GAUHATI UNIVERSITY



DEPARTMENT OF STATISTICS

FYUGP

Syllabus

Statistics (Major +Minor)

under NEP

Effective from Academic Year 2023 – 24

Program Specific Outcomes

PSO1: Demonstrate proficiency for deep understanding of the Statistical concepts and tools like Probability, Distribution, Sample Survey, Inference and others needed to interpret any real life scenario with a component of uncertainty in the light of Statistical theory.

PSO2: Ability to critically analyze a situation for practical application of Statistics and use relevant Statistical software to scrutinize data and extract value from it.

PSO3: Develop communication skills and a spirit to work as a team to find focused solutions to the problems in the society modeled in the framework of Statistical theory.

PSO4: Instill a spirit of life long endeavor to grow as skilled professionals in Statistics with strong adherence to a value system showing respect to the culture and fellow human beings.

Course Structure

Semester	Course Code	Course Name	Credit	Core/Elective
1	STA1100104MJ	Descriptive Statistics & Probability-1	3+1	Core/Compulsory
	STA1100104MN	Descriptive Statistics & Probability-1	3+1	Core/Compulsory
2	STA1200104MJ	Statistical and Numerical Methods	3+1	Core/Compulsory
	STA1200104MN	Statistical and Numerical Methods	3+1	Core/Compulsory
3	STA2300104MJ	Survey Sampling & Design of Experiments-1	3+1	Core/Compulsory
	STA2300204MJ	Statistical Inference-2	3+1	Core/Compulsory
	STA2300104MN	Survey Sampling & Design of Experiments-1	3+1	Core/Compulsory
4	STA2400104MJ	Probability-2 and Probability Distributions-2	4	Core/Compulsory
	STA2400204MJ	Mathematical Methods	4	Core/Compulsory
	STA2400304MJ	Linear Algebra and System of Equations	4	Core/Compulsory
	STA2400404MJ	Practical 4	4	Core/Compulsory
	STA2400104MN	Operations Research-1	3+1	Core/Compulsory
5	STA3500104MJ	Sampling Distributions and Test of Significance	4	Core/Compulsory
	STA3500204MJ	Design of Experiments- 2	4	Core/Compulsory

	STA3500304MJ	Practical 5	4	Core/Compulsory
	STA3500104MN	Statistical Inference	3+1	Core/Compulsory
6	STA3600104MJ	Applied Statistics	4	Core/Compulsory
	STA3600204MJ	Bivariate/Multivariate Analysis, Stochastic Process & Computer Programming	4	Core/Compulsory
	STA3600304MJ	Operations Research	4	Core/Compulsory
	STA3600404MJ	Practical 6	4	Core/Compulsory
	STA3600104MN	Applied Statistics 1	3+1	Core/Compulsory
7	STA4700104MJ	Probability and Distribution Theory	4	Core/Compulsory
	STA4700204MJ	Survey Sampling	3+1=4	Core/Compulsory
	STA4700304MJ	Mathematical Methods	4	Core/Compulsory
	STA4700404MJ	Research Methodology	4	Core/Compulsory
	STA4700104MN	Operations Research-2	3+1=4	Core/Compulsory
8 **(Option 1: Honours)**	STA4800104MJ	Design of Experiment and Linear Models	4	Core/Compulsory
	STA4800204MJ	Demography and Statistics for National Development	4	Core/Compulsory
	STA4800304MJ	Operations Research	4	Core/Compulsory
	STA4800404MJ	Statistical Analysis using Software	4	Core/Compulsory
	STA4800104MN	Applied Statistics-2	3+1	Core/Compulsory
8 (**Option 2: Honours with Research)**	STA4800104MJ	Design of Experiment and Linear Models	4	Core/Compulsory

	STA4800204MJ	Demography and Statistics for National Development	4	Core/Compulsory
	STA4800304MJ	Operations Research	4	Core/Compulsory
	STA4800412MJ	Dissertation	12	Core/Compulsory
	STA4800104MN	Applied Statistics-2	3+1	Core/Compulsory

Semester 1

Course code: STA1100104MJ

Course Name: Descriptive Statistics & Probability

Credits: 4 (Theory: 03 credits, Practical/Lab: 01 credit)

Course Level: 100-199

Number of Contact classes: 60

Number of Non contact classes : 0

Prerequisites: Mathematics at 10+2 level

Course Objectives: The objective is to give students foundational ideas about the various statistical methods, measures of central tendency and basics of probability. The students are introduced to the methods of collecting data, their representational formats and basic statistical tools.

Learning Outcomes: At the end of the course, students will be able to analyse a data set, represent the data in tabular and diagrammatic form, prepare the frequency distribution, find the summary measures viz. the measures of central tendency, measure of dispersion, measures of skewness and kurtosis of a univariate data.

Course Outcomes:

CO1: Recall and define fundamental concepts in descriptive statistics and probability, such as mean, median, mode, variance, standard deviation, probability distributions, and basic rules of probability.

CO2: Interpret and explain the significance of descriptive statistical measures and probability concepts in real-world contexts. Describe the relationship between descriptive statistics and probability and how they are used to analyze and interpret data.

CO3: Apply descriptive statistical techniques to summarize and analyze data sets, including calculating measures of central tendency, dispersion, and constructing frequency distributions.Apply probability concepts to solve problems involving uncertainty, such as calculating probabilities of events, using probability distributions to model real-world situations, and making predictions based on probability calculations.

CO4: Analyze and interpret data using descriptive statistics and probability techniques, identifying patterns, trends, and relationships within datasets. Evaluate the appropriateness of different statistical methods and probability models for analyzing specific types of data.

CO5: Assess the strengths and limitations of descriptive statistics and probability in addressing real life questions and making informed decisions, and propose improvements or alternative approaches when necessary.

Unit I: Statistical Methods: **Credits: 1**

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, boxplot. Collection and Scrutiny of Data: Primary data-designing a questionnaire and a schedule; Secondary data- their Major sources including some government publications.

Unit 2: Measures of Central Tendency, Dispersion and location: **Credits: 1**

Mathematical measures of central tendency. Measures of Dispersion: range, quartile deviation, mean deviation, standard deviation, coefficient of variation, Moments, skewness and kurtosis, Deciles, percentiles, quartiles.

Unit 3 : Probability: **Unit 3 & 4 combined Credits: 1**

Introduction, random experiments, sample space, 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.

Unit 4: Random variables and Expectations:

Discrete and continuous random variables, p.m.f., p.d.f. and c.d.f., illustrations and properties. Expectation of univariate random variables.

Unit 5 : Practical 1 **Credits: 1**

Note : Students can use calculators / Ms Excel / R programming as convenient**.**

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

4. Medhi, J., Statistical Methods: An Introductory text (New Age International (P) Ltd. 2000).

Semester 1

Course code: STA1100104MN

Course Name: Descriptive Statistics & Probability

Credits: 4 (Theory: 03 credits, Practical/Lab: 01 credit)

Course Level: 100-199

Number of Contact classes: 60

Number of Non contact classes : 0

Prerequisites: Mathematics at 10+2 level

Course Objectives: The objective is to give students foundational ideas about the various statistical methods, measures of central tendency and basics of probability. The students are introduced to the methods of collecting data, their representational formats and basic statistical tools.

Learning Outcomes: At the end of the course, students will be able to analyse a data set, represent the data in tabular and diagrammatic form, prepare the frequency distribution, find the summary measures viz. the measures of central tendency, measure of dispersion, measures of skewness and kurtosis of a univariate data.

Course Outcomes:

CO1: Recall and define fundamental concepts in descriptive statistics and probability, such as mean, median, mode, variance, standard deviation, probability distributions, and basic rules of probability.

CO2: Interpret and explain the significance of descriptive statistical measures and probability concepts in real-world contexts. Describe the relationship between descriptive statistics and probability and how they are used to analyze and interpret data.

CO3: Apply descriptive statistical techniques to summarize and analyze data sets, including calculating measures of central tendency, dispersion, and constructing frequency distributions.Apply probability concepts to solve problems involving uncertainty, such as calculating probabilities of events, using probability distributions to model real-world situations, and making predictions based on probability calculations.

CO4: Analyze and interpret data using descriptive statistics and probability techniques, identifying patterns, trends, and relationships within datasets. Evaluate the appropriateness of different statistical methods and probability models for analyzing specific types of data.

CO5: Assess the strengths and limitations of descriptive statistics and probability in addressing real life questions and making informed decisions, and propose improvements or alternative approaches when necessary.

Unit I: Statistical Methods: **Credits: 1**

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, boxplot. Collection and Scrutiny of Data: Primary data-designing a questionnaire and a schedule; Secondary data- their Major sources including some government publications.

Unit 2: Measures of Central Tendency, Dispersion and location: **Credits: 1**

Mathematical measures of central tendency. Measures of Dispersion: range, quartile deviation, mean deviation, standard deviation, coefficient of variation, Moments, skewness and kurtosis, Deciles, percentiles, quartiles.

Unit 3 : Probability: **Unit 3 & 4 combined Credits: 1**

Introduction, random experiments, sample space, 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.

Unit 4: Random variables and Expectations:

Discrete and continuous random variables, p.m.f., p.d.f. and c.d.f., illustrations and properties. Expectation of univariate random variables.

Unit 5 : Practical 1 **Credits: 1**

Note : Students can use calculators / Ms Excel / R programming as convenient**.**

6. Graphical representation of data.
7. Problems based on measures of central tendency & dispersion.
8. Problems based on measures of location.
9. Problems based on combined mean, variance and coefficient of variation.
10. Problems based on 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.

4. Medhi, J., Statistical Methods: An Introductory text (New Age International (P) Ltd. 2000).

Semester 2

Course code : STA1200104MJ

Course Name :Statistical and Numerical Methods

Credits: 4 (Theory: 03 credits, Practical/Lab: 01 credit)

Course Level : 100-199

Number of Contact classes : 60

Number of Non contact classes : 00

Prerequisites : NIL

Course Objectives: The course will expose students to the need and nuances of correlation and basic probability distributions along with notions of Uncertainty and Randomness, Probability & Random variables and Basic Data Analysis.

Learning Outcomes: At the end of the course, students will be able to apply the tools of correlation and model building in data analysis along with learning the use of basic probability distributions.

Course Outcomes:

CO1: Discuss key concepts related to correlation and regression analysis, such as correlation coefficients, scatterplots, regression lines, and the interpretation of regression coefficients. Demonstrate an understanding of the mathematical principles underlying correlation and regression analysis, including covariance, correlation, least squares regression, and the assumptions underlying these techniques.

CO2: Demonstrate formulation of null and alternative hypotheses, selecting appropriate test statistics, determining critical values or p-values, and drawing conclusions based on the results. Demonstrate an understanding of the fundamental concepts of finite difference methods, including numerical solution techniques.

CO3: Apply the understanding of correlation and regression to real-world scenarios, such as predicting sales based on advertising expenditure or assessing the relationship between variables in scientific research. Apply different probability distributions, including the binomial, Poisson, and normal distributions. Illustrate the characteristics and properties of each distribution, such as mean, variance, skewness, and kurtosis, and discern when each distribution is appropriate for modeling real-world phenomena.

CO4: Apply various hypothesis testing techniques, such as z-tests, t-tests, F-tests, and chi-square tests, to analyze and interpret data from different research scenarios.

CO5: Apply and solve physical or mathematical problems by finite difference approximation, such as forward, backward, and Newton's divided difference, Lagrange's formula, and numerical integration.

Unit 1: Bivariate data analysis: **Unit 1 & 2 combined Credits: 1**

Definition, scatter diagram, Karl Pearson's correlation coefficient and its properties, partial and multiple correlation (3 variables only), rank correlation, correlation ratio. Simple linear regression, principle of least squares.

Unit 2: Basic Probability Distributions:

Standard probability distributions: Binomial, Poisson, Uniform, Normal. Fitting of these distributions.

Unit 3 : Testing of Hypothesis: **Credits: 1**

Null and alternative hypotheses, level of significance, Type I and Type II errors, their probabilities and critical region, size and power, Large sample tests, single mean, difference of two means (technique only; without derivation),

t – test for testing single mean, difference of two means, paired t test (technique only without derivation),

F – test for testing equality of variance (technique only without derivation).

