Annexure-III

Dr. Shakuntala Misra National Rehabilitation University,

Lucknow, Uttar Pradesh, 226017

DEPARTMENT OF MATHEMATICS AND STATISTICS

SYLLABUS FOR POST-GRADUATE (PG) STATISTICS

As per Postgraduate (PG) Programmes Regulation-2024

Master of Science (M.Sc. Statistics)

(Academic Year 2025-26 and onwards)

BoS Meeting held on 28/07/2025

PROGRAMME PREREQUISITES

To study this program, a student must have completed an undergraduate degree with Mathematics/Statistics as a core / allied subject (S).

PROGRAMME OUTCOMES (POs)

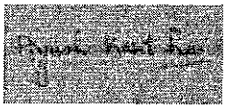
Students with a degree in M.Sc. (Statistics) should have knowledge of different concepts, fundamentals, and a deep understanding of Statistics and the ability to apply this knowledge in various fields of economy, industry, science, social science, etc. They may pursue their future career in the field of Data Science, Data Analytics, Research, and Statistical Services in both public and private sectors as Data Scientists, Risk analysts, Business analysts, Researchers, Academics, ISS, Research officers in the banking & financial sector.

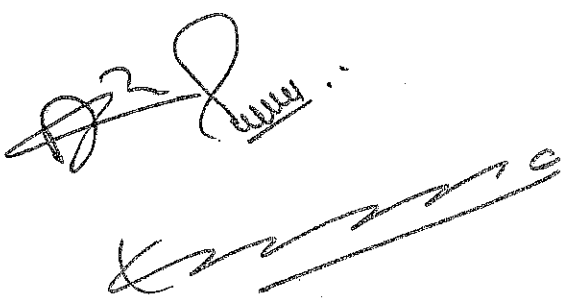
Extensive knowledge of Statistical Software, namely Microsoft Excel, SPSS, R, Python, Tableau, Power BI, etc., is imparted in this program that will be helpful for their professional aspects.

PROGRAMME SPECIFIC OUTCOMES (PSOs)

After completing M.Sc. (Statistics), the student shall be

- Able to apply different concepts, principles and methodologies of Statistics.
- Able to use appropriate statistical tools for decision-making.
- Able to compete in administrative services like Indian Statistical Services (ISS), Civil Services Examination, RBI Grade-B, State PSC Examination, etc.
- Able to use Statistics for identifying and solving real-life problems related to industry, science, etc.
- Able to use computational techniques and statistical software, including programming languages like R, Python, etc., for statistical computation.
- Able to appreciate and use appropriate statistical skills in interdisciplinary areas like health, finance, insurance, business, agriculture, government, industry, IT, epidemiology etc.
- Able to compete with industrial/private sector demand in the field of data analysis, marketing survey, etc., professionally and pursue their future career in the field of Statistics.
- Able to develop original critical thinking for identifying new problems and providing relevant solutions.





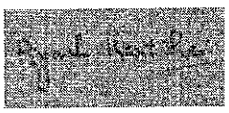
COURSE STRUCTURE
M.Sc. (STATISTICS)

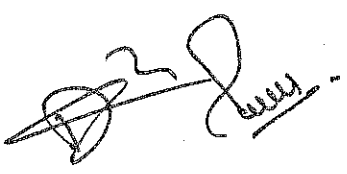
SEMESTER I

COURSE NO.	NAME OF THE COURSE	CREDITS
STAT401	Mathematical Analysis	4
STAT402	Advanced Statistical Methods for Data Analysis	4
STAT403	Advanced Sampling Techniques	4
STAT404	Advanced Probability Theory	4
STAT405	Lab based on theory papers and MS Excel	4
TOTAL CREDITS		20

SEMESTER II

COURSE NO.	NAME OF THE COURSE	CREDITS
STAT406	Advanced Statistical Inference 01/05	4
STAT407	Advanced Multivariate Analysis 04/05	4
STAT408	Statistical Quality Control and Reliability 06/05	4
STAT409	Regression Analysis and Econometrics 08/05	4
STAT410	Lab based on theory papers and SPSS	4
TOTAL CREDITS		20





(FOR COURSE WORK + RESEARCH MODE)

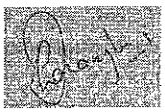
SEMESTER III

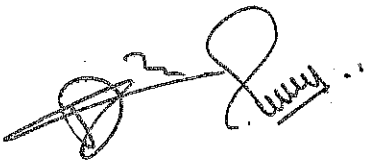
COURSE NO.	NAME OF THE COURSE	CREDITS
STAT501	Decision Theory and Bayesian Inference	4
STAT502	Design of Experiments	4
STAT515	Lab based on theory papers and R	2
STAT516	Research Project and Dissertation	10*
TOTAL CREDITS		10

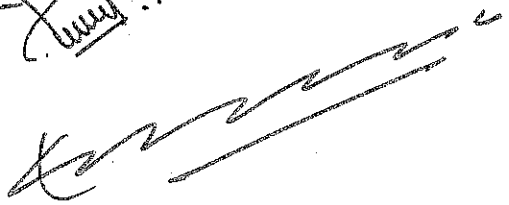
(* To be evaluated in IV semester)

SEMESTER IV

COURSE NO.	NAME OF THE COURSE	CREDITS
STAT508	Computer Intensive Statistical Methods 01/05	4
STAT509	Statistical Machine Learning and Data Mining 04/05	4
STAT517	Lab based on theory papers and Software	2
STAT516A	Research Project and Dissertation	10*+10*
TOTAL CREDITS		30







Structure of One-year PG Program (Coursework + Research mode)

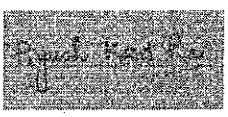
OR (Coursework mode)

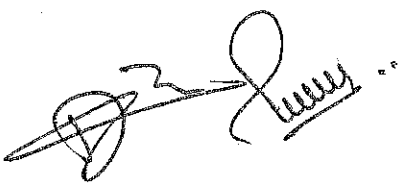
SEMESTER I

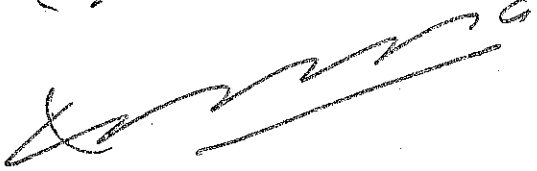
COURSE NO.	NAME OF THE COURSE	CREDITS
STAT501	Decision Theory and Bayesian Inference	4
STAT502	Design of Experiments	4
STAT503	Operation Research	4
STAT504 OR STAT505 OR STAT506	Health Statistics and Clinical Trials OR Official Statistics and Population Studies OR Survival Analysis	4
STAT507	Lab based on theory papers and R	4
TOTAL CREDITS		20

SEMESTER II

COURSE NO.	NAME OF THE COURSE	CREDITS
STAT508	Computer Intensive Statistical Methods	4
STAT509	Statistical Machine Learning and Data Mining	4
STAT510	Data Analysis Using Tableau and Power BI	4
STAT511 OR STAT512 OR STAT513	Time Series Analysis OR Financial Statistics OR Actuarial Statistics	4
STAT514	Lab based on theory papers and Software	4
TOTAL CREDITS		20







(FOR COURSE WORK + RESEARCH MODE)

SEMESTER I

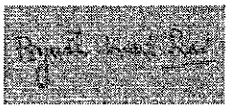
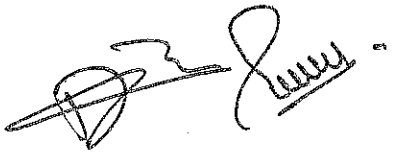
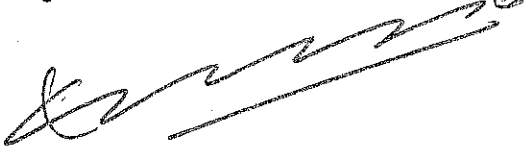
COURSE NO.	NAME OF THE COURSE	CREDITS
STAT501	Decision Theory and Bayesian Inference	4
STAT502	Design of Experiments	4
STAT515	Lab based on theory papers and R	2
STAT516	Research Project and Dissertation	10*
TOTAL CREDITS		10

(* To be evaluated in II semester)

SEMESTER II

COURSE NO.	NAME OF THE COURSE	CREDITS
STAT508	Computer Intensive Statistical Methods	4
STAT509	Statistical Machine Learning and Data Mining	4
STAT517	Lab based on theory papers and Software	2
STAT516	Research Project and Dissertation	10*+10*
TOTAL CREDITS		30

- Credit means the number of hours of instruction required per week over the duration of a semester. A four-credit course in a semester means four one-hour instructions per week, with each one-hour instruction counted as one credit.
- Maximum 40% courses in a given semester shall be earmarked as MOOCs on the Swayam platform if available as MOOCs.

M.Sc. SYLLABUS DESCRIPTION

SEMESTER I

STAT401: MATHEMATICAL ANALYSIS **4 CREDITS**

Course Objectives: This course covers the fundamentals of Numerical Analysis, Linear Algebra, Real Analysis and Complex Analysis. It focuses on the utility of abstract concepts and teaches an understanding and construction of proofs.

Course Specific Outcomes:

- Understand the concept of sequence and series of real numbers, and establish their convergence and divergence.
- Determine the limit and continuity of functions defined on subsets of the real line.
- Recognize the difference between point-wise and uniform convergence of a sequence of functions
- Use the definitions of vector space and related things and determine the orthogonal basis.
- To understand the linear transformation and its matrix representation.
- To understand the concept of numerical differentiation and numerical integration and to get the solution of ordinary differential equations.
- To understand the concept of analytic function and the implications of various theorems.
- To solve complex integrals and calculus problems.

UNIT I: Vector spaces, subspaces, linear dependence, basis, dimension, algebra of linear transformations. Algebra of matrices, rank and determinant of matrices, linear equations. Eigenvalues and eigenvectors, Cayley-Hamilton theorem. Matrix representation of linear transformations. Change of basis, canonical forms, diagonal forms, triangular forms, Jordan forms. Inner product spaces, orthonormal basis.

UNIT II: Numerical solutions of algebraic equations, Method of iteration and Newton-Raphson method, Finite differences, Lagrange, Hermite and spline interpolation, Numerical differentiation and integration, Numerical solutions of ODEs using Picard, Euler, modified Euler and Runge-Kutta methods.

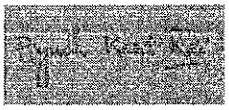
UNIT III: Complex Analysis: Algebra of complex numbers, the complex plane, polynomials, power series, transcendental functions such as exponential, trigonometric and hyperbolic functions. Analytic functions, Cauchy-Riemann equations. Contour integral, Cauchy's theorem, Cauchy's integral formula, Liouville's theorem, Maximum modulus principle, Schwartz lemma.

