Central University of Jharkhand

Department of Statistics

Vision of the Department

- To foster a culture of statistical excellence and analytical acumen, the Department of Statistics at Central University of Jharkhand envisions empowering individuals to become adept practitioners and innovators in the field of Statistics.
- To cultivate a community of statisticians who can contribute significantly to the advancement of knowledge and betterment of the society.

Mission of the Department

- To serve as a catalyst for positive transformation within the realm of statistical education and research
- To foster a vibrant knowledge community characterized by multi-disciplinary learning and commitment to excellence
- To cultivate statisticians who will be equipped to contribute meaningfully to the holistic development and self-sufficiency of fellow citizens
- To advance knowledge, address societal challenges, and empower individuals to thrive in an ever-evolving world

Programme Offered - M.A./M.Sc. Statistics

Programme Objectives

- To equip students with exceptional education in both theoretical and applied statistics, enabling them to have brilliant careers in the field.
- To instill essential competencies required for statisticians, encompassing both traditional theory and contemporary statistical applications.
- To prepare students for employment in various sectors such as industry, academia, and other organizations.

The specific objectives include

- Cultivating logical reasoning skills and fostering a capacity for statistical thinking.
- Providing a comprehensive understanding of key statistical models and analytical tools necessary for addressing complex data analysis problems.

- Offering exposure to a range of statistical software packages, enhancing proficiency in both analysis and programming.
- Developing effective communication and technical writing abilities to articulate statistical concepts clearly, both orally and in writing, using appropriate terminology for diverse audiences.
- Nurturing skills in collaborative teamwork across disciplines and instilling principles of professional accountability and ethics.

Programme Outcomes

Knowledge Domain: Demonstrate comprehension of the theoretical and computational underpinnings of probability theory, inference, sample surveys, multivariate techniques, regression analysis, and stochastic processes, emphasizing their significance in data analytics.

Problem Analysis: Apply principles of scientific inquiry and critical thinking to solve problems and make informed decisions, systematically finding, analyzing, evaluating, and applying information.

Presentation and Interpretation of Data: Exhibit proficiency in manipulating, visualizing, and computing standard statistical summaries from data sets.

Modern tool usage: Acquire proficiency in selecting and employing appropriate methods, procedures, resources, and computing tools such as Excel, MATLAB, SPSS, and R, while understanding their limitations.

Technical Skills: Utilize modeling, simulation, and data analysis tools to address real-world problems, generating solutions capable of predicting and explaining complex phenomena.

Analyze ethical issues relevant to academia, profession, and research, adhering to ethical norms in data analysis and research practices.

Communication: Effectively communicate statistical concepts and activities to peers and society, including comprehension of writing effective reports, designing documentation, and delivering presentations.

Project Management: Apply statistical principles effectively in managing projects both individually and within diverse teams, fostering multidisciplinary collaboration.

Lifelong Learning: Demonstrate the ability to independently explore and learn statistical tools, adapting to technological advancements and continuing professional development.

Curriculum Structure

First Semester

Sl. No.	Course No.	Course Title	L-T-P	Credits
1.	STA 111010	Programming and Data Structure	3-0-1	4

2.	STA 111020	Analysis and Linear Algebra	3-1-0	4
3.	STA 111030	Measure Theory and Probability	3-1-0	4
4.	STA 111040	Numerical Analysis	3-0-1	4
5.	STA 111050	Statistical Inference-I	3-0-1	4
6.		Foundations of Statistics*		Non credit
		Total		20

***Noncredit course for statistics students who have not studied statistics course in UG level. This course can be offered to students of other departments as a credit course. The credits will be as per norms of the department.**

Second Semester

Sl. No.	**Course No.**	**Course Title**	**L-T-P***	**Credits**
1.	STA 121010	File Organization and Database Systems	3-1-0	4
2.	STA 121020	Linear Model and Regression Analysis	3-0-1	4
3.	STA 121030	Stochastic Processes	3-1-0	4
4.	STA 121040	Statistical Inference-II	3-0-1	4
5.	STA 121050	Sampling Methods	3-0-1	4
		Total		20