Categorical Data Analysis: Categorical data: Tests of proportions (testing single proportion, difference of two proportions,) tests of association, independence of attributes and goodness-of-fit using Chi- square Test (technique only without derivation),

Unit 4: Finite Difference: **Credits: 1**

Definition, Operators Δ & E, their properties, Difference table, missing terms, Interpolation: Definition, Newton's Forward and Backward interpolation formula, Gauss Interpolation formula. Divided Difference (DD): Definition, DD table, Newton's DD formula. Lagrange's interpolation formula. Numerical Integration: Introduction, General quadrature formula, Trapezoidal, Simpson's 1/3rd & 3/8th rules, Newton-Raphson method.

Unit 5 : Practical 2 **Credits: 1**

Note : Students can use calculators / Ms Excel / R programming as convenient.

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. Problems based on area property of normal distribution.
7. To find the ordinate for a given area for normal distribution.
8. Fitting of normal distribution when parameters are given.
9. Fitting of normal distribution when parameters are not given.
10. Practicals on Unit-1
11. Practicals on Unit-3
12. Practicals on Unit-4

SUGGESTED READING:

1. Goon,A.M.,Gupta,M.K.andDasgupta,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. 2nd Edn. (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.

Semester 2

Course code : STA1200104MN

Course Name :Statistical and Numerical Methods

Credits: 4 (Theory: 03 credits, Practical/Lab: 01 credit)

Course Level : 100-199

Number of Contact classes : 60

Number of Non contact classes : 00

Prerequisites : NIL

Course Objectives: The course will expose students to the need and nuances of correlation and basic probability distributions along with notions of Uncertainty and Randomness, Probability & Random variables and Basic Data Analysis.

Learning Outcomes: At the end of the course, students will be able to apply the tools of correlation and model building in data analysis along with learning the use of basic probability distributions.

Course Outcomes:

CO1: Discuss key concepts related to correlation and regression analysis, such as correlation coefficients, scatterplots, regression lines, and the interpretation of regression coefficients. Demonstrate an understanding of the mathematical principles underlying correlation and regression analysis, including covariance, correlation, least squares regression, and the assumptions underlying these techniques.

CO2: Demonstrate formulation of null and alternative hypotheses, selecting appropriate test statistics, determining critical values or p-values, and drawing conclusions based on the results. Demonstrate an understanding of the fundamental concepts of finite difference methods, including numerical solution techniques.

CO3: Apply the understanding of correlation and regression to real-world scenarios, such as predicting sales based on advertising expenditure or assessing the relationship between variables in scientific research. Apply different probability distributions, including the binomial, Poisson, and normal distributions. Illustrate the characteristics and properties of each distribution, such as mean, variance, skewness, and kurtosis, and discern when each distribution is appropriate for modeling real-world phenomena.

CO4: Apply various hypothesis testing techniques, such as z-tests, t-tests, F-tests, and chi-square tests, to analyze and interpret data from different research scenarios.

CO5: Apply and solve physical or mathematical problems by finite difference approximation, such as forward, backward, and Newton's divided difference, Lagrange's formula, and numerical integration.

Unit 1: Bivariate data analysis: **Unit 1 & 2 combined Credits: 1**

Definition, scatter diagram, Karl Pearson's correlation coefficient and its properties, partial and multiple correlation (3 variables only), rank correlation, correlation ratio. Simple linear regression, principle of least squares.

Unit 2: Basic Probability Distributions:

Standard probability distributions: Binomial, Poisson, Uniform, Normal. Fitting of these distributions.

Unit 3 : Testing of Hypothesis: **Credits: 1**

Null and alternative hypotheses, level of significance, Type I and Type II errors, their probabilities and critical region, size and power, Large sample tests, single mean, difference of two means (technique only; without derivation),

t – test for testing single mean, difference of two means, paired t test (technique only without derivation),

F – test for testing equality of variance (technique only without derivation).

Categorical Data Analysis: Categorical data: Tests of proportions (testing single proportion, difference of two proportions,) tests of association, independence of attributes and goodness-of-fit using Chi- square Test (technique only without derivation),

Unit 4: Finite Difference: **Credits: 1**

Definition, Operators Δ & E, their properties, Difference table, missing terms, Interpolation: Definition, Newton's Forward and Backward interpolation formula, Gauss Interpolation formula. Divided Difference (DD): Definition, DD table, Newton's DD formula. Lagrange's interpolation formula. Numerical Integration: Introduction, General quadrature formula, Trapezoidal, Simpson's 1/3rd & 3/8th rules, Newton-Raphson method.

Unit 5 : Practical 2 **Credits: 1**

Note : Students can use calculators / Ms Excel / R programming as convenient.

13. Fitting of binomial distributions for n and p=q =½.

14. Fitting of binomial distributions for given n and p.
15. Fitting of binomial distributions after computing mean and variance.
16. Fitting of Poisson distributions for given value of lambda.
17. Fitting of Poisson distributions after computing mean.
18. Problems based on area property of normal distribution.
19. To find the ordinate for a given area for normal distribution.
20. Fitting of normal distribution when parameters are given.
21. Fitting of normal distribution when parameters are not given.
22. Practicals on Unit-1
23. Practicals on Unit-3
24. Practicals on Unit-4

SUGGESTED READING:

6. Goon,A.M.,Gupta,M.K.andDasgupta,B.(2003): An Outline of Statistical Theory, Vol. I, 4th Edn. World Press, Kolkata.
7. Rohatgi V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2nd Edn. (Reprint) John Wiley and Sons.
8. Hogg, R.V. and Tanis, E.A. (2009): A Brief Course in Mathematical Statistics. Pearson Education.
9. Johnson, R.A. and Bhattacharya, G.K.(2001): Statistics-Principles and Methods, 4th Edn. John Wiley and Sons.
10. 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.

Semester 3

Course code : STA2300104MJ

Course Name : Survey Sampling and Design of Experiments-1

Credits: 4 (Theory: 03 credits, Practical/Lab: 01 credit)

Course Level : 200-299

Number of Contact classes : 60

Number of Non contact classes : 00

Prerequisites : NIL

Course Objective : This course is designed to provide students with knowledge about the techniques of data collection.

Learning Outcomes: At the end of the course, students will be able to know the basic designs of sampling schemes.

Course Outcome:

CO1: Describe basic concepts of population and sample, complete enumeration versus sampling, principal steps in a sample survey, sampling and non-sampling errors.

CO2: Discuss basic principle of sample survey, different types of sampling: Simple random sampling, Stratified random sampling, Systematic sampling.

CO3: Illustrate the basic principles of Design of Experiments and lay out of basic design: CRD and RBD

CO4: Apply ANOVA (One way and Two way) in Design of Experiments.

CO5: Determine the sample size (in case of proportional allocation only) for field survey.

Unit1: Survey Sampling: **Unit 1 & 2 combined Credits: 1**

Complete enumeration, controlled experiments, observational studies and sample surveys, Concept of population and sample, complete enumeration versus sampling, principal steps in a sample survey, sampling and non-sampling errors. Types of sampling: non-probability and probability sampling, basic principle of sample survey.

Unit 2: **Credits: 1**

Simple random sampling: Simple random sampling with and without replacement, definition and procedure of selecting a sample, estimates of : population mean, total and mean square. Determination of sample size- preliminary formulas only.

Unit 3: Stratified random sampling and Systematic Sampling: **Credits: 1**

Technique of stratified sampling, estimates of population mean and total, variances of these estimates (with derivation), proportional and optimum allocations and their comparison with SRS (with derivation), determination of sample size (in case of proportional allocation only). Systematic Sampling: Technique, estimates of population mean and total, variances of these estimates (N=n x k). Comparison of systematic sampling with SRS (with derivation).

Unit 4 : Design of Experiments **Credits: 1**

Basic principles of Design, Basic designs: Completely Randomized Design (CRD), Randomized Block Design (RBD)– layout, model and statistical analysis (without derivations), (analysis with missing observations not required).

One way and two way ANOVA.

Unit 5 : Practical 3 **Credits: 1**

Note : Students can use calculators / Ms Excel / R programming as convenient.

List of Practicals : Practicals on Unit-2, 3 & 4.

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.

5. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2001): Fundamentals of Statistics (Vol.2), World Press.

6. Cochran, W.G. and Cox, G.M. (1959): Experimental Design. Asia Publishing House.

7. Das, M.N. and Giri, N.C. (1986): Design and Analysis of Experiments. Wiley Eastern Ltd.

8. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2005): Fundamentals of Statistics. Vol. II, 8th Edn. World Press, Kolkata.

Semester 3

Course code : STA2300204MJ
Course Name : Statistical Inference-2

Credits: 4 (Theory: 03 credits, Practical/Lab: 01 credit)

Course Level : 200-299

Number of Contact classes : 60

Number of Non contact classes : 00

Course Objective: This course has the objective of exposing students to concepts of estimation and testing of hypothesis - its types, and desirable properties of an estimator and how to find a good estimate from a sample data
Learning Outcomes: At the end of the course, students shall be able to apply how to examine the properties of estimators and how to test different types of statistical hypothesis.

Course outcomes:

CO1: Describe the concepts of estimation, unbiasedness, sufficiency, consistency and efficiency, non-parametric tests and distribution free procedures.

CO2: Discuss factorization theorem. minimum variance unbiased estimator (MVUE). Cramer-Rao inequality and MVB estimators, testing of hypothesis problems based on the traditional approach and p-value approach.

CO3: Discuss the different methods of estimation such as method of moments, method of maximum likelihood.
CO4: Illustrate different non-parametric tests such as Test for randomness based on total number of runs, Empirical distribution function, Kolmogrov-Smirnov test for one sample, Sign tests-one sample and two samples, Wilcoxon-Mann-Whitney test, Kruskal-Wallis test.

CO5: Utilize the above learnt concepts to solve numerical problems.

Unit 1: Estimation: **Credits: 01**

Concepts of estimation, unbiasedness, sufficiency, consistency and efficiency. Factorization theorem. Minimum variance unbiased estimator (MVUE). Cramer-Rao inequality and MVB estimators.

Methods of estimation - Method of moments, method of maximum likelihood estimation

Unit 2 : Hypothesis Testing II **Credits: 01**

Null and alternative hypotheses, level of significance, Type I and Type II errors, their probabilities and critical region- harder problems and concepts (over and above what is covered in unit 3 of paper STA 201). Testing of hypothesis based on traditional and p-value approach

MP test, UMP test, unbiased test, Neyman Pearson Lemma (with proof) and its use, power curve. Likelihood ratio test, properties of likelihood ratio tests (without proof).

Unit 3: Non-parametric Tests: **Credits: 01**

Nonparametric Tests: Introduction and Concept, Concept of Distribution free procedure, Test for randomness based on total number of runs, Empirical distribution function, Kolmogrov-Smirnov test for one sample, Sign tests-one sample and two samples, Wilcoxon-Mann-Whitney test, Kruskal-Wallis test – all without derivation.

Unit 4: Practicals from units 2 and 3 **Credits: 01**

SUGGESTED READING:

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, Mc Graw 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.

Semester 3

Course code : STA2300104MN

Course Name : Survey Sampling and Design of Experiments-1

Credits: 4 (Theory: 03 credits, Practical/Lab: 01 credit)

Course Level : 200-299

Number of Contact classes : 60

Number of Non contact classes : 00

Prerequisites : NIL

Course Objective : This course is designed to provide students with knowledge about the techniques of data collection.

Learning Outcomes: At the end of the course, students will be able to know the basic designs of sampling schemes.

Course Outcome:

CO1: Describe basic concepts of population and sample, complete enumeration versus sampling, principal steps in a sample survey, sampling and non-sampling errors.

CO2: Discuss basic principle of sample survey, different types of sampling: Simple random sampling, Stratified random sampling, Systematic sampling.

CO3: Illustrate the basic principles of Design of Experiments and lay out of basic design: CRD and RBD

CO4: Apply ANOVA (One way and Two way) in Design of Experiments.

CO5: Determine the sample size (in case of proportional allocation only) for field survey.

Unit1: Survey Sampling: **Unit 1 & 2 combined Credits: 1**

Complete enumeration, controlled experiments, observational studies and sample surveys, Concept of population and sample, complete enumeration versus sampling, principal steps in a sample survey, sampling and non-sampling errors. Types of sampling: non-probability and probability sampling, basic principle of sample survey.

Unit 2: **Credits: 1**

Simple random sampling: Simple random sampling with and without replacement, definition and procedure of selecting a sample, estimates of : population mean, total and mean square. Determination of sample size- preliminary formulas only.

Unit 3: Stratified random sampling and Systematic Sampling: **Credits: 1**

Technique of stratified sampling, estimates of population mean and total, variances of these estimates (with derivation), proportional and optimum allocations and their comparison with SRS (with derivation), determination of sample size (in case of proportional allocation only). Systematic Sampling: Technique, estimates of population mean and total, variances of these estimates (N=n x k). Comparison of systematic sampling with SRS (with derivation).