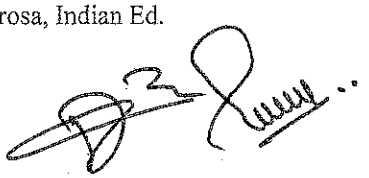
UNIT IV: Elementary set theory, basic operations, finite, countable and uncountable sets, Real number system as complete ordered field, Archimedean property, Sequences and series, convergence, limit supremum, limit infimum, Taylor series, Laurent series.

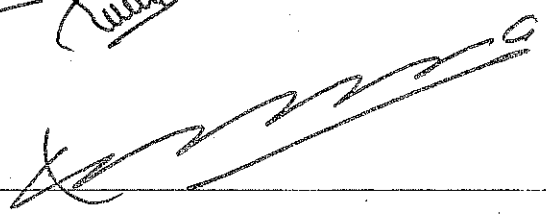
UNIT V: Bolzano-Weierstrass theorem, Heine-Borel theorem. Continuity, uniform continuity, differentiability, mean value theorem. Sequences and series of functions, uniform convergence. Riemann sums and Riemann integral.

References

Apostol, T. M. (1985): Mathematical Analysis. Narosa, Indian Ed.







Bradie, B. (2006): A Friendly Introduction to Numerical Analysis. Pearson Education, India.

Burden, R. L., & Faires, J. D. (2015): Numerical Analysis (10th ed.). Cengage Learning.

Courant, R., & John, F. (1998): Introduction to Calculus and Analysis (Vol. 1, reprint). Wiley.

Gerald, C. F., & Wheatley, P. O. (2007): Applied Numerical Analysis (7th ed.). Pearson Education, India (Archive.org).

Hadley, G. (1987): Linear Algebra. Narosa Publishing House, New Delhi.

Hilderbrand, F. B. (1987): Introduction to Numerical Analysis (2nd ed.). Tata McGraw Hill.

Lay, David C. (2021): Linear Algebra and its Applications (6th ed.). Pearson (Archive.org).

Miller, K. S. (1957): Advanced Real Calculus. Harper, New York

Rao, A. R., & Bhimasankaram, P. (2000): Linear Algebra (2nd ed.). Tata McGraw-Hill, New Delhi.

Sastry, S. S. (2012): Introductory Methods of Numerical Analysis (5th ed.). Prentice Hall of India Pvt. Ltd., New Delhi (Archive.org).

Saxena, H. C. (2005): Finite Differences and Numerical Analysis (15th Rev. ed.). S. Chand and Co., New Delhi.

Scarborough, J. B. (1966): Numerical Mathematical Analysis (6th ed.). Oxford and IBH.

Searle, S. R. (1982): Matrix Algebra Useful for Statistics. John Wiley & Sons, New York.

Singh, B. M. (2008): Introductory Linear Algebra. South Asian Publishers Pvt. Ltd., New Delhi.

Sundararajan, D. (2019): Numerical Linear Algebra and Applications. Elsevier.

Trefethen, L. N., & Bau, D. (2022): Numerical Linear Algebra (2nd ed.). SIAM.

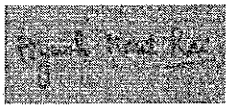
STAT402: ADVANCED STATISTICAL METHODS FOR DATA ANALYSIS **4 CREDITS**

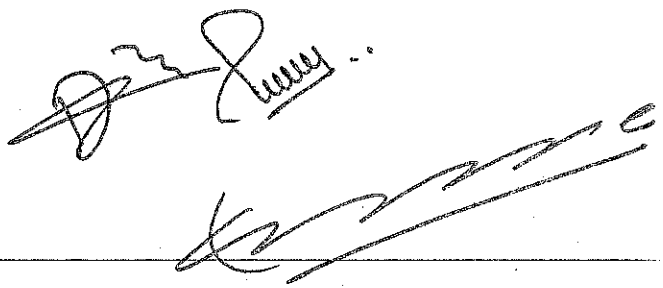
Course Objectives: The objective of the course is to impart necessary knowledge about theoretical aspects of various Statistical tools and techniques to students from different undergraduate programmes. Starting with the basic techniques of collection, tabulation, and graphical representation, the course introduces students to basic methods of data analysis, elementary probability distributions, and testing of hypotheses.

Course Specific Outcomes: After culmination of this course, a student shall be:

- Able to analyse, present and interpret the data.
- Able to describe data with the perspective of both univariate and bivariate probability distributions.
- Able to understand concepts like correlation, sampling distribution, etc., their utility and significance.
- Able to test the statistical hypothesis using Parametric and non-parametric tests.

UNIT I: Data types, scale of measurement, creating and managing datasets, Summarizing data: Frequency and probability distributions, measures of central tendency, measures of dispersion, skewness and kurtosis. Visualizing data: Histogram, bar chart, pie chart, stem and leaf display, scatter





plot, box and whisker plot. Correlation coefficient, Partial and multiple correlation and rank correlation. Bivariate distributions, Marginal and Conditional distributions.

UNIT II: Concept of discrete and continuous random variables. Standard discrete and continuous distributions: Bernoulli, Binomial, Poisson, Geometric, Negative Binomial, Hypergeometric, Multinomial, Uniform, Normal, Exponential, Gamma, Beta, Cauchy Distribution.

UNIT III: Concept of random sample from a distribution, parameter, statistic and standard error. Sampling distributions of sample mean, sample variance, t, chi-square and F (Central and Non-central) (elementary properties only)

UNIT IV: Basics of testing of hypothesis: Null and alternative hypotheses, critical region, type-I error, type-II error, power of the test, level of significance, concept of p-value. Parametric tests: Testing the mean, proportion, and variance of a single population, testing the differences in means and proportions of two independent populations. Small sample tests: t, F and chi-square tests for one and two independent/dependent populations, concept of location and scale.

UNIT V: Non-parametric test: one-sample sign test, run test for randomness, Wilcoxon rank sum test (or Mann-Whitney test), Wilcoxon signed-rank test, chi-squared goodness-of-fit test, contingency analysis: chi-square test of independence.

References

Agresti, A., Franklin, C. and Klingenberg, B. (2018): Statistics: The Art and Science of Learning from data, Fourth Edition, Pearson.

Goon, A.M., Gupta, M.K. and Dasgupta, B. (2013): Fundamentals of Statistics, Vol I, World Press, Kolkata

Goon, A.M., Gupta, M.K. and Dasgupta, B. (2011): Fundamentals of Statistics, Vol II, World Press, Kolkata

Hogg. R. V. Tanis, E. and Zimmerman, D. (2014): Probability and Statistical Inference, Ninth Edition, Pearson.

Mood, A.M, Graybill, F.A. and Boes, D.C. (2017): Introduction to the Theory of Statistics, Third Edition, McGraw-Hill

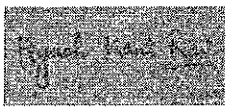
Miller, L. and Miller, M. (2013): John E. Freund's Mathematical Statistics with Applications, (8th Edn), Pearson Education, Asia.

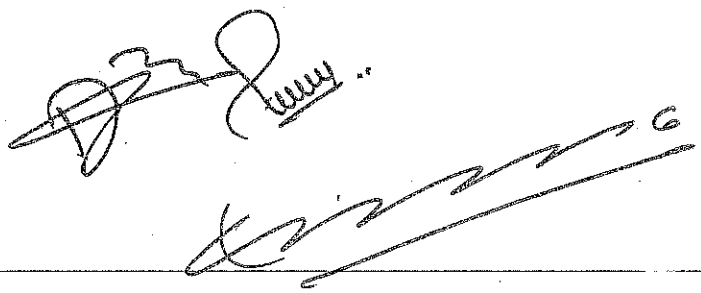
STAT403: ADVANCED SAMPLING TECHNIQUES **4 CREDITS**

Course Objectives: The objective of the course is to define the concepts of population under study, the sampling frame. The emphasis of the course is to study various sampling methods, methods for determining sample size and compiling information, and the applications of sampling techniques in various disciplines.

Course-specific outcomes: After the study of this course, the students will

- Be able to know the population, sample and sampling frame.
- Understand the knowledge of adopting a suitable sampling plan in different situations.





- Learn to develop statistical inferences about the population.
- Be capable of determining the appropriate required sample size from the population under study.

UNIT I: Review of Fundamental Probability Sampling Designs: Simple Random Sampling (SRSWR/WOR), Stratified Random Sampling, Ratio method of estimation, Combined and Separate ratio estimator, Bias of ratio estimator, comparison with SRS, Regression method of estimation, Cluster sampling, two stage sampling with equal and unequal clusters, Two phase sampling, systematic sampling.

UNIT II: Unequal probability sampling: PPSWR/WOR methods (including Cumulative Total and Lahiri's scheme) and related estimators of a finite population mean. Hansen-Hurwitz and Desraj estimators for general sample size and Murthy's estimator for a sample of size 2.

UNIT III: Horvitz-Thompson estimator, its variance and unbiased estimator of variance, IPPS schemes of sampling due to Midzuno-Sen, Rao-Hartley-Cochran and Samphord, their estimators and variances, comparison with SRS.

UNIT IV: Introduction to the Jackknife and Bootstrap: estimate of bias, estimate of variance. Ratio Estimation in reference to Jackknife and bootstraps, Relationship between the jackknife and the bootstrap estimator.

UNIT V: Interpenetrating sub-sampling. Non-sampling errors. Randomized Response techniques (Warner's method: related and unrelated questionnaire methods). Small Area estimation and developing small domain statistics (basic concepts). Super population modelling (basic concept).

References

Chaudhuri, A. and Mukerjee, R. (1988): Randomized Response: Theory and Techniques, New York: Marcel Dekker Inc.

Cochran, W.G.: Sampling Techniques (3rd Edition, 1977): Wiley (Indian Edition).

Des Raj and Chandok (1998): Sampling Theory, Narosa.

Gray, H.L., and Schucany (1972): The generalized jackknife statistic. New York. Marcel Dekker, Inc.

Mukhopadhyay, P. (2009): Theory and methods of survey sampling, PHI Learning, Delhi.

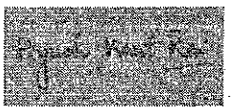
Murthy, M. N. (1977): Sampling Theory & Methods, Statistical Publishing Society, Calcutta.

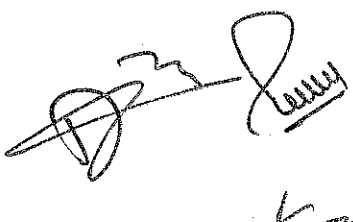
Singh, D. and Chaudhary, F.S. (1986): Theory and Analysis of Sample Survey Designs. New Age International Publishers.

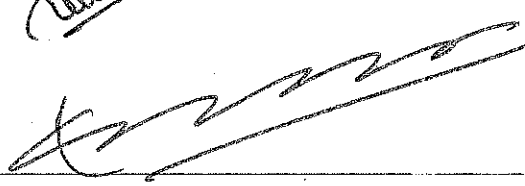
Sukhatme P.V. and Sukhatme B.V. (1954): Sampling Theory of Surveys with Applications. Piyush Publications, New Delhi.

