Syllabus for Four Years Undergraduate Programme

Subject: STATISTICS

UNDER NATIONAL EDUCATION POLICY 2020

TRIPURA UNIVERSITY
(A Central University)
Suryamaninagar, Tripura – 799022, India.

(Effective from Academic Session 2023-24)

(For University Campus and Colleges)

Course Structures– Under NEP 2020

STATISTICS (MAJOR)

Year	Semester	Paper	Title
1	1	Course-I (Th-4)	Descriptive Statistics and Mathematics
		Course-II (Th-2)	Numerical Analysis
		Course-II (Pr-2)	Practical -I
	2	Course-III (Th-4)	Probability and Probability Distributions
		Course-IV (Th-2)	Bivariate Analysis
		Course-IV (Pr-2)	Practical -II
2	3	Course-V (Th-4)	Bivariate Normal Distribution, Convergence and Sampling Distribution
		Course-VI (Th-2)	Sample Survey
		Course-VI (Pr-2)	Practical -III
	4	Course-VII (Th-4)	Testing of Hypothesis
		Course-VIII (Th-2)	Theory of Estimation
		Course-VIII (Pr-2)	Practical -IV
3	5	Course-IX (Th-4)	ANOVA, ANCOVA and Experimental Designs
		Course-X (Th-2)	Multivariate analysis
		Course-X (Pr-2)	Practical -V
		Course-XI (Th-4)	Demography
		Course-XII (Th-2)	Index Numbers and Psychometry
		Course-XII (Pr-2)	Practical -VI
	6	Course-XIII (Th-4)	Bio Statistics
		Course-XIV (Th-2)	Statistical Quality Control
		Course-XIV (Pr-2)	Practical -VII
		Course-XV (Th-4)	LPP and Operations Research
		Course-XVI (Th-2)	Time Series Analysis
		Course-XVI (Pr-2)	Practical -VIII
4	7	Course-XVII (Th-4)	Measure theory, Probability and Distribution theory
		Course-XVIII(Th-2)	Mathematical Analysis - I
		Course-XVIII (Pr-2)	Practical -IX
		Course-XIX (Th-4)	Sampling techniques
		Course-XX (Th-2)	Mathematical Analysis - II
		Course-XX (Pr-2)	Practical -X
	8	Course-XXI (Th-4)	Statistical inference
		Course-XXII (Th-2)	Official Statistics
		Course-XXII (Pr-2)	Practical -XI
		Course-XXIII (Th-4)	Linear algebra and Linear model
		Course-XXIV (Th-2)	Statistics for national development
		Course-XXIV (Pr-2)	Practical -XII

STATISTICS (MINOR)

Year	Semester	Paper	Title
1	1	Course-I (Th-3 + Pr-1)	Basic Statistics and Numerical Analysis
	2	Course-II (Th-3 + Pr-1)	Probability, Random Variable and Bivariate Analysis
2	3	Course-III (Th-3 + Pr-1)	Probability Distributions and Index Numbers
	4	Course-IV (Th-3 + Pr-1)	Sampling and Multivariate Analysis-I
3	5	Course-V (Th-3 + Pr-1)	Estimation, Test of Significance and Design of Experiment -I
	6	Course-VI (Th-3 + Pr-1)	SQC, Vital Statistics and Time Series Analysis
4	7	Course-VII (Th-3 + Pr-1)	Sampling and Multivariate Analysis-II
	8	Course-VIII (Th-3 + Pr-1)	Estimation, Test of Significance and Design of Experiment - II

Skill Enhancement Courses (SEC) in Statistics

Paper	Title
SEC - I	Use of Software for Statistical Data Analysis
SEC - II	Statistical Survey Methods

Subject Prerequisites:

To study this subject a student must had the subject Mathematics in Class 12^{th}.

Programme Outcomes (POs):

Students having degree in B.Sc. (with Statistics) should have knowledge and expertise of various concepts and fundamentals of Statistics and ability to apply this knowledge in several fields of academia, administration and industry. The students may pursue their carrier in the field of Statistics and allied subjects research.

Programme Specific Outcomes (PSOs):

After completing B.Sc. (with Statistics) the student should have

- Knowledge of different theorems, principles, concepts, methodologies, tools and techniques (skills) of Statistics
- Ability to do data collection, tabulation, and representation through graphically and mathematically, analysis and interpretation by using appropriate statistical tools.
- Ability to identify and solve several statistical real life problems of research and industry.
- Familiarity with various computational techniques and statistical software including programming languages (i.e., R, Python) for statistical computation.
- Capability to use appropriate statistical techniques in different interdisciplinary areas, like health, agriculture, finance, PSUs, telecommunications and bio-statistics.
- Ability to compete with industrial and private sector research and official demand of data analysis, marketing survey and pursue their career in the field of advanced and modern statistics.
- Ability to develop original thinking of formulating new problems and providing respective solutions to pursue higher studies and research in the field of statistics and allied subjects.
- Ability to address several real-life unsolved problems by developing of new statistical models and generate different ideas of start-up to build up nations' development.

Statistics (Major) Syllabus

Statistics Major [1st Semester]
Paper: Course-I (Credit 4 Th)

Descriptive Statistics and Mathematics

Course outcomes:
After completing this course a student will have:

- ✓ Knowledge of Statistics, its scope and importance in various fields.
- ✓ Ability to understand concepts of sample vs. population and difference between different types of data.
- ✓ Knowledge of methods for summarising data sets, including common graphical tools (such as boxplots, histograms and stem plots). Interpret histograms and boxplots.
- ✓ Ability to describe data with measures of central tendency and measures of dispersion.
- ✓ Ability to understand measures of skewness and kurtosis and their utility and significance.
- ✓ Ability to understand the concept of probability along with basic laws and axioms of probability.
- ✓ Ability to understand the terms mutually exclusive and independence and their relevance.
- ✓ Ability to identify the appropriate method (i.e. union, intersection, conditional, etc.) for solving a problem.
- ✓ Ability to apply basic probability principles to solve real life problems.
- ✓ Ability to understand the concept of random variable (discrete and continuous), concept of probability distribution.

Unit I (Statistical Methods and Central tendency)

Introduction to Statistics: Definition, scope and Limitations of statistics, Use of statistics. Collection and classification of data: Primary data and secondary data, methods of collection of data, Scrutiny of data. Classification, principles of classification, types of classification.

Tabular presentations of data. Diagrammatic representation of data. Frequency distribution and its constructions. Graphical presentations of frequency distribution.

Concept of central tendency, Different measures of central tendencies. Empirical relationships between different measures.

Unit II (Dispersion and Moments)

Concept of dispersion, Different measures of dispersion and their properties. Different types of moments, relationships between raw and central moments. Sheppard's corrections for moments (without proof).Skewness and Kurtosis and their measures.Boxplot.

Unit III (Elementary Mathematics)

Permutation and combination, Arithmetic and Geometric Progression. Binomial expansion for positive and negative indices. Series Expansions of Exponential and Logarithmic Functions. The principle of mathematical induction.

Unit IV (Calculus and Mathematical Analysis)

Limit, Continuity and Differentiability of functions. Total and Partial Differentiation. Maximum and Minimum of univariate and bivariate functions. Integration of univariate and bivariate functions. Beta and Gamma Integration.

Definition of a Matrix, Different types of matrix, Matrix operations, Elementary matrices and their uses, Rank of a matrix, Inverse of a matrix, Determinants, Quadratic forms, Reduction of Quadratic form to canonical form. Basic concept of Characteristic roots and vectors.

Suggested Reading:

[1] Goon A.M., Gupta M.K. andDasgupta B. (2002): Fundamentals of Statistics (Vol-I), World Press, Kolkata.
[2] Goon A.M., Gupta M.K. andDasgupta B. (1994): An Outline of Statistical Theory (Vol-I), World Press, Kolkata.
[3] Rohatgi V.K. (1984): An Introduction to Probability Theory and Mathematical Statistics, John Wiley.
[4] Kendall M.G. and Stuart A. (1966): Advanced Theory of Statistics (Vol-IandII).
[5] Gupta S. C., Kapoor V. K.: Fundamentals of Mathematical Statistics, Sultan Chand and Sons.

Statistics Major [1st Semester]
Paper: Course-II (Credit 2 Th)

Numerical Analysis

Course outcomes:

After completing this course a student will have:

- ✓ Knowledge of interpolation.
- ✓ Knowledge of numerical integration.
- ✓ Ability to solve the numerical equations.

Unit I (Numerical Analysis - I)

Interpolation: Difference operators (Δ, E, D), Polynomial approximation, Difference table. Interpolation: Newton's forward and backward interpolation formulae, Divided difference, Lagrange's interpolation formula.

Unit I (Numerical Analysis - II)

Numerical Integration: Trapezoidal and Simpson's one-third rules. Euler maclaurin summation formula.

Numerical solutions of univariate equation: Bisection, Iteration and Newton-Raphson methods. Convergences of Iteration and Newton-Raphson methods.

Stirling's approximation to n! for large n.

Suggested Reading:

[1] Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics (Vol-I), World Press, Kolkata.
[2] Goon A.M., Gupta M.K. and Dasgupta B. (1994): An Outline of Statistical Theory (Vol-I), World Press, Kolkata.
[3] Rohatgi V.K. (1984): An Introduction to Probability Theory and Mathematical Statistics, John Wiley.
[4] Kendall M.G. and Stuart A. (1966): Advanced Theory of Statistics (Vol-IandII).
[5] Gupta S. C., Kapoor V. K.: Fundamentals of Mathematical Statistics, Sultan Chand and Sons.

Statistics Major [1st Semester]
Paper: Course-II (Credit 2 Pr)

Practical-I

(Computational tools: Calculator / Spreadsheet / SPSS / R / Python)

Numerical issues based on the two theory papers mentioned above in terms of Descriptive Statistics, Mathematics, and Numerical Analysis.

Statistics Major [2nd Semester]
Paper: Course-III (Credit 4 Th)

Probability and Probability Distributions

Course outcomes:

After completing this course a student will have:

- ✓ Knowledge of different convergent relational analysis of probability space.
- ✓ Ability to understand the concept of probability along with basic laws and axioms of probability.
- ✓ Ability to apply basic probability principles to solve real life problems.
- ✓ Ability to understand the concept of random variable (discrete and continuous), concept of probability distribution.
- ✓ Ability to formulate different generating functions and application of order statistics in real-life examples

Unit I (Probability)

Random experiment, Sample point, Sample space, different types of Events, Meaning of Probability, Classical, Statistical and Axiomatic definitions of Probability. Limitation of classical definition of Probability, Theorem on the Probability of union of Events. Conditional Probability, Theorem on conditional Probability, Statistical independence of Events, Bayes' theorem and its application.

