Use of Statistical Packages: R

SUGGESTED READING:

1. Cook, R. D. and Weisberg, S. (1982). Residual and Influence in Regression. Chapman and Hall.
2. Draper, N. R. and Smith, H. (1998). Applied Regression Analysis. 3rd Ed. Wiley.
3. Gunst, R. F. and Mason, R. L. (1980). Regression Analysis and Its Applications – A Data Oriented Approach. Marcel and Dekker.
4. Rao, C. R. (1973). Linear Statistical Inference and Its Applications. Wiley Eastern.
5. Weisberg, S. (1985). Applied Linear Regression. Wiley.

MJWRST20B Regression Techniques (PRACTICAL/LAB. WORK) (Credit 1)

List of Practical

1. Multiple linear regression
2. Model adequacy checking
3. Diagnostics for leverage and influence
4. Polynomial regression models
5. Multicollinearity
6. Variable selection and model building
7. Nonlinear regression

SEMESTER VIII

Major Courses in Statistics

MJST21 Stochastic Process (Credit 4)

Course Objective: *This course covers a vast area of advanced mathematical statistics- stretching to stochastic process.*

Learning Outcomes: *After completing the course the students will be able to understand:*

1. *Stability of stochastic process—stationarity and limiting distribution of a process*
2. *Markovian model, classifications of state under discrete time Markov model*
3. *Gambler's ruin, Random walk model*
4. *Poisson process, death and birth process, queueing theory*

Introduction to Stochastic Processes (SP): classification of SP's according to state space and time domain. Countable state Markov chains (MC's), Chapman-Kolmogorov equations, calculation of n-step transition probability and its limit. Stationary distribution, classification of states, transient Mc, random walk and gambler's ruin problem. Applications from social, biological and physical sciences.

Discrete state space continuous MC: Kolomogorov-Feller differential equations. Poisson process, birth and death process. Applications to queues and storage problems. First-passage time and other problems. Wiener Process. Martingales and related results.

Renewal theory: Elementary renewal theorem and applications. Statement and applications of key renewal theorem.

SUGGESTED READING:

1. Adke, S. R. and Manjunath, S. M. (1984): An Introduction to Finite Markov Processes, Wiley Eastern.
2. Bhat, B. R. (2000): Stochastic Models: Analysis and Applications, New Age International, India.
3. Jagers, P. (1974): Branching Processes with Biological applications, Wiley
4. Karlin, S. and Taylor, H. M. (1975): A First Course in Stochastic Processes, Vol.1, Academic Press.
5. Medhi, J. (1982): Stochastic Processes, Wiley Eastern.

MJST22A Statistical Inference IV (Theory) (Credit 3)

Course Objective: *This course deals with Bayesian methods which have some advantages over the classical methods, viz. these provide a natural and principled way of combining prior information with data, within a solid decision theoretical framework. These also provide inferences that are conditional on the data and are exact, without reliance on asymptotic approximation. Small sample inference proceeds in the same manner as if one had a large sample. These advantages make these methods widely applicable to the data scientists. This course is designed to enlighten the students about the basics of Bayesian inferences.*

Learning Outcomes: *After completing the course the students will be able to understand:*

1. Explain in detail the Bayesian framework for data analysis and its flexibility and be able to demonstrate when the Bayesian approach can be beneficial
2. Develop, analytically describe, and implement both single and multiparameter probability models in the Bayesian framework.
3. Demonstrate the role of the prior distribution in Bayesian inference and be able to articulate the usage of non-informative priors and conjugate priors.
4. Show high level Interpretation of Bayesian Analysis Results and be able to readily perform Bayesian model evaluation and assessment.
5. Demonstrate the necessary skills to: fit hierarchical models, provide thorough technical specifications for these models.
6. Perform Bayesian computation using Markov chain Monte Carlo methods using R
7. Demonstrate how Bayesian Methods can be used to solve real world problems.
8. Communicate complex statistical ideas to a diverse audience.
9. Demonstrate the necessary research skills to form a hypothesis, collect and analyse data, and reach appropriate conclusions.

Loss functions, expected loss, decision rules, optimal decision rules,
Concepts of admissibility, Bayes rules, admissibility of Bayes rules. Minimax Estimation.