STAT404: ADVANCED PROBABILITY THEORY **4 CREDITS**

Course Objectives: This course covers the fundamentals of probability theory using measure theoretic approach. It focuses on the utility of abstract concepts such as WLLN, SLLN, CLT, etc. and teaches their applications.







Course Specific Outcomes: After the culmination of this course, a student shall be:

- Able to understand the concepts, laws, axioms and theorems of probability
- Able to understand the measure-theoretic approach to probability and its relevance.
- Able to identify the different probability distribution models for problem solving.
- Able to understand the concept of measurable function, random variable and random vector.
- Able to understand the modes of convergence and their interrelationships
- Able to understand the laws of large numbers and the Central Limit Theorem.

UNIT I: Classes of sets, fields, sigma-field, minimal sigma-field, Borel sigma-field in R^k, sequence of sets, limsup and liminf of a sequence of sets. Measure, Probability measure, properties of a measure, Bayes' Theorem and its application.

UNIT II: Measurable functions, Random variables, sequence of random variables, Caratheodory extension theorem (statement only), Lebesgue and Lebesgue-Steljes measures on R^k, Almost sure convergence, Convergence in probability, Convergence in distribution, Convergence in r^{th} mean and their properties

UNIT III: Integration of a measurable function with respect to a measure, Monotone convergence theorem, Fatou's lemma and its different lemma, Dominated convergence theorem and its different lemma,

UNIT IV: Borel- Cantelli Lemma, Independence, Weak law and strong law of large numbers for iid sequences, Characteristic function, inversion theorem, uniqueness theorem, Levy's continuity theorem (statement only), Central Limit Theorem for a sequence of independent random variables under Lindeberg's condition, CLT for iid random variables.

UNIT V: Exponential family of distributions, Geometric Power Series Distribution, Compound, truncated and mixture distributions. Markov, Holder, Jensen, Kolmogorov and Liapunov inequalities.

References

Ash, Robert. (1972): Real Analysis and Probability. Academic Press.

Bhat, B.R. (2015): Probability Theory. New Age International (P) Ltd., New Delhi.

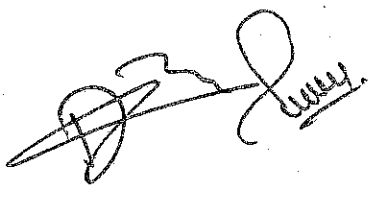
Billingsley, P. (1986): Probability and Measure. Wiley.

Dudewicz, E.J. and Mishra, S.N. (1988): Modern Mathematical Statistics. Wiley, Int'l Students' Edition.

Rao, C.R. (1973): Linear Statistical Inference and Its Applications, 2/e. Wiley Eastern.

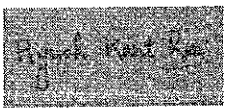
Rohatgi, V.K. and Saleh, A.K.M.E. (2006): An Introduction to Probability Theory and Mathematical Statistics. Wiley (Indian Edition).

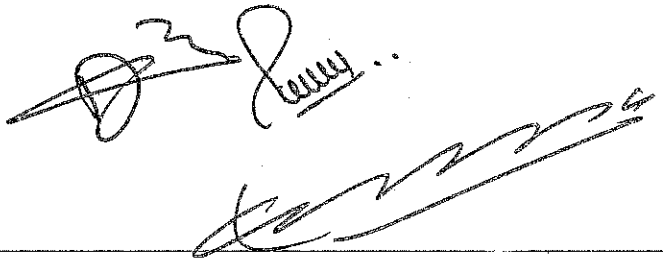
STAT405: LAB BASED ON THEORY PAPERS AND M.S. EXCEL **4 CREDITS**



SEMESTER OUTCOME

- **MATHEMATICAL ANALYSIS** paper will cover important topics of ISS exam, CSIR NET, state public service exams and assistant statistical officer exams conducted by different states along with some topics in field of research.
- **ADVANCED STATISTICAL METHODS FOR DATA ANALYSIS** paper will help you to strengthen basic statistical methods topics, including important topics of statistical inference. It covers the syllabus of state public services exams, assistant statistical officer exams conducted by different states, ISS exam, UGC NET, etc.
- **ADVANCED SAMPLING TECHNIQUES** paper will improve basic concepts of sampling as well as detailed knowledge of unequal probability sampling. It will cover the syllabus of state public services exams, assistant statistical officer exams conducted by different states, ISS exam etc.
- **ADVANCED PROBABILITY THEORY** paper will provide a detailed study of probability theory, which will help to learn important results and lemmas that will be helpful in ISS exam, CSIR NET, state public service exams, and assistant statistical officer exams conducted by different states, along with some topics in the field of research.





SEMESTER II

STAT406: ADVANCED STATISTICAL INFERENCE **4 CREDITS**

Course Objectives: The objective of the course is to make the students acquainted with the classical approach of the inferential procedures for drawing conclusions from data while allowing for random variation. The course aims at forming the foundations of the basic elements of statistical inference, viz. point estimation, interval estimation and the theory of testing of hypothesis.

Course Specific Outcomes: After culmination of this course, a student shall be:

- Able to understand the concept of statistic, estimator and their properties.
- Able to understand the implication of likelihood, information, sufficiency and completeness.
- Able to understand the methods of estimation
- Able to understand the concept of testing hypothesis and their relevance.

UNIT I: Estimator and its properties- Unbiasedness, Consistency, Efficiency, Mean Square Error, Best Estimator, Information in data about the parameters as variation in Likelihood Principle, Sufficiency, Neyman- Factorization Criterion, Invariance property of sufficiency under one-one transformation of sample space and parameter space. Exponential families and Pitman Families,

UNIT II: Methods of estimation: maximum likelihood method: Type I, Type II, Type III and Type IV, Methods of Moments and method of least squares and their properties. Choice of estimators based on unbiasedness, minimum variance, mean squared error, minimum variance unbiased estimators, Rao Blackwell Theorem, Completeness, Lehmann - Scheffe theorem.

UNIT III: Necessary and sufficient conditions for MVUE, Cramer Rao Regularity conditions, Cramer - Rao lower bound approach, Fisher Information for one and several parameters models, Chapman Robin Keiffer bound. Minimal Sufficient Statistic.

UNIT IV: Testing of Hypothesis, Concepts of critical regions, two kinds of errors, size function, power function, level, MP and UMP test in class of size tests, Neyman - Pearson Lemma, MP test for simple null against simple alternative hypothesis.

UNIT V: Likelihood ratio test, UMP tests for simple null hypothesis against one sided alternative and for one sided null against one sided alternative in one parameter exponential family, non-existence of UMP test for simple null against two sided alternatives in one parameter exponential family.

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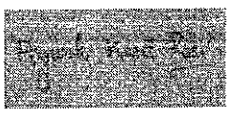

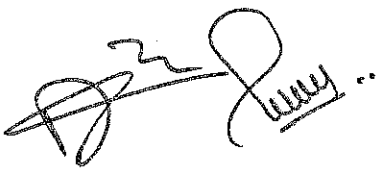

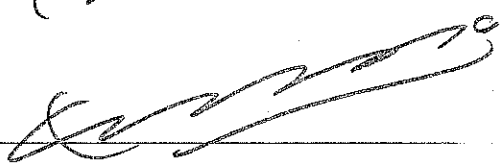

STAT407: ADVANCED MULTIVARIATE ANALYSIS 4 CREDITS

Course Objectives: The objective of the course is to impart necessary knowledge about theoretical aspects of multivariate distribution theory, giving special emphasis to the inferential procedures related to random sampling from multivariate populations. The course is designed so that the students learn various multivariate data analysis tools and techniques to analyze real-world problems involving multivariate datasets.

Course Specific Outcomes: After successful completion of this course, students will

- Acquire knowledge of various multivariate distributions, including Multivariate normal, Hotelling's T, and Wishart Distribution.
- Have a deep understanding of inferential procedures related to multivariate populations.
- Acquire knowledge of Multivariate regression and multivariate analysis of variance and their empirical applications.
- Be able to carry out and apply commonly used multivariate data analysis techniques, and interpret results.

UNIT I: Concept of random vector, multivariate distribution and its distribution function. Multivariate normal distribution, its properties and characterization. Maximum likelihood estimators of parameters. Distribution of sample mean vector. Inference concerning the mean vector when the covariance matrix is known.

UNIT II: Multivariate central limit theorem. Wishart matrix, its distribution and properties. Hotelling's T^2-statistic its distribution and properties. Applications in tests on mean vector for one and more multivariate normal populations. Mahalanobis' D^2.

UNIT III: Likelihood ratio test criteria for testing the independence of sets of variables, equality of covariance matrices, equality of a covariance matrix to a given matrix, equality of a mean vector and a covariance matrix to a given vector and a given matrix.

UNIT IV: Classification and discrimination procedures for discrimination between two multivariate normal populations, sample discriminant function, tests associated with discriminant functions, classification into more than two multivariate normal populations, Fisher's discriminant analysis.

UNIT V: Principal components, canonical variables and canonical correlations. Elements of factor analysis and cluster analysis. Multivariate analysis of variance [MANOVA] of one-way classified data. Wilk's lambda criterion.

References

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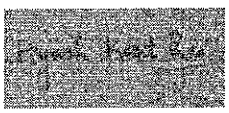

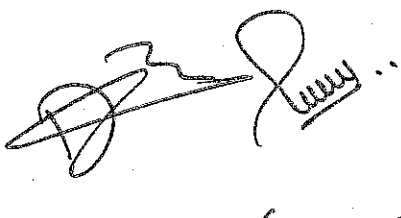

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STAT408: STATISTICAL QUALITY CONTROL AND RELIABILITY **4 CREDITS**

Course Objectives: The objective of the course is to impart necessary knowledge about theoretical as well as practical aspects of statistical quality control and reliability. The course is designed so that the students learn various quality control techniques to analyze real-world problems related to the manufacturing industry and service sectors.

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

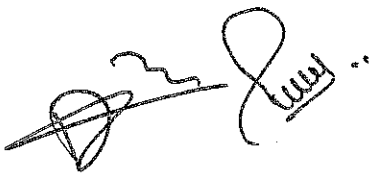
- Use different control charts to statistically control the ongoing process.
- Use a Sampling plan to sentence about the lot.
- Determine the reliability, hazard rate, failure density, and other characteristics of the system.
- Use different lifetime distributions under complete samples as well as under censored sample.

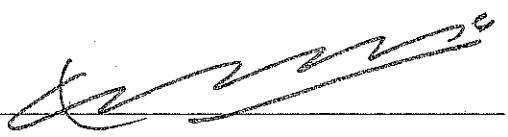
UNIT I: Quality Control- Concept of quality and meaning of control, Product and Process controls. Concept of 3-sigma limits and 6-sigma approach. Modified and Specifications limits. Different types of control charts: charts for variables: $(\bar{X}, R)$, $(\bar{X}, s)$ chart. Charts for attributes: p, np and c chart with their applications in industry.