Third Semester

Sl. No.	**Course No.**	**Course Title**	**L-T-P***	**Credits**
1.	STA 211010	Machine Learning	3-0-1	4
2.	STA 211020	Time Series and Forecasting Methods	3-1-0	4
3.	STA 211030	Multivariate Analysis	3-0-1	4
4.	STA 215050	Elective –I	3-0-1/3-1-0	4
5.	STA 215060	Elective –II	3-0-1/3-1-0	4
6.	STA 213040	Seminar	0-0-4	2
		Total		22

Fourth Semester

Sl. No.	**Course No.**	**Course Title**	**L-T-P***	**Credits**
1.	STA 221010	Experimental Designs	3-0-1	4
2.	STA 221020	Statistical Software	3-0-1	4
3.		Elective –III	3-0-1/3-1-0	4

4.		Elective –IV	3-0-1/3-1-0	4
5.	STA 223030	Project	0-0-12	6
		Total		22

Total Credits: 84

LIST OF ELECTIVES

Electives – I & II

Sl.no.	Course No.	Course Title	L-T-P*	Credits
1.	STA 215050	Statistical Decision Theory	3-1-0	4
2.	STA 215060	Demography	3-1-0	4
3.	STA 215070	Statistical Quality Control	3-1-0	4
4.	STA 215080	Survival Analysis	3-1-0	4
5.	STA 215090	Optimization Techniques	3-1-0	4
6.	STA 215100	Statistics for Clinical Trials	3-1-0	4
7.	STA 215110	Data Warehousing & Data Mining.	3-1-0	4
8.	STA 215120	Statistical Finance	3-1-0	4
9.	STA 215130	Categorical Data Analysis	3-1-0	4
10.	STA 215140	Reliability Theory	3-1-0	4
11.	STA 215150	Order Statistics	3-1-0	4
12.	STA 215160	Foundations of R Software	MOOCs	4
13.	STA 215170	Statistical Learning for Reliability Analysis		4
14.	STA 215180	Fundamentals of Artificial Intelligence		4
15.	STA 215190	Learning Analytics Tools		4
16.	STA 215200	Economics of Banking and Finance Markets		4
17.	STA 215210	Banking and Insurance		4
18.	STA 215220	Data Analysis and Decision Making – III		4
19.	STA 215230	Introduction to Marketing Essentials		4

Electives –III & IV

Sl. No.	Subject No.	Course Title	L-T-P*	Credits
1.	STA 225040	Statistical Simulations	3-1-0	4
2.	STA 225050	Actuarial Statistics	3-1-0	4
3.	STA 225060	Large Scale Data Analysis	3-1-0	4
4.	STA 225070	Computer Network	3-1-0	4
5.	STA 225080	Internet Technologies	3-1-0	4
6.	STA 225090	Quantitative Epidemiology	3-1-0	4
7.	STA 225100	Geographical Information System	3-1-0	4
8.	STA 225110	Bayesian Inference	3-1-0	4
9.	STA 225120	Non- Parametric Inference	3-1-0	4

10.	STA 225130	Non-Linear Regression Models	3-1-0	4
11.	STA 225140	Generalized Linear Models	3-1-0	4
12.	STA 225150	Essentials of Data Science with R Softwares-1: Probability and Statistical Inference	MOOCs	4
13.	STA 225160	Data Analytics with Python		4
14.	STA 225170	Business Statistics		4

- In the elective papers suitable MOOCS courses may be incorporated as per availability in SWAYAM platform.
- * L - Lecture hrs/week; T - Tutorial hrs/week; P-Practical/Lab hrs/week

DETAILED SYLLABUS

Course Title	**:**	**Foundations of Statistics**
Number of Credits	**:**	**Non-credit**

Course Objective

To inculcate in the students the foundation of statistical concepts to make them ready to learn other advance aspects of statistics. The students will learn about location and variation of data. They will learn about testing of hypothesis and also, finding the association between variables.