Unit 4 : Design of Experiments **Credits: 1**

Basic principles of Design, Basic designs: Completely Randomized Design (CRD), Randomized Block Design (RBD)– layout, model and statistical analysis (without derivations), (analysis with missing observations not required).

One way and two way ANOVA.

Unit 5 : Practical 3 **Credits: 1**

Note : Students can use calculators / Ms Excel / R programming as convenient.

List of Practicals : Practicals on Unit-2, 3 & 4.

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.

5. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2001): Fundamentals of Statistics (Vol.2), World Press.

6. Cochran, W.G. and Cox, G.M. (1959): Experimental Design. Asia Publishing House.

7. Das, M.N. and Giri, N.C. (1986): Design and Analysis of Experiments. Wiley Eastern Ltd.

8. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2005): Fundamentals of Statistics. Vol. II, 8th Edn. World Press, Kolkata.

Semester 4

Course code : STA2400104MJ

Course Name : Probability-2 and Probability Distributions-2

Credits: 4 (Theory: 04 credits, Practical/Lab: 00 credit)

Course Level : 200-299

Number of Contact classes : 60

Number of Non contact classes : 00

Course Objective: This course has the objective of providing exposure to random variable and large scale properties of probability distributions. This is a fundamental course on probability theory, random variables and their distributions to make further progress on statistical analysis. Students in this course This course also introduces the ideas of Statistical Inference and its importance in real world applications

Learning Outcomes: At the end of the course, students shall be able to appreciate the large sample implications of various statistical measures and also learn about a number of statistical distributions. They will be able to determine whether or not moments exist of any given random variable and if so, to determine them. They will also be able to use tools like Probability Generating function and Moment generating functions to study distributions in addition to learning several univariate discrete and continuous distributions and their characterizations.

Course outcomes:

CO1: Define the concepts of two dimensional random variables, joint, marginal and conditional p.m.f, p.d.f., and c.d.f., independence of variables, bivariate transformations, conditional expectations, conditional variance, moments, factorial moments, cumulants, order statistics, generating functions.

CO2: Explain the properties of generating functions.

CO3: Classify the two dimensional random variable and explain their properties; explain the Chebyshev's Lemma, Weak Law of Large Numbers (WLLN) due to Bernoulli, Khintchine and Lyapunov, Central Limit Theorem (CLT)-De-Moivre's and Levy – Lindeberg CLT and apply these ideas to solve numerical problems.

CO4: Illustrate the various probability distributions such as Geometric, Negative Binomial, Hypergeometric, Multinomial, Exponential, Weibull, Cauchy, Beta and Gamma distributions, Lognormal, their properties and limiting cases and utilize these ideas to solve numerical problems.

CO5: Determine the distribution of the rth order statistic, smallest and largest order statistics. Joint distribution of rth and sth order statistics, distribution of sample median and sample range.

Unit 1: Functions of Random variables **Credits: 1**

Two dimensional random variables: discrete and continuous type, joint, marginal and conditional p.m.f, p.d.f., and c.d.f., independence of variables, bivariate transformations, conditional expectations, conditional variance.

Moments, factorial moments, Cumulants, Generating functions – mgf, pgf, cgf together wih their properties.

Unit2: Probability–II **Credits: 1**

Chebyshevs Lemma (with proof), Weak Law of Large Numbers (WLLN) due to Bernoulli, Khintchine and Lyapunov. Central Limit Theorem (CLT)-De-Moivre's and Levy – Lindeberg CLT (with proof) -

Unit3: Probability Distributions II : **Credits: 1**

Geometric, Negative Binomial, Hypergeometric, Multinomial, Exponential, Weibull, Cauchy, Beta and Gamma distributions along with their properties and limiting/approximation cases, Lognormal.

Normal distribution – harder problems and theory (over and above what is covered in unit 2 of paper STA0200104Mj).

Unit 4 : Order Statistics: **Credits: 1**

Introduction, distribution of the rth order statistic, smallest and largest order statistics. Joint distribution of rth and sth order statistics, distribution of sample median and sample range.

List of reference books:

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

Semester 4

Course Code: STA2400204MJ

Course Name: Mathematical Methods

Credits: 4 (Theory: 04 credits, Practical/Lab: 00 credit)

Course Level: 200-299

Number of Contact classes : 60

Number of Non-contact classes : 00

Course Objective: This course has the objective of providing student with the necessary mathematical basics of Calculus and Algebra in so far as they are used in the study of Statistics.

Learning Outcomes: At the end of the course, students shall be able to use the mathematical results of Calculus and Algebra to develop better understanding of some Statistical theories like Distribution theory and Multivariate analysis.

Course Outcomes:

CO1: Relate Calculus as a preliminary tool to understand Distribution theory and other concepts in Statistics.

CO2: Solve problems on constrained optimizations, functions of several variables and to classify between homogeneous and non- homogeneous differential equations including methods to solve them.

CO3: Apply various tests to investigate the convergence of infinite series and relate the application of infinite series in discrete distributions.

CO4: Interpolate or extrapolate a numerical series and solve transcendental equations by numerical methods.

CO5: Illustrate some real-life applications of calculus and numerical analysis specially in the domain of Statistics.

Unit1: Calculus **Credits: 2**

Indeterminate forms: L-Hospital's rule, Maxima and minima of functions of one and two variables, constrained optimization techniques (with Lagrange's multiplier) along with some problems. Jacobian- transformation of variables. Beta and Gamma functions: properties and relationship between them.

Exact differential equations, Integrating factors, change of variables, Total differential equations, Differential equations of first order and first degree, Homogeneous and non-homogeneous linear differential equations of order n with constant coefficients, Different forms of particular integrals.

Unit 2 : Infinite Series: **Credits: 1**

Infinite series, positive termed series and their convergence; Comparison test, D'Alembert's ratio test, Cauchy's nth root test, Raabe's test (For all the tests, statement only is required, without proof. Applications only).

Unit 3: Numerical Analysis: **Credits: 1**

Factorial notation, Zero differences, Central differences due to Bessel. Stirling's approximation to factorial n. Solution of difference equations of first order, Numerical methods for determination of approximate solutions of equations – Regula Falsi method, Bisection method.

SUGGESTED READINGS:

1. Gorakh Prasad: Differential Calculus, Pothishala Pvt. Ltd., Allahabad (14th Edition-1997).

2. Gorakh Prasad: Integral Calculus, Pothishala Pvt. Ltd., Allahabad (14th Edition-2000).

3. Zafar Ahsan: Differential Equations and their Applications, Prentice-Hall of India Pvt. Ltd., New Delhi

4. Piskunov, N: Differential and Integral Calculus, Peace Publishers, Moscow.

5. Bartle, R. G. and Sherbert, D.R. Introduction to Real Analysis (John Wiley and Sons,

New Delhi, 2007).

6. Simmons, G.F. Differential Equations with Applications and Historical Notes (Tata McGraw- Hill, New Delhi, 1991).

Semester 4

Course code: STA2400304MJ

Course Name: Linear Algebra and System of Equations

Credits: 4 (Theory: 04 credits, Practical/Lab: 00 credit)

Course Level : 200-299

Number of Contact classes : 60

Number of Non contact classes : 00

Course Objective: This course has the objective of providing students with the necessary mathematical basics on matrices.

Learning Outcomes: At the end of the course, students shall be able to explain the basics of matrices and solve numerical problems based on basics of matrix theory in addition to solving systems of linear equations.

Course outcomes:

CO1: Explain the concept of rank and calculate the rank of the sum and the product of two matrices.

CO2: Compute Characteristic roots and vectors of a matrix and apply some of their properties to solve simple problems in Statistics.

CO3: Discuss Cayley Hamilton theorem and its applications, Classify different Quadratic forms and indicate methods to diagonalize them.

CO4: Define vector spaces, vector subspaces, differentiate between linear dependent and independent vectors and assess whether a set of vectors constitutes a basis or not and to identify the dimension of a vector space.

CO5: Compute the determinant and inverse of a matrix by various methods and solve a system of linear equations with illustration on some of its applications.

Unit 1: Linear Algebra **Credits: 2**

Rank of a matrix, standard theorems on ranks, rank of the sum and the product of two matrices. Partitioning of matrices and simple properties. Characteristic roots and Characteristic vector, Properties of characteristic roots, Cayley Hamilton theorem, Quadratic forms, Linear orthogonal transformation and their diagonalization.

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

Unit 2: Determinants and System of Linear Equation: **Credits: 2**

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, Jacobi's Theorem, product of determinants. Use of determinants in solution of linear equations, the system of linear equations, row reduction and echelon forms, the matrix equations AX=B, solution of linear equations, linear independence, Applications of linear equations, inverse of a matrix.

SUGGESTED READINGS:

1. Lay David C.: Linear Algebra and its Applications, Addison Wesley ,2000.
2. Schaum's Outlines: Linear Algebra, Tata McGraw-Hill Edition, 3rd Edition, 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 Algebra, Narosa Publishing House (Reprint), 2002.
10. Searle, S.R.: Matrix Algebra Useful for Statistics. John Wiley & Sons., 1982.

Semester 4

Course code : STA2400404MJ

Course Name : Practical 4

Credits: 4 (Theory: 00 credits, Practical/Lab: 04 credits)

Course Level : 200-299

Number of Contact classes : 60

Number of Non contact classes : 00

Course Objective: This course has will expose students to the art of applying mathematical skills in practical situations

Learning Outcomes: At the end of the course, students shall be able to apply mathematical techniques to practical situations.

Course outcomes:

CO1: Compute characteristic roots and vectors of a matrix and apply some of their properties to solve simple problems in Statistics, compute the determinant and inverse of a matrix by various methods and solve a system of linear equations, fit negative binomial and exponential distribution to given data.

CO2: Solve problems on constrained optimizations, functions of several variables and to classify and solve homogeneous and non- homogeneous differential equations.

CO3: Apply various tests to investigate the convergence of infinite series and relate the application of infinite series in discrete distributions.

CO4: Calculate the rank of the sum and the product of two matrices, apply Cayley Hamilton theorem, classify different Quadratic forms.

CO5: Interpolate or extrapolate a numerical series and solve transcendental equations by numerical methods.

Note: Students can use Excel/Spreadsheet/ R programming

Practicals based on the following:

(a) **Unit** 1: Practicals based on Unit 3 (Numerical Analysis) of paper STA402 **Credits: 2**

(b) **Unit** 2: Practicals based on Rank of a matrix, inverse of a matrix, quadratic forms, Solutions of linear equations, of paper STA 403 **Credits: 1**

(c) **Unit** 3: Practicals based on Unit 1 and fitting of negative binomial and exponential distribution of paper STA 401 **Credits: 1**

SUGGESTED READINGS:

Biswas, S. (1997): A Textbook of Matrix Algebra, NewAgeInternational,1997.

Semester 4

Course Code: STA2400104MN

Course Name: Operations Research - 1

Credits: 4 (Theory: 03 credits, Practical/Lab: 1 credit)

Course Level: 200-299

Number of Contact classes : 60

Number of Non-contact classes : 00

Course Objective: This course has the objective of inculcating the skills of Operations Research

Learning Outcomes: At the end of the course, students shall be able to use techniques of operations research to obtain optimization in field level problems.

Course Outcome:

CO1: Discuss optimization techniques using OR tools VIZ. LPP, Replacement problem, and Network Analysis.

CO2: Distinguish use of different methods to various kinds of LPP on the basis of type of constraints and number of variables in real life problems.

CO3: Choose an optimal replacement policy for a given item/equipment/machine.

CO4: Determine different types of floats and slacks, determination of critical path in network problem.

Unit 1: Linear Programming Problem: **Credit: 1**

Linear Programming Problem, Mathematical formulation of LPP, Graphical solution of an LPP, Simplex procedure for solving LPP (without derivation) (three variables variable only).

Unit 2: Replacement problem: **Credit: 1**

Replacement of items with deterministic deterioration (items that deteriorate with time), case of money value changing with time, group replacement policy.

Unit 3: Network problems-CPM & PERT: **Credit: 1**

Conception of network, idea of network node, activities, dummy activity, construction of network diagram. Network scheduling using C.P.M: determination of different types of floats and slacks, determination of critical path.

Unit 4: Practical from Unit 1, 2 and 3 **Credit: 1**

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

Semester 5
Course code : STA3500104MJ
Course Name : Sampling Distributions and Test of Significance
Credits: 4 (Theory: 04 credits, Practical/Lab: 00 credit)
Course Level : 300-399
Number of Contact classes : 60
Number of Non contact classes : 00

Course Objective: This course will enable students 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.
Learning Outcomes: At the end of the course, students shall be able to understand the concepts of variability in sample measures and their distributions.