UNIT II: Basic concepts of process monitoring and control; process capability and process optimization. General theory and review of control charts; O.C. and A.R.L. of control charts, Exponentially weighted moving average charts. Cu-sum charts using V masks and decision intervals. General ideas on economic designing of control chart. Assumptions and costs. Duncan's model for the economic design of $\bar{X}$ chart.

UNIT III: 100% inspection sampling, sampling inspection v/s 100% inspection. AQL and LTPD, Concept of producer's and consumer's risk, Single, Double, Multiple and sequential sampling plans for attributes. OC, AOQL, ASN and ATI curves.

UNIT IV: Reliability Theory- Reliability concepts and measures, components and systems, coherent systems, Hazard rate and bath-tub failure rate curve. Constant, linearly increasing and non-linear increasing hazard models. Gamma, normal and truncated normal failure laws. Estimation of parameters and tests in these models.





UNIT V: Series, parallel, k-out of n, series-parallel, parallel-series, and non-series parallel configurations. Notions of ageing – IFR, IFRA, NBU, DMRL and NBUE classes and their duals. Reliability estimation based on failure times in various censored life-tests and in tests with replacement of failed items. Stress-strength reliability and its estimation.

References

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Bowkder, A.K. and Goode, H.P. (1952): Sampling Inspection by Variables, Mc-Graw Hill Book Company.

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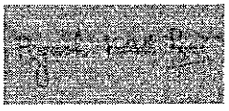
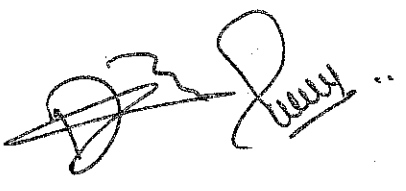
STAT409: REGRESSION ANALYSIS AND ECONOMETRICS **4 CREDITS**

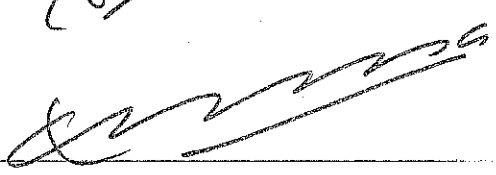
Course Objectives: The objective of Regression Analysis is to provide the tools necessary for using the modelling approach for the statistical analysis of a response variable. The course is designed to develop an intuitive and conceptual understanding of regression and simultaneous equation models to describe and estimate economic phenomena. It also focuses on the formulation, estimation and testing of econometric models when some basic model assumptions are violated.

Course-specific outcomes: After the culmination of this course, a student shall be:

- Able to understand the concepts of regression, simple and multiple linear regression.
- Able to understand the implications of faulty assumptions
- Able to understand the concept of model adequacy, outlier, leverage, etc.
- Able to understand the test(s) of hypotheses for model parameters and their relevance
- Able to understand the concept of general linear regression model(s).
- Able to understand the concept of Seemingly Unrelated Regression Equations model and Simultaneous equation models.







UNIT I: Two-Variable Linear Regression Model- Least Squares Estimators of Coefficients and Their Properties, Inference in Least Squares Model, The General Linear Regression Model, Ordinary Least Squares Estimator and Its Properties, Inference in General Linear Regression Model.

UNIT II: Generalized Least Squares Estimation. Measures of model adequacy: definition of residuals, standardized residuals, residual plots, statistical tests on residuals, Press statistics. Restricted Regression: Restricted Least Squares and its Properties, lagged variables, distributed lag models, estimation of lags by OLS method, Koyck's geometric lag model.

UNIT III: Generalized linear models; definition of GLM, link function, estimation of parameters and inference in GLM, prediction and estimation with GLM, Logistic Regression model: Estimation of parameters and their variance, Poisson regression: Estimation of parameters and their variance.

UNIT IV: Heteroscedasticity: Tests for Heteroscedasticity – Bartletts's, Breusch-Pagan and Goldfeld Quandt Tests, Multicollinearity: Exact and Near Multicollinearity, Consequences and Detection of Multicollinearity, Farrar Glauber Test, Remedies for Multicollinearity, Ridge Regression Autocorrelation: Sources and Consequences, AR(1) Process Tests for Autocorrelation, Durbin Watson Test, Errors In Variables Model.

UNIT V: Simultaneous Equations Models: Structural and Reduced forms, Identification Problem. Rank and Order Conditions of Identification, Restrictions on Structural Parameters. Estimation in Simultaneous Equations Models: Indirect Least Squares 2SLS Estimators, Limited Information Estimators, K-Class Estimators, Instrumental Variable.

References

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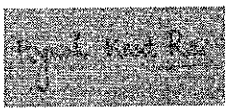

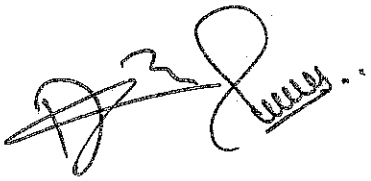

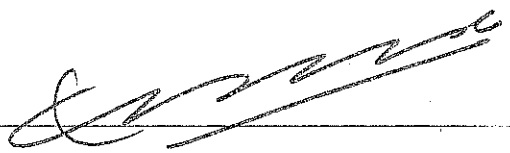

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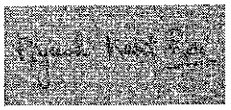
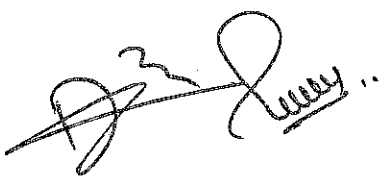
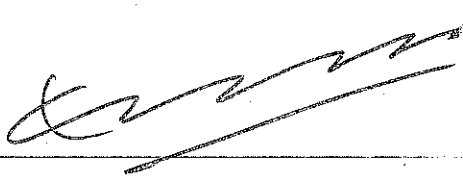
STAT410: Lab based on theory papers and SPSS **4 CREDITS**

SEMESTER OUTCOME

- **ADVANCED STATISTICAL INFERENCE** paper will cover important topics of ISS exam, CSIR NET, state public service exams and assistant statistical officer exams conducted by different states along with some topics in field of research.
- **ADVANCED MULTIVARIATE ANALYSIS** paper is very important field in data analysis. It will give useful aspects on most important field of multivariate analysis which will be helpful in ISS exam, RBI GRADE B, research field, real life problems in data analysis etc.
- **STATISTICAL QUALITY CONTROL AND RELIABILITY** paper **will help** students to learn various quality control techniques to analyze real-world problems related to manufacturing industry and service sectors. as well as government exams like ISS exam, DSSSB, RPSC etc.
- **REGRESSION ANALYSIS AND ECONOMETRICS** will be useful for student if he will opt, to gain detailed knowledge on important topics of govt. exams like ISS, DSSSB, state public services exam etc. It will also help to analyze real life problems in data mining, time series analysis etc.







(FOR COURSE WORK MODE)

SEMESTER III

STAT501: DECISION THEORY AND BAYESIAN INFERENCE 4 CREDITS

Course Outcome:

The objective of this course is to provide an understanding of decision theory and fundamentals of Bayesian Inference, including the concept of subjectivity and priors, by examining a simple Bayesian framework.

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

- Understand and utilize past experience along with present observation and improve the inferences.
- Equip students with skills to carry out and interpret posterior data-based modeling and analyses.
- Understand decision theoretical concepts, game theory and their applications.
- Understand the Bayesian estimation and testing procedures and compare them with classical inference

UNIT I: Subjective interpretation of probability in terms of fair odds. Evaluation of (i) subjective probability of an event using a subjectively unbiased coin (ii) subjective prior distribution of a parameter. Bayes' theorem for random variables and its applications.

UNIT II: Importance of prior in computation of posterior distribution, Natural Conjugate family of priors for different discrete and continuous distributions. Non-informative, improper and invariant priors. Jeffrey's invariant prior.

UNIT III: Bayesian point estimation: as a prediction problem from the posterior distribution. Bayes estimators for (i) absolute error loss (ii) squared error loss (iii) 0 - 1 loss. Generalization to convex loss functions. Evaluation of the estimate in terms of the posterior risk.

UNIT IV: Bayesian interval estimation: Credible intervals. Highest posterior density regions. Interpretation of the confidence coefficient of an interval and its comparison with the interpretation of the confidence coefficient for a classical confidence interval.

UNIT V: Bayesian testing of Hypothesis: Specification of the appropriate form of the prior distribution for a Bayesian testing of hypothesis problem. Prior odds, Posterior odds, Bayes factor for various types of testing hypothesis problems, and Bayesian prediction problem. Large sample approximations for the posterior distribution.

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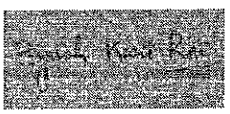

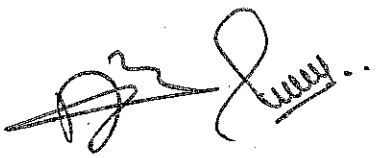

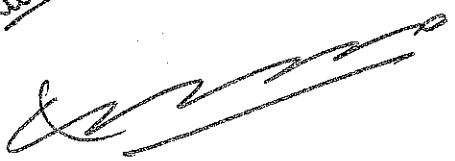

STAT 502: DESIGN OF EXPERIMENTS **4 CREDITS**

Course Outcome:

To provide the background of fundamental theories and practices of statistical design of experiments used in various disciplines, especially in agriculture, biological, manufacturing, and medical industries. To give the idea in which situation which design should be used. The analysis of complete and incomplete block design, factorial designs and use of confounding in the design of experiments.

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

- To understand the theory as well as practical applicability of various designs of experiments in various disciplines.
- Understand the concept of complete designs
- Learn about balanced incomplete block designs
- To know the use of confounding in the design of experiments

UNIT I: Introduction to Design of Experiments (basic concepts), Basic Principles of design of experiments, uniformity trials, Contrasts, Orthogonal contrasts. Fixed, Random, and Mixed-Effect Models. Multiple comparison tests.

UNIT II: Completely Randomized Design, Randomized Block Design and Latin Square Design, Graeco Latin Square design, Analysis of missing data. Model validation and use of transformation.

UNIT III: Incomplete block design, balanced incomplete block design (BIBD), partially balanced incomplete block design (PBIBD), General block design and its information matrix (C), Generalized inverse of C, criteria for connectedness, balance and orthogonality. Intrablock analysis of Incomplete block design. Intra and Inter-block analysis of BIBD. Efficiency of BIBD over RBD, Analysis of covariance.

UNIT IV: Factorial experiments, main and interaction effects; best estimates and testing the significance of factorial effects; study of 2^2, 2^3, 2^n, 3^2, 3^3 and 3^n factorial experiments in randomized blocks; Complete and partial confounding. Fractional replication of the 2^k design.

UNIT V: Split plot and Strip plot design, Response surface methodology, first order designs and Analysis.