Unit II (Random variable, Expectation and Generating functions)

Definition of discrete and continuous random variables.Probability mass function (p.m.f.).Probability density function (p.d.f).Cumulative distribution function (c.d.f.) and its properties. Expectation and moments,

Moment generating function (m.g.f.). Probability generating function (p.g.f).Characteristic function (Definition and properties only).

Unit III (Discrete Probability distributions)

Uniform, Bernoulli, Binomial, Poisson, Hypergeometric, Negative Binomial, Geometric and Power Series distributions.

Unit IV (Continuous Probability distributions)

Uniform, Exponential, Normal, Gamma, Beta, Laplace, Log-normal, Weibull, Cauchy.

Suggested Reading:

[6] Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics (Vol-I), World Press, Kolkata.
[7] Goon A.M., Gupta M.K. and Dasgupta B. (1994): An Outline of Statistical Theory (Vol-I), World Press, Kolkata.
[8] Rohatgi V.K. (1984): An Introduction to Probability Theory and Mathematical Statistics, John Wiley.
[9] Kendall M.G. and Stuart A. (1966): Advanced Theory of Statistics (Vol-IandII).
[10] Gupta S. C., Kapoor V. K.: Fundamentals of Mathematical Statistics, Sultan Chand and Sons.

Statistics Major [2nd Semester]
Paper: Course-IV (Credit 2 Th)
Bivariate Analysis

Course outcomes:

After completing this course a student will have:

- ✓ Knowledge of the method of least squares for curve fitting to theoretically describe experimental data with a function or equation and to find the parameters associated with the model.
- ✓ Knowledge of the concepts of correlation and simple linear regression for regression analysis.
- ✓ Ability to interpret results from correlation and regression,
- ✓ Ability to compute and interpret rank correlation.
- ✓ Ability to understand concept of qualitative data and its analysis.

Unit I (Bivariate Correlation and Regression)

Bivariate data, Scatter diagram, Correlation coefficient and its properties. Spearman's Rank correlation. Intraclass Correlation.

Principle of Least squares. Concept of regressions, Regression lines, Important results relating to regression lines. Fitting of Polynomial, Inverse, Exponential and Growth curve.

Unit II (Bivariate Analysis)

Bi-variate frequency distribution. The p.m.f., p.d.f. and c.d.f. in the bivariate case. Marginal and conditional distributions. Independence, conditional expectation and conditional variance.

Theorem on sum and product of expectations of variables. Cauchy-Schwarz inequality.

Suggested Reading:

[11] Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics (Vol-I), World Press, Kolkata.
[12] Goon A.M., Gupta M.K. and Dasgupta B. (1994): An Outline of Statistical Theory (Vol-I), World Press, Kolkata.
[13] Rohatgi V.K. (1984): An Introduction to Probability Theory and Mathematical Statistics, John Wiley.
[14] Kendall M.G. and Stuart A. (1966): Advanced Theory of Statistics (Vol-IandII).
[15] Gupta S. C., Kapoor V. K.: Fundamentals of Mathematical Statistics, Sultan Chand and Sons.

Statistics Major [2nd Semester]
Paper: Course-IV (Credit 2 Pr)

Practical-II

(Computational tools: Calculator / Spreadsheet / SPSS / R / Python)

Numerical issues based on the two theory papers mentioned above in terms of Probability, Distribution and Bivariate Analysis.

Statistics Major [3rd Semester]
Paper: Course-V (Credit 4 Th)

Bivariate Normal Distribution, Convergence and Sampling Distribution

Course outcomes:
After completing this course a student will have:

- ✓ Knowledge of the concept of Sampling distributions.
- ✓ Ability to understand the difference between parameter and statistic and standard error and standard deviation.
- ✓ Knowledge of the sampling distribution of the sum and mean.
- ✓ Ability to understand the t, f and chi-square distribution and to identify the main characteristics of these distributions.

Unit I (Bivariate Normal Distribution)
Bivariate normal distribution and its properties.

Unit II (Convergence and Truncated distributions)
Convergence in probability (Definition only).Convergence in distribution (Definition only).Tchebycheff's Inequality. Weak law of large numbers (Definition only). Bernoulli's law of large numbers (Definition only).Central limit theorem (Definition only). De-Moiver-Laplace Theorem.

Truncated distributions: Binomial, Poisson, Exponential and Normal distributions.

Unit III (Sampling Distributions – I)
Sampling distribution of statistic and its Standard Error. Derivation of standard error formulae for mean and sample proportion. Derivation of large sample standard error of sample moments, standard deviation and coefficient of variation.

Definitions, properties derivations and use of χ^2 distribution. Frequency χ^2 and Yates' correction. Derivations of distributions of sample mean and variance in case of sampling from normal population.

Unit IV (Sampling Distributions – II)
Definitions, properties derivations and use of t and F distributions.

Order statistics: Concept of Order statistics. Exact sampling distributions of order statistics (continuous case).Extreme values and extreme order statistics (continuous case). Distribution of sample median and sample range (continuous case).

Suggested Reading:

[1] Goon A.M., Gupta M.K. and Dasgupta B.: Fundamentals of Statistics (Vol-II), World Press, Kolkata.
[2] MukhopadhyayParimal: Theory and Methods of Survey Sampling - 2nd Edition, PHI Learning Private Limited, Delhi.
[3] Singh D, Chaudhary F.S.: Theory and analysis of sample survey designs, John Wiley.
[4] Cochran W. G.: Sample survey techniques, John Wiley.
[5] Gupta S. C., Kapoor V. K.: Fundamentals of Applied Statistics, Sultan Chand and Sons.
[6] Bhuyan K.C. (2017) Design of Experiments and Sampling Methods. New Central Book Agency (P) Ltd.
[7] 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
[8] Murthy, M.N. (1977): Sampling Theory and Statistical Methods, Statistical Pub. Society, Calcutta
[9] Des Raj and Chandhok P. (1998): Sample Survey Theory, Narosa Publishing House.

Statistics Major [3rd Semester]
Paper: Course-VI (Credit 2 Th)

Sample Survey

Course outcomes:
After completing this course a student will have:

- ✓ Knowledge of the concept of Sampling distributions.
- ✓ Knowledge of the sampling distribution of the sum and mean.
- ✓ Ability to understand the concept of sampling and how it is different from complete enumeration.
- ✓ Knowledge of various probability and non-probability sampling methods along with estimates of population parameters
- ✓ Ability to identify the situations where the various sampling techniques shall be used.
- ✓ Knowledge of sampling and non-sampling errors.

Unit I (Introduction to Sample Survey and Simple random sampling)

Concepts of a finite population and of a sample. Need for sampling. Complete enumeration and sample surveys.

Planning and execution of sample survey. Biases and Errors. Judgment and probability samplings. Tables of random numbers and their uses.

Concepts of random sampling, statistic and parameter.

Simple random sampling with and without replacement. Associated unbiased estimators of population total, mean and proportion. Their variances and unbiased estimators of variances.

Unit II (Stratified andSystematic sampling)

Basic concept of Stratified random sampling. Estimation of population mean and population total. Proportional and optimum allocations. Comparison with simple random sampling.

Concept of Linear and Circular Systematic sampling. Estimation of population mean and total.

Suggested Readings:

[1] Cochran, W. G: Sampling Techniques. Wiley Eastern.
[2] Sampath, S: Sampling Theory and Methods. Narosa Publising House.
[3] Singh, Daroga and Chaudhary, F. S: Theory and Analysis of Sample Survey Designs. New Age International (P) Limited Publishers.
[4] Mukhopadhyay, Parimal: Theory and Methods of Survey Sampling. Prentice Hall.
[5] Murthy, M. N: Sampling Theory and Methods. Statistical Publishing Society.
[6] Mukhopadhyay, Parimal: Small Area Estimation in Survey Sampling. Narosa Publising House.
[7] Sukhatme, P.V. and Sukhatme, B.V.: Sampling Theory of Surveys with Applications, Piyush Publications, New Delhi.

Statistics Major [3rd Semester]
Paper: Course-VI (Credit 2 Pr)

Practical-III

(Computational tools: Calculator / Spreadsheet / SPSS / R / Python)

Numerical issues based on the two theory papers mentioned above in terms of Bivariate Normal Distribution, Convergence and Sampling Distribution and Sample Survey.

Statistics Major [4thSemester]
Paper: Course-VII (Credit 4 Th)

Testing of Hypothesis

Course outcomes:

After completing this course a student will have:

- ✓ Knowledge of the terms like null and alternative hypotheses, two-tailed and one tailed alternative hypotheses, significant and insignificant, level of significance and confidence, p value etc.
- ✓ Ability to understand the concept of MP, UMP and UMPU tests
- ✓ Ability to understand under what situations one would conduct the small sample and large sample tests (in case of one sample and two sample tests).

Unit I (Test of Significance - I)
Null and alternative hypotheses (simple and composite), Type-I and Type-II errors, critical region, level of significance, power of a test. Concept of P value. Exact tests of hypotheses under normal set-up for a single mean, the equality of two means, a single variance and the ratio of two variances.

Unit II (Test of Significance - II)
Exact tests relating to binomial and Poisson distributions. Tests of significance for correlation coefficient and regression coefficients of a bivariate normal distribution. Contingency tables and Chi-square test of independence, Chi-square test for goodness of fit. Transformation of Statistic.

Unit III (Theory of Test of Significance)
Most powerful (MP) test. Uniformly most powerful (UMP) test. Uniformly most powerful unbiased (UMPU) test. Fundamental Neyman-Pearson Lemma and its uses in the constructions of MP and UMP tests (single parameter with range independent of the parameter). Combination of probabilities in test of significance, Likelihood ratio test and its application to test for the equality of means.

Unit – IV (Nonparametric Tests)
Nonparametric tests: Sign test. Two sample Median test. Wilcoxon signed-rank test. Run test. Test of randomness. Mann-Whitney U-test. Kolmogorov-Smirnov Test, Kruskal-Walli Test, Friedman test.

Suggested Reading:

[1] Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics (Vol-I), World Press, Kolkata.
[2] Goon A.M., Gupta M.K. and Dasgupta B. (1994): An Outline of Statistical Theory (Vol-Iand II), World Press, Kolkata.
[3] Rohatgi V.K. (1984): An Introduction to Probability Theory and Mathematical Statistics, John Wiley.
[4] Kendall M.G. and Stuart A. (1966): Advanced Theory of Statistics (Vol-IandII).
[5] Gupta S. C., Kapoor V. K.: Fundamentals of Mathematical Statistics, Sultan Chand
[6] Bhuyan K.C. (2010): Probability Distribution Theory and Statistical Inference. New Central Book Agency (P) Ltd.