Course Outcome:

CO1: Define random sample, parameter and statistic, sampling distribution of a statistic, sampling distribution of sample mean, standard errors of sample mean, sample variance and sample proportion.
CO2: Discuss exact sampling distributions viz: chi square, t and F and its application in real life scenario.
CO3: Explain non central sampling distribution viz: Non central chi square, Non Central t and Non central F.
CO4: Illustrate the concept of large sample tests, testing single proportion, difference of two proportions, single mean, difference of two means.
CO5: Compare central and non central sampling distributions. Distinguish between small and large sample tests.

Unit 1: Sampling Distributions:

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

Unit 2: Exact sampling distributions- Chi square distribution:

Definition and derivation of p.d.f. 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 χ^2distribution.Applications of this distribution, Tests of significance and confidence intervals based on distribution. Non central chi square distribution (derivation of pdf).

(**Combined credits for unit 1 and Unit 2 are 1)**

Unit 3: Exact sampling distributions- t distribution:

Credits: 01

Student's and Fishers t- distribution, Student's and Fishers t distribution, Derivation of its p.d.f., nature of probability curve with different degrees of freedom, mean, variance, moments and limiting form of t distribution, Applications of this distribution**.** Non Central t distribution (with derivation of pdf)

Unit 4: Exact sampling distributions- F distribution:

Credits: 01

Snedecor'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 χ^2 distributions, Applications of this distribution. Test of significance and confidence Intervals based on t and F distributions. Non Central F distribution (with derivation of pdf)

Unit 5 : Large sample tests **Credits: 01**

Large sample tests, testing single proportion, difference of two proportions, single mean, difference of two means.

SUGGESTED READING:

1. Goon, A.M., Gupta,M.K. and Dasgupta, B. (2003): AnOutline 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. 2nd Edn. (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.

Semester 5
Course code : STA3500204MJ
Course Name : DESIGN OF EXPERIMENTS 2
Credits: 4 (Theory: 04 credits, Practical/Lab: 00 credit)
Course Level : 300-399
Number of Contact classes : 60
Number of Non contact classes : 00

Course Objective: This course has the objective of providing student the knowledge of art of analysis of field experiments
Learning Outcomes: At the end of the course, students shall be able to understand the different types of commonly used field experimental techniques.

Course Outcome:
CO1: Recall fixed, random and mixed effect models, analysis of variance (one way and two way), principles of design of experiments, basic designs: CRD, RBD.

CO2: Discuss analysis of covariance, RBD with more than one observation per cell, Latin Square Design (LSD), analysis with missing observations, Split Plot Design, Strip Plot Design.

CO3: Discuss factorial experiments 2^n and 3^n

CO4: Explain confounding technique to reduce block size in factorial experiment.

CO5: Discuss simple regression analysis along with estimation and hypothesis testing.

Unit 1: Analysis of Variance: **Credit: 01**

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 observation per cell for fixed effect models.

Unit 2: Design of Experiments **Credit: 02**

Role, historical perspective**,** terminology, experimental error, basic principles, uniformity trials, choice of size and shape of plots and blocks. Review of Completely Randomized Design (CRD),Randomized Block Design (RBD) – one observation and more than one observations per cell, Latin Square Design (LSD) – layout, model and statistical analysis, relative efficiency, analysis with missing observations (one missing observation), Split Plot Design, Strip Plot Design.

Unit 3: Factorial Experiments: **Credits: 01**

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

SUGGESTED READING:

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
6. Goon, A.M., Gupta, M.K., Das Gupta, B. (2005), Fundamentals of Statistics, Vol. I, World Press, Calcutta.

Semester 5
Course code : STA3500304MJ
Course Name : Practical 5
Credits: 4 (Theory: 00 credits, Practical/Lab: 04 credit)
Course Level : 300-399
Number of Contact classes : 60
Number of Non contact classes : 00

Course Objective: This course has the objective of teaching students how to apply concept of statistical inference and field experiments in practice.

Learning Outcomes: At the end of the course, students shall be able to practically apply field experimentation techniques as well as sampling techniques.

Course outcomes:

CO1: Test the equality of single mean, significance of difference between two means (both independent samples and paired sample case) for both small and large samples, significance of difference of proportions in two large samples using t-test and Z-test,

CO2: Test the goodness-of-fit of samples and association of attributes using chi-square test, equality of means and significance of multiple correlation coefficient using F-test, significance of Karl Pearson correlation coefficient using t-test.

CO3: Test the significance of difference between various treatments for some basic designs such as CRD, RBD, LSD, designs with one missing observation, split plot design; the significance of the main effects and the interaction effects for factorial experiments, determine the confounded effects in a 2^n factorial design.

CO4: Test the randomness of sample using runs test, equality of median using Sign test, homogeneity of three of more than three samples using Kruskal-Wallis test, goodness-of-fit of a sample using Kolmogorov-Smirnov one sample test, homogeneity of two samples using Wilcoxon-Mann-Whitney test.

CO5: Construct the most powerful tests and uniformly most powerful tests for testing simple versus simple/composite null hypothesis using Neyman Pearson Lemma; construct the simple regression model and devise a testing of hypothesis procedure to test the significance of the regression coefficients.

Note: Students can use (Calculator/ Ms Excel/R Programming)

Practicals from the following :

(a) Units 2-5 of paper 501 **Credits: 02**

(b) Units 1-3 of 502 **Credits: 02**

SUGGESTED READING:

1. Goon, A.M., Gupta, M.K. and Dasgupta, B. (2005): Fundamentals of Statistics. Vol.
II, 8thEdn. World Press, Kolkata.
2. Kempthorne, O. (1965): The Design and Analysis of Experiments. John Wiley.
3. Montgomery, D. C. (2008): Design and Analysis of Experiments, John Wiley.

Semester 5

Course code : STA3500104MN

Course Name : Statistical Inference

Credits: 4 (Theory: 03 credits, Practical/Lab: 01 credit)

Course Level : 300-399

Number of Contact classes : 60

Number of Non contact classes : 00

Course Objective: This course has the objective of exposing students to concepts of estimation and testing of hypothesis - its types, and desirable properties of an estimator and how to find a good estimate from a sample data

Learning Outcomes: At the end of the course, students shall be able to apply how to examine the properties of estimators and how to test different types of statistical hypothesis.

Course outcomes:

CO1: Describe the concepts of estimation, unbiasedness, sufficiency, consistency and efficiency, non-parametric tests and distribution free procedures.

CO2: Discuss factorization theorem. Testing of hypothesis problems based on the traditional approach and p-value approach.

CO3: Discuss the different methods of estimation such as method of moments, method of maximum likelihood.

CO4: Illustrate different non-parametric tests such as Test for randomness based on total number of runs, Empirical distribution function, Kolmogrov-Smirnov test for one sample, Sign tests-one sample and two samples, Wilcoxon-Mann-Whitney test.

CO5: Utilize the above learnt concepts to solve numerical problems.

Unit 1: Estimation: **Credit: 1**

Concepts of point estimation, unbiasedness, sufficiency, consistency and efficiency. Factorization theorem.

Methods of point estimation - Method of moments, method of maximum likelihood estimation.

Interval estimation: concepts and simple problems.

Unit 2 : Hypothesis Testing **Credit: 1**

Null and alternative hypotheses, level of significance, Type I and Type II errors, their probabilities and critical region. Testing of hypothesis based on traditional and p-value approach

MP test, UMP test, unbiased test, Neyman Pearson Lemma (with proof) and its use, power curve.

Unit 3: Non-parametric Tests: **Credit: 1**

Nonparametric Tests: Introduction and Concept, Concept of Distribution free procedure, Test for randomness based on total number of runs, Empirical distribution function, Kolmogrov-Smirnov test for one sample, Sign tests-one sample and two samples, Wilcoxon-Mann-Whitney test– all without derivation.

Unit 4: Practical: **Credit: 1**

Practicals from methods of estimation, power curve and practicals from unit 3.

SUGGESTED READING:

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, Mc Graw 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.

Semester 6
Course code : STA3600104MJ
Course Name : Applied Statistics
Credits: 4 (Theory: 04 credits, Practical/Lab: 00 credit)
Course Level : 300-399
Number of Contact classes : 60
Number of Non contact classes : 00

Course Objective: This course has the objective of exposing students to the different domains of applied statistics.

Learning Outcomes: At the end of the course, students shall be able to understand how statistics is directly applied in economic analysis, govt. and society.

Course outcomes:

CO1: Define and construct index numbers of prices and quantities (Laspeyres', Paasche's, Fisher's and Marshal-Edgeworth's).

CO2: Outline the organisations involved in official data collection in India along with major publications on such official statistics in India.

CO3: Explain the importance of statistical methods in industrial research and practice, how tolerance limits are determined, chance and assignable causes of variations in quality, prepare various control charts for process and product control.

CO4: Explain various methods of fertility, mortality and reproduction, construction of life tables.

CO5: Use various methods like method of free-hand curve, moving average method, method of semi-averages and method of least squares to measure trend and method of ratio to trend to measure seasonal variations, fit k-variable regression model.

Unit 1: Time Series:

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, moving average method, method of semi-averages and method of least squares (linear, quadratic and modified exponential), Measurement of seasonal variations by method of ratio to trend.

Unit 2: Index Numbers:

Index numbers: Definition, Uses and limitations of index numbers.

Criteria/tests for a good index number, different types of index numbers- price, quantity, value. Wholesale price index number, Index of Industrial Production.

Construction of index numbers of prices and quantities – Laspeyres' , Paasche's, Fisher's and Marshal-Edgeworth's Index numbers.

Consumer price index number.

(**Combined Credits for Unit 1 and Unit 2 are 01**)

Unit 3: Statistical Quality Control: **Credits:01**

Statistical Quality Control: Importance of statistical methods in industrial research and practice. Rational subgroup., 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, R-charts and sigma chart. Control charts for attributes: p and c-charts. Product control – basic ideas of Single sampling and double sampling plans .

Unit4: Demography and official Statistics: **Credits :01**

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 – differences between complete and abridged life table.

Measurement of fertility and reproduction: CBR, GFR, and TFR. Measurement of population growth: GRR, NRR.

Present Official Statistical System in India, Methods of collection of official statistics, their reliability and limitations. Role of Ministry & 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, Economy, Development and Finance.

Unit5: Regression Analysis **Credits: 01**

Simple regression analysis, Estimation and hypothesis testing in case of simple regression models. Concept of multiple linear regression model, estimation of regression coefficients using matrix method (without proof). Fitting of k variable regression model. Testing significance of regression coefficients (without proof). Computation of R-square.

Suggested Readings:

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

Semester 6
Course code : STA3600204MJ
Course Name : Bivariate/Multivariate Analysis, Stochastic Process and Computer Programming
Credits: 4 (Theory: 04 credits, Practical/Lab: 00 credit)
Course Level : 300-399
Number of Contact classes : 60
Number of Non contact classes : 00

Course Objective: Students have to move from univariate to higher dimensional analysis. Moreover, this course will enable students to understand the transition from fundamental probability theory to stochastic process. It covers the structure of discrete time and

continuous time stochastic processes. This course will also expose students to elements of programming logic.

Learning Outcomes: On completion of the course, students will be able to understand the basics of stochastic process, Markov models, Poisson process and its applications, learn the analysis of higher dimensional random variables. They will also be able to write basic computer programs.

Course Outcome:

CO1: Discuss the concept of Bivariate and Multivariate distributions along with their properties.

CO2: Discuss basic structure of C programming, character set, C tokens, Keywords and Identifiers and execution of a C program and Data types.

CO3:Explain different operators and expressions of C -programming, various loop structures.

CO4: Illustrate the concept of Stochastic process, Markov Chain , Poisson Process and its application.

CO5: Develop basic C programs

Unit 1: Bivariate Distributions: **Credits: 01**

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

Unit 2: Multivariate Normal Distributions**:**

Credits: 01

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

Multivariate Normal distribution and its properties. Marginal and conditional distribution, Sampling distribution for mean vector and variance- covariance matrix without derivation). Hotelling T^2–concept and applications.