References

Aloke Dey (1986): Theory of Block Designs, Wiley Eastern.

Angela Dean and Daniel Voss (1999): Design and Analysis of Experiments, Springer.

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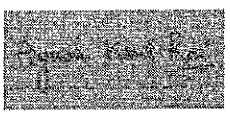

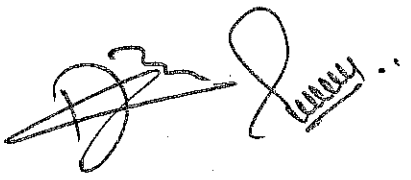

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STAT 503: OPERATIONS RESEARCH **4 CREDITS**

Course Outcome:

To study the fundamentals of operations research to solve the problems covered in the course content. To understand the mathematical formulations of linear programming problems and their applications in real-life problems.

Course Specific Outcomes: After studying the content, students will be able to

- To identify and develop operational research models from verbal descriptions of real-life problems.
- To solve mathematical problems by using different optimization techniques.
- To identify the project scheduling in the optimum time.
- To understand the decision-making problems and their solutions.

UNIT I: Introduction, definition and scope of operations research, Different types of models used in OR. Various phases of OR. Decision-making under uncertainty and risk involves the use of different criteria.

Allocation Problems: Mathematical formulation of L.P.P, Graphical method to solve a L.P.P, Simplex method to solve a L.P.P with slack, Surplus and Artificial variables. Construction of the dual of an L.P.P., sensitivity analysis.

UNIT II: Transportation Problem: Bellman's principle of optimality, Mathematical formulation of a transportation problem, Northwest corner rule, unit cost penalty method and method of matrix minima. Optimality test, unbalanced transportation problem, and Degeneracy in transportation problems.

UNIT III: Assignment Problems: Assignment problems, formulation of these problems and their solutions, Unbalanced Assignment problems. Project Management: Rules for drawing the network diagram, CPM and PERT techniques- basic concept, Probability of project completion.

UNIT IV: Inventory Control: Problems of inventory and the various costs associated with inventory control. EOQ models with uniform/non-uniform rate of demands when shortages are allowed and not allowed, while the replenishment of inventory is instantaneous. EOQ models with uniform rate of demands when shortages are allowed/not allowed and replenishment of the inventory is non-instantaneous. Single-period inventory models with no setup cost and demand rate is discrete/continuous r. v, Newspaper Boy problem.

UNIT V: Game Theory: Criteria of pure and mixed strategies, pay-off matrix and saddle point. Solution of zero-sum two-person games- 2×2, 2×n, m×2, and m×n games.

Queuing Theory: Introduction of the queuing system, various components of a queuing system. Pure Birth Process; Pure Death Process, Birth and Death Process, Steady-state solutions of M/M/1(Generalised), M/M/1: FCFS/K/∞, M/M/C, M/M/C: FCFS/K/∞, M/G/1 models.

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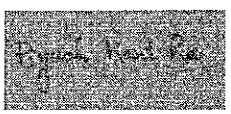

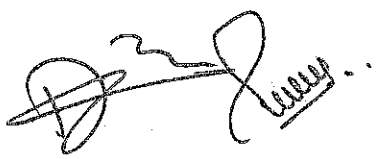

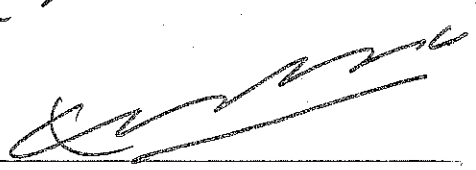

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STAT 504: HEALTH STATISTICS AND CLINICAL TRIALS **4 CREDITS**

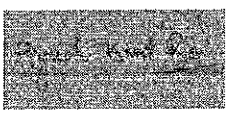
Course Objectives: Health Statistics is one area of Applied Statistics that concerns itself with the application of statistical methods to medical, epidemiological and health-related problems.

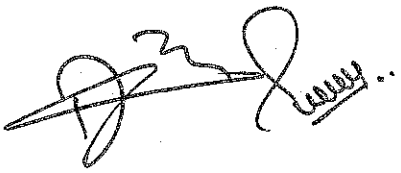
Course-specific outcomes: After successful completion of this course, students will

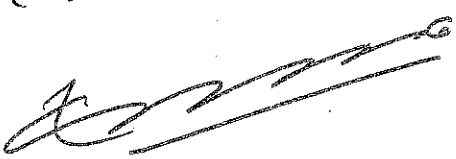
- Tackle the challenges associated with the study design and data analysis conducted in health sciences.
- Acquire knowledge of various measures of disease occurrence and association.
- Be able to calculate the appropriate sample size in different studies. Understand different models related to disease modeling.
- Have a deep understanding of techniques related to survival data analysis. See the relationship between a vector of covariates x and the rate of occurrence of specific types of failure.
- Explain the key concepts in the design of clinical trials.
- Identify the key issues in data management for clinical trials.

UNIT I: Study designs in epidemiology, communicating results of epidemiological studies, and ethical issues in epidemiology. Measures of disease occurrence and association, variation and bias, identifying non-causal association and confounding, Cohort Study designs, statistical power and sample size computations.

UNIT II: Log-linear models, 2xk and 2x2x2 contingency tables, Logistic model, Analysis of binary data. Causal Inference, Longitudinal data, Cross-control study designs, matched case-control studies.







Defining and assessing heterogeneity of effects and interaction. Sensitivity and specificity of a diagnostic test.

UNIT III: Survival data, Product-limit estimator, Proportional hazards model, multivariate survival data, Agreement and Reliability, Meta-analysis.

UNIT IV: Introduction to clinical trials: the need and ethics of clinical trials, bias and random error in clinical studies, conduct of clinical trials, overview of Phase I-IV trials, multi-center trials. Data management: data definitions, case report forms, database design; data collection systems for good clinical practice.

UNIT V: Design of clinical trials: parallel vs. cross-over designs, cross-sectional vs. longitudinal designs, review of factorial designs, objectives and endpoints of clinical trials.

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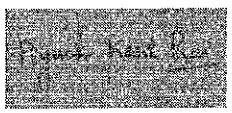
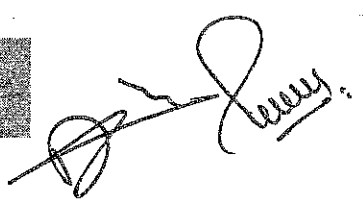
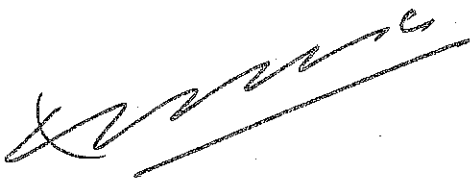
STAT 505: OFFICIAL STATISTICS AND POPULATION STUDIES **4 CREDITS**

Course Outcome: The course aims to study various features of the demography. It also gives the study of the distribution of population with respect to birth, migration, aging, and death. The students will







also be able to work on the planning and execution of government plans and for the other sectors as well.

Course-specific Outcomes:

After successful completion of this course will be able to:

- Learn the most important techniques and features of demography.
- Understand measures of mortality, construction of abridged life tables, infant mortality rate and its adjustment model life tables etc.
- Learn different models of Population growth and their filling to population data.
- Be equipped with tools used in Official statistics along with vision and mission of CSO and NSSO

UNIT I: Official Statistics, its need, uses, reliability, limitations, transparency, its variability. Vision and mission of CSO and NSSO, their activities, Publications, etc., Role of NSC and its functioning.

UNIT II: Sources and measures of mortality, Types of Life Table and its measures. Sources, measures, determinants and estimation of fertility. Construction of abridged life tables, infant mortality rate and its adjustments, and model life table. Stable and quasi-stable populations, intrinsic growth rate.

UNIT III: Models of Population Growth and their application to population data. Internal migration and its measurement, migration models, concept of internal migration. Methods of Population Projection, component method of population projection, nuptiality and its measurements.

UNIT IV: Sources of demographic data, census, registration, ad hoc surveys, hospital records, Demographic profiles of the Indian census, coverage, and content errors in demographic data. Chandrasekharan- Deming formula to check completeness of registration data, adjustment of age data.

UNIT V: SRS Report, Maternal Mortality Rate, Physical Quality life index, Evolution of family planning methods: achievement and challenges, National Population Policy of India, Human Development Index, Evolution of Family Welfare program in India, National Environment Policy, Sustainable Development goals and NITI AAYOG's SDG report for India, Different initiatives for Older persons and elders by GOI.

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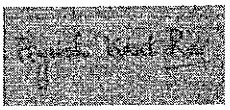

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STAT 506: SURVIVAL ANALYSIS **4 CREDITS**

Course Outcome: The course aims to study various features of the survival data. It also gives the study of survival function using parametric and non-parametric distributions. The students will also be able to work on the planning and execution of government plans and for other sectors as well.

Course-specific outcome: After successful completion of this course, the student will be able to:

- Decide the type of censoring and truncation that is the basis for given survival data.
- Estimate survival functions using parametric and non-parametric methods.
- Compare survival functions of two or more populations

UNIT I: Concepts of time, Order and random Censoring, likelihood in these cases. Life distributions-Exponential Gamma, Weibull, Lognormal, Pareto, Linear Failure rate.

UNIT II: Parametric inference (Point estimation, Confidence Intervals, Scores, LR, MLE tests (Rao-Willks-Wald)) for these distributions. Life tables, failure rate, mean residual life and their elementary properties. Ageing classes - and their properties, Bathtub Failure rate.

UNIT III: Estimation of survival function - Actuarial Estimator, Kaplan-Meier Estimator, Estimation under the assumption of IFR/DFR. Tests of exponentiality against non-parametric classes- Total time on test, Deshpande test.

UNIT IV: Two-sample problem-Gehan test, Log rank test. Mantel-Haenszel test, Tarone–Ware tests.

Semi-parametric regression for failure rate - Cox's proportional hazards model with one and several covariates. **UNIT V:** Rank test for the regression coefficients, Competing risks model, parametric and non-parametric inference for this model. Multiple decrement life table.