Statistics Major [4th Semester]
Paper: Course-VIII (Credit 2 Th)

Theory of Estimation

Course outcomes:
After completing this course a student will have:

- ✓ Knowledge of the concept of Point and Interval Estimation and discuss characteristics of a good estimator.
- ✓ Ability to understand and practice various methods of estimations of parameters.

Unit I (Point Estimation)

Concepts of estimation.Point estimation. Requirement of a good estimator: unbiasedness, sufficiency, consistency and efficiency. Different problems related to unbiasedness, consistency and efficiency. Minimum variance unbiased estimator (MVUE). Best Linear Unbiased Estimator (BLUE).

Unit II (Methods of Estimation and Interval Estimation)

Different Methods of Estimation: Method of moments, method of maximum likelihood (MLE) and method of minimum Chi-square. Properties of MLE (statement only) and related problems. Basic concept of Bayes rule and related simple problems. Cramer-Rao inequality. MVB estimators and related problems.

Concepts of confidence interval and confidence coefficient, Method of Construction of confidence interval. Exact confidence intervals under normal set-up for a single mean, single variance, difference of two means and ratio of two variances. Confidence interval using large sample and confidence interval using Chebyshev's inequality.

Suggested Reading:

[7] Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics (Vol-I), World Press, Kolkata.

[8] Goon A.M., Gupta M.K. and Dasgupta B. (1994): An Outline of Statistical Theory (Vol-Iand II), World Press, Kolkata.

[9] Rohatgi V.K. (1984): An Introduction to Probability Theory and Mathematical Statistics, John Wiley.

[10] Kendall M.G. and Stuart A. (1966): Advanced Theory of Statistics (Vol-IandII).

[11] Gupta S. C., Kapoor V. K.: Fundamentals of Mathematical Statistics, Sultan Chand

[12] Bhuyan K.C. (2010): Probability Distribution Theory and Statistical Inference. New Central Book Agency (P) Ltd.

Statistics Major [4th Semester]

Paper: Course-VIII (Credit 2 Pr)

Practical-IV

(Computational tools: Calculator / Spreadsheet / SPSS / R / Python)

Numerical issues based on the two theory papers mentioned above in terms of Testing of Hypothesis and Theory of Estimation.

Statistics Major [5th Semester]

Paper: Course-IX (Credit 4 Th)

ANOVA, ANCOVA and Experimental Designs

Course outcomes:

After completing this course a student will have:

- ✓ Knowledge of the concept of Analysis of Variance (ANOVA) and it's applications.
- ✓ Ability to carry out the ANOVA for One way and Two way Classification.
- ✓ Ability to carry out the post-hoc analysis for finding the significant factors.
- ✓ Knowledge of the concept of Design of experiment and its basic principles.
- ✓ Ability to perform the basic symmetric designs CRD, RBD and LSD with and without missing observations.
- ✓ Knowledge of the analysis when covariates are important and able to do the ANCOVA.
- ✓ Knowledge of the concept of factorial experiments and their practical applications.

Unit I (ANOVA)

Introduction: Heterogeneity and Analysis of variance. Linear Hypothesis. Orthogonal splitting of total variation. Selection of valid error.

Analyses of variances for one-way and two-way classified data (fixed effects models). Analysis of variance with equal but more than one observation in each cell for two-way classified data (fixed effects model).

Unit II (Applications of ANOVA and ANCOVA)

Application of the technique of analysis of variance in the study of relationship: Test for the relationship between two variables. Test for the linearity of regression. Test for polynomial regression. Test for the homogeneity of a group of regression coefficients. Test for equality of regression equations for '*p'* groups. Test for multiple linear regression model.

Analysis of covariance: Analysis of covariance for a one-way layout with one concomitant variable. Analysis of covariance for an RBD with one concomitant variable.

Unit III (Design of Experiments I)

Principles of experimental design: Randomization, Replication and Local Control. Uniformity trials. Shapes and sizes of plots and blocks.

Standard designs and their analyses: Completely randomized design (CRD). Randomized block design (RBD). Latin square design (LSD). Comparison of efficiency of a RBD with that of a CRD.

Missing plot techniques in a RBD and in a LSD with one observation missing.

Unit IV (Design of Experiments II)

Factorial experiments: A 2^2 experiment and a 2^3 experiment. Orthogonality and confounding in factorial design. Complete and partial confounding in 2^2 and 2^3 experiments.

Suggested Reading:

[1] Gupta S. C., Kapoor V. K.: Fundamentals of Applied Statistics, Sultan Chand and Sons

[2] H. Scheffe: The Analysis of Variance, Wiley, 1961.

[3] H. Toutenburg and Shalabh: Statistical Analysis of Designed Experiments, Springer 2009.

[4] D. C. Montagomery: Design and Analysis of Experiments, 5th Edition, Wiley 2001(Low price edition is available). D. D. Joshi: Linear Estimation and Design of Experiments, Wiley Eastern, 1987.
[5] George Casella: Statistical Design, Springer, 2008.
[6] Max D. Morris: Design of Experiments- An Introduction Based on Linear Models, CRC Press, 2011.
[7] N. Giri: Analysis of Variance, South Asian Publishers, New Delhi 1986.
[8] H. Sahai and M.I. Ageel: The Analysis of Variance-Fixed, Random and Mixed Models, Springer, 2001.

Statistics Major [5th Semester]
Paper: Course-X (Credit 2 Th)

Multivariate analysis

Course outcomes:

After completing this course a student will have:

- ✓ Ability to understand the basic concepts of matrices in order to study multivariate distribution.
- ✓ Ability to understand bivariate normal distribution and its applications.
- ✓ Knowledge of the applications of multivariate normal distribution and Maximum Likelihood estimates of mean vector and dispersion matrix.
- ✓ Knowledge of the formal definition of order statistics.
- ✓ Ability to identify the application of theory of order statistics in real life problems.
- ✓ Ability to apply the concept of order statistics and find out its' respective distributions.
- ✓ Ability to apply distribution free tests (Non-parametric methods) for one and two sample cases**.**

Unit I (Introduction to Multivariate data)

Multivariate probability mass/density function, Distribution function, Marginal and Conditional distributions, Mean vector and Dispersion matrix, MGF. Multiple linear regression. Multiple and partial correlation coefficient and their properties.

Unit II (Multivariate Normal and Multinomial distribution)

Multivariate Normal distribution: Marginal and Conditional distributions, Mean vector and Dispersion matrix, MGF. Multinomial distribution and its properties.

Suggested Reading:

[1] Gupta S. C., Kapoor V. K.: Fundamentals of Applied Statistics, Sultan Chand and Sons.
[2] Johnson and Wichern: Applied Multivariate Statistical Analysis, Pearson India.
[3] Douglas C. Montgomery, Elizabeth A. Peck, G. Geoffrey Vining ,Introduction to Linear Regression Analysis, (Wiley).
[4] Rohatgi, V.K: An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern, New Delhi.
[5] Corder G.W., Foreman, D.I. : Nonparametric Statistics : A Step by Step Approach, Wiley

Statistics Major [5th Semester]
Paper: Course-X (Credit 2 Pr)

Practical-V

(Computational tools: Calculator / Spreadsheet / SPSS / R / Python)

Numerical issues based on the two theory papers mentioned above in terms of Multivariate analysis ANOVA, ANCOVA and Experimental Designs.

Statistics Major [5th Semester]
Paper: Course-XI (Credit 4 Th)

Demography

Course outcomes:

After completing this course a student will have:

- ✓ Knowledge about Demographic data.
- ✓ Ability to estimate the measures the fertility and mortality.
- ✓ Knowledge of population projections.

Unit I (Concept of Demography and Adjustment of Demographic Data)

Definition and Scope: Evolution of demography as a scientific discipline; Nature and scope of demography and changes in it over time. Multi-disciplinary nature of Demography, its linkage with other social science disciplines. Basic demographic concepts. Components of population change. Demographic transition (description rather than theory).

Data requirements, types of demographic data. Coverage and content errors in demographic data. Use of balancing equation and Chandrasekharan-Demining formula to check completeness of registration data.

Measures of age structure: Percent distribution, Median age, age-sex pyramid, dependency ratio and potential support ratio. Factors affecting age and sex structure . Adjustment of age data, Techniques of evaluation of age data using Whipple's index, Myer's index, UN Joint score.

Unit II (Measures of Fertility)

Need and Importance of the study Fertility; Sources of fertility data. Basic concept and measures of fertility: Crude Birth Rate (CBR), General Fertility Rate (GFR), Age Specific Fertility Rate (ASFR), Total Fertility rate (TFR), Child-Woman Ratio (CWR), Sex Ratio at Birth (SRB). Standardized Birth Rates: Direct Standardized (Crude) birth rate, Indirect Standardized (Crude) birth rate, Sex Age Adjusted Birth Rate (SAABR), Coale's Fertility Indices.

Cohort measures of fertility: Cohort total fertility rate (CTFR), Mean number of children ever born (MNCEB), Parity Progression Ratios (PPR), Birth Interval Analysis (BIA).

Reproduction Measures: Gross reproduction rate (GRR), Net reproduction rate (NRR).

Fertility frameworks and Models: Determinants of natural fertility; Bongaarts proximate determinants of fertility; Coale-Trussell's model for age patterns of fertility.

Unit III (Measures of Mortality)

Need and Importance of the study Mortality; Sources of mortality data. Basic Concepts and definitions: Miscarriage, abortion, fetal deaths, still births, live birth, deaths, early and late neonatal death, infant death, child death Introduction and basic measures of mortality: crude death rate (CDR) and Age-Specific Death Rates (ASDRs) and their relative merits and demerits. Need and importance of standardization of mortality Ratios/Rates; Direct and indirect techniques of standardization of mortality rates;

Conventional measures of infant mortality (IMR) and its sub-divisions- Neo-natal (early and late) and Post-Neonatal mortality. Need for adjustment of IMR; Numerator and denominator separation factor approaches for estimating adjusted rate.

Various measures of pregnancy wastage: Fetal Death Ratio, Still Birth Rate, Peri-natal Mortality Ratio/Rate; and Maternal Mortality Ratio/Rate.

Life table: Definition, assumptions, different columns of life table, uses of life table. Construction of life table: Conventional approach, Model life tables.

Unit IV (Indirect Estimation of Fertility and Mortality and Population Projection)

Reverse Survival, Rele technique; P/F ratio technique for estimating fertility. Brass Method of Estimating Child Mortality; Indirect Estimation Methods using Age-Distribution at two censuses.