Unit 3: Computer Programming **Credits: 01**

History and importance of C. Components, basic structure programming, character set, C tokens, Keywords and Identifiers and execution of a C program. Data types: Basic data types, Enumerated data types, derived data types. Constants and variables: declaration and assignment of variables, Symbolic Constant.
Operators and Expressions: Arithmetic, relational, logical, assignment, increment/decrement, operators, precedence of operators in arithmetic, relational and logical expression.
library functions. Decision making and branching - if…else, nesting of if…else, else if, . Looping in C: for, nested looping.

Unit 4: Stochastic Process **Credits: 01**

Stochastic Process: Introduction, Stationary Process. Definition of Markov Chain, transition probability matrix, order of Markov chain, Markov chain as graphs, higher transition probabilities. Generalization of independent Bernoulli trials, classification of states and chains. Poisson Process: postulates of Poisson Process, properties of Poisson Process with applications.

SUGGESTED READING:

1. Anderson,T.W.(2003):AnIntroductiontoMultivariateStatisticalAnalysis,3rdEdn.,JohnWiley.
2. Muirhead,R.J.(1982):AspectsofMultivariateStatisticalTheory,JohnWiley.
3. Kshirsagar, A.M.(1972):MultivariateAnalysis,1stEdn.MarcelDekker.
4. Johnson, R.A. and Wichern, D.W.(2007): Applied Multivariate Analysis, 6thEdn., Pearson & Prentice Hall.
5. Mukhopadhyay, P.: Mathematical Statistics.
6. Balagurusamy, E. (2011): Programming in ANSI C, 6th Edition, Tata McGraw Hill.
7. Medhi, J. (2009): Stochastic Processes, New Age International Publishers.
8. Basu, A.K. (2005): Introduction to Stochastic Processes, Narosa Publishing.

Semester 6

Course code : STA3600304MJ

Course Name : Operations Research

Credits: 4 (Theory: 04 credits, Practical/Lab: 00 credit)

Course Level : 300-399

Number of Contact classes : 60

Number of Non contact classes : 00

Course Objective: This course has the objective of inculcating the skills of Operations Research

Learning Outcomes: At the end of the course, students shall be able to use techniques of operations research to obtain optimization in field level problems.

Course Outcome:

CO1: Discuss optimization techniques using OR tools VIZ. LPP, Transportation problem, Replacement problem, Inventory Control and Network.

CO2: Distinguish use of different methods to various kinds of LPP on the basis of type of constraints and number of variables in real life problems.

CO3: Solve transportation problem using North West corner rule, Least cost method.

CO4: Choose an optimal replacement policy for a given item/equipment/machine.

CO5: Determine different types of floats and slacks, determination of critical path in network problem.

Unit 1: Linear Programming Problem: **Credits: 01**

Linear Programming Problem, Mathematical formulation of LPP, Graphical solution of an LPP, Simplex procedure for solving LPP (without derivation) (three more variables variable) , slack and surplus variable

Unit 2: Transportation problem:

Transportation Problem, Initial solution by North West corner rule, Least cost method

Unit 3: Replacement problem:

Replacement of items with deterministic deterioration (items that deteriorate with time), case of money value changing with time, group replacement policy.

(Combined Credits for Unit 2 and Unit 3 are 01)

Unit 4: Network problems-CPM & PERT: **Credits: 01**

Conception of network, idea of network node, activities, dummy activity, construction of network diagram. Network scheduling using C.P.M: determination of different types of floats and slacks, determination of critical path.

Unit 5 : Inventory Control: **Credits : 01**

Inventory Management: ABC inventory system, characteristics of inventory system. EOQ Model and its variations (with and without shortages).

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

Semester 6
Course code : STA3600404MJ
Course Name : Practical-6
Credits: 4 (Theory: 00 credits, Practical/Lab: 04 credit)
Course Level : 300-399
Number of Contact classes : 60
Number of Non contact classes : 00

Course Objective: This practical level course has the objective of providing student hands on training on application of skills of operations research and applications of Statistics.

Learning Outcomes: At the end of the course, students shall be able to use techniques of operations research to attain optimality as well as apply applied statistical techniques to field level problems in industry, govt and society.

Course Objectives:

CO1: Apply statistical methods and techniques, including time series analysis, index number computation, SQC, and demographic analysis, to real-world datasets and scenarios. Utilize appropriate computing tools to conduct analyses, interpret results, and draw meaningful conclusions about trends, patterns, and variations in data related to economic, industrial, and demographic phenomena.

CO2: Analyze and evaluate the effectiveness and relevance of different statistical methodologies, such as time series decomposition methods, index number formulas, control chart interpretations, and demographic measures, in addressing specific analytical objectives.

CO3: Develop methodologies and models to address specific research questions or practical challenges, incorporating statistical techniques and computational tools to optimize decision-making processes and organizational performance.

CO4: Analyze and evaluate the effectiveness and efficiency of different mathematical approaches and optimization algorithms in addressing specific

operational challenges related to LPP, replacement problems, inventory control, and transportation.

CO5: Design and execute comprehensive operations research studies to address complex real-world problems. They will integrate multiple operations research methodologies to develop holistic solutions that optimize resource utilization, improve decision-making processes, and enhance organizational performance.

Practicals on the following:

(a) all units of STA601(Applied Statistics) **Credits : 02**

(b) all units of STA603(Operations Research) **Credits: 02**

Reference books :

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
5. Parimal Mukhopadhyay, Applied Statistics

Semester 6

Course code : STA3600104MN

Course Name : Applied Statistics 1

Credits: 4 (Theory: 03 credits, Practical/Lab: 01 credit)

Course Level : 300-399

Number of Contact classes : 60

Number of Non contact classes : 00

Course Objective: This course has the objective of exposing students the different domains of applied statistics.

Learning Outcomes: At the end of the course, students shall be able to understand how statistics is directly applied in economic analysis, govt. and society.

Course outcomes:

CO1: Define and construct index numbers of prices and quantities (Laspeyres', Paasche's, Fisher's and Marshal-Edgeworth's).

CO2: Outline the organisations involved in official data collection in India along with major publications on such official statistics in India.

CO3: Explain the importance of statistical methods in industrial research and practice, how tolerance limits are determined, chance and assignable causes of variations in quality,prepare various control charts for process and product control.

CO4: Explain various methods of fertility, mortality and reproduction, construction of life tables.

CO5: Use various methods like method of free-hand curve, moving average method, method of semi-averages and method of least squares to measure trend and method of ratio to trend to measure seasonal variations, fit k-variable regression model.

Unit 1: Time Series:

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, moving average method and method of least squares (linear only), Measurement of seasonal variations by method of ratio to trend.

Unit 2: Index Numbers:

Index numbers: Definition, Uses and limitations of index numbers.

Criteria/tests for a good index number.

Different types of index numbers- price, quantity, value. Wholesale price index number.

Construction of index numbers of prices and quantities – Laspeyres' , Paasche's, Fisher's Index numbers.

Consumer price index number.

(Combined Credits of units 1 and 2 are 1)

Unit 3: Statistical Quality Control: Credit: 1

Statistical Quality Control: Importance of statistical methods in industrial research and practice. Rational subgroup., 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, R-charts. Control charts for attributes: p and c-charts.

Unit4: Demography and official Statistics:

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. Complete life (mortality) tables.

Measurement of fertility and reproduction: CBR, GFR, and TFR. Measurement of population growth: GRR, NRR.

Present Official Statistical System in India, Methods of collection of official statistics, their reliability and limitations. Role of Ministry & Program Implementation (MoSPI), Central Statistical Office (CSO), National Sample Survey Office (NSSO), and National Statistical Commission.

Unit 5: Regression Analysis:

Bivariate linear regression model- fitting, estimation of regression coefficients, Testing significance of regression coefficients (without proof). Computation of R-square.

(Combined Credits of units 4 and 5 are 1)

Unit 6 : Practical from Unit 1, 2 and 3 Credit: 1

SUGGESTED READING:

1. Mukhopadhyay,P.(1999):AppliedStatistics,NewCentralBookAgency,Calcutta.
2. Gun, A.M., Gupta, M.K. and Dasgupta, B. (2008): Fundamentals of Statistics, Vol. II,9thEditionWorldPress,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.
5. Mukhopadhyay, P. (1999): Applied Statistics, Books and Allied(P)Ltd.
6. Gun, A.M., Gupta, M.K. and Dasgupta, B. (2008): Fundamentals of Statistics, Vol. II, 9th Edition, World Press.
7. Biswas,S.(1988):Stochastic Processes in Demography & Application, Wiley Eastern Ltd.
8. Croxton, Fredrick E., Cowden, Dudley J. and Klein, S. (1973): Applied General Statistics, 3rd Edition. Prentice Hall of India Pvt. Ltd.

9. Keyfitz N., Beckman John A.: Demography through Problems S-Verlag New York.

Semester 7

Course code : STA4700104MJ

Course Name : Probability and Distribution Theory

Credits: 4 (Theory: 04 credits, Practical/Lab: 00 credit)

Course Level : 400

Number of Contact classes : 60

Number of Non contact classes : 00

Course Outcomes (COs)

After successful completion of this course, the students will be able to:

CO1

Analyze the properties of moment generating functions, probability generating functions, characteristic functions and multivariate distribution functions, and apply them to derive distributional results involving conditional expectation, conditional variance and convolution of random variables.

CO2

Apply advanced probability theorems and inequalities, including Markov, Cramér, Hölder, Jensen, Inversion, Uniqueness, Borel's 0–1 Law and Kolmogorov's 0–1 Law, to establish theoretical results and solve advanced problems in probability.

CO3

Evaluate the various modes of convergence of random variables and sequences of random variables, and employ fundamental limit theorems, including Helly–Bray Theorem, Continuity Theorem, Slutsky's Theorem, Three-Series Criterion, Kolmogorov's Inequality and the Strong Law of Large Numbers, in probabilistic inference.

CO4

Analyze and interpret advanced probability distributions, including Cauchy, Laplace, Lognormal and Bivariate Exponential distributions, and formulate statistical models involving censoring, truncation and finite mixture distributions for real-life applications.

Group A: Probability

Unit 1 (1 Credit)

Moment generating function (mgf), probability generating function (pgf), characteristic function and their properties for bivariate and multivariate cases.

Distribution functions for bivariate and multivariate cases; conditional expectation and conditional variance in the multivariate case.

Moment inequalities (Markov, Cramér, Hölder and Jensen). Inversion Theorem, Uniqueness Theorem, Borel's 0–1 Law, Kolmogorov's 0–1 Law and Convolution Theorem.

Unit 2 (2 Credits)

Convergence of random variables: convergence in probability, almost sure convergence, convergence in mean square and convergence in distribution. Helly's Theorem, Helly–Bray Theorem, Continuity Theorem of characteristic functions and Slutsky's Theorem.

Convergence of sequences of random variables, Three-Series Criterion, Kolmogorov's Inequality and the Strong Law of Large Numbers (SLLN).

References

1. Bhat, B. R., Srivenkataramana, T. and Pao Madhava, K. S. (1997). Statistics: A Beginner's Text, Vol. II. New Age International.
2. Edward, P. J., Ford, J. S. and Lin (1974). Probability for Statistical Decision Making. Prentice Hall.
3. Goon, A. M., Gupta, M. K. and Dasgupta, B. (1999). Fundamentals of Statistics, Vol. II. World Press.

4. Mood, A. M., Graybill, F. A. and Boes, D. C. (1974). Introduction to the Theory of Statistics. McGraw-Hill.
5. Feller, W. An Introduction to Probability Theory and Its Applications (3rd Ed.). John Wiley.
6. Coxe, Cramer and Clarke. Basic Statistical Computing. Chapman and Hall.
7. David, S. (1996). Elementary Probability. Oxford University Press.
8. Hoel, P. G. (1971). Introduction to Mathematical Statistics. Asia Publishing House.
9. Meyer, P. L. (1970). Introductory Probability and Statistical Applications. Addison-Wesley.

Group B: Distribution Theory

Unit 3 (1 Credit)

Statistical distributions: Cauchy, Laplace, Lognormal and Bivariate Exponential distributions.

Concepts of different types of censoring and truncation.

Censoring in Exponential and Weibull distributions.

Truncation in Poisson and Normal distributions.

Mixture distributions: definition, finite mixtures and mixtures of Binomial distributions with examples.

References

10. Dudewicz, E. J. and Mishra, S. N. (1988). Modern Mathematical Statistics. Wiley.
11. Rohatgi, V. K. (1984). An Introduction to Probability Theory and Mathematical Statistics. Wiley Eastern.
12. Rao, C. R. (1973). Linear Statistical Inference and Its Applications (2nd Ed.). Wiley Eastern.
13. Johnson, N. L., Kemp and Kotz, S. (2005). Univariate Discrete Distributions (3rd Ed.). Wiley.
14. Johnson, N. L., Kotz, S. and Balakrishnan. Univariate Continuous Distributions (2nd Ed., Vols. 1 & 2). Wiley.
15. Johnson, N. L., Kotz, S. and Balakrishnan. Multivariate Discrete Distributions (2nd Ed.). Wiley.