References

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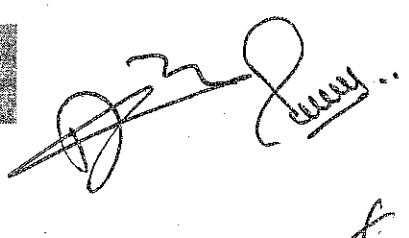
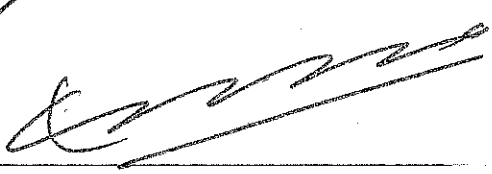
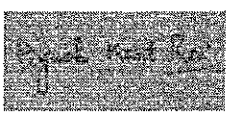
STAT 507: LAB BASED ON THEORY PAPERS AND R **4 CREDITS**

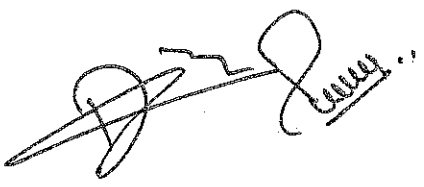




SEMESTER OUTCOME

- **DECISION THEORY AND BAYESIAN INFERENCE** paper will cover important topics of the ISS exam, state public service exams, and assistant statistical officer exams conducted by different states, along with some topics in the field of research. It will cultivate the ability of students in the field of decision theory based statistical measures, which will be helpful for further studies in the field of investigation, computation of posterior distribution using Bayes' law.
- **DESIGN OF EXPERIMENTS** paper will be helpful in the field of agricultural research and different national and state-level exams like ISS, UGC NET, DSSSB, etc. This paper will also open another branch from this semester for students to go in agriculture field if he/she will be interested.
- **OPERATIONS RESEARCH** paper will cover important topics of ISS exam, state public service exams etc. It will be helpful in analyzing real-life problems to gain optimized results with minimum resources and cost.
- **HEALTH STATISTICS AND CLINICAL TRIALS** paper will further help students to pursue his/ her career in the field of health statistics, as in the previous semester. It will cover important topics of the ISS exam and the various government exams in the medical field, etc.
- **OFFICIAL STATISTICS AND POPULATION STUDIES** paper will be useful for students in different exams like ISS, UGC NET, DSSSB, etc. It will be helpful in the research field of Population studies, conducted by IIPS, Mumbai.
- **SURVIVAL ANALYSIS** paper will cover important topics coming in the ISS exam, different exams in the field of health statistics conducted by the GOI.





SEMESTER IV

STAT508: COMPUTER INTENSIVE STATISTICAL METHODS **4 CREDITS**

Course Outcome: This topic helps to understand how to generate random numbers in uniform (0,1) using simulation techniques and application of the Monte Carlo approach for computation. It will help to understand resampling techniques like jackknife, bootstrap, etc.

Course Specific Outcomes: After culmination of this course, students will be able to

- Understand the concepts, laws, axioms and theorems, simulation and random number generation.
- Understand the efficient algorithms for random number generation.
- Identify the use of Monte Carlo method for computation.
- Understand the concept of statistical analysis of simulated data.
- Understand various resampling methods like jackknife and bootstrap.
- Understand the computational rigor of regression and multivariate data.

UNIT I: Random number generation, multiplicative congruential method, mixed congruential method, Estimation of π, Inverse transformation method and its significance.

UNIT II: Inverse transform method for discrete distribution, generation of random numbers from discrete uniform, Bernoulli, binomial, geometric, and Poisson distributions. Acceptance-rejection technique for discrete random variables. Composition approach for mixture distributions. Generation of random vectors.

UNIT III: Inverse transform method for continuous distribution, generation of random numbers from continuous distributions like uniform, exponential, gamma distributions, etc. Acceptance Rejection Technique for continuous random variables like beta, gamma, truncated gamma, normal, etc.

UNIT IV: Statistical analysis of simulated data for point estimation, interval estimation and testing of hypothesis. Monte Carlo methods for evaluation of integrals using random numbers, Monte-Carlo methods for estimation of parameters, Jack-Knife, Bootstrap, cross validation, Monte Carlo methods and permutation tests.

UNIT V: Regression Analysis, scatter plot, residual analysis. Graphical representation of multivariate data, cluster Analysis, and principal component analysis for dimension reduction. Bayesian calculations for non-conjugate priors: (i) Importance sampling, (ii) Obtaining a large sample of parameter values from the posterior distribution using acceptance-rejection methods, and Markov Chain Monte Carlo methods.

References

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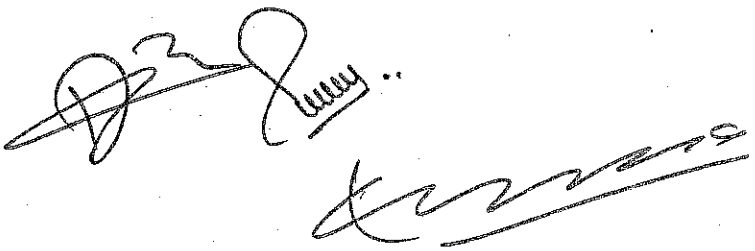

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STAT509: STATISTICAL MACHINE LEARNING & DATA MINING **4 CREDITS**

Course Outcome: This course will present statistical methods that have proven to be of value in the field of knowledge discovery in databases, with special attention to techniques that help managers to make intelligent use of these repositories by recognizing patterns and making predictions.

Course Specific Outcomes: After successful completion of this course, student will be able to:

- Learn the most important concepts and techniques of data handling / data mining.
- Understand different data mining tools like association rule mining, classification rule, clustering of data etc.
- Learn different multivariate concepts like logistic regression, principal component analysis etc.
- Be able to analyze large datasets with the help of different statistical packages/ software using data mining techniques

UNIT I: Introduction to databases, what is Data Mining? The Cross Industry Standard Practice for data mining- CRISP-DM: The Six Phases, Data Mining tasks in discovering Knowledge in Data-Description, Estimation, Prediction, Classification, Clustering, Association, Fallacies of Data Mining.

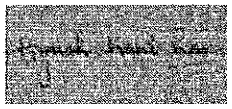
Data Pre-processing: representation, visualization, cleaning, reduction, transformation, outlier detection, Exploratory data analysis, data warehouses and Introduction to Online analytical data processing (OLTP).

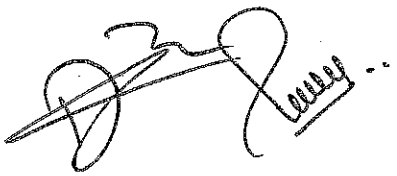
UNIT II: Association Rule Mining: Introduction to Affinity analysis or Market basket analysis, Support, Confidence, frequent itemsets, and the A Priori Algorithm, Usefulness of Association rules, applications to electronic commerce, Clustering: Single linkage and Complete linkage clustering, Distance measures, k-mean clustering, Hierarchical clustering, Imputation of Missing Data.

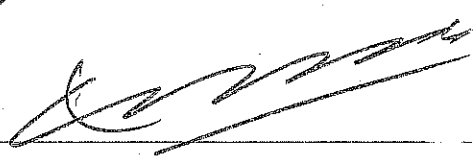
UNIT III: Classification and Regression Trees (CART): Classification trees, Minimum Spanning tree node, impurity function, entropy function, choosing the best split pruning algorithm for classification trees, Regression trees, Terminal node value and splitting strategy, pruning the tree and best pruned subtree.

UNIT IV: Logistic Regression: Interpreting a Dichotomous and polychotomous predictor and Continuous predictor, Assumption of Linearity, zero cell problem, Support Vector Machine: SVM with linear class boundaries, multiclass SVM, Latent variable models for blind source separation: Independent Component analysis and its applications, Random Forest classifier

UNIT V: Naïve Bayes classification: Bayesian approach, Posterior odds ratio, Bayesian Belief Networks Maximum a Posteriori Classification, Neural Networks: Input and Output Encoding, Neural







networks for estimation and prediction, Sigmoid Activation Function, Back Propagating Rules, Gradient Descent Method, Sensitivity Analysis,

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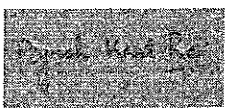
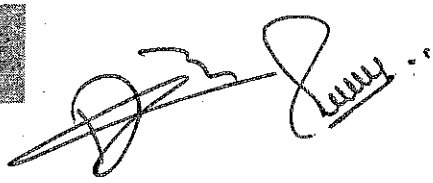
STAT510: DATA ANALYSIS USING TABLEAU AND POWER BI **4 CREDITS**

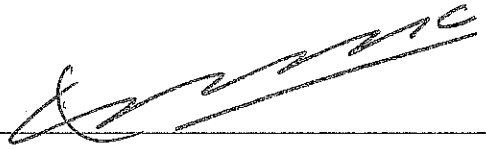
Course Outcome: To provide comprehensive knowledge and practical skills in creating, managing, visualizing, analyzing, and interpreting data using Tableau and Power BI.

Course-specific outcomes: After successful completion of this course, students will be able to:

- Develop interactive dashboards and visualizations in Tableau and Power BI.
- Integrate various data sources and perform data transformation.







- Apply advanced visualization techniques and best practices for data storytelling.
- Perform data analysis and gain insights to support decision-making processes.

UNIT I: Introduction to Tableau

Overview of Tableau: Introduction, Installation, and User Interface. Connecting to Data: Types of data connections, importing data, data cleaning and data preparation. Basic Visualizations: Creating bar charts, line charts, pie charts, scatter plots, stem and leaf and box and whisker plot. Filters and Parameters: Using filters, quick filters, and parameters for dynamic visualization. Interactive Dashboards: Building dashboards, layout, interactivity, and design best practices.

UNIT II: Advanced Tableau Techniques

Calculated Fields and Table Calculations: Basic calculations, string manipulations, and data calculations. Advanced Charts and Graphs: Heat maps, treemaps, bullet graphs, and Pareto charts. Data blending and Joins: Blending multiple data sources and performing joins. Storytelling with Data: Creating story points, narrative flow, and publishing to Tableau Public.

UNIT III: Introduction to Power BI

Overview of Power BI: Introduction, Installation, and User Interface. Getting Data: Importing data from various sources, direct query, and data transformation with Power Query. Building Basic Visualizations: Bar charts, line charts, pie charts, stem and leaf, box and whisker plot and tables.

UNIT IV: Advanced Power BI Techniques

Reports and Dashboards: Creating and customizing reports and designing interactive dashboards. Using DAX: Introduction to Data Analysis Expressions (DAX) for calculations and data manipulation.

Advanced Data Modeling: Relationships, hierarchies and advanced DAX functions. Time Intelligence: Creating date tables, time-based calculations and period-to-period comparisons.

UNIT V: Advanced Power BI Techniques

Custom Visuals and Themes: Using custom visuals, designing custom themes and importing visuals from the marketplace. Integration and Sharing: Embedding Power BI reports, sharing dashboards and Power BI service features.

References

Eremenko, K. (2018): Tableau 10: A Practical Guide to Using Tableau for Data Visualization. Packt Publishing.

Helmers, M., & Wade, G. (2018): Mastering Microsoft Power BI: Expert Techniques for Effective Data Analytics and Business Intelligence. Packt Publishing.

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Meert, R., & Paruchuri, M. (2021): Pro Power BI Desktop. Apress.

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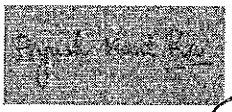

STAT511: TIME SERIES ANALYSIS **4 CREDITS**

Course Outcome: To provide a background of the fundamental theories and practices of statistical linear modeling and time series analysis of observational, experimental data, and survey data of various types.