Concepts of population projections; population estimates, forecasts and projections, uses of population projections. Methods of interpolation, extrapolation using linear, exponential, polynomial, logistics, Gompertz curves. Cohort component method: basic methodology; projection of mortality, fertility and migration components.

Suggested Reading:

[1] Gupta S. C., Kapoor V. K.: Fundamentals of Applied Statistics, Sultan Chand and Sons.
[2] Box, G.E.P and Jenkins, G.M: Time Series Analysis - Forecasting and Control. Holden-day, San Francisco.
[3] Anderson, T. W: The Statistical Analysis of Time Series. Wiley, N. Y.
[4] Suddhen Biswas: Statistics of Quality Control, New Central Book Agency
[5] Douglas C. Montgomery: Statistical Quality Control: A Modern Introduction, Wiley Publication.
[6] K.B. Pathak F. Ram: Techniques of Demographic Analysis, Himalaya Publishing House

Statistics Major [5th Semester]
Paper: Course-XII (Credit 2 Th)

Index Numbers and Psychometry

Course outcomes:

After completing this course a student will have:

- ✓ Knowledge about different index number.
- ✓ Ability to estimate index numbers.
- ✓ Ability of scaling of data.

Unit I (Index Numbers)

Price, Quantity and Value indices. Price Index Numbers: Construction, uses and limitations. Test for index numbers, various formulae and their comparisons. Chain Index Number. Conversion of fixed based to chain based index numbers and vice-versa. Some Important Indices: Consumer Price Index, Wholesale Price Index and Index of Industrial Production – methods of construction and uses. Compilation of indices, base shifting, splicing and deflating of index numbers.

Unit II (Psychometry)

Scaling of Data: Scales of measurements, Some scaling procedures - Scaling test items in terms of difficulty, Scaling of test-scores in several tests, Scaling of ratings and ranking in terms of normal curve.

Test theory: Linear model of test theory, Parallel tests, Error variance of parallel test.

Reliability: Definition, Effect of test-length on the reliability of a test, Practical methods of estimating test reliability.

Validity: Definition and different concepts of validity.

Suggested Reading:

[7] Gupta S. C., Kapoor V. K.: Fundamentals of Applied Statistics, Sultan Chand and Sons.

[8] Box, G.E.P and Jenkins, G.M: Time Series Analysis - Forecasting and Control. Holden-day, San Francisco.

[9] Anderson, T. W: The Statistical Analysis of Time Series. Wiley, N. Y.

[10] Suddhen Biswas: Statistics of Quality Control, New Central Book Agency

[11] Douglas C. Montgomery: Statistical Quality Control: A Modern Introduction, Wiley Publication.

[12] K.B. Pathak F. Ram: Techniques of Demographic Analysis, Himalaya Publishing House

Statistics Major [5th Semester]
Paper: Course-XII (Credit 2 Pr)

Practical-VI

(Computational tools: Calculator / Spreadsheet / SPSS / R / Python)

Numerical issues based on the two theory papers mentioned above in terms of Demography and Index Numbers and Psychometry.

Statistics Major [6th Semester]
Paper: Course-XIII (Credit 4 Th)

Biostatistics

Course outcomes:

After completing this course a student will have:

- ✓ Knowledge about epidemiology.
- ✓ Ability to understand survival analysis.

Unit I (Measures of morbidity and Assessing the validity and reliability of diagnostic and screening test)

Prevalence and incidence rate, association between prevalence and incidence, uses of prevalence and incidence, problems with incidence and prevalence measurements; Clinical agreement: kappa statistics, intra-class correlation; Surveillance.

Validity of screening test - sensitivity, specificity, positive predictive value and negative predictive value; Reliability; Relationship between validity and reliability; ROC curve and its applications; Overall accuracy.

Association; causation; causal inference; Errors and bias; Confounding; Controlling confounding; Measurement of interactions; Generalizability. Estimating risk: Estimating association - absolute risk, relative risk, odds ratio; Estimating potential for prevention - attributable risk; comparison of relative risk and attributable risk; Odds ratios for retrospective studies; Odds ratios approximating the prospective RR; Exact inference for odds ratio analysis of matched case-control data Statistical process control: special and common causes of variation, Shewhart, CUSUM and EWMA charts.

Unit II (Issues in epidemiology)

Introduction: Definition and objectives of epidemiology; epidemiology and clinical practice; the epidemiologic approach: infectious disease, occupational and disaster epidemiology.

The dynamics of disease transmission. Identifying the roles of genetic and environmental factors in disease causation. Epidemiology and public policy.

Unit III (Survival Analysis I)

Introduction to survival analysis; motivating the need; concepts and definitions; concept of censoring and type of censoring. Survival function, probability density function, hazard function; relationship between the three types of function; survival curve; estimating medium survival time; estimation of these function in the absence and presence of censoring; application of these functions in survival analysis. Survival distributions- Weibull distribution; exponential distribution; lognormal distribution; gamma distribution.

Nonparametric methods of estimating survival function- introduction; Kaplan-Meier estimates; life table estimates; life table vs. Kaplan-Meier estimates; The Mantel-Haenszel test.

Unit IV (Survival Analysis II)

Comparing survival curves- Generalized Wilconxon (Breslow, Gehan); logrank test. Regression methods for survival analysis- introduction to Cox-proportional hazard models; proportionality assumption in Cox-proportional hazard models; test of proportionality; interpretation of coefficients; application of Cox-proportional hazard models in Epidemiology and Public Health. Discrete-time survival models: introduction.

Suggested Reading:

[1] Altman D G: Practical Statistics for Medical Research, London: Chapman and Hall, 2006.
[2] Rosner B: Fundamentals of Biostatistics, ed. 6, 2006.
[3] Bonita R, Beaglehole R, Kjellstrom T: Basic Epidemiology, ed. 2. World Health Organization, 2006.
[4] Gordis L: Epidemiology, ed. 3. Philadelphia, 2004.
[5] Baker, D. et al.: Environmental Epidemiology: A Text Book on Study Methods and Public Health Applications, WHO/SDE/99.7, 1999.
[6] Dunn G, Everitt B: Clinical Biostatistics: An Introduction to Evidence-based Medicine. Edward Arnold, 1995.
[7] Lee E T: Statistical Methods for survival Data Analysis, ed. 2. New York, John Wiley and Sons.
[8] Armitage P, Berry G: Statistical Methods in Medical Research, ed.4, Wiley Blackwell, 2001.
[9] Choe MK, Retherford RD: Statistical Models for Causal Analysis, Wiley- Interscience, 1993.

Statistics Major [6th Semester]
Paper: Course-XIV (Credit 2 Th)

Statistical Quality Control

Course outcomes:

After completing this course a student will have:

- ✓ Knowledge about statistical quality of manufacture.
- ✓ Ability to estimate different control chart.
- ✓ Knowledge about different inspection plan and their quality.

Unit I (SQC-I)

Introduction: Concepts of quality and quality control. Process control and product control. Chance and assignable Causes of quality variation. Construction and Statistical basis of 3-σ Control charts, Rational Sub-grouping.

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

Basic concept of 6-σ Control limits.

Unit II (SQC-II)

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

Suggested Reading:

[1] Gupta S. C., Kapoor V. K.: Fundamentals of Applied Statistics, Sultan Chand and Sons.
[2] Suddhen Biswas: Statistics of Quality Control, New Central Book Agency
[3] Douglas C. Montgomery: Statistical Quality Control: A Modern Introduction, Wiley Publication.

Statistics Major [6th Semester]
Paper: Course-XIV (Credit 2 Pr)

Practical-VII

(Computational tools: Calculator / Spreadsheet / SPSS / R / Python)

Numerical issues based on the two theory papers mentioned above in terms of Biostatistics a Statistical Quality Control.

Statistics Major [6th Semester]
Paper: Course-XV (Credit 4 Th)

LPP and Operations Research

Course outcomes:

After completing this course a student will have:

- ✓ Knowledge about basic LPP.
- ✓ Ability to estimate transportation and assignment problems.
- ✓ Knowledge about Queuing System (General concept), networking and game theory.

UNIT I (Basics of LPP and Simplex method)

Introduction to linear programming problem (LPP), Formulation of LPP (only problems), graphical solution of LPP- Problems. The simplex algorithm (numerical problems only)

Simplex: two-phase method (numerical problems only), Big-M method (numerical problems only).

UNIT II (Transportation and Assignment Problems)

Transportation problem: Its definition, feasible solution by North-West corner rule, matrix-minimaand VAM methods. (Numerical problems only)

Assignment problem: Meaning of assignment problem, Hungarian method for optimal solution. (numerical problems only)

Unit III (Queuing Theory)

Queuing System: General concept, steady state distribution, queuing model, M/M/1 with finite and infinite system capacity, waiting time distribution and relevant problems.

Unit IV (Networking and Game Theory)

Networking: Basic concepts. Network scheduling by PERT/CPM. Shortest route and minimal spanning tree problem.

Nature of Games. Two person zero sum games - Pay off Matrix, maximin-minimax principle, solution to rectangular game using graphical method, dominance and modified dominance property to reduce the game matrix and solution to rectangular game with mixed strategy.

Suggested Reading:

[1] Taha H. A. (2007): Operations Research: An Introduction, Prentice Hall of India.

[2] Kanti Swarup, Gupta P.K. and Man Mohan (2014): Operations Research, 16th 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.

Statistics Major [6th Semester]
Paper: Course-XVI (Credit 2 Th)

Time Series Analysis

Course outcomes:

After completing this course a student will have:

- ✓ Knowledge about Time series data and its different components.
- ✓ Ability to estimate trend of various time series data by various methods.

Unit I (Time Series-I)

Definition and Examples of time series from various fields, Components of a times series, Additive and Multiplicative models. Trend and Seasonal Components: Estimation of trend by free hand curve method, method of semi averages, fitting a various mathematical curve, and growth curves. Detrending. Estimation of seasonal component by ratio to moving-average method, ratio to trend method, link relative method, De-seasonalization.

Unit II (Time Series-II)

Cyclic Component: Harmonic Analysis. Random Component: Variate component method. Some Special Processes: Moving average (MA) process and Autoregressive (AR) process of orders one and two, Estimation of the parameters of AR (1) and AR (2) – Yule-Walker equations. Forecasting: Exponential smoothing methods, Short term forecasting methods: Brown's discounted regression, Box-Jenkins method and Bayesian forecasting.