Course content

Unit	Content	Hours
I	Introduction, Measures of Central Tendency: Mean, median, mode, geometric mean, harmonic mean. Measures of Dispersion: range, mean deviation, variance, standard deviation. Quartiles. Quartile deviation, Coefficient of variation, Measures of skewness and kurtosis.	**10**
II	Random experiment, outcomes, sample space, events, classical definition of probability, random variables, probability mass function, probability density function, cumulative distribution function, mathematical expectation, Variance, Binomial, Poisson, Geometric, Exponential, Normal distributions.	**10**
III	Null hypothesis, alternative hypothesis, type I error, type II error, level of significance, p-value and power of test. Tests for mean based on normal distribution – one sample t-test, two-sample t-test, paired-sample t-test. Tests for variance based on normal distribution – one sample and two-sample problem.	**10**
IV	Karl Pearson's correlation coefficient, Spearman's rank correlation coefficient, principle of least square, lines of regression, simple linear regression, coefficient of determination. Partial correlation & its coefficient, multiple linear regressions,	**10**

	coefficient of multiple determinations.	
	Tutorial/Practical	**20**

Suggesting Readings:

1. Gupta, S.C. & Kapoor, V.K. (2010). Fundamentals of Mathematical Statistics, Sultan Chand & Sons, Educational Publishers, New Delhi.
2. Das, N.G. (2012). Statistical Methods, Vol I & II. Tata McGraw Hill.
3. Snedecor, G.W. and Cochran, W.G. (1967) : Statistical Methods, Iowa State university Press.

Course outcome: After learning the course, the students will be able to:

- Understand Statistics and other related basic concepts
- Understand random experiment and the way to conduct them
- Find the association between variables
- Frame and test the hypothesis regarding significance of sample mean.

CORE COURSES

SEMESTER I

Course Code	**:**	STA 111010
Course Title	**:**	**Programming and Data Structure**
Number of Credits	**:**	**4:(3+0+1)**

Course Objective

The course offers insights into how the selection of data structures and algorithmic design approaches influences program performance. It equips students with the requisite data structures and algorithmic methodologies tailored for specific applications. This knowledge proves invaluable in tackling problems using various data structures like linear lists, stacks, queues, binary trees, binary search trees, and graphs, enabling them to proficiently write programs to address these challenges. Additionally, the course emphasizes efficient implementation strategies for diverse data structures and problem-solving solutions.

Course Content

Unit	Content	Hours
I	Developing algorithms, Programming preliminaries, Numeric constant and variable, Data type declaration, Arithmetic operators and expression, Input and Output statements	**15**
II	Sequential and conditional statements, loops, Arrays and its applications, Logical expression , Functions , Character strings, Structures, Pointer data type and its applications, Stacks and queues, Lists and Trees,	**15**
III	Recursion, Bit level operation. Direct address tables, Indexing, hash tables, open	**10**

	addressing, Binary search tree, height balanced tree, Red-black tree, B-tree.	
	Tutorial/Practical	**20**

Suggesting Readings:

1. Langsam, Y., Augenstein, M., & Tenenbaum, A. M. *Data Structures using C and C++*. PHI Learning, New Delhi.
2. Tremblay, J. P., & Sorenson, P. G. (1985). An Introduction to Data Structures with Applications. Tata McGraw-Hill.
3. Horowitz E. & S. Sahni (2009). Fundamentals of Data Structures. University Press.
4. A.V. Aho, J.E. Hopecraft & J.D. Ullman (1987). Data Structures and Algorithms. Addition –Wesley Publishing Co.
5. Lipschutz, Seymour. Schaum's Outline of Theory and Problems of Data Structures. Tata McGraw-Hill.