Markov Chain Monte Carlo methods: Gibbs sampling for multivariate simulation, Metropolis-Hastings Algorithm.

Bayesian Linear Regression with Conjugate priors, Bayesian Model Selection, Bayesian Information Criterion

The Bayes Factor, Hierarchical Bayes Examples, Exchangeability, Hierarchical Bayesian Analysis Shrinkage and Bayesian Estimation.

Bayesian Probit and Logistic Regression (Multi-category Ordinal Response).

SUGGESTED READINGS:

J.O. Berger: Statistical Decision Theory and Bayesian Analysis
C.P. Robert: The Bayesian Choice
J.K. Ghosh, M. Delampady& T. Samanta: Bayesian Inference
P. Lee: Bayesian Statistics – An Introduction
Berger, J. O. (1985): Statistical Decision Theory and Bayesian Analysis, 2nd Ed., Springer.

MJST22B Statistical Inference IV (PRACTICAL/LAB. WORK) (Credit 1)

List of Practical

1. Gibbs sampling technique
2. Metropolis-Hastings algorithm
3. Bayesian linear regression
4. Comparing means of two groups
5. Comparing more than two groups.

Minor Courses in Statistics

MNST04A Applied Statistics (Theory)Credit 3

Course Objectives: *This course is designed for students who will come from other disciplines.*

Learning Outcomes: *This course is designed in such a way that after the completion of this course, students from other disciplines can start doing some elementary analysis of data.*

Economic Time Series: Components of time series, Decomposition of time series- Additive and multiplicative model with their merits and demerits, Illustrations of time series. Measurement of trend by method of free-hand curve, method of semi-averages and method of least squares (linear, quadratic and modified exponential).Measurement of seasonal variations by method of ratio to trend.

Index numbers: Definition, Criteria for a good index number, different types of index numbers. Construction of index numbers of prices and quantities, consumer price index number. Uses and limitations of index numbers.

Statistical Quality Control: Importance of statistical methods in industrial research and practice. Determination of tolerance limits. Causes of variations in quality: chance and assignable. General theory of control charts, process & product control, Control charts for variables: X- bar and R-charts. Control charts for attributes: p and c-charts.

Demographic Methods: Introduction, measurement of population, rates and ratios of vital events. Measurement of mortality: CDR, SDR (w.r.t. Age and sex), IMR, Standardized death rates.

Life (mortality) tables: definition of its main functions and uses. Measurement of fertility and reproduction: CBR, GFR, and TFR. Measurement of population growth: GRR, NRR.

SUGGESTED READING:

1. Mukhopadhyay, P. (1999): Applied Statistics, New Central Book Agency, Calcutta.
2. Gun, A.M., Gupta, M.K. and Dasgupta, B. (2008): Fundamentals of Statistics, Vol. II, 9th Edition World Press, Kolkata.
3. Gupta, S. C. and Kapoor, V.K. (2008): Fundamentals Of Applied Statistics, 4th Edition(Reprint), Sultan Chand & Sons
4. Montogomery, D. C. (2009): Introduction to Statistical Quality Control, 6th Edition, Wiley India Pvt. Ltd.

MNST04B Applied Statistics (Practical) Credit 1

PRACTICAL/ LAB WORK

List of Practical

1. Measurement of trend: Fitting of linear, quadratic trend, exponential curve and plotting of trend values and comparing with given data graphically.
2. Measurement of seasonal indices by Ratio-to-trend method and plotting of trend values and comparing with given data graphically.
3. Construction of price and quantity index numbers by Laspeyre's formula, Paasche's formula, Marshall-Edgeworth's formula, Fisher's Formula. Comparison and interpretation.
4. Construction of wholesale price index number, fixed base index number and consumer price index number with interpretation
5. Construction and interpretation of X bar & R-chart
6. Construction and interpretation p-chart (fixed sample size) and c-chart
7. Computation of measures of mortality
8. Completion of life table
9. Computation of measures of fertility and population growth

Research Courses in Statistics

MJRST23 Dissertation (Credit 8)

Without Research Courses in Statistics

MJWRST23 Project (Credit 4)