Suggested Reading:

[1] Gupta S. C., Kapoor V. K.: Fundamentals of Applied Statistics, Sultan Chand and Sons.
[2] Box, G.E.P and Jenkins, G.M: Time Series Analysis - Forecasting and Control. Holden-day, San Francisco.
[3] Anderson, T. W: The Statistical Analysis of Time Series. Wiley, N. Y.
[4] Suddhen Biswas: Statistics of Quality Control, New Central Book Agency
[5] Douglas C. Montgomery: Statistical Quality Control: A Modern Introduction, Wiley Publication.
[6] K.B. Pathak F. Ram: Techniques of Demographic Analysis, Himalaya Publishing House

Statistics Major [6th Semester]
Paper: Course-XVI (Credit 2 Pr)

Practical-VIII

(Computational tools: Calculator / Spreadsheet / SPSS / R / Python)

Numerical issues based on the two theory papers mentioned above in terms of LPP, Operations Research and Time Series Analysis.

Statistics Major [7th Semester]
Paper: Course-XVII (Credit 4 Th)

Measure theory, Probability and Distribution theory

Course outcomes:
After completing this course a student will have:

- ✓ Ability to understand the concept of field and measurable function.
- ✓ Knowledge of different convergent relational analysis of probability space.
- ✓ Ability to understand the concept of probability along with basic laws and axioms of probability.
- ✓ Ability to apply basic probability principles to solve real life problems.
- ✓ Ability to understand the concept of random variable (discrete and continuous), concept of probability distribution.
- ✓ Ability to solve different laws of large numbers, central limit theorem.
- ✓ Ability to formulate different generating functions and application of order statistics in real-life examples

Unit – I (Set and Measure Theory)

Classes of sets, fields, sigma-fields, minimal sigma-field, Borel sigma field. Measures and their elementary properties. Measurable functions, Lebesgue measures, Lebesgue-Stieltjes measures and signed measure. Integration, monotone convergence theorem, Fatou's lemma, dominated convergence theorem. Absolute continuity. Radon Nikodym theorem, Product measures, Fubini's theorem.

Basics of probability spaces, random variables, expectations and moments. Basic theorems on probability. Basic, Cr, Markov's, Holder's, Minkowski, Jensen's, Liapounov's, inequalities.

Characteristic function and their elementary properties, moments and applications, uniqueness theorem (statement only), inversion theorem and its applications, continuity theorem, Polya's conditions (statement only), Bochner's theorem (statement only). Bivariate and multivariate characteristic functions.

Unit – II (Convergence of Probability)

Convergence of a sequence of random variables: convergence in probability, almost sure convergence, convergence in rth mean and in distribution, their relationship.

Definition of independence, Borel-Cantelli lemma, Borel 0-1 law and Kolmogorov's 0-1 law, Chebyshev's and Khinchine's WLLN, necessary and sufficient condition for the WLLN, Kolmogorov's inequalities (statement only), SLLN and Kolmogorov's theorem.

Central limit theorem, Lindeberg-Levy and Liapunov forms of CLT. Statement of Lindeberg-Feller's CLT and examples.

Unit – III (Probability Distributions)

Probability Distribution- Bernoulli, Binomial, Multinomial, Hypergeometric, Poisson, Geometric and Negative binomial distribution, Uniform, Exponential, Cauchy, Beta, Gamma, Normal, t, F and chi-square distributions. Power series distribution and various distributions as its particular cases. Exponential family of distributions.

Unit – III (Order Statistics and Various Generating Functions)

Order statistics and their distributions and properties. Joint and marginal distributions of order statistics. Extreme values and their asymptotic distribution (statement only) with applications. Distributions of range, asymptotic distributions of sample median and sample quantiles.

Properties of distribution functions and characteristic functions, marginal and conditional distributions of bivariate discrete and continuous distributions, compound, truncated and mixture of distributions, concepts of convolution.

Suggested Reading:

[1] Ash, R.B. and Doleans-Dade, C.A.: Probability and Measure Theory. Elsevier.

[2] Billingsley, P: Probability and Measure. John Wiley.

[3] Basu, A. K: Measure Theory and Probability. Prentice Hall of India.

[4] Bhat, B.R: Modern Probability Theory. New Age International Publishers.

[5] Chung, K. L: A Course in Probability Theory. Academic Press, New York.

[6] Feller, W: An Introduction to Probability Theory and its Applications, Vol I. John Wiley.

[7] Johnson, N.L., Kotz, S. and Balakrishnan, N: Discrete Univariate Distributions. John Wiley.

[8] Johnson, N.L., Kotz, S. and Balakrishnan, N: Continuous Univariate Distributions. John Wiley.

[9] Mood, M, Graybill, F. A and Bose, D.C: Introduction to the Theory of Statistics. Tata McGraw-Hill, New Delhi.

[10] Rohatgi, V.K: An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern, New Delhi.

Statistics Major [7th Semester]
Paper: Course-XVIII (Credit 2 Th)

Mathematical Analysis – I

Course outcomes:
After completing this course a student will have:

- ✓ Knowledge of Monotonic function and their convergence.
- ✓ Ability to understand various series sequence and set.
- ✓ Ability to understand the concept of function of several variable, partial derivatives.

Unit – I (Real Analysis - I)
Elementary set theory, finite, countable and uncountable sets, real number system as a complete ordered field, Archimedean property, supremum, infimum. Sequences and series, convergence, limsup, liminf. Bolzano Weierstrass theorem, Heine Borel theorem. Continuity, uniform continuity, differentiability, mean value theorem.

Unit – II (Real Analysis - II)
Monotonic functions, types of discontinuity, functions of bounded variation, absolute continuity of functions, standard properties. Pointwise and uniform convergence of sequence and series of functions. Cauchy's criterion and Weirstrass M-test. Power series and radius of convergence.
Riemann sums and Riemann integral, Improper Integrals. Riemann Stieltjes integral, Multiple integral. Functions of several variables, directional derivative, partial derivative, and derivative as a linear transformation, inverse and implicit function theorems.

Suggested Readings :

[1] Goldberg, R. R .: Methods of Real Analysis.
[2] Burkill , J. C.: First Course of Mathematical Analysis.
[3] Rudin.W: Principles of Mathematical Analysis. Mc Graw Hill
[4] Malik .S.C. and Arora, S: Mathematical Analysis. Wiley Eastern Ltd.
[5] Jain, P. K and Kaushik, K. K: An Introduction to Real Analysis. S. Chand.
[6] Apostol, T.M: Mathematical Analysis. Addison- Wesley.
[7] Bartle, R.G: Elements of Real Analysis. John Wiley and Sons.
[8] Berbarian, S.K: Fundamentals of Real Analysis. Springer-Verlag.

Statistics Major [7th Semester]
Paper: Course-XVIII (Credit 2 Pr)

Practical-IX

(Computational tools: Calculator / Spreadsheet / SPSS / R / Python)

Numerical issues based on the two theory papers mentioned above in terms of Measure theory, Probability and Distribution theory and Mathematical Analysis – I.

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Statistics Major [7th Semester]
Paper: Course-XIX (Credit 4 Th)

Sampling Techniques

Course outcomes:

After completing this course a student will have:

- ✓ Knowledge of different Sampling Techniques.
- ✓ Ability to understand the estimation of parameter using different sampling technique.
- ✓ Knowledge of the sampling distribution of the sum and mean.
- ✓ Ability to understand the concept of sampling and how it is different from complete enumeration.
- ✓ Knowledge of various probability and non-probability sampling methods along with estimates of population parameters
- ✓ Ability to identify the situations where the various sampling techniques shall be used.

Unit – I (Basic Sampling Theory)

Basic concepts of finite population and sampling techniques. Simple random sampling – with and without replacements, characteristics and methods of selection, estimation of population mean/total, standard error and its estimate, determination of sample size.

Unit – II (Different Random Sampling Techniques)

Stratified random sampling – definition, method of selection, estimation of population mean/total with standard error and its estimate, problems of allocations-proportional and optimum, comparison with unrestricted sampling.

Systematic sampling – method of selection, estimation of population mean/total, sampling variance, comparison with simple random sampling and stratified sampling.

Cluster sampling – equal and unequal size, estimation of population mean/total, standard error and its estimation, comparison with mean per unit estimator. Two-stage sampling with equal and unequal first stage units, estimation of population mean/total, standard error and its estimation, comparison with single-stage sampling.

Unit – III (Ratio and Regression Estimators)

Use of auxiliary information in sample surveys. Methods of estimation – ratio, product, difference and regression methods, sampling variance and efficiency of the estimators.

Unit – IV (Probability Sampling)

Concept of sampling design, sampling scheme, estimator, sampling strategy, Unequal probability sampling with replacement – probability proportional to size with replacement sampling, estimation of mean/total, method of selection, standard error of estimate and it's estimation, comparison with SRSWR, gain due to PPSWR sampling.

Unequal probability sampling without replacement – Des Raj's ordered estimator, Murthy's unordered estimator, Horvitz-Thompson estimator of population mean/total and estimate of variance, Yates-Grundy estimator of variance. Midzuno Scheme of Sampling, and Rao-Hartly-Cochran sampling procedures.

Suggested Readings:

[1] Cochran, W. G: Sampling Techniques. Wiley Eastern.

[2] Sampath, S: Sampling Theory and Methods. Narosa Publising House.

[3] Singh, Daroga and Chaudhary, F. S: Theory and Analysis of Sample Survey Designs. New Age International (P) Limited Publishers.

[4] Mukhopadhyay, Parimal: Theory and Methods of Survey Sampling. Prentice Hall.
[5] Murthy, M. N: Sampling Theory and Methods. Statistical Publishing Society.
[6] Mukhopadhyay, Parimal: Small Area Estimation in Survey Sampling. Narosa Publising House.
[7] Sukhatme, P.V. and Sukhatme, B.V.: Sampling Theory of Surveys with Applications, Piyush Publications, New Delhi.

Statistics Major [7th Semester]
Paper: Course-XX (Credit 2 Th)

Mathematical Analysis - II

Course outcomes:

After completing this course a student will have:

- ✓ Ability to identify the analytic function and complex analysis.
- ✓ Knowledge of Furier Series, Fourier and Laplace transforms.

Unit – I (Laplace and Fourier Transformations)

Furier Series, Fourier and Laplace transforms.

Unit – II (Complex Analysis)

Analytic function, Cauchy-Riemann equations. Statement of Cauchy theorem and of Cauchy integral formula with applications, Taylor's series. Singularities, Laurent series. Residue and contour integration.