Course Outcome: On successful completion of the course students will be able to

- Develop knowledge of basic data structures for storage and retrieval of ordered or unordered data. Data structures include: arrays, linked lists, stacks, queues, binary trees, heaps.
- Develop knowledge of applications of data structures including the ability to implement algorithms for the creation, insertion, deletion, searching, and sorting of each data structure.
- Learn to analyze and compare algorithms for efficiency.
- Apply Algorithm for solving problems like sorting, searching, insertion and deletion of data

Course Code	:	STA 111020
Course Title	:	**Analysis and Linear Algebra**
Number of Credits	:	**4: (3+1+0)**

Course Objective

To provide students with a robust understanding of fundamental concepts and techniques in both analysis and linear algebra. The course will taught students about topics such as limits, continuity, differentiation, integration, vector spaces, matrices, and linear transformations. The objectives of the course include enabling students to develop proficiency in analyzing mathematical functions and structures, understanding the theoretical underpinnings of calculus and linear algebra, and applying mathematical methods to solve real-world problems across various disciplines. Additionally, students will learn to interpret mathematical results, communicate mathematical ideas effectively, and employ analytical reasoning to tackle complex mathematical problems. By the end of the course, students will possess the knowledge and skills necessary to apply analysis and linear algebra concepts in advanced mathematical contexts and contribute to advancements in research and applications in mathematics and related fields.

Course Content

Unit	Content	Hours
I	Sequences and series, convergence, limsup, liminf, .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, Improper Integrals. Monotonic functions, types of discontinuity, functions of bounded variation, Lebesgue measure, Lebesgue integral.	**10**
II	Functions of several variables, directional derivative, partial derivative, and derivative as a linear transformation, inverse and implicit function theorems. Metric spaces, compactness, connectedness. Normed linear Spaces. Spaces of continuous functions as examples.	**10**
III	Linear Algebra: 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.	**10**
IV	Matrix representation of linear transformations. Change of basis, canonical forms, diagonal forms, triangular forms, Jordan forms. Inner product spaces, orthonormal basis. Quadratic forms, reduction and classification of quadratic forms	**10**
	Tutorial/Practical	**20**

Suggesting Readings:

1. Bartle, R.G. & Sherbert, D.R. (2011). Introduction to Real Analysis, 4th Edition. Wiley.
2. Saff, E.B. & Snider, A.D. (2014). Fundamentals of Complex Analysis with Applications to Engineering, Science and Mathematics, 3rd Edition. Pearson.
3. Rudin, W. (2013). Principles of Mathematical Analysis, 3rd Edition. McGraw Hill.
4. Biswas, S. (2012). A Textbook of Matrix Algebra, 3rd Edition. PHI Learning

Course Outcome: On successful completion of the course students will be able to

- Apply linear algebra to solve system of linear equations and system of linear differential equations.

- Find orthogonal vectors, bases, dimensions of matrices and linear operators.
- Find eigenvalues and eigenvectors of matrices and linear operators and study their nature.
- Deal with analytical techniques to solve linear system that is essential in most branches of engineering.
- Use the essential tool of matrices and linear algebra in a comprehensive manner.

Course Code	**:**	STA 111030
Course Title	**:**	**Measure theory and Probability**
Number of Credits	**:**	**4: (3+1+0)**

Course Objective

To equip students with a comprehensive understanding of measure theory, enabling them to grasp fundamental concepts and apply them effectively in various contexts. The subject will lay down strong foundational principles of measure theory, including key definitions, theorems, and techniques, in minds of students. Students will acquire knowledge to analyze and solve problems in diverse areas, employing both theoretical understanding and practical applications of advanced probability.

Course Content

Unit	Content	Hours
I	Fields, sigma-fields and generators, semi-fields, Borel sigma-field on R. Monotone classes, monotone class theorem, p_i-lambda theorem. Measures, finite, sigma-finite measures. Probability measures, properties. Independence of events, Borel-Cantelli lemmas. Measurable functions and properties, Generated sigma-fields. Induced measures. Compositions. Examples.	**10**
II	Product sigma-fields, Borel sigma-field on Euclidean spaces. Extensions of measures, Caratheodory's theorem (statement). Lebesgue measure on R and R_k: construction, properties. Random variables and vectors, probability distributions, distribution functions. Convergence in measure, almost everywhere and their connection.	**10**
III	Integration: simple, nonnegative, general measurable functions, integrability, Monotone Convergence Theorem, Dominated Convergence Theorem, Fatou's lemma. Change of variables. L_p spaces, Holder's and Minkowski's inequalities. Expectations, Moment inequalities-Chebychev, Markov, Liapunov, Minkowski, Cauchy-Schwartz, Kolmogorov and Jensen. Generating functions.	**10**
IV	Absolute continuity and singularity of measures. Radon-Nikodym Theorem (Statement). Discrete and absolutely continuous distributions. Lebesgue's differentiation theorem (statement), probability densities.	**10**