Semester 7

Course code : STA4700204MJ

Course Name : Survey Sampling

Credits: 4 (Theory: 04 credits, Practical/Lab: 00 credit)

Course Level : 400

Number of Contact classes : 60

Number of Non contact classes : 00

Course Outcomes : After successful completion of this course, the students will be able to:

CO1

Analyze and design appropriate probability sampling strategies, including stratified and unequal probability sampling techniques, for efficient estimation in finite populations.

CO2

Apply advanced estimation procedures, including PPS sampling, Horvitz–Thompson, Hansen–Hurwitz, Des Raj, Murthy, ratio, regression and product estimators, to obtain unbiased and efficient estimates of population parameters.

CO3

Evaluate the efficiency and suitability of cluster, two-stage, multistage and systematic sampling designs by comparing their statistical properties and operational applicability under different population structures.

CO4

Formulate sampling designs for complex surveys by integrating double sampling, post-stratification, interpenetrating sub-sampling and quota sampling techniques to address practical survey and official statistics problems.

Unit 1:

Construction of strata in Stratified random sampling, optimum no. of strata, Method of collapsed strata, Post Stratification.

Unit 2:

Unequal probability sampling: PPS with replacement and without replacement including Lahiri's scheme; Nonnegative variance estimation, ordered and unordered estimators, Horvitz-Thompson, Hansen- Hurwitz and DesRaj estimators for general sample size, Murthy's estimator for a sample of size 2.

(Unit 1 & 2 =1 credit)

Unit 3: **(1 credit)**

Ratio method of estimation including Hartley-Ross and Jack knife estimators, Optimum property of Ratio estimators, Combined and Separate ratio estimator. Regression method of Estimation, Product method of Estimation.

Unit 4:

Cluster sampling: Equal size cluster sampling: estimators of population mean and total and their standard errors, comparison of cluster sampling with SRS in terms of intra-class correlation coefficient.

Two-stage sampling with equal number of second stage units, estimation of population mean and total and Multi-stage sampling, Systematic sampling (comparison of systematic, Simple and stratified random sampling for population in random error); Systematic sampling from population with linear trend, periodic variation, auto correlated population.

Unit 5:

Non sampling errors, Double Sampling in ratio and regression methods of estimation, Concept of Inter penetrating sub-sampling, Basics of quota sampling.

(Unit 4 and 5 combined credit=1)

Unit 6: (Credit 1)

Suggested Laboratory Practicals

PPSWR / PPSWOR, Lahiri's method, Horvitz–Thompson estimator, Hansen–Hurwitz estimator, Des Raj estimator, Murthy estimator, Ratio estimation, Hartley–Ross estimator, Cluster sampling.

Two-stage sampling, Systematic sampling with comparison.

References:

1. Sukhatme:Sampling theory of surveys with application:IndianSocietyof Agricultural Statistics.
2. CochranW.G.:SamplingTechnique(Thirdedition):WeleyEastern.
3. Murthy MN: Sampling theory and Methods: Statistical publishing society kolkata
4. Des Raj and Chandok: Sampling design: Jata McGrow Hill
5. SinghD.andChoudhuryF.S.:TheoryandAnalysisofSampleSurveyDesign:New Age International Publishers.
6. Mukhopadhyay,Parimal:Theory and Methods of Survey Sampling.

Semester 7
Course code : STA4700304MJ

Course Name : Mathematical Methods

Credits: 4 (Theory: 04 credits, Practical/Lab: 00 credit)

Course Level : 400

Number of Contact classes : 60

Number of Non contact classes : 00

Course Outcomes (COs)

After successful completion of this course, the students will be able to:

CO1

Analyze the properties of real numbers, sequences, series, power series and functions of several variables, and apply the concepts of convergence, continuity and differentiability to solve advanced mathematical problems relevant to statistics.

CO2

Apply differential and integral calculus, including partial differentiation, constrained optimization, multiple integration, Riemann integration and improper integrals, to formulate and solve multivariable mathematical models arising in statistical applications.

CO3

Evaluate advanced mathematical structures involving linear transformations, inner product spaces, orthonormal bases and matrix representations, and interpret their significance in statistical theory and computation.

CO4

Formulate and solve mathematical problems using canonical forms, Jordan forms, generalized inverses, Moore–Penrose inverse and matrix equations, integrating concepts from real analysis and linear algebra for advanced statistical modelling.

Group A: Real Analysis and Special Functions

Unit 1 (1 Credit)

Finite, countable and uncountable sets; Archimedean property; supremum; infimum; lim sup; lim inf; Bolzano–Weierstrass theorem; sequences of real numbers; convergence of sequences; bounded sequences; monotonic sequences; Cauchy criterion for convergence; convergence of series; tests of convergence; alternating series; absolute and conditional convergence; uniform convergence tests; power series; radius of convergence; applications of power series.

Unit 2 (Units 2 and 3 combined: 1 Credit)

Differentiation; partial derivatives of higher order; saddle point; functions of several variables; directional derivative; constrained maxima and minima of functions; derivative as a linear transformation; inverse and implicit function theorems.

Unit 3

Double and triple integrals and their applications. Riemann sums and Riemann integral. Improper integrals.

References

1. Apostol, T. M. (1985). Mathematical Analysis. Narosa, Indian Edition.
16. Courant, R. and John, F. (1965). Introduction to Calculus and Analysis. Wiley.
17. Miller, K. S. (1957). Advanced Real Calculus. Harper, New York.
18. Rudin, Walter (1976). Principles of Mathematical Analysis. McGraw-Hill.
19. Andrews, G. E., Askey, Richard and Roy, Ranjan (2000). Special Functions. Cambridge University Press.
20. Rainville, E. D. (1960). Special Functions. The Macmillan Company, New York.

Group B: Linear Algebra

Unit 1 (1 Credit)

Introduction to Euclidean space. Inner product. Linear space with inner product. Orthonormal basis of a linear space.

Unit 2 (1 Credit)

Matrix representation of linear transformations. Change of basis, canonical forms, diagonal forms, triangular forms, Jordan forms, generalized inverse, Moore–Penrose inverse and matrix equations.

References

21. Graybill, F. A. (1983). Matrices with Applications in Statistics (2nd Ed.). Wadsworth.
22. Rao, C. R. (1973). Linear Statistical Inference and Its Applications (2nd Ed.). John Wiley and Sons.
23. Searle, S. R. (1982). Matrix Algebra Useful for Statistics. John Wiley and Sons.

Semester 7

Course code : STA4700404MJ

Course Name : Research Methodology

Credits: 4 (Theory: 04 credits, Practical/Lab: 00 credit)

Course Level : 400

Number of Contact classes : 60

Number of Non contact classes : 00

Course Outcomes (COs)

- CO1. Understand the philosophy of scientific research, formulate research problems, and design appropriate research studies.
- CO2. Develop complete research proposals, identify research gaps, and adopt reproducible and open research practices for conducting scientific investigations.
- CO3. Retrieve, evaluate, organize, communicate, and disseminate scientific information using scholarly databases, scientific writing tools, citation management and research metrics.
- CO4. Demonstrate high standards of research integrity by adhering to publication ethics, responsible authorship, plagiarism prevention, and internationally accepted ethical guidelines.

Unit 1: Foundations of Scientific Research (1 Credit)

- Evolution of scientific inquiry and development of the scientific method
- Meaning, objectives and significance of research
- Principles and Characteristics of scientific research
- Types of research: basic, applied, action, quantitative, qualitative, mixed-method, experimental, observational and computational research

- Significance of research
- Identification and formulation of research problems
- Research questions, objectives and hypotheses
- Literature survey: purpose, sources, search strategies and identification of research gaps
- Principles, classification and selection of research designs

Unit 2: Research Planning, Proposal Development and Reproducible Research (1 Credit)

- Components of a research proposal
- Funding agencies for statistical research in India (ANRF, DST, CSIR, UGC, ICSSR, DBT etc.)
- Research documentation and laboratory/research notebooks
- Reproducibility and replicability
- Open science: Open Access, Open Data, repositories and preprints

Unit 3: Scientific Communication, Scholarly Publishing and Research Metrics (1 Credit)

- Scientific literature and peer review
- Open-access, subscription and predatory journals
- Scientific databases: Web of Science, Scopus, Google Scholar, MathSciNet, zbMATH, CrossRef, DOAJ
- Researcher identifiers: ORCID and DOI
- Scientific writing: papers, theses, reports, conference papers, posters and presentations
- Referencing styles (APA, MLA), bibliography management
- Research metrics: Journal Impact Factor, CiteScore, SNIP, SJR, h-index, i10-index strengths and limitations

Unit 4: Research Integrity, Publication Ethics and Responsible Conduct of Research (1 Credit)

- Principles of research ethics and responsible conduct
- Scientific integrity and intellectual honesty
- Authorship, contributorship and conflict of interest
- Confidentiality, data protection and ethical approval
- Scientific misconduct: fabrication, falsification, plagiarism, self-plagiarism, duplicate publication, salami publication, image manipulation and selective reporting
- Detection and prevention of plagiarism

- COPE guidelines
- Retractions and corrections
- Ethical use of Artificial Intelligence in research

References and textbooks

2. Kothari, C. R. & Garg, G. Research Methodology: Methods and Techniques (4th ed.).
3. Kumar, R. Research Methodology: A Step-by-Step Guide for Beginners (6th ed.).
4. Creswell, J. W. & Creswell, J. D. Research Design (6th ed.).
5. Krishnaswamy, K. N., Sivakumar, A. I. & Mathirajan, M. Management Research Methodology.

Semester 7

Course code : STA4700104MN

Course Name : Operations Research-2

Credits: 4 (Theory: 03 credits, Practical/Lab: 01 credit)

Course Level : 400

Number of Contact classes : 60

Number of Non contact classes : 00

Course Outcomes

CO1. Formulate and solve linear programming problems using the simplex method and transportation algorithms.

CO2. Apply inventory control models to determine optimal inventory policies.

CO3. Analyze two-person zero-sum games using pure and mixed strategies.

CO4. Apply operations research techniques to practical decision-making problems.

Unit 1: Linear Programming Problem (Credit: 1)

Introduction to Linear Programming Problems; simplex procedure (with derivation) for problems involving three or more variables; slack and surplus variables; transportation problem; initial basic feasible solution by North-West Corner Rule and Least Cost Method.

Unit 2: Inventory Control (Credit: 1)

Inventory management; ABC inventory system; characteristics of inventory systems; Economic Order Quantity (EOQ) model; EOQ models with and without shortages.

Unit 3: Game Theory (Credit: 1)

Introduction to game theory; two-person zero-sum games; minimax-maximin principle; saddle points; games without saddle points; pure and mixed strategies; solution of 2×2 games.

Unit 4: Practical (Credit: 1)

Practical exercises based on Units 1, 2 and 3.

Textbooks

Taha, H. A. (2017). Operations Research: An Introduction (10th ed.). Pearson.

Kanti Swarup, Gupta, P. K., & Man Mohan. (2019). Operations Research. Sultan Chand & Sons.

Hillier, F. S., & Lieberman, G. J. (2021). Introduction to Operations Research (11th ed.). McGraw-Hill.

Reference Books

Hadley, G. (2002). Linear Programming. Narosa Publishing House.

Sharma, J. K. (2017). Operations Research: Theory and Applications. Macmillan.

Ravindran, A., Phillips, D. T., & Solberg, J. J. (2007). Operations Research: Principles and Practice (2nd ed.). Wiley.

EIGHT SEMESTER : Option 1: Honours

Semester 8
Course code : STA4800104MJ

Course Name : Design of Experiment and Linear Models

Credits: 4 (Theory: 04 credits, Practical/Lab: 00 credit)

Course Level : 400

Number of Contact classes : 60

Number of Non contact classes : 00

Course Outcomes (COs)

After successful completion of this course, the students will be able to:

CO1

Analyze advanced experimental designs, including randomized block designs with missing observations, confounding in factorial experiments, and incomplete block designs, to select suitable designs for agricultural, industrial and scientific investigations.

CO2

Apply the principles of balanced and partially balanced incomplete block designs, intra-block and inter-block analyses, and recovery of information to obtain efficient estimates from designed experiments.