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

- To decompose the time series data into its components.
- Identify the random behaviour of time series data.
- Fit various time series models like ARMA, ARIMA, Exponential, etc.
- Analyze the past behaviour of the series and predict the future.

UNIT I: Time Series Analysis: Economic time series, different components, illustration, additive and multiplicative models, determination of trend, seasonal and cyclical fluctuations.

UNIT II: Time-series as discrete parameter stochastic process, auto covariance and autocorrelation functions and their properties. Exploratory time Series analysis, tests for trend and seasonality, exponential and moving average smoothing. Holt and Winters smoothing, forecasting based on smoothing.

UNIT III: Detailed study of the stationary processes: (1) moving average (MA), (2) autoregressive (AR), (3) ARMA, and (4) AR integrated MA (ARIMA) models. Box-Jenkins models, choice of AR and MA periods.

UNIT IV: Discussion (without proof) of estimation of mean, auto covariance and autocorrelation functions under large sample theory, estimation of ARIMA model parameters. Introduction to VAR, ARCH and GARCH models.

UNIT V: Spectral analysis of weakly stationary process. Periodogram and correlogram analyses. Computations based on Fourier transform. Spectral decomposition of weak AR process and representation as a one-sided MA process - necessary and sufficient conditions. Implication in prediction problems.

References

Anderson, T. W. (1971): The Statistical Analysis of Time Series. Wiley, N.Y.

Bloomfield, P. (2000): Fourier Analysis of Time Series: An Introduction (2nd ed.). Wiley.

Box, G. E. P., Jenkins, G. M., Reinsel, G. C., & Ljung, G. M. (2015): Time Series Analysis: Forecasting and Control (5th ed.). Wiley.

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Findley, D. F. (Ed.) (1981): Applied Time Series Analysis II. Academic Press.

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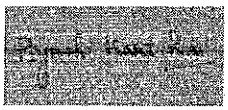

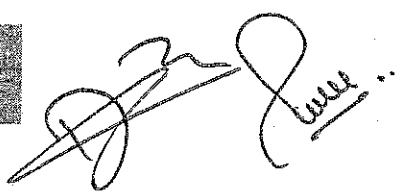

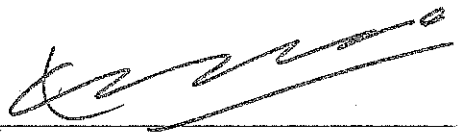

Granger, C.W. J., & Newbold, P. (2014): Forecasting Economic Time Series (4th ed.). Academic Press.

Hyndman, R. J., & Athanasopoulos, G. (2018): Forecasting: Principles and Practice (2nd ed.). OTexts.

Kendall, M. G., & Stuart, A. (1966): The Advanced Theory of Statistics, Volume 3. Charles Griffin, London.

Kendall, Sir Maurice, & Ord, J. K. (1990): Time Series (3rd ed.). Edward Arnold.

Koopmans, L. H. (1995): The Spectral Analysis of Time Series (Reprint ed.). Academic Press.

Montgomery, D. C., & Johnson, L. A. (1976): Forecasting and Time Series Analysis. McGraw-Hill.

Nelson, C. R. (1973): Applied Time Series for Managerial Forecasting. Holden-Day.

Priestley, M. B. (1981): Spectral Analysis and Time Series. Academic Press.

Shumway, R. H., & Stoffer, D. S. (2017): Time Series Analysis and Its Applications: With R Examples (4th ed.). Springer.

STAT512: FINANCIAL STATISTICS **4 CREDITS**

Course Outcome: The main outcome of the course is to equip students with the knowledge and skills necessary to analyze financial data, assess risk, make informed investment decisions, and communicate their findings effectively in a professional context.

Course-specific outcomes: After successful completion of this course, students will be able to:

- Understand the Indian Financial system and the functioning of financial markets in India.
- Understand and work in the money market, equity, stocks, market index, and Portfolio management sectors.
- Work in the option market, call and put options, etc.
- Understand and work in Future markets, Mechanics and strategies, Future prices, and expected spot prices.

UNIT I: Main theme: Risk - Return Trade-off. Money market, Fixed income, equity, stocks and bonds, Treasury notes, Market indexes, Rates of interest, compound interest, inflation, Risk in a portfolio context, law of one price and arbitrage.

UNIT II: Risk and risk aversion, mean-variance analysis, allocation between risky and risk-free portfolios.

Diversification and portfolio risk, Markowitz portfolio selection, optimal portfolios.

UNIT III: Capital assets, pricing model, passive strategy, risk premium, Index models and diversification, CAPM and index model.

UNIT IV: Options markets, American and European options, call and put options, open strategies, option-like instruments, option valuation. Binomial option pricing, Black-Scholes option valuation. Uses of the Black-Scholes formula. Futures markets, Mechanics and strategies, Futures prices, expected spot prices.

UNIT V: Stochastic Models in Finance: Continuous time process- geometric Brownian Motion. Ito's lemma, Hedging Portfolios,: Delta, Gamma, and Theta hedging. Binomial Model for European Options: Cox -Ross- Rubinstein approach to option pricing. Discrete Dividends

References:

Tsay, R. S. (2010): Analysis of Financial Time Series (3rd ed.). Wiley.

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Campbell, J. Y., Lo, A. W., & MacKinlay, A. C. (1997): The Econometrics of Financial Markets. Princeton University Press.

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Shreve, S. E. (2004): Stochastic Calculus for Finance II: Continuous-Time Models (Vol. 11). Springer Science & Business Media.

Arrow, K. J. (1971): Essays in the Theory of Risk Bearing, North Holland

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Hull John C. (1993): Options, Futures and Other Derivative Securities, Prentice Hall

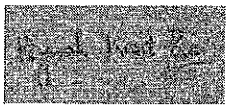
STAT513: ACTUARIAL STATISTICS **4 CREDITS**

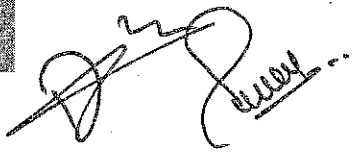
Course Outcome: This course will help to understand the utility theory and insurance models to assess risk and uncertainty in various financial contexts. Use probability theory to model and solve real-world actuarial problems.

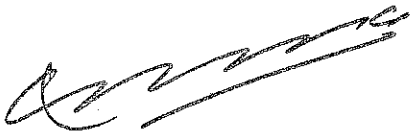
Course Specific Outcomes-

- Acquire knowledge of models or individual claims and their sums, survival function.
- Know how to construct life tables, and understand different types of insurance.
- Have an understanding of annuity benefits through multiple life functions evaluation for special mortality laws.
- Understand the distribution of aggregate claims, the compound Poisson distribution, and its application.

UNIT I: Utility theory, insurance and utility theory, models for individual claims and their sums, survival function, curtate future lifetime, force of mortality. Life table and its relation with survival







function, examples, assumptions for fractional ages, some analytical laws of mortality, select and ultimate tables.

UNIT II: Multiple life functions, joint life and last survivor status, insurance and annuity benefits through multiple life functions evaluation for special mortality laws.

UNIT III: Multiple decrement models, deterministic and random survivorship groups, associated single decrement tables, central rates of multiple decrement, net single premiums and their numerical evaluations.

UNIT IV Principles of compound interest: Nominal and effective rates of interest and discount, force of interest and discount, compound interest, accumulation factor, continuous compounding.

UNIT V: Life insurance: Insurance payable at the moment of death and at the end of the year of death-level benefit insurance, endowment insurance, deferred insurance and varying benefit insurance, recursions, and commutation functions.

References

Dickson, D.C.M., Hardy, M.R., & Waters, H.R. (2013): Actuarial Mathematics for Life Contingent Risks. Cambridge University Press.

Milevsky, M.A. (2011): The Calculus of Retirement Income: Financial Models for Pension Annuities and Life Insurance. Cambridge University Press.

Jones, D.A. (2004): Survival Models and Their Estimation. Actex Publications.

Norberg, R. (2015): Probability and Statistics with Integrated Software R. Springer.

Cramer, H. (2007): Mathematical Methods of Statistics. Princeton University Press

N.L. Bowers, H.U. Gerber, J.C. Hickman, D.A. Jones and C.J. Nesbitt, (1986): Actuarial Mathematics, Society of Actuaries, Ithaca, Illiois, U.S.A. Second Edition (1997): Chapters: 1, 2, 3, 8, 9, 11.

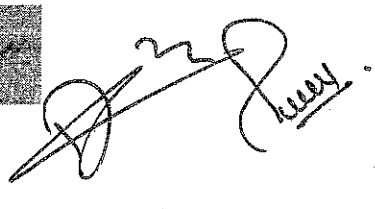
Spurgeon E.T. (1972): Life Contingencies, Cambridge University Press.

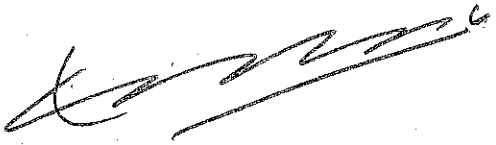
Neill, A. (1977): Life Contingencies, Heineman.

STAT514: LAB BASED ON THEORY PAPERS AND SOFTWARE **4 CREDITS**

SEMESTER OUTCOME

- **COMPUTER INTENSIVE STATISTICAL METHODS** paper will be helpful in analyzing real-life problems using simulation techniques.
- **STATISTICAL MACHINE LEARNING & DATA MINING** paper will further help students to pursue his/ her career in the field of data science by extracting important information from the generated raw form of data using trending statistical software R, Python, etc.
- **DATA ANALYSIS USING TABLEAU AND POWER BI** paper will groom students to go into the field of data analysis using trending statistical software in the corporate sector.
- **TIME SERIES ANALYSIS** paper will cover important topics of ISS exam, state public service exams, and assistant statistical officer exams conducted by different states, along with some topics in the field of research. It will be helpful in real-life problems in forecasting and future prediction.





- **FINANCIAL STATISTICS** paper will be useful for students to analyze financial data, assess risk, make informed investment decisions, and communicate their findings effectively in a professional context. It will be helpful in exams for the posts of Special Officer in banking organization.
- **ACTUARIAL STATISTICS** paper will help to understand the utility theory and insurance models to assess risk and uncertainty in various financial contexts. It will cover important topics coming in field of research in actuarial science. It will also be useful in covering various topics of mains exam of Insurance companies.

(FOR COURSE WORK + RESEARCH MODE EXTRA CODES)

STAT 515: LAB BASED ON THEORY PAPERS AND R **2 CREDITS**

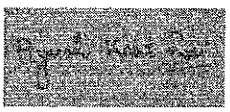
STAT 516: RESEARCH PROJECT AND DISSERTATION ** **10 CREDITS**

Course Objectives: Students shall develop research skills through focused study of a research topic of choice. The students shall develop a research project under the mentorship of any faculty of the Department of Physics or any equivalent faculty or scientist as approved by the Department. The candidate will continue the research project from the IX semester and shall make a presentation as well as submit a Master's dissertation thesis.