Suggested Readings :

[1] Goldberg, R. R .: Methods of Real Analysis.
[2] Burkill, J. C.: First Course of Mathematical Analysis.
[3] Ahlfors: Complex Analysis.
[4] Rudin.W: Principles of Mathematical Analysis. Mc Graw Hill
[5] Malik .S.C. and Arora, S: Mathematical Analysis. Wiley Eastern Ltd.
[6] Jain, P. K and Kaushik, K. K: An Introduction to Real Analysis. S. Chand.
[7] Apostol, T.M: Mathematical Analysis. Addison- Wesley.
[8] Bartle, R.G: Elements of Real Analysis. John Wiley and Sons.
[9] Berbarian, S.K: Fundamentals of Real Analysis. Springer-Verlag.

Statistics Major [7th Semester]
Paper: Course-XX (Credit 2 Pr)

Practical-X

(Computational tools: Calculator / Spreadsheet / SPSS / R / Python)

Numerical issues based on the two theory papers mentioned above in terms of Sampling Techniques and Mathematical Analysis – II.

Statistics Major [8th Semester]
Paper: Course-XXI (Credit 4 Th)

Statistical Inference

Course outcomes:

After completing this course a student will have:

- ✓ Knowledge of the terms like null and alternative hypotheses, two-tailed and one tailed alternative hypotheses, significant and insignificant, level of significance and confidence, p value etc.
- ✓ Ability to understand the concept of MP, UMP and UMPU tests
- ✓ Ability to understand under what situations one would conduct the small sample and large sample tests (in case of one sample and two sample tests).
- ✓ Knowledge of the concept of Point and Interval Estimation and discuss characteristics of a good estimator.
- ✓ Ability to understand and practice various methods of estimations of parameters.

Unit – I (Estimation Theory)

Theory of Estimation: Methods of estimation: maximum likelihood method, method of moments, minimum chi-square method, least-squares method. Unbiasedness, efficiency, consistency. Sufficient statistics, Fisher-Neyman factorisation theorem and obtaining sufficient statistic. Minimal sufficient statistics and exponential family, sufficiency and completeness, sufficiency and invariance. Uniformly minimum variance unbiased estimators. Rao-Blackwell theorem and Lehmann-Scheffe theorem. Cramer-Rao lower bound and Bhattacharya system of lower bounds in the single-parameter regular case. Cramer-Rao linequality. Estimation by confidence intervals.

Unit- II (Hypothesis Testing)

Tests of hypothesis: Simple and composite hypotheses, two types of errors, critical region, review of notions of nonrandomized and randomized tests, level, size, power function, generalized Neyman-Pearson lemma (Sufficiency part only), fundamental Neyman-Pearson lemma (Proof: Existence and Sufficiency parts), UMP Tests. Monotone Likelihood ratio. UMPU Tests, one parameter exponential family (without derivation). Concepts of locally most powerful tests. Similar tests, Neyman structure, UMPU tests for composite hypotheses.

Unit – III (Advanced Testing)

Likelihood ratio test, its properties and its asymptotic distribution. Applications of the LR method.
Sequential tests, SPRT and its properties, Wald's fundamental identity, OC and ASN functions. Sequential estimation.

Unit – IV (Nonparametric Tests)

Nonparametric tests: U-statistics, Kernel and systematic kernel. Test for randomness, Sign test, Median test, Mann-Whitney test, Wilcoxon test for one and two-samples, rank correlation and test of independence. Kolmogorov-Smirnov Test, Kruskal-Walli Test, Friedman test.

Suggested Readings:

[1] Kale, B. K: A first Course on Parametric Inference. Narosa Publishing House.
[2] Lehmann E. L: Theory of Point Estimation. John Wiley.
[3] Lehmann, E. L: Testing Statistical Hypotheses. John Wiley.
[4] Rao, C. R: Linear Statistical Inference and Its Applications. Wiley Eastern.
[5] Mukhopadhaya, P: Mathematical Statistics. Books and Allied (P) Ltd.

[6] Wald, A: Sequential Analysis. John Wiley, NY.
[7] Gibbons, J.D. and Chakraborti, S: Nonparametric Statistical Inference. Marcel Dekker.
[8] Randles, R.H. and Wolfe, D.A: Introduction to the Theory of Nonparametric Statistics. John Wiley.
[9] Lehmann, E. L: Nonparametrics: Statistical Methods Based on Ranks. Spinger.

Statistics Major [8th Semester]
Paper: Course-XXII (Credit 2 Th)

Official Statistics

Course outcomes:

After completing this course a student will have:

- ✓ Enhance the knowledge of Official statistics.
- ✓ Ability to identify the International statistical system.
- ✓ Knowledge of understanding the concept of different official statistics.

Unit – I (Official Statistics -I)

Introduction to Indian and International statistical systems. Role, function and activities of Central and State statistical organizations. Organization of large scale sample surveys.

Role of National Sample Survey Organization. General and special data dissemination systems.

Population growth in developed and developing countries, evaluation of performance of family welfare programmes, projections of labour force and manpower. Scope and content of population census of India.

Unit – II (Official Statistics -II)

System of collection of Agricultural Statistics. Crop forecasting and estimation, productivity, fragmentation of holdings, support prices, buffer stocks, impact of irrigation projects.

Statistics related to industries, foreign trade, balance of payment, cost of living, inflation, educational and other social statistics.

Suggested Readings:

[1] Keyfitz, N: Applied Mathematical Demography, Springer Verlag.
[2] UNESCO: Principles for Vital Statistics Systems. Series M -12.
[3] David B. Grusky, S. M. Ravi Kanbr, Amartya Kumar Sen: Poverty and Inequality. Standford University Press.
[4] Chaubey Y. P: Poverty Measurements: Issues, Approaches and Indices. New Age International (P) Limited.
[5] UNO: Yearly Human Development Reports.
[6] World Bank: Yearly Reports.
[7] CSO. National Accounts Statistics- Sources and Health.
[8] Sen, A. (1997). Poverty and Inequality.
[9] Datt R., Sundharam, K. P. M. (Revised edition). Indian Economy, (Sultan Chand and company Ltd.)
[10] Basic Statistics Relating to the Indian Economy (CSO) 1990.
[11] Guide to Official Statistics (CSO) 1999.
[12] Statistical System in India (CSO) 1995.

Statistics Major [8th Semester]
Paper: Course-XXII (Credit 2 Pr)

Practical-XI

(Computational tools: Calculator / Spreadsheet / SPSS / R / Python)

Numerical issues based on the two theory papers mentioned above in terms of Statistical Inference and Official Statistics.

Statistics Major [8th Semester]
Paper: Course-XXIII (Credit 4 Th)

Linear Algebra and Linear Models

Course outcomes:

After completing this course a student will have:

- ✓ Knowledge of the terms like elementary matrix operation and vector space and vector sub-space.
- ✓ Ability to understand the concept of Linear models and Gauss Markov Model.
- ✓ Ability to understand the representation of simple linear regression model.
- ✓ Knowledge of finding the Best Linear Unbiased Estimator.
- ✓ Formation of ANOVA and ANCOVA through linear models.

Unit – I (Matrix Theory - I)

Matrices: Elementary operations, reduced row-echelon form, consistency of system of equations, solutions of systems of equations, homogeneous system, inverse of a matrix, determinants, Cramer's rule. Vector spaces and subspaces, linear independence of vectors, basis, linear transformations and matrices, kernel, nullity theorem, rank of a matrix. Inner Product spaces, C-S inequality, triangle inequality, orthonormal basis, Gram-Schmidt construction of orthonormal basis.

Unit – II (Matrix Theory - II)

Basics of theory of matrices and determinants, row and column spans of real matrices, rank, elementary matrices, idempotent matrices, eigenvalues and eigenvectors of a matrix, spectral decomposition of a real symmetric matrix, definiteness-positive, non-negative of real matrices, g-inverses: existence and definition, some important results on g-inverses, bilinear and quadratic forms, extrema of quadratic forms.

Unit – III (Linear Models – I)

A brief review of linear algebra: vector spaces and matrices, characteristics roots and vectors of square matrices, quadratic forms and their canonical reduction.

Linear statistical models, illustrations, Gauss-Markov model, normal equations and least square estimators, estimable linear functions, g-inverse and solution of normal equations. Error space and estimation space. Variances and covariances of BLUEs. Estimation of error variance, estimation with correlated observations, least squares estimates with restriction on parameters. Simultaneous estimates of linear parametric functions. Fundamental theorems of least squares and applications to the tests of linear hypotheses.

Unit – IV (Linear Models – II)

Test of hypotheses for one and more than one linear parametric functions. Fisher-Cochran theorem, distribution of quadratic forms. SS of a linear estimate of an estimable function, set of linear estimate, df etc. Sheffe's and Tukey's approach.

Simple and multiple linear regressions, fit of polynomials and use of orthogonal polynomials.

Analysis of Variance - fixed, mixed and random effect models. Analysis of covariance.

Suggested Readings:

[1] Datta, K.E: Matrix and Linear Algebra, Prentice-Hall of India Private Ltd.

[2] Rao, C.R: Linear Statistical Inference and its Applications, Wiley Eastern Ltd.

[3] Searle, S.R: Matrix Algebra useful for Statistics, John Wiley, NY.

[4] Kshirsagar, A M: A Course in Linear Models. Marcel Dekker, N. Y.

[5] Joshi, D D: Linear Estimation and Design of Experiments. New Age International Publication.

[6] Mukhopadhyay, P: Mathematical Statistics. Books and Allied (P) Ltd.

[7] Chatterjee, S. and Price, B: Regression Analysis by Example. John Wiley, New York.

[8] Hoffman, K. and Kunze, R., Linear Algebra, second edition, Prentice-Hall, New Delhi, 1978.

[9] Rao, A. R. and Bhimashankaram, P., Linear Algebra, second edition, TRIMHindustan Book Agency, 2000.

Statistics Major [8th Semester]

Paper: Course-XXIV (Credit 2 Th)

Statistics for National Development

Course outcomes:

After completing this course a student will have:

- ✓ Ability to understand the concept of economic development.
- ✓ Ability to understand the concept of estimation of national income.

Unit – I (Development Index and National Income)

Concept of economic development – role of statistics, growth in per capita income and distributive justice. Indices of development, Human Development Index.

Estimation of National Income - product approach, income approach and expenditure approach.

Measures of unemployment.

Unit – II (Population Growth and Development Measures)

Population growth in developing and developed countries. Population projection using Leslie matrix. Labour force projection.

Measuring inequality of incomes, Gini coefficient, Theil's measure. Poverty measurement different issues, measures of incidence and intensity, combined measures, e.g. Indices due to Kakwani, Sen. etc.

Suggested Readings:

[1] Keyfitz, N: Applied Mathematical Demography, Springer Verlag.

[2] UNESCO: Principles for Vital Statistics Systems. Series M -12.

[3] David B. Grusky, S. M. Ravi Kanbr, Amartya Kumar Sen: Poverty and Inequality. Standford University Press.