CO3

Evaluate linear statistical models by employing least squares estimation, hypothesis testing, multiple comparison procedures, and analysis of variance to draw valid statistical inferences.

CO4

Develop and interpret advanced regression ndiagnio and econometric models, including multiple and logistic regression, generalized least squares, restricted regression, simultaneous equation models and distributed lag models, for analysing complex real-world data.

Syllabus:

Unit 1 (1 Credit)

Analysis of two missing observations in Randomized Block Design (RBD). Analysis of variance with two concomitant variables. Complete and partial confounding in 2^4 and 2^5 factorial experiments. Complete confounding in 3^2 factorial experiments.

Unit 2 (1 Credit)

Incomplete block designs and their intra-block and inter-block analysis. Criteria for connectedness, balance and orthogonality of block designs (BIBD). Recovery of intra-block information of BIBD. Introduction to Partially Balanced Incomplete Block Designs (PBIBD).

Unit 3 (1 Credit)

Linear model: Gauss–Markov setup, normal equations and least squares estimator. Error and estimation space. Variance and covariance of least squares estimates. Estimation of error variance. Estimation with correlated observations. Least squares estimation under parameter restrictions. Tests of hypotheses for one and more than one linear parametric

function. Multiple comparison tests due to Tukey, Scheffé, Student–Newman–Keuls and Duncan.

Unit 4 (1 Credit)

Multiple linear regression, maximum likelihood estimation and hypothesis testing, testing in multiple linear regression, analysis of variance for linear models, indicator (dummy) variables, use of R^2 and adjusted R^2, regression diagnostics, multicollinearity, heteroscedasticity, autocorrelation, Durbin–Watson test, logistic regression models – binary response variables, odds ratio, logit function.

References

6. Das, M. N. and Giri, N. C. Experimental Design.
7. Kempthorne, O. Design of Experiments.
8. Joshi, D. D. Linear Estimation.
9. Gujarati, Damodar N. Basic Econometrics.
10. Dougherty, Christopher. Introduction to Econometrics.
11. Wooldridge, Jeffrey M. Introductory Econometrics: A Modern Approach.
12. Draper, N. R. and Smith, H. Applied Regression Analysis.
13. Kmenta, Jan. Elements of Econometrics.
14. Mukhopadhyay, Parimal. Applied Statistics.
15. Rao, C. R. Linear Statistical Inference and Its Applications.
16. Montgomery, Douglas C., Peck, E. A. and Vining, G. G. Introduction to Linear Regression Analysis.

Semester 8

Course code : STA4800204MJ

Course Name : Demography and Statistics for National Development

Credits: 4 (Theory: 04 credits, Practical/Lab: 00 credit)

Course Level : 400

Number of Contact classes : 60

Number of Non contact classes : 00

Course Outcomes (COs)

After successful completion of this course, the students will be able to:

CO1

Analyze demographic data sources, census information and life table techniques, including abridged life table construction, mortality models and national life tables, to interpret population characteristics and mortality patterns.

CO2

Apply demographic methods for population projection and survival analysis using stable and stationary population models, logistic curve fitting, Leslie matrix, actuarial estimator and Kaplan–Meier estimator.

CO3

Evaluate migration patterns and population policies by interpreting internal and international migration measures, migration models, post-censal estimates and population census statistics for demographic planning.

CO4

Develop evidence-based statistical interpretations for national development by analysing sector-wise statistics, national accounts, population census data, socio-economic indicators and official survey results for informed policy and decision making.

Unit 1 (1 Credit)

Sources of demographic data: census, registration, ad hoc surveys and hospital records. Demographic profiles of the Indian Census. Life tables and their applications. Methods of construction of abridged life tables (Greville and Chiang methods). Gompertz and Makeham curves. National life tables and United Nations model life tables.

Unit 2 (1 Credit)

Stable and stationary population models. Population projection by logistic curve fitting and Leslie matrix. Estimation of survival function using actuarial estimator and Kaplan–Meier estimator.

Unit 3 (1 Credit)

Internal migration and its measurement. Migration models. Concept of international migration. Net migration. International and post-censal estimates. Decennial Population Census in India. National Population Policy.

Unit 4 (1 Credit)

Sector-wise statistics: Agriculture, Health, Education, Women and Child Development. Important surveys and censuses, indicators, agencies and their uses. National Accounts: definition, basic concepts, issues, strategy, collection of data and release. Population Census: need, data collected, periodicity, methods of data collection, dissemination and agencies involved. Miscellaneous: socio-economic indicators, gender statistics, important surveys and censuses.

References

17. Swanson, D. A. et al. Methods and Materials of Demography.
18. Chiang, C. L. (1968). Introduction to Stochastic Processes in Biostatistics. John Wiley.
19. Keyfitz, N. (1977). Applied Mathematical Demography. Springer-Verlag.
20. Central Statistical Organisation (CSO). National Accounts Statistics: Sources and Methods.
21. Keyfitz, N. Applied Mathematical Demography. Springer-Verlag.
22. Agarwala, S. N. India's Population Problems. Tata McGraw-Hill.
23. Bose, Ashish. Demographic Diversity of India. B.R. Publishing.
24. Registrar General & Census Commissioner of India. Census of India Administrative Atlas and Primary Census Abstracts.
25. Government of India, Ministry of Statistics and Programme Implementation (MoSPI). National Statistical Office publications, National Accounts Statistics and Social Statistics reports.
26. UNDP. Human Development Reports.
27. United Nations. Principles and Recommendations for Population and Housing Censuses.
28. World Bank. World Development Indicators.
29. UNICEF. The State of the World's Children (latest editions).

Semester 8
Course code : STA4800304MJ

Course Name : Operations Research

Credits: 4 (Theory: 04 credits, Practical/Lab: 00 credit)

Course Level : 400

Number of Contact classes : 60

Number of Non contact classes : 00

Course Outcomes (COs)

Upon successful completion of this course, the students will be able to:

CO1. Explain the principles of linear programming, duality and optimization techniques.

CO2. Apply simplex, transportation, assignment and dynamic programming methods to optimization problems.

CO3. Analyse strategic decision-making problems using game theory and queuing models.

CO4. Evaluate sequencing, scheduling and stochastic service systems for operational efficiency.

CO5. Apply simulation techniques and random variate generation methods for modelling complex systems.

CO6. Develop optimization and simulation models for solving real-life operations research problems.

Course Content

Unit 1 (Credit: 1)

Linear Programming Problems (LPP): Duality in linear programming; symmetric and asymmetric duals; two-phase simplex algorithm; transportation and assignment problems; travelling salesman problem.

Unit 2 (Credit: 1)

Game Theory: Two-person zero-sum games; minimax principle; saddle points; games without saddle points; pure and mixed strategies; solution of 2×2 games;

graphical solution procedures; equivalence of rectangular games and linear programming.

Unit 3 (Credit: 1)

Queuing Theory: Specification and performance measures of queuing models; steady-state solutions of M/M/1 and M/M/c queues; queue-length and waiting-time distributions; sequencing and scheduling problems; two-machine n-job and three-machine n-job problems with identical machine sequence.

Unit 4 (Credit: 1)

Simulation: Generation of random numbers; inverse transform method; acceptance–rejection method; simulation of discrete and continuous random variates; Markov Chain Monte Carlo (MCMC).

References

1. Taha, H. A. Operations Research: An Introduction (10th ed.). Pearson.

2. Hillier, F. S. and Lieberman, G. J. Introduction to Operations Research (11th ed.). McGraw-Hill.

3. Ravindran, A., Phillips, D. T. and Solberg, J. J. Operations Research: Principles and Practice. Wiley.

4. Swarup, K., Gupta, P. K. and Mohan, M. Operations Research. Sultan Chand & Sons.

5. Winston, W. L. Operations Research: Applications and Algorithms. Cengage.

6. Sharma, J. K. Operations Research: Theory and Applications. Macmillan.

7. Hadley, G. Linear Programming. Addison-Wesley.

8. Ross, S. M. Simulation (5th ed.). Academic Press.

9. Law, A. M. Simulation Modeling and Analysis (5th ed.). McGraw-Hill.

10. Gross, D., Shortle, J. F., Thompson, J. M. and Harris, C. M. Fundamentals of Queueing Theory (5th ed.). Wiley.

Semester 8

Course code : STA4800404MJ

Course Name : Statistical Analysis using Software

Credits: 4 (Theory: 00credits, Practical/Lab: 04 credits)

Course Level : 400

Number of Contact classes : 60

Number of Non contact classes : 00

Course Outcomes (COs)

Upon successful completion of this course, the students will be able to:

CO1. Analyse experimental data using standard designs and ANOVA.

CO2. Apply linear model using statistical software.

CO3. Solve optimization problems using operations research techniques.

CO4. Perform simulation studies using random number and random variate generation techniques.

Course Content

Unit 1: Practical based on Design of Experiments (2 Credits)

Analysis of RBD with two missing observations, Analysis of covariance with two concomitant variables, Complete and partial confounding in 2^4 and 2^5 factorial experiments, Complete confounding in 3^2 factorial experiments, Balanced Incomplete Block Design (BIBD),

Unit 2: Practical based on Linear Models (1 Credit)

Least squares estimation, Gauss–Markov linear model, Solution of normal equations, Estimation of error variance, Variance–covariance matrix of estimates, Estimation under parameter restrictions, Hypothesis testing for linear parametric functions, Multiple comparison procedures , Multiple regression analysis, Residual diagnostics, Analysis of variance for regression, Multicollinearity diagnostics.

Unit 3: Practical based on Linear Programming and Simulation (1 Credit)

Dual formulation and solution of linear programming problems, Random number generation,

Software

All practical exercises shall be performed using R/RStudio. Students shall maintain a laboratory record containing program codes, outputs and interpretations.

Semester 8
Course code : STA4800104MN

Course Name : Applied Statistics-2

Credits: 4 (Theory: 03credits, Practical/Lab: 01 credits)

Course Level : 400

Number of Contact classes : 60

Number of Non contact classes : 00

Course Objectives

To introduce statistical methods used in educational measurement and evaluation.

To develop an understanding of demand analysis and income distribution using statistical tools.

To provide practical exposure to applications of educational and economic statistics.

Course Outcomes

CO1. Apply scaling techniques and interpret educational test scores using standard statistical measures.

CO2. Evaluate the reliability and validity of educational tests and combine scores using appropriate statistical procedures.

CO3. Analyze consumer demand, elasticity, income distribution and demand forecasting using statistical methods.

CO4. Apply educational and economic statistical techniques to analyze real-world datasets using appropriate software.

Unit 1: Educational Statistics (Credit: 1.5)

Definition of scaling; scaling procedures; scaling individual test items in terms of difficulty; scaling of scores on a test; Z (σ) scores, standard scores, normalized scores and T-scores; computation of T-scores from a frequency distribution; comparison of T-scores and standard scores; percentile scores; merits and demerits of percentile scores; scaling of rankings and

ratings using the normal probability curve; reliability of test scores; self-correlation; reliability coefficient; effect of test length on reliability; estimation of reliability from a single administration; dependence of reliability on group size and variability; index of reliability; combining scores from different tests by percentiles, median mental age, weighted scores and conversion to comparable score series; validity of test scores; criterion-related validity; indirect measures of validity; distinction between reliability and validity.

Unit 2: Demand Analysis (Credit: 1.5)

Meaning of demand; demand function; law of demand; Giffen's paradox; price, cross and income elasticity of demand; estimation of elasticity by the family budget method; Lorenz curve and Gini coefficient; Engel's law; Engel curve and its forms; Pareto's law of income distribution; demand forecasting: meaning, need and importance; methods of demand forecasting including consumer survey, expert opinion, market experiments, time series analysis and econometric methods.

Unit 3: Practical (Credit: 1)

Practical exercises based on Educational Statistics and Demand Analysis, including computation of standard scores, T-scores, reliability measures, Lorenz curve, Gini coefficient, Engel curve, elasticity of demand and demand forecasting.

Textbooks

Garrett, H. E. (1926). Statistics in Psychology and Education. Longmans, Green and Co.

Ahuja, H. L. (2017). Managerial Economics: Analysis of Managerial Decision Making (9th ed.). S. Chand.

Mukhopadhyay, P. (1999). Applied Statistics. New Central Book Agency.

Gupta, S. C., & Kapoor, V. K. (2020). Fundamentals of Applied Statistics. Sultan Chand & Sons.

Reference Books

Gun, A. M., Gupta, M. K., & Dasgupta, B. (2008). Fundamentals of Statistics, Vol. II (9th ed.). World Press.