MJWRST241A Introduction to Operations Research (Theory) (Credit 3)

Course Objective: *The objective of the course is to provide basic idea about operations research and utilizing optimization techniques as its basic tools. Use of statistical and mathematical tools in operations research and their applications to decision making process is primary concern. Role of operations research under different constraint conditions are to be studied.*

Learning Outcomes: *On completion of the course, students will be able to:*
1. Formulate the problem in operations research.
2. Establish the relationship between the variables and constraints by constructing the model.
3. Identify the possible alternative solutions and select the optimal one.
4. Install, test and establish the optimal solution.
5. Learn the tools like Linear Programming Problems, Transportation, assignment and game gamming.
6. Familiar with different inventory models.

Introduction to Operations Research, phases of O.R., model building, various types of O.R. problems. Linear Programming Problem, Mathematical formulation of the L.P.P, graphical

solutions of a L.P.P. Simplex method for solving L.P.P. Charne's M-technique for solving L.P.P. involving artificial variables. Special cases of L.P.P. Concept of Duality in L.P.P: Dual simplex method. Post-optimality analysis.

Transportation Problem: Initial solution by North West corner rule, Least cost method and Vogel's approximation method (VAM), MODI's method to find the optimal solution, special cases of transportation problem. Assignment problem: Hungarian method to find optimal assignment, special cases of assignment problem.

Game theory: Rectangular game, minimax-maximin principle, solution to rectangular game using graphical method, dominance and modified dominance property to reduce the game matrix and solution to rectangular game with mixed strategy. Networking: Shortest route and minimal spanning tree problem.

Inventory Management: ABC inventory system, characteristics of inventory system. EOQ Model and its variations, with and without shortages, Quantity Discount Model with price breaks.

SUGGESTED READING:

1. Taha, H. A. (2007): Operations Research: An Introduction, 8th Edition, Prentice Hall of India.
2. Kanti Swarup, Gupta, P.K. and Manmohan (2007): Operations Research, 13th Edition, Sultan Chand and Sons.
3. Hadley, G: (2002) : Linear Programming, Narosa Publications
4. Hillier, F.A and Lieberman, G.J. (2010): Introduction to Operations Research- Concepts and cases, 9th Edition, Tata McGraw Hill

MJWRST241B Introduction to Operations Research (PRACTICAL/LAB. WORK) (Credit 1)

List of Practical

1. Mathematical formulation of L.P.P and solving the problem using graphical method, Simplex technique and Charne's Big M method involving artificial variables.
2. Identifying Special cases by Graphical and Simplex method and interpretation
   a. Degenerate solution
   b. Unbounded solution
   c. Alternate solution
   d. Infeasible solution
3. Post-optimality
   a. Addition of constraint
   b. Change in requirement vector
   c. Addition of new activity
   d. Change in cost vector
4. Allocation problem using Transportation model
5. Allocation problem using Assignment model
6. Networking problem
   a. Minimal spanning tree problem
   b. Shortest route problem
7. Problems based on game matrix
   a. Graphical solution to mx2 / 2xn rectangular game
   b. Mixed strategy
8. To find optimal inventory policy for EOQ models and its variations
9. To solve all-units quantity discounts model

MJWRST242A Introduction to Data Science (Theory) (Credit 3)

Course Objective: *The aim of this module is to apply quantitative modeling and data analysis techniques to solve real world business problems, communicate findings and effectively present results using data presentation and visualization techniques.*

Learning Outcomes: *After finishing this paper the students should be able to*
(1) recognize and analyze business related problemsusin data.
(2) demonstrate knowledge of statistical data analysis techniques utilized in business decision making.
(3) apply principles of Data Science to solve business problems.
(4) use open source software to solve real-world problems.
(5) apply algorithms to build machine intelligence.

Definitions, Data wrangling, Descriptive Analytics and visualization, Feature extraction techniques, Supervised learning: Regression and Classification, Unsupervised learning, Ensemble learning (averaging, Decision tree, Logistic regression, Support Vector Machines, Bagging, Random Forest, Boosting and gradient boosting), association rules, Elementary text analysis.