Course Outcomes:

- Student will get expertise on software skills, including data interpretation and presentation skills, etc.
- Students will get exposure to writing and reviewing research projects and will get motivated towards research as a career.

STAT517: LAB BASED ON THEORY PAPERS AND SOFTWARE **2 CREDITS**



Department of Mathematics and Statistics
Semester-Wise Details of M.Sc. (Statistics) Evaluation System as per NEP-2020
(Course work)

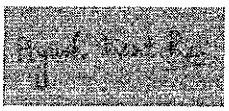
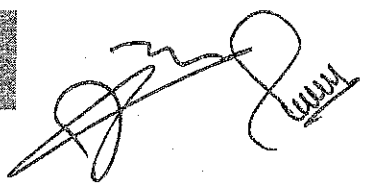
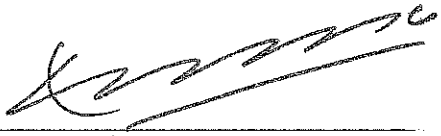
Semester I

Sub Code	Title of the paper	Internal Assessment	External Assessment	Total	Credits
STAT401	Mathematical Analysis	25	75	100	4
STAT402	Advanced Statistical Methods for Data Analysis	25	75	100	4
STAT403	Sampling Techniques	25	75	100	4
STAT404	Advanced Probability Theory	25	75	100	4
STAT405	Lab based on theory papers and MS Excel	25	75	100	4
Total Credits in Semester I		**125**	**375**	**500**	**20**

Semester II

Sub Code	Title of the paper	Internal Assessment	External Assessment	Total	Credits
STAT406	Advanced Statistical Inference	25	75	100	4
STAT407	Advanced Multivariate Analysis	25	75	100	4
STAT408	Statistical Quality Control and Reliability	25	75	100	4
STAT409	Regression Analysis and Econometrics	25	75	100	4
STAT410	Lab based on theory papers and SPSS	25	75	100	4
Total Credits in Semester II		**125**	**375**	**500**	**20**

Students will get a "PG Diploma" if willing to exit after the successful completion of 1st Year of the PG program. (As per NEP norm)

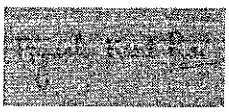
Semester III

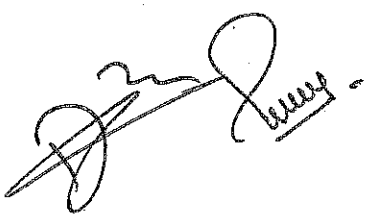
Sub Code	Title of the paper	Internal Assessment	External Assessment	Total	Credits
STAT501	Decision Theory and Bayesian Inference	25	75	100	4
STAT502	Design of Experiments	25	75	100	4
STAT503	Operation Research	25	75	100	4
STAT504 OR STAT505 OR STAT506	Health Statistics and Clinical Trials OR Official Statistics and Population Studies **OR** Survival Analysis	25	75	100	4
STAT507	Lab based on theory papers and R	25	75	100	4
Total Credits in Semester III		**125**	**375**	**500**	**20**

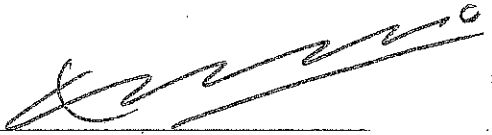
Semester IV

Sub Code	Title of the paper	Internal Assessment	External Assessment	Total	Credits
STAT508	Computer Intensive Statistical Methods	25	75	100	4
STAT509	Statistical Machine Learning and Data Mining	25	75	100	4
STAT510	Data Analysis Using Tableau and Power BI	25	75	100	4
STAT511 OR STAT512 OR STAT513	Time Series Analysis OR Financial Statistics OR Actuarial Statistics	25	75	100	4
STAT514	Lab based on theory papers and Software	25	75	100	4
Total Credits in Semester IV		**125**	**375**	**500**	**20**

1. Total credits in Sem I + Sem II + Sem III+ Sem IV = 80
2. Total marks in Sem I+ Sem II+ Sem III+ Sem IV = 2000
3. Students of M.Sc. 1st year and 2nd year in Statistics acquired 40 + 40 = 80 credits, will be awarded a P.G Degree (M.Sc. in Statistics)







Department of Mathematics and Statistics
Evaluation System of M.Sc. (Statistics) Program
as per NEP-2020
(Course work + Research mode)

Semester III

Sub Code	Title of the paper	Internal Assessment	External Assessment	Total	Credits
STAT501	Decision Theory and Bayesian Inference	25	75	100	4
STAT502	Design of Experiments	25	75	100	4
STAT515	Lab based on theory papers and R	25	75	100	2
STAT516	Research Project and Dissertation				10*
Total Credits in Semester III		**75**		**300**	**10**

(*To be evaluated in IV semester)

Semester IV

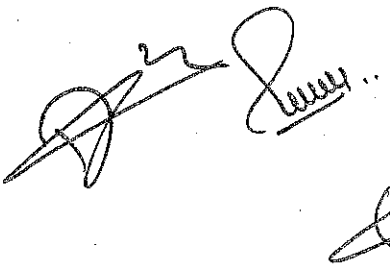
Sub Code	Title of the paper	Internal Assessment	External Assessment	Total	Credits
STAT505	Computer Intensive Statistical Methods	25	75	100	4
STAT506	Statistical Machine Learning and Data Mining	25	75	100	4
STAT517	Lab based on theory papers and Software	25	75	100	2
STAT518	Research Project and Dissertation	25 (Viva Voce)	75 (Dissertation)	100	10*+10*
Total Credits in Semester IV		**100**	**300**	**400**	**30**

Note: 1. Research Project and Dissertation of semester III and semester IV will be evaluated in semester IV, combined with 20 credits. Students will do a training program/ internship in semester III and submit the certificate to the department for evaluation.

2. Total credits in Sem I + Sem II + Sem III+ Sem IV = 80

3. Total marks in Sem I+ Sem II+ Sem III+ Sem IV = 1700.

4. Students of M.Sc. 1st year and 2nd year in Statistics acquired 40 + 40 = 80 credits, will be awarded a P.G Degree (M.Sc. in Statistics)



Evaluation System of one-year PG Program (M.Sc. Statistics) as per NEP-2020 (Course Work Mode)

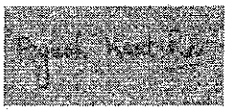
Semester I

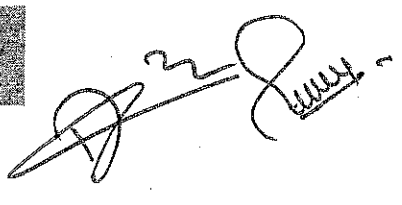
Sub Code	Title of the paper	Internal Assessment	External Assessment	Total	Credits
STAT501	Decision Theory and Bayesian Inference	25	75	100	4
STAT502	Design of Experiments	25	75	100	4
STAT503	Operation Research	25	75	100	4
STAT504 OR STAT505 OR STAT506	Health Statistics and Clinical Trials OR Official Statistics and Population Studies **OR** Survival Analysis	25	75	100	4
STAT507	Lab based on theory papers and R	25	75	100	4
Total Credits in Semester III		**125**	**375**	**500**	**20**

Semester II

Sub Code	Title of the paper	Internal Assessment	External Assessment	Total	Credits
STAT508	Computer Intensive Statistical Methods	25	75	100	4
STAT509	Statistical Machine Learning and Data Mining	25	75	100	4
STAT510	Data Analysis Using Tableau and Power BI	25	75	100	4
STAT511 OR STAT512 OR STAT513	Time Series Analysis OR Financial Statistics OR Actuarial Statistics	25	75	100	4
STAT514	Lab based on theory papers and Software	25	75	100	4
Total Credits in Semester IV		**125**	**375**	**500**	**20**

1. Total credits in Sem I + Sem II = 40
2. Total marks in Sem I+ Sem II = 1000
3. Students of M.Sc. (Statistics) one year programme acquired 40 credits, will be awarded a P.G Degree (M.Sc. in Statistics)





Evaluation System of One year PG Program (M.Sc. Statistics) as per NEP-2020 (Course work + Research mode)

Semester I

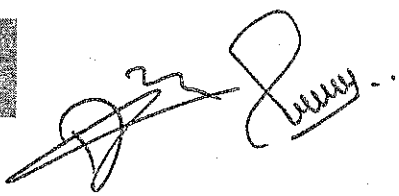
Sub Code	Title of the paper	Internal Assessment	External Assessment	Total	Credits
STAT501	Decision Theory and Bayesian Inference	25	75	100	4
STAT502	Design of Experiments	25	75	100	4
STAT515	Lab based on theory papers and R	25	75	100	2
STAT516	Research Project and Dissertation				10*
Total Credits in Semester I		**75**	**225**	**300**	**10**

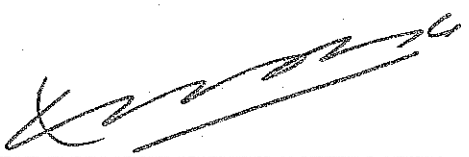
(*To be evaluated in II semester)

Semester II

Sub Code	Title of the paper	Internal Assessment	External Assessment	Total	Credits
STAT505	Computer Intensive Statistical Methods	25	75	100	4
STAT506	Statistical Machine Learning and Data Mining	25	75	100	4
STAT517	Lab based on theory papers and Software	25	75	100	2
STAT518	Research Project and Dissertation	25 (Viva Voce)	75 (Dissertation)	100	10*+10*
Total Credits in Semester II		**100**	**300**	**400**	**30**

Note: 1. ** Research Project of semester I and semester II will be evaluated in semester II, combinedly with 20 credits. Students will do a training program/ internship course in both semesters and submit the certificate to the department for evaluation.





2. Total credits in Sem I + Sem II = 40

3. Total marks in Sem I+ Sem II = 700

4. Students of M.Sc. (Statistics) one year programme acquired 40 credits, will be awarded a P.G Degree (M.Sc. in Statistics)

Evaluation System for Research Project of PG Program

(M.Sc. Statistics) (NEP 2020)

(Course work + Research mode)

Dissertation (75)		Viva Voce	Total Marks
Midterm Evaluation (25)	End Term Evaluation (50)	(25)	(100)

	Marks
Midterm Evaluation Component	
(1) Review of literature with reference	10
(2) Identification of Problem	05
(3) Representation of Objective	05
(4) Midterm Presentation	05
	Total: 25
End Term Evaluation Component	
(5) Methodology	10
(6) Result Analysis	10
(7) Publication in peer-reviewed Journals	10
(8) Global / Local /Social Impact	10
(9) Prediction of Future Scope	10
	Total: 50
Viva Voce	
(10) Presentation by the student	15
(11) Personal Interaction	10
	Total: 25

Evaluation shall be done by a board comprising a supervisor (Internal Faculty Member) and an Examiner (External Subject expert nominated by the university).