	Strong law of large numbers, Central limit theorem – Lindberg-Levy, Liapunov & Lindberg -Feller.	
	Tutorial/Practical	**20**

Suggesting Readings:

1. Ash, Robert, (1972), Real Analysis and Probability, Academic Press.
2. Barra, G.D. (1981), Measure Theory and Integration, New Age International (P)Ltd. Publisher, New Delhi.
3. Bhat, B.R. (2014). Modern Probability Theory, 04th edition, New Age International.
4. Bilingsley. P. (2012). Measure Theory and Probability, 04th edition. Wiley.
5. Rao, C.R. (2001), Linear Statistical Inference and its Applications, 02nd edition, Wiley Eastern.
6. Rohatagi, V.K. and Saleh, A.K. Md. E. (2015), An Introduction to Probability and Statistics, 03rd edition, Wiley.

Course Outcome: On successful completion of this unit, students will be able to:

- Understand the basic concepts of measure and integration theory.
- Understand the basic theory on the basis of examples andapplications.
- Use abstract methods to solve problems and to use a wide range ofreferences and critical thinking.
- Use weak and strong law of large numbers in statistical theory

Course Code	**:**	STA 111040
Course Title	**:**	**Numerical Analysis**
Number of Credits	**:**	**4: (3 +0 +1)**

Course Objective

This course covers the mathematical and computational foundations of the numerical approximation and solution of scientific problems; simple optimization; vectorization; clustering; polynomial and spline interpolation; pattern recognition; integration and differentiation; solution of large-scale systems of linear and nonlinear equations; modeling and solution with sparse equations; explicit schemes to solve ordinary differential equations.

Course Content

Unit	Content	Hours

I	Root finding for nonlinear equations – Newton-Raphson, Secant, Regular-Falsi methods and their convergence, Newton's method for system of nonlinear equations.	**10**
II	Interpolation Newton's formulae, Lagrange, Hermite, Spline interpolation with error analysis. Numerical differentiation.	**10**
III	Numerical integration – Newton –Cotes formulae open and closed type- Trapezoidal, Simpson and Weddle rules, Gaussian quadrature formulae –Gauss-Laguerre, Gauss-Hermite integration , composite integration, methods, double integration .	**10**
IV	System of linear algebraic equations – Gauss elimination, Jacobi Gauss Seidel, relaxation methods and their convergence. Numerical methods for determining Eigen value.	**10**
	Tutorial/Practical	**20**

Suggesting Readings:

1. K. Atkinson: An Introduction to Numerical Analysis, 2nd edition, Wiley, 1989.
2. R.L. Burden and J.D. Faires: Numerical analysis, 7th edition, Brooks Cole, 2001.
3. P.J. Davis: Interpolation and Approximation, Dover, 1975.
4. J.M. Ortega: Numerical Analysis: A Second Course, SIAM, 1987.
5. S.S. Sastry: Introductory Methods of Numerical Analysis, Phi Learning, 2009.

Course Outcomes: On completion of this course the students will be able to:

- Demonstrate an understanding of common numerical methods and how they are used to obtain approximate solutions to mathematical problems.
- Apply numerical methods to obtain approximate solutions to mathematical problems.
- Derive numerical methods for various mathematical operations and tasks, such as interpolation, differentiation, integration, the solution of linear and nonlinear equations, and the solution of differential equations.
- Analyse and evaluate the accuracy of common numerical methods.