Suggested Readings:

1. Bruce, Andrew and Peter, Gedeck: Practical Statistics for Data Scientists, 2nd Edition, 2020.
2. An Introduction to Statistical Learning- with Applications in R: Gareth James, Daniela Witten, Trevor Hastie, Springer, 2013.
3. The Elements of Statistical Learning- Data mining, Inference and Prediction: Trevor Hastie, Robert Tibshirani, Jerome Friedman, Springer, 2003
4. Machine Learning for Hackers: Drew Conway and John Myles White, O'Reilly, 2012

MJWRST242B Introduction to Data Science with Python (PRACTICAL/LAB. WORK) (Credit 1)

List of Practical

1. Data wrangling: missing value imputation, transformation, normalization, scaling, outlier detection.
2. Supervised learning techniques:
   (a) Regression
   (b) Temporal prediction
   (c) Classification
3. Unsupervised learning techniques: Clustering and grouping of variables and objects.

MJWRST243A Categorical Data Analysis and Advanced Data Analysis Techniques (Theory) (Credit 3)

Course Objective: *In most of the applied research problems, it is a common practice to deal with categorical variables. Besides, some of the analyses are to be made on the basis of simulated data because of the lack of proper real-life data set. This particular course is designed to give some idea about the inferences on categorical data as well as about some popular classical and Bayesian computing techniques which are appropriate in absence of proper data support.*

Learning Outcomes: *After completion of the course, the students will be able to*

1. Perform the analysis of contingency tables and fitting of generalized linear models.
2. Perform Gibbs sampling technique to simulate data from a high-dimensional posterior distribution.
3. Apply Markov Chain Monte Carlo Technique for simulation.
4. Apply Bootstrap and jackknife resampling techniques.

Categorical Data: Odds ratio, relative risk and their asymptotic distribution, Measures of ordinal association.

Generalized linear models and its properties.

Logisitic and Poisson regression: logit model for dichotomous data with single and multiple explanatory variables, ML estimation, large sample tests about parameters,
goodness of fit, analysis of deviance, variable selection, extension to polytomous data,
Introduction to Poisson regression.

Introduction to Hierarchical log-linear models. Fitting of log-linear models.

EM algorithm: applications to missing and incomplete data problems, mixture models, Application in Cluster analysis

Markov Chain Monte Carlo methods: Gibbs sampling for multivariate simulation, Metropolis-Hastings Algorithm.

Bootstrap methods: resampling paradigms, bias and standard errors, confidenceintervals, bootstrapping in regression. Jackknife and cross-validation: jackknife in sample surveys, cross-validation for tuning parameters.

SUGGESTED READING:

1. Agresti (1990). Categorical Data Analysis. Wiley, New York.
2. P. McCullagh and J.A. Nelder (1999). Generalized Linear Models, Second edition. Chapman and Hall, New York.
3. Robert and Casella (2004): Monte Carlo Statistical Methods, Springer
4. Efron, B. and Tibshirani, R.J. (1993) An Introduction to the Bootstrap. Chapman & Hall, New York, London.
5. J.K. Ghosh, M. Delampady& T. Samanta: Bayesian Inference

MJWRST243B Categorical Data Analysis and Advanced Data Analysis Techniques (PRACTICAL/LAB. WORK) (Credit 1)

List of Practical

1. Testing independence of attributes from contingency table.
2. Association between ordinal categorical variable.
3. Fitting of logit and probit model.
4. Poisson Regression
5. Application of EM algorithm
6. Bootstrap and Jackknife resampling techniques.
7. Gibbs sampling
8. Metropolis-Hastings algorithm.

MJWRST244A Reliability Analysis (Theory) (Credit 3)

Course Objective: *To impart the concept of reliability and how statistical and probabilistic theories are applied to model and explain life of a mechanical component along with prediction of the same.*

Learning Outcomes: *After completing this course, students will be able to*
1. model and explain the operation time of a mechanical component.
2. predict the reliability of a component, system and of a finished product.
3. explain the nature of the lifetime of an item as well.

Reliability concepts and measures, Components & systems: coherent systems, reliability of the coherent systems. Cuts and paths, modular decomposition, bounds on system reliability; structural and reliability importance of components.

Life distributions, reliability function, hazard rate, common life distributions: exponential, weibull, gamma etc.