[4] Chaubey Y. P: Poverty Measurements: Issues, Approaches and Indices. New Age International (P) Limited.

[5] UNO: Yearly Human Development Reports.

[6] World Bank: Yearly Reports.

[7] CSO. National Accounts Statistics- Sources and Health.

[8] Sen, A. (1997). Poverty and Inequality.

[9] Datt R., Sundharam, K. P. M. (Revised edition). Indian Economy, (Sultan Chand and company Ltd.)
[10] Basic Statistics Relating to the Indian Economy (CSO) 1990.

Statistics Major [8th Semester]
Paper: Course-XXIV (Credit 2 Pr)

Practical-XII

(Computational tools: Calculator / Spreadsheet / SPSS / R / Python)

Numerical issues based on the two theory papers mentioned above in terms of Linear Algebra, Linear Models and Statistics for National Development.

----------End of Major syllabus----------

Statistics (Minor) Syllabus

Statistics (Minor) [1st Semester]

Paper: Course-I

Basic Statistics and Numerical Analysis

Theory (Credit: 3)

Unit I (Statistical Methods and Central tendency)

Introduction to Statistics: Definition, scope and Limitations of statistics, Use of statistics. Collection and classification of data: Primary data and secondary data, methods of collection of data, Scrutiny of data. Classification, principles of classification, types of classification.

Tabular presentations of data. Diagrammatic representation of data. Frequency distribution and its constructions. Graphical presentations of frequency distribution.

Concept of central tendency, Different measures of central tendencies. Empirical relationships between different measures.

Unit II (Dispersion and Moments)

Concept of dispersion, Different measures of dispersion and their properties. Different types of moments, relationships between raw and central moments. Sheppard's corrections for moments (without proof). Skewness and Kurtosis.

Unit III (Numerical Analysis)

Interpolation: Difference operators (Δ, E, D), Polynomial approximation, Difference table. Interpolation: Newton's forward and backward interpolation formulae, Divided difference, Lagrange's interpolation formula.

Numerical Integration: Trapezoidal and Simpson's one-third rules.

Numerical solutions of univariate equation: Bisection, Iteration and Newton-Raphson methods.

Practical (Credit: 1)

(Computational tools:** Calculator / Spreadsheet / SPSS / R / Python**)

Numerical problems based on Statistical Methods, Central tendency, Dispersion, Moments and Numerical Analysis.

Suggested Reading:

[1] Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics (Vol-I), World Press, Kolkata.

[2] Goon A.M., Gupta M.K. and Dasgupta B. (1994): An Outline of Statistical Theory (Vol-I), World Press, Kolkata.

[3] Rohatgi V.K. (1984): An Introduction to Probability Theory and Mathematical Statistics, John Wiley.

[4] Kendall M.G. and Stuart A. (1966): Advanced Theory of Statistics (Vol-I and II).

[5] Gupta S. C., Kapoor V. K.: Fundamentals of Mathematical Statistics, Sultan Chand and Sons.

[6] Kalyan K. Mukherjee: Numerical Analysis, New Central Book Agency (P) Ltd, Kolkata.

[7] Sastry S.S(1987): Introductory Methods of Numerical Analysis, Prentice Hall..

[8] Jain, Iyengar, Jain: Numerical Methods, New Age International Publishers.

Statistics (Minor) [2nd Semester]
Paper: Course-II

Probability, Random variable and Bivariate Analysis

Theory (Credit: 3)

Unit I (Probability)

Random experiment, Sample point, Sample space, different types of Events, Meaning of Probability, Classical, Statistical and Axiomatic definitions of Probability. Limitation of classical definition of Probability, Theorem on the Probability of union of Events. Conditional Probability, Theorem on conditional Probability, Statistical independence of Events, Bayes' theorem and its application.

Unit II (Random variable and Expectation)

Definition of discrete and continuous random variables. Probability mass function (p.m.f.). Probability density function (p.d.f). Cumulative distribution function (c.d.f.) and its properties. Expectation and moments, Theorem on sum and product of expectations of variables. Bi-variate frequency distribution. The p.m.f., p.d.f. and c.d.f. in the bivariate case. Marginal and conditional distributions. Independence, conditional expectation and conditional variance. Cauchy-Schwarz inequality. Tchebycheff's Inequality. Moment generating function (m.g.f.).

Unit III (Bivariate Correlation and Regression)

Bivariate data, Scatter diagram, Pearson Correlation coefficient and its properties. Spearman's Rank correlation.

Principle of Least squares. Concept of regressions, Fitting of regression lines, Important results relating to regression lines. Fitting of Polynomial, Inverse, Exponential and Growth curve.

Practical (Credit: 1)

(Computational tools:** Calculator / Spreadsheet / SPSS / R / Python**)

Numerical problems based on Probability, Random variable, Expectation, Bivariate Correlation and Regression.

Suggested Reading:

[1] Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics (Vol-I), World Press, Kolkata.
[2] Goon A.M., Gupta M.K. and Dasgupta B. (1994): An Outline of Statistical Theory (Vol-I), World Press, Kolkata.
[3] Rohatgi V.K. (1984): An Introduction to Probability Theory and Mathematical Statistics, John Wiley.
[4] Kendall M.G. and Stuart A. (1966): Advanced Theory of Statistics (Vol-I and II).
[5] Gupta S. C., Kapoor V. K.: Fundamentals of Mathematical Statistics, Sultan Chand and Sons.

Statistics (Minor) [3rd Semester]
Paper: Course-III

Probability distributions and Index numbers

Theory (Credit: 3)

Unit I (Discrete Probability distributions)
Uniform, Bernoulli, Binomial, Poisson and Geometric distributions.

Unit II (Continuous Probability distributions)
Uniform, Exponential, Normal, Gamma and Beta distributions.

Unit III (Index numbers)
Definition, construction and use of price index numbers. Laspeyres', Passache's, Fisher's and Edgeworth-Marshall's index numbers. Time and factor reversal tests. Chain index number, wholesale and consumer price index numbers.

Practical (Credit: 1)

(Computational tools:** Calculator / Spreadsheet / SPSS / R / Python**)

Numerical problems based on Discrete Probability distributions, Continuous Probability distributions and Index numbers.

Suggested Reading

[1] Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics (Vol-I), World Press, Kolkata.
[2] Goon A.M., Gupta M.K. and Dasgupta B. (1994): An Outline of Statistical Theory (Vol-I), World Press, Kolkata.
[3] Rohatgi V.K. (1984): An Introduction to Probability Theory and Mathematical Statistics, John Wiley.
[4] Kendall M.G. and Stuart A. (1966): Advanced Theory of Statistics (Vol-I and II).
[5] Gupta S. C., Kapoor V. K.: Fundamentals of Mathematical Statistics, Sultan Chand and Sons.
[6] Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics (Vol-II), World Press, Kolkata.
[7] Gupta S.C., Kapoor V. K.: Fundamentals of Applied Statistics, Sultan Chand and Sons.
[8] Mukhopadhyay P. (1999): Applied Statistics. New Central Book Agency Pvt. Ltd.

Statistics (Minor) [4th Semester]
Paper: Course-IV

Sampling and Multivariate Analysis - I

Theory (Credit: 3)

Unit I (Sampling Distributions - I)

Concepts of Random sampling, statistic and parameter. Sampling distribution of statistic and its Standard Error. Definition, properties and applications of Chi-square, t and F statistics (derivation of these statistics not required). Contingency table and frequency chi-square (derivation not required). Distributions of sample mean and variance in case of sampling from normal population (derivation not required).

Unit II (Sample Survey - I)

Concepts of a finite population and of a sample. Need for sampling. Complete enumeration and sample surveys.

Planning and execution of sample survey. Biases and Errors. Judgment and probability samplings. Tables of random numbers and their uses.

Simple random sampling with and without replacement. Associated unbiased estimators of population total, mean and proportion. Their variances and unbiased estimators of variances.

Unit III (Multivariate Analysis - I)

Basic concept of multivariate probability mass/density function. Multiple linear regression. Multiple and partial correlation coefficient and their properties.

Practical (Credit: 1)

(Computational tools:** Calculator / Spreadsheet / SPSS / R / Python**)

Numerical problems based on Sampling Distributions, Sample Survey and Multivariate Analysis.

Suggested Reading:

[1] Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics (Vol-I), World Press, Kolkata.
[2] Goon A.M., Gupta M.K. and Dasgupta B. (1994): An Outline of Statistical Theory (Vol-I), World Press, Kolkata.
[3] Rohatgi V.K. (1984): An Introduction to Probability Theory and Mathematical Statistics, John Wiley.
[4] Kendall M.G. and Stuart A. (1966): Advanced Theory of Statistics (Vol-I and II).
[5] Gupta S. C., Kapoor V. K.: Fundamentals of Mathematical Statistics, Sultan Chand and Sons.
[6] Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics (Vol-II), World Press, Kolkata.
[7] Gupta S.C., Kapoor V. K.: Fundamentals of Applied Statistics, Sultan Chand and Sons.
[8] Mukhopadhyay P. (1999): Applied Statistics. New Central Book Agency Pvt. Ltd.

Statistics (Minor) [5th Semester]
Paper: Course-V

Estimation, Test of Significance and Design of Experiment - I

Theory (Credit: 3)

Unit I (Estimation - I)

Concepts of estimation. Point estimation. Requirement of a good estimator: unbiasedness, sufficiency, consistency and efficiency. Different problems related to unbiasedness, consistency and efficiency. Minimum variance unbiased estimator (MVUE). Best Linear Unbiased Estimator (BLUE). Maximum Likelihood method of Estimation (MLE). Properties of MLE (statements only) and related problems.

Concepts of confidence interval and confidence coefficient, Method of Construction of confidence interval, Exact confidence intervals under normal set-up for a single mean, single variance, difference of two means and ratio of two variances.

Unit II (Test of Significance - I)

Null and alternative hypotheses (simple and composite), Type-I and Type-II errors, critical region, level of significance, power of a test. Concept of P value. Exact tests of hypotheses under normal set-up for a single mean, the equality of two means, a single variance and the ratio of two variances. Tests of significance for correlation coefficient (null case) and regression coefficients of a bivariate normal distribution.

Unit III (ANOVA and Design of Experiments - I)

Analysis of Variance (ANOVA). Linear hypothesis. Basic concepts of fixed, random and mixed effect model. Analysis of variances for one-way and two-way classified data under fixed effect model.

Basic principles of experimental Design: randomization, replication and local control. Uniformity trials. Shapes and sizes of plots and blocks. Completely Randomized design (CRD), Randomized Block design (RBD) and Latin Square design (LSD). Missing plot techniques in a RBD and in a LSD.