Course Code	:	STA 111050
Course Title	:	**Statistical Inference- I**
Number of Credits	:	**4 (L: 3, T: 1, P: 0)**

Course Objective

The course objective for Statistical Inference- I is to provide students with a comprehensive understanding of the principles, methods, and techniques used in drawing conclusions and making predictions from data. Students will learn the theoretical foundations of statistical inference and estimation theory. They will also explore hypothesis testing methodologies. Additionally, students will gain practical experience in applying these concepts through hands-on data analysis.

Course Content

Unit	Content	Hours
I	Criteria of a good estimator- unbiasedness, consistency, efficiency, sufficiency. Minimal sufficient statistic. Exponential and Pitman families of distributions. Cramer-Rao lower bound approach to obtain minimum variance unbiased estimator. Uniformly minimum variance unbiased estimator, Complete statistic, Rao-Blackwell theorem, Lehmann-Scheffe theorem.	**10**
II	Methods of estimation: Method of moments, minimum chi-square estimation, maximum likelihood estimator and its properties, CAN & BAN estimators. Ancillary statistic and Basu' s theorem. Simple and composite hypothesis, concept of critical regions, test functions, two types of error, power of the test, level of significance, Neyman-Pearson lemma, uniformly most powerful (UMP) tests.	**10**
III	Types A, A1 critical regions, likelihood ratio test (LRT) with its asymptotic distribution, UMP tests for monotone likelihood ratio family of distributions. Similar tests with Neyman structure, Construction of similar and UMPU tests through Neyman structure.	**10**
IV	Confidence interval, construction of confidence intervals using pivotal, shortest expected length confidence interval, uniformly most accurate one sided confidence interval and its relation to UMP test for one sided null against one sided alternative hypotheses.	**10**
	Tutorial/Practical	**20**

Suggesting Readings:

1. Rohatgi, V.K. & Saleh, A.K. Md.E. (2015). An Introduction to Probability and Statistics, 3rd Edition. Wiley.
2. Lehmann, E.L. & Casella, G. (2014). Theory of Point Estimation, 2nd Edition. Springer.
3. Lehmann, E.L. & Romano, J.P. (2010). Testing Statistical Hypotheses, 3rd Edition. Springer.
4. Casella, G. & Berger, R.L. (2013). Statistical Inference, 2nd Edition. Cengage Learning

Course Outcome: On completion of this course the students will be able to:

- Grasp the fundamentals of statistical inference, including the principles underlying the construction of a reliable estimator.

- Apply a range of basic parametric estimation techniques and testing procedures to address real-life problems, demonstrating proficiency in selecting appropriate methods for different scenarios.
- Comprehend the concept of confidence intervals and key principles such as the Neyman-Pearson fundamental lemma, MP test, UMP test, among others, enabling them to make informed decisions in statistical analysis.
- Analyze and interpret data effectively, utilizing statistical inference tools to draw meaningful conclusions and make informed judgments.

SEMESTER II

Course Code	**:**	STA 121010
Course Title	**:**	**File Organization and Database Systems**
Number of Credits	**:**	**4 (L: 3, T: 0, P: 1)**

Course Objective

To provide students with a comprehensive understanding of principles, methods, and technologies used in organizing and managing data. The objectives include enabling students to grasp the fundamental concepts of file organization, such as indexing, hashing, and sorting, and understand their applications in data storage and retrieval. Additionally, students will learn the principles of relational database management systems (RDBMS), data modeling, query languages, and transaction management. Furthermore, students will develop proficiency in designing, implementing, and optimizing database systems to meet organizational needs efficiently. By the end of the course, students will be equipped with the knowledge and skills necessary to analyze data storage requirements, design appropriate file structures and database schemas, and effectively manage data in organizational settings.