Mukhopadhyay, P. (1999). Applied Statistics. Books and Allied (P) Ltd.

Biswas, S. (1988). Stochastic Processes in Demography and Applications. Wiley Eastern.

Croxton, F. E., Cowden, D. J., & Klein, S. Applied General Statistics. Prentice Hall.

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EIGHT SEMESTER :

Option 2: Honours with Research

Semester 8

Course code : STA4800104MJ

Course Name : Design of Experiment and Linear Models

Credits: 4 (Theory: 04 credits, Practical/Lab: 00 credit)

Course Level : 400

Number of Contact classes : 60

Number of Non contact classes : 00

Course Outcomes (COs)

After successful completion of this course, the students will be able to:

CO1

Analyze advanced experimental designs, including randomized block designs with missing observations, confounding in factorial experiments, and incomplete block designs, to select suitable designs for agricultural, industrial and scientific investigations.

CO2

Apply the principles of balanced and partially balanced incomplete block designs, intra-block and inter-block analyses, and recovery of information to obtain efficient estimates from designed experiments.

CO3

Evaluate linear statistical models by employing least squares estimation, hypothesis testing, multiple comparison procedures, and analysis of variance to draw valid statistical inferences.

CO4

Develop and interpret advanced regression ndiagnio and econometric models, including multiple and logistic regression, generalized least squares, restricted regression, simultaneous equation models and distributed lag models, for analysing complex real-world data.

Syllabus:

Unit 1 (1 Credit)

Analysis of two missing observations in Randomized Block Design (RBD). Analysis of variance with two concomitant variables. Complete and partial confounding in 2^4 and 2^5 factorial experiments. Complete confounding in 3^2 factorial experiments.

Unit 2 (1 Credit)

Incomplete block designs and their intra-block and inter-block analysis. Criteria for connectedness, balance and orthogonality of block designs (BIBD). Recovery of intra-block information of BIBD. Introduction to Partially Balanced Incomplete Block Designs (PBIBD).

Unit 3 (1 Credit)

Linear model: Gauss–Markov setup, normal equations and least squares estimator. Error and estimation space. Variance and covariance of least squares estimates. Estimation of error variance. Estimation with correlated observations. Least squares estimation under parameter restrictions. Tests of hypotheses for one and more than one linear parametric function. Multiple comparison tests due to Tukey, Scheffé, Student–Newman–Keuls and Duncan.

Unit 4 (1 Credit)

Multiple linear regression, maximum likelihood estimation and hypothesis testing, testing in multiple linear regression, analysis of variance for linear models, indicator (dummy) variables, use of R^2 and adjusted R^2, regression diagnostics, multicollinearity, heteroscedasticity, autocorrelation, Durbin–Watson test, logistic regression models – binary response variables, odds ratio, logit function.

References

30. Das, M. N. and Giri, N. C. Experimental Design.
31. Kempthorne, O. Design of Experiments.
32. Joshi, D. D. Linear Estimation.
33. Gujarati, Damodar N. Basic Econometrics.
34. Dougherty, Christopher. Introduction to Econometrics.
35. Wooldridge, Jeffrey M. Introductory Econometrics: A Modern Approach.
36. Draper, N. R. and Smith, H. Applied Regression Analysis.
37. Kmenta, Jan. Elements of Econometrics.
38. Mukhopadhyay, Parimal. Applied Statistics.
39. Rao, C. R. Linear Statistical Inference and Its Applications.
40. Montgomery, Douglas C., Peck, E. A. and Vining, G. G. Introduction to Linear Regression Analysis.

Semester 8

Course code : STA4800204MJ

Course Name : Demography and Statistics for National Development

Credits: 4 (Theory: 04 credits, Practical/Lab: 00 credit)

Course Level : 400

Number of Contact classes : 60

Number of Non contact classes : 00

Course Outcomes (COs)

After successful completion of this course, the students will be able to:

CO1

Analyze demographic data sources, census information and life table techniques, including abridged life table construction, mortality models and national life tables, to interpret population characteristics and mortality patterns.

CO2

Apply demographic methods for population projection and survival analysis using stable and stationary population models, logistic curve fitting, Leslie matrix, actuarial estimator and Kaplan–Meier estimator.

CO3

Evaluate migration patterns and population policies by interpreting internal and international migration measures, migration models, post-censal estimates and population census statistics for demographic planning.

CO4

Develop evidence-based statistical interpretations for national development by analysing sector-wise statistics, national accounts, population census data, socio-economic indicators and official survey results for informed policy and decision making.

Unit 1 (1 Credit)

Sources of demographic data: census, registration, ad hoc surveys and hospital records. Demographic profiles of the Indian Census. Life tables and their applications. Methods of construction of abridged life tables (Greville and Chiang methods). Gompertz and Makeham curves. National life tables and United Nations model life tables.

Unit 2 (1 Credit)

Stable and stationary population models. Population projection by logistic curve fitting and Leslie matrix. Estimation of survival function using actuarial estimator and Kaplan–Meier estimator.

Unit 3 (1 Credit)

Internal migration and its measurement. Migration models. Concept of international migration. Net migration. International and post-censal estimates. Decennial Population Census in India. National Population Policy.

Unit 4 (1 Credit)

Sector-wise statistics: Agriculture, Health, Education, Women and Child Development. Important surveys and censuses, indicators, agencies and their uses. National Accounts: definition, basic concepts, issues, strategy, collection of data and release. Population Census: need, data collected, periodicity, methods of data collection, dissemination and agencies involved. Miscellaneous: socio-economic indicators, gender statistics, important surveys and censuses.

References

41. Swanson, D. A. et al. Methods and Materials of Demography.
42. Chiang, C. L. (1968). Introduction to Stochastic Processes in Biostatistics. John Wiley.

43. Keyfitz, N. (1977). Applied Mathematical Demography. Springer-Verlag.
44. Central Statistical Organisation (CSO). National Accounts Statistics: Sources and Methods.
45. Keyfitz, N. Applied Mathematical Demography. Springer-Verlag.
46. Agarwala, S. N. India's Population Problems. Tata McGraw-Hill.
47. Bose, Ashish. Demographic Diversity of India. B.R. Publishing.
48. Registrar General & Census Commissioner of India. Census of India Administrative Atlas and Primary Census Abstracts.
49. Government of India, Ministry of Statistics and Programme Implementation (MoSPI). National Statistical Office publications, National Accounts Statistics and Social Statistics reports.
50. UNDP. Human Development Reports.
51. United Nations. Principles and Recommendations for Population and Housing Censuses.
52. World Bank. World Development Indicators.
53. UNICEF. The State of the World's Children (latest editions).

Semester 8

Course code : STA4800304MJ

Course Name : Operations Research

Credits: 4 (Theory: 04 credits, Practical/Lab: 00 credit)

Course Level : 400

Number of Contact classes : 60

Number of Non contact classes : 00

Course Outcomes (COs)

Upon successful completion of this course, the students will be able to:

CO1. Explain the principles of linear programming, duality and optimization techniques.

CO2. Apply simplex, transportation, assignment and dynamic programming methods to optimization problems.

CO3. Analyse strategic decision-making problems using game theory and queuing models.

CO4. Evaluate sequencing, scheduling and stochastic service systems for operational efficiency.

CO5. Apply simulation techniques and random variate generation methods for modelling complex systems.

CO6. Develop optimization and simulation models for solving real-life operations research problems.

Course Content

Unit 1 (Credit: 1)

Linear Programming Problems (LPP): Duality in linear programming; symmetric and asymmetric duals; two-phase simplex algorithm; transportation and assignment problems; travelling salesman problem.

Unit 2 (Credit: 1)

Game Theory: Two-person zero-sum games; minimax principle; saddle points; games without saddle points; pure and mixed strategies; solution of 2×2 games; graphical solution procedures; equivalence of rectangular games and linear programming.

Unit 3 (Credit: 1)

Queuing Theory: Specification and performance measures of queuing models; steady-state solutions of M/M/1 and M/M/c queues; queue-length and

waiting-time distributions; sequencing and scheduling problems; two-machine n-job and three-machine n-job problems with identical machine sequence.

Unit 4 (Credit: 1)

Simulation: Generation of random numbers; inverse transform method; acceptance–rejection method; simulation of discrete and continuous random variates; Markov Chain Monte Carlo (MCMC).

References

1. Taha, H. A. Operations Research: An Introduction (10th ed.). Pearson.

2. Hillier, F. S. and Lieberman, G. J. Introduction to Operations Research (11th ed.). McGraw-Hill.

3. Ravindran, A., Phillips, D. T. and Solberg, J. J. Operations Research: Principles and Practice. Wiley.

4. Swarup, K., Gupta, P. K. and Mohan, M. Operations Research. Sultan Chand & Sons.

5. Winston, W. L. Operations Research: Applications and Algorithms. Cengage.

6. Sharma, J. K. Operations Research: Theory and Applications. Macmillan.

7. Hadley, G. Linear Programming. Addison-Wesley.

8. Ross, S. M. Simulation (5th ed.). Academic Press.

9. Law, A. M. Simulation Modeling and Analysis (5th ed.). McGraw-Hill.

10. Gross, D., Shortle, J. F., Thompson, J. M. and Harris, C. M. Fundamentals of Queueing Theory (5th ed.). Wiley.

Semester 8

Course code : STA4800412MJ

Course Name : Dissertation

Credits: 12 (Theory: 00credits, Practical/Lab: 00 credits)

Course Level : 400

Number of Contact classes : 60

Number of Non contact classes : 00

Semester 8

Course code : STA4800104MN

Course Name : Applied Statistics-2

Credits: 4 (Theory: 03credits, Practical/Lab: 01 credits)

Course Level : 400

Number of Contact classes : 60

Number of Non contact classes : 00

Course Objectives

To introduce statistical methods used in educational measurement and evaluation.

To develop an understanding of demand analysis and income distribution using statistical tools.

To provide practical exposure to applications of educational and economic statistics.

Course Outcomes

CO1. Apply scaling techniques and interpret educational test scores using standard statistical measures.

CO2. Evaluate the reliability and validity of educational tests and combine scores using appropriate statistical procedures.

CO3. Analyze consumer demand, elasticity, income distribution and demand forecasting using statistical methods.

CO4. Apply educational and economic statistical techniques to analyze real-world datasets using appropriate software.

Unit 1: Educational Statistics (Credit: 1.5)

Definition of scaling; scaling procedures; scaling individual test items in terms of difficulty; scaling of scores on a test; Z (σ) scores, standard scores, normalized scores and T-scores; computation of T-scores from a frequency distribution; comparison of T-scores and standard scores; percentile scores; merits and demerits of percentile scores; scaling of rankings and ratings using the normal probability curve; reliability of test scores; self-correlation; reliability coefficient; effect of test length on reliability; estimation of reliability from a single administration; dependence of reliability on group size and variability; index of reliability; combining scores from different tests by percentiles, median mental age, weighted scores and conversion to comparable score series; validity of test scores; criterion-related validity; indirect measures of validity; distinction between reliability and validity.

Unit 2: Demand Analysis (Credit: 1.5)

Meaning of demand; demand function; law of demand; Giffen's paradox; price, cross and income elasticity of demand; estimation of elasticity by the family budget method; Lorenz curve and Gini coefficient; Engel's law; Engel curve and its forms; Pareto's law of income distribution; demand forecasting: meaning, need and importance; methods of demand forecasting including consumer survey, expert opinion, market experiments, time series analysis and econometric methods.

Unit 3: Practical (Credit: 1)

Practical exercises based on Educational Statistics and Demand Analysis, including computation of standard scores, T-scores, reliability measures, Lorenz curve, Gini coefficient, Engel curve, elasticity of demand and demand forecasting.

Textbooks

Garrett, H. E. (1926). Statistics in Psychology and Education. Longmans, Green and Co.

Ahuja, H. L. (2017). Managerial Economics: Analysis of Managerial Decision Making (9th ed.). S. Chand.

Mukhopadhyay, P. (1999). Applied Statistics. New Central Book Agency.

Gupta, S. C., & Kapoor, V. K. (2020). Fundamentals of Applied Statistics. Sultan Chand & Sons.

Reference Books

Gun, A. M., Gupta, M. K., & Dasgupta, B. (2008). Fundamentals of Statistics, Vol. II (9th ed.). World Press.

Mukhopadhyay, P. (1999). Applied Statistics. Books and Allied (P) Ltd.

Biswas, S. (1988). Stochastic Processes in Demography and Applications. Wiley Eastern.

Croxton, F. E., Cowden, D. J., & Klein, S. Applied General Statistics. Prentice Hall.

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