Practical (Credit: 1)

(Computational tools:** Calculator / Spreadsheet / SPSS / R / Python**)

Numerical problems based on Estimation, Test of Significance, ANOVA and Design of Experiments.

Suggested Reading:

[1] Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics (Vol-I), World Press, Kolkata.
[2] Goon A.M., Gupta M.K. and Dasgupta B. (1994): An Outline of Statistical Theory (Vol-I), World Press, Kolkata.
[3] Rohatgi V.K. (1984): An Introduction to Probability Theory and Mathematical Statistics, John Wiley.
[4] Kendall M.G. and Stuart A. (1966): Advanced Theory of Statistics (Vol-I and II).
[5] Gupta S. C., Kapoor V. K.: Fundamentals of Mathematical Statistics, Sultan Chand and Sons.
[6] Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics (Vol-II), World Press, Kolkata.
[7] Gupta S.C., Kapoor V. K.: Fundamentals of Applied Statistics, Sultan Chand and Sons.
[8] Mukhopadhyay P. (1999): Applied Statistics. New Central Book Agency Pvt. Ltd.

Statistics (Minor) [6th Semester]
Paper: Course-VI

SQC, Vital Statistics and Time series analysis

Theory (Credit: 3)

Unit I (Statistical Quality Control)

Concepts of quality and quality control. Process control and product control. Chance and assignable Causes of quality variation. Construction and Statistical basis of 3-σ Control charts, Rational Sub-grouping. Construction and use of control charts for mean, range, number of defectives (including the case of varying sub-group size), fraction defective and number of defects.

Unit II (Vital Statistics)

Introduction and sources of demographic data, 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: definition of its main functions and uses. Measurement of fertility and reproduction: CBR, GFR, and TFR. Measurement of population growth: GRR, NRR.

Unit III (Time series analysis)

Different components of a time series. Determination of trend by free hand smoothing, Method of moving average and by fitting of a mathematical curve. Determination of seasonal indices by simple average method, method of trend ratios and ratios to moving averages.

Practical (Credit: 1)

(Computational tools:** Calculator / Spreadsheet / SPSS / R / Python**)

Numerical problems based on Statistical Quality Control, Vital Statistics, Time series analysis.

Suggested Reading

[1] Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics (Vol-II), World Press, Kolkata.
[2] Gupta S.C., Kapoor V. K.: Fundamentals of Applied Statistics, Sultan Chand and Sons.
[3] Mukhopadhyay P. (1999): Applied Statistics. New Central Book Agency Pvt. Ltd.

Statistics (Minor) [7th Semester]
Paper: Course-VII

Sampling and Multivariate Analysis - II

Theory (Credit: 3)

Unit I (Sampling Distributions - II)

Derivations of Chi-square, t and F statistics. Derivations of distributions of sample mean and variance in case of sampling from normal population. Derivation of large sample standard error of sample moments, standard deviation and coefficient of variation.

Order statistics: Concept of Order statistics. Exact sampling distributions of order statistics (continuous case).Extreme values and extreme order statistics (continuous case). Distribution of sample median and sample range (continuous case).

Unit II (Sample Survey - II)

Basic concept of Stratified random sampling. Estimation of population mean and population total. Proportional and optimum allocations. Comparison with simple random sampling.

Concept of Linear and Circular Systematic sampling. Estimation of population mean and total.

Concept of Two-stage and Two-phase sampling. Estimation of population mean and total.

Unit III (Multivariate Analysis - II)

Multivariate probability mass/density function, Distribution function, Marginal and Conditional distributions, Mean vector and Dispersion matrix, MGF.

Multivariate Normal distribution and its properties, Marginal and conditional distributions. Mahalanobis distance and its Applications. Multinomial distribution and its properties.

Practical (Credit: 1)

(Computational tools:** Calculator / Spreadsheet / SPSS / R / Python**)

Numerical problems based on Estimation, Test of Sampling Distributions, Sample Survey and Multivariate Analysis.

Suggested Reading:

[1] Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics (Vol-I), World Press, Kolkata.
[2] Goon A.M., Gupta M.K. and Dasgupta B. (1994): An Outline of Statistical Theory (Vol-I), World Press, Kolkata.
[3] Rohatgi V.K. (1984): An Introduction to Probability Theory and Mathematical Statistics, John Wiley.
[4] Kendall M.G. and Stuart A. (1966): Advanced Theory of Statistics (Vol-I and II).
[5] Gupta S. C., Kapoor V. K.: Fundamentals of Mathematical Statistics, Sultan Chand and Sons.
[6] Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics (Vol-II), World Press, Kolkata.
[7] Gupta S.C., Kapoor V. K.: Fundamentals of Applied Statistics, Sultan Chand and Sons.
[8] Mukhopadhyay P. (1999): Applied Statistics. New Central Book Agency Pvt. Ltd.

Statistics (Minor) [8th Semester]
Paper: Course-VIII

Estimation, Test of Significance and Design of Experiment - II

Theory (Credit: 3)

Unit I (Estimation - II)

Cramer-Rao inequality. MVB estimators and related problems. Sufficiency. Rao–Blackwell theorem and its applications.

Confidence interval using large sample and confidence interval using Chebyshev's inequality. Uniformly Most Accurate Confidence Interval, Unbiased Confidence Interval.

Different Methods of Estimation: Method of moments, method of maximum likelihood (MLE) and method of minimum Chi-square.

Unit II (Test of Significance - II)

Most powerful (MP) test. Uniformly most powerful (UMP) test. Uniformly most powerful unbiased (UMPU) test. Fundamental Neyman-Pearson Lemma and its uses in the constructions of MP and UMP tests (single parameter with range independent of the parameter). Combination of probabilities in test of significance, Likelihood ratio test and its application to test for the equality of means.

Nonparametric tests: Sign test. Two sample Median test. Wilcoxon signed-rank test. Run test. Test of randomness. Mann-Whitney U-test. Kolmogorov-Smirnov Test, Kruskal-Walli Test, Friedman test.

Unit III (ANOVA and Design of Experiments - II)

Analysis of variance with equal but more than one observation in each cell for two-way classified data (fixed effects model).

Analysis of covariance: Analysis of covariance for a one-way layout with one concomitant variable. Analysis of covariance for an RBD with one concomitant variable.

Factorial experiments: A 2^2 experiment and a 2^3 experiment. Orthogonality and confounding in factorial design. Complete and partial confoundings in 2^2 and 2^3 experiments. A 2^n experiment in 2^k blocks per replicate.

Practical (Credit: 1)

(Computational tools:** Calculator / Spreadsheet / SPSS / R / Python**)

Numerical problems based on Estimation, Test of Significance, ANOVA and Design of Experiments.

Suggested Reading:

[1] Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics (Vol-I), World Press, Kolkata.
[2] Goon A.M., Gupta M.K. and Dasgupta B. (1994): An Outline of Statistical Theory (Vol-I), World Press, Kolkata.
[3] Rohatgi V.K. (1984): An Introduction to Probability Theory and Mathematical Statistics, John Wiley.
[4] Kendall M.G. and Stuart A. (1966): Advanced Theory of Statistics (Vol-I and II).
[5] Gupta S. C., Kapoor V. K.: Fundamentals of Mathematical Statistics, Sultan Chand and Sons.
[6] Goon A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics (Vol-II), World Press, Kolkata.
[7] Gupta S.C., Kapoor V. K.: Fundamentals of Applied Statistics, Sultan Chand and Sons.
[8] Mukhopadhyay P. (1999): Applied Statistics. New Central Book Agency Pvt. Ltd.

Skill Enhancement Courses (SEC) in Statistics

SEC-I (Statistics)

Use of Software for Statistical Data Analysis

Practical / Assignment (Credit:)

This skill based course is structured to enhance use of software as well data analysis.

- Basic concept of Software. Different types of Softwares with respect to Software license (Open-source, Freeware, Proprietary, Add-ons). Platform dependent and platform independent Softwares.
- Statistical Software. Necessity of Statistical Software. Brief knowledge about available Statistical Softwares (R, SPSS, Minitab, Statistica, S-PLUS, Stata, Systat, SAS, Scilab, SciPy, SigmaXL etc.). Difference between Spreadsheet and Statistical Softwares.
- SPSS and R: Inserting and analysing of data.
- Basic concept of python programming language

Suggested Reading:

1. Cunningham, B.J. (2012): Using SPSS: An Interactive Hands-on approach.
2. Braun W. J., Murdoch D. J. (2007): A First Course in Statistical Programming with R. Cambridge University Press. New York.
3. Gardener, M. (2012): Beginning R: The Statistical Programming Language, Wiley Publications.
4. Moore, D.S., McCabe, G.P. and Craig, B.A. (2014): Introduction to the Practice of Statistics, W.H. Freeman.
5. Yashavant P. Kanetkar: Let Us C, BPB Publications.
6. Byron Gottfried: PROGRAMMING WITH C, SCHAUM'S OUTLINE SERIES, McGRAW-HILL
7. William H. Press, Brian P. Flannery, Saul A. Teukolsky, William T. Vetterling: Numerical Recipes in C: The Art of Scientific Computing, CAMBRIDGE UNIVERSITY PRESS.
8. "R Manuals" in R software.

SEC-II (Statistics)

Statistical Survey Methods

Practical / Assignment (Credit:)

This skill based course is structured to enhance survey techniques, data manipulation and data processing skills.

In this course students will learn about how to conduct a survey. Particularly preparation of sample size estimation, drawing of random number, prepare sampling frame, identification of sampling unit, questionnaire preparation, choose an appropriate survey design etc. The course also looks after data processing, editing of data, analyze the data and interpretation of data. Assignment will be given to each student and they have to submit within a stipulated time period.

Suggested Reading:

1. Goon A.M., Gupta M.K. andDasgupta B.: Fundamentals of Statistics (Vol-II), World Press, Kolkata.
2. MukhopadhyayParimal: Theory and Methods of Survey Sampling - 2nd Edition, PHI Learning Private Limited, Delhi.
3. Singh D, Chaudhary F.S.: Theory and analysis of sample survey designs, John Wiley.
4. Cochran W. G.: Sample survey techniques, John Wiley.
5. Gupta S. C., Kapoor V. K.: Fundamentals of Applied Statistics, Sultan Chand and Sons.
6. Bhuyan K.C. (2017) Design of Experiments and Sampling Methods. New Central Book Agency (P) Ltd.
7. 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
8. Murthy, M.N. (1977): Sampling Theory and Statistical Methods, Statistical Pub. Society, Calcutta
9. Des Raj and Chandhok P. (1998): Sample Survey Theory, Narosa Publishing House