Course Content

Unit	Content	Hours
I	**DBMS Concept:** Data and information, Introduction to Database System and Architecture, Introduction to Relational Database Management System, Data Model, Database Schema and Instances, Data Integrity and Referential Integrity rule.	**10**
II	**Database Design**: Entity-Relationship Model, Construction of ER Diagram (Tutorials / case studies) Generalization, aggregation, ER diagrams to tables.	**10**
III	**Structured Query Language :** Relational algebra and calculus, SQL, DDL, DML, SQL commands, operators, Insert, update , retrieve and delete operations. SQL query optimization. Practical: Database creation , Updating and Modification using SQL.	**10**

	Normalization: Concepts of Keys**,** Functional dependencies, Transitive dependencies, Multivalued dependency, normal forms- 1NF, 2NF, 3NF	
IV	**File Organization:** Database Systems versus File Systems, types of File Organizations, Sequential File Organization, Indexed File Organization, Heap File Organization , Hash File Organization , B+ Tree File Organization , ISAM (Indexed Sequential Access Method),Performance and evaluations	**10**
	Tutorial/Practical	**20**

Suggesting Readings:

1. Silberschatz, A., Korth, H. F., & Sudarshan, S. (2016). *Introduction to Data base Management System.*
2. Date, C. J. (1990). An introduction to database systems. Volume 1.
3. Elmasri, R., & Navathe, S. (2003). Fundamentals of Database Systems Addison Wesley. Reading, MA.
4. Majumdar & Bhattachrya, Database Management System, Tata McGraw-Hill
5. Ramakrishna, Gehkre, *Database Management System*, Tata McGraw- Hill
6. Leon, A., & Leon, M. (2010). *Database management systems*. Vikas Publishing House Pvt. Limited.
7. Ullman, J. D. (1984). *Principles of database systems.* Galgotia publications.
8. Shah, N. (2016). *Database Systems Using Oracle*. Pearson Education India.
9. Gupta, P. K. D., & KRISHNA, P. R. (2013). *Database management system Oracle SQL and PL/SQL*. PHI Learning Pvt. Ltd..
10. Martin, J. (1977). *Computer database organization*. Prentice Hall PTR.

Course Outcomes: On completion of this course the students will be able to:

- Understanding and articulating data models and schemas within Database Management Systems (DBMS).
- Familiarizing themselves with the functionalities inherent in database management systems, particularly focusing on relational databases.
- Demonstrating proficiency in utilizing SQL, the standardized language for interacting with relational databases.
- Grasping the fundamentals of functional dependencies and database design principles to create efficient database structures.
- Gaining insights into transaction management and query processing techniques, facilitating effective data manipulation and retrieval within a database environment.

Course Code	**:**	STA 121020
Course Title	**:**	**Linear Model & Regression Analysis**
Number of Credits	**:**	**4 (L: 3, T: 0, P: 1)**

Course Objective

To make students well equipped with a robust understanding of regression analysis, enabling them to effectively analyze data, interpret results, and make informed decisions in various fields where regression techniques are applied. This course will allow students to learn how categorical variables are used in regression analysis.

Course Content

Unit	Content	Hours
I	Gauss-Markov linear Models, theory of linear estimation, Estimability of linear parametric functions, method of least squares, normal equations, Gauss-Markov theorem, Estimation of error variance. Distribution of quadratic forms.	**10**
II	Simple Linear Regression: Simple linear regression model. Least-squares estimation of parameters. Hypothesis testing on the slope and intercept. Interval estimation in simple linear regression. Prediction of new observations. Coefficient of determination. Estimation by maximum likelihood. Multiple linear regression: Multiple linear regression models. Estimation of the model parameters. Hypothesis testing in multiple linear regression. Confidence intervals in multiple regression. Coefficient of determination and Adjusted R^2 .	**10**
III	Model Adequacy: Checking of linearity between study and explanatory variable, Residual Analysis, Detection and treatment of outliers, Residual plots. The PRESS statistic. Outlier test based on Studentized Residual (R-student). Test for lack of fit of the regression model. Transformation and Weighting to Correct Model Inadequacies: Variance stabilizing transformations. Transformations to linearize the model. Analytical methods for selecting a transformation on study variable. Diagnostic for Leverage and Influence: Leverage, measures of influence.	**10**
IV	Polynomial Regression Models: Polynomial models in one variable. Computational techniques for variable selection. Logistic Regression: Introduction, Linear predictor and link functions, logit, probit, odds ratio, test of hypothesis.	**10**
	Tutorial/Practical	**20**

Suggesting Readings:

1. Bapat, R.B. (2012). Linear Algebra and Linear Models, 3rd Edition. Hindustan Book Agency.
2. Montegomery, D.C., Peck, E.A. & Vining, G.G. (2015). Introduction to Linear Regression Analysis, 5th Edition. Wiley.