Reliability estimation based on failure time in various censored life tests. Stress-strength reliability and its estimation.

Notions of ageing, IFR, IFRA, NBU, DMRL and NBUE and their duals, loss of memory property of the exponential distribution. Closures of these classes under formation of Coherent systems, Convolution and Mixtures.

Univariate shock models and life distribution arising out of them. Bivariate shock models, common bivariate exponential distribution and their properties.

Maintenance and replacement policies; availability of repairable systems; modeling of a repairable system by a non-homogeneous Poisson process.

Basic ideas of accelerated life testing and basic ideas of software reliability.

MJWRST244B Reliability Analysis (PRACTICAL/LAB. WORK) (Credit 1)

List of Practical

1. Estimation of component reliability
2. Estimation of system reliability
3. Estimation failure rate function
4. Kaplan-Meier estimate and related problems

INDIAN KNOWLEDGE SYSTEM (IKS) INCLUSION

Objectives:

(*1) To enlighten the students about the development of Statistical Science in Indian perspective.*
(2) How to use existent statistical measures and techniques in analyzing the data collected from indigenous domains.

Learning outcome:

After completion of these courses, the students will be able to

(5) Represent the indigenous data in tabular and diagrammatic form.
(6) Find the summary measures, viz. the measures of central tendency, measure of dispersion, measures of skewness and kurtosis of a univariate data.
(7) Calculate price and quantity index numbers using simple and weighted average of price relatives, the Chain Base index numbers and consumer price index number.
(8) Coverage and content errors in demographic data
(9) Measure of fertility and mortality in National platform.
(10) Population growth and population projection
(11) Understand the concept of population, sample, non-probability, probability sampling and basic principle of sample survey.
(12) Apply various sampling techniques in real-life studies as well as in different research field.
(13) Realize the present official statistical system in India.
(14) Understand role of Ministry of Statistics & Program Implementation, GOI
(15) Understand the general idea of experiments and hence planning/layout of conducting experiments.

MJST01T

Statistical Methods: Definition and scope of Statistics, concepts of statistical population and sample. Data: quantitative and qualitative, attributes, variables, scales of measurement, nominal, ordinal, interval and ratio. Presentation: tabular and graphical, including histogram and ogives, consistency and independence of data with special reference to attributes.

Measures of Central Tendency: mathematical and positional. Measures of Dispersion: range, quartile deviation, mean deviation, standard deviation, coefficient of variation, Moments, absolute moments, factorial moments, skewness and kurtosis.

MJST01P

List of Practical

1. Graphical representation of data.
2. Problems based on measures of central tendency.
3. Problems based on measures of dispersion.
4. Problems based on combined mean and variance and coefficient of variation.
5. Problems based on moments, skewness and kurtosis.

MJST03T

Index Numbers: Definition, construction of index numbers and problems thereof for weighted and unweighted index numbers including Laspeyre's, Paasche's, Edgeworth-Marshall and Fisher's. Chain index numbers, conversion of fixed based to chain base index numbers and vice-versa. Consumer price index numbers.

MJST03P

13. To calculate price and quantity index numbers using simple and weighted average of price relatives.
14. To calculate chain-base index numbers.
15. To calculate consumer price index numbers

MJST10T

Population Theories: Coverage and content errors in demographic data, use of balancing equations and Chandrasekharan-Deming formula to check completeness of registration data. Adjustment of age data, use of Myer and UN indices, Population composition, dependency ratio.

Introduction and sources of collecting data on vital statistics, errors in census and registration data. Measurement of population, rate and ratio of vital events. Measurements of Mortality: Crude Death Rate (CDR), Specific Death Rate (SDR), Infant Mortality, Rate (IMR) and Standardized Death Rates.

Central Mortality Rates and Force of Mortality. Life (Mortality) Tables: Assumption, description, construction of Life Tables and its uses.

Graduation of mortality curves: Gompertz and Makeham's formula

Abridged Life Tables; Concept and construction of abridged life tables by Reed-Merrell method, Greville's method and King's Method.

Measurements of Fertility: Crude Birth Rate (CBR), General Fertility Rate (GFR), Specific Fertility Rate (SFR) and Total Fertility Rate (TFR). Measurement of Population Growth: Crude rates of natural increase, Pearl's Vital Index, Gross Reproduction Rate (GRR) and Net Reproduction Rate (NRR).

Stationary, Stable and quasi stable populations, intrinsic growth rate. Logistic curve and its fitting using Pearl and Reed's method, Rhode's method and Fisher's method, component method for population projection. Stochastic models for population growth.

MJST10P

List of Practical

5. To calculate CDR and Age Specific death rate for a given set of data
6. To find Standardized death rate by:- (i) Direct method (ii) Indirect method
7. To construct a complete life table
8. To fill in the missing entries in a life table
6. To calculate probabilities of death at pivotal ages and use it construct abridged life table using (i) Reed-Merrell Method, (ii) Greville's Method and (iii) King's Method
9. To calculate CBR, GFR, SFR, TFR for a given set of data
10. To calculate Crude rate of Natural Increase and Pearle's Vital Index for a given set of data
11. Calculate GRR and NRR for a given set of data and compare them

MJST13T

Concept of population and sample, complete enumeration versus sampling, sampling and non-sampling errors. Types of sampling: non-probability and probability sampling, basic principle of sample survey, simple random sampling with and without replacement, definition and procedure of selecting a sample, estimates of: population mean, total and proportion, variances of these estimates, estimates of their variances and sample size determination.

Stratified random sampling: Technique, estimates of population mean and total, variances Of these estimates, proportional and optimum allocations and their comparison with SRS.Practical difficulties in allocation, estimation of gain in precision, post stratification And its performance. Systematic Sampling: Technique, estimates of population mean and total, variances of these estimates ($N=n\times k$). Comparison of systematic sampling with SRS and stratified sampling in the presence of linear trend and corrections.

Introduction to Ratio and regression methods of estimation, first approximation to the population mean and total (for SRS of large size), Bias and MSE of these estimates and estimates of them, variances in terms of correlation coefficient for regression method of estimation and their comparison with SRS.

Cluster sampling (equal clusters only) estimation of population mean and its variance, comparison (with and without randomly formed clusters). Relative efficiency of cluster sampling with SRS in terms of intra class correlation. Concept of sub sampling. Two-stage sampling (equal size case) estimation of population mean, variance of the estimator and optimum allocation problem. Double sampling method for ratio and regression methods of estimation.

Present official statistical system in India, Methods of collection of official statistics, their reliability and limitations. Role of Ministry of Statistics & Program Implementation (MoSPI), Central Statistical Office (CSO), National Sample Survey Office (NSSO), and National Statistical Commission. Government of India's Principal publications containing data on the topics such as population, industry and finance.

MJST13P

List of Practical

1. To select a SRS with and without replacement.
2. For a population of size 5, estimate population mean, population mean square and population variance. Enumerate all possible samples of size 2 by WR and WOR and establish all properties relative to SRS.
3. For SRSWOR, estimate mean, standard error, the sample size

4. Stratified Sampling: allocation of sample to strata by proportional and Neyman's methods Compare the efficiencies of above two methods relative to SRS
5. Estimation of gain in precision in stratified sampling.
6. Comparison of systematic sampling with stratified sampling and SRS in the presence of a linear trend.
7. Ratio and Regression estimation: Calculate the population mean or total of the population. Calculate mean squares. Compare the efficiencies of ratio and regression estimators relative to SRS.
8. Cluster sampling: estimation of mean or total, variance of the estimate, estimate of intra-class correlation coefficient, efficiency as compared to SRS.
9. Two-stage sampling: estimation of mean or total.\
10. Double sampling for ratio and regression methods of estimation of population mean/total: finding the estimated bias and MSE of the estimators

MJST15T

Experimental designs: Role, historical perspective, terminology, experimental error, basic principles, uniformity trials, fertility contour maps, choice of size and shape of plots and blocks.

Basic designs: Completely Randomized Design (CRD), Randomized Block Design (RBD), Latin Square Design (LSD) – layout, model and statistical analysis, relative efficiency

MJST15P

List of Practical
1. Analysis of a CRD
2. Analysis of an RBD
3. Analysis of an LSD