3. Khuri, A.I. (2010). Linear Model Methodology. CRC Press. .
4. Rao, C.R. (2009). Linear Statistical Inference and its Applications, 2nd Edition. Wiley.
5. Draper, N.R. & Smith, H. (2011). Applied Regression Analysis, 3rd Edition. Wiley

Course Outcome: On completion of this course the students will be able to:

- Gain insights into transaction management and query processing techniques, facilitating effective data manipulation and retrieval within a database environment.
- Comprehend the principles of regression analysis and the fundamental assumptions underlying it.
- Utilize least squares estimation techniques to estimate regression coefficients effectively.
- Evaluate the goodness-of-fit of regression models using appropriate metrics.
- Identify and address specification errors in regression models through rigorous testing procedures.
- Gain insight into outliers, leverage points, and influential observations, and understand their impact on regression analysis.
- Develop an understanding of simple logistic regression and interpret its results in practical scenarios.

Course Code	**:**	STA 121030
Course Title	**:**	**Stochastic Processes**
Number of Credits	**:**	**4 (L: 3, T: 1, P: 0)**

Course Objective

To provide students with a thorough understanding of stochastic processes, encompassing their theoretical foundations, classifications, and applications across various domains. Through lectures, exercises, and real-world examples, students will learn to analyze and model stochastic phenomena, including Markov chains, Poisson processes, etc. By the end of the course, students will be equipped with the analytical skills and practical knowledge necessary to apply stochastic processes in problem-solving contexts and to explore advanced topics in the field

Course Content

Unit	Content	Hours
I	Definition and classification of stochastic processes, Markov Chains: Definition, Examples and classification, Discrete renewal equation and basic limit theorem, Absorption probabilities, Criteria for recurrence.	**10**
II	Continuous time Markov chains, Examples, General pure birth process, Poisson process, Birth and death process, Finite state continuous time Markov chains.	**10**
III	Galton-Watson branching processes, Generating function, Extinction probabilities, Continuous time branching processes, Extinction probabilities, Branching processes with general variable life time	**10**

IV	Renewal equation, Renewal theorem, Applications, Generalizations and variations of renewal processes, Applications of renewal theory, Brownian motion.	**10**
	Tutorial/Practical	**20**

Suggesting Readings:

1. Kulkarni, Vidyadhar: Modeling and Analysis of Stochastic systems, G. Thomson Science and Professional.
2. Bhat, B.R.: Stochastic Models: Analysis and Applications, (2nd New Age International, India).
3. Medhi J.: Stochastic processes, new Age International (P) Ltd.
4. Karlin S. and Taylor H.M. : A First Course in Stochastic Process, Academic Press
5. Hoel P.G., Port S.C. and Stone C.J.: Introduction to Stochastic Process, Universal Book Stall. 6. Parzen E. : Stochastic Process, Holden-Day
6. Cinlar E. Introduction to Stochastic Processes, Prentice Hall.
7. Adke S.R. and Manjunath S.M.: An Introduction to Finite Markov Processes, Wiley Eastern.
8. Ross S.M.: Stochastic Process, John Wiley. 10. John G. Kemeny, J. Laurie Snell, Anthony W.

Course Outcome: On completion of this course the students will be able to:

- Define stochastic process and identify its type.
- Understand the concept of Markov chain and its basic properties.
- Define Poisson process and understand its properties with some applications.
- Understand the basic concept and applications of renewable theory and branching process.

Course Code	**:**	STA 121040
Course Title	**:**	**Statistical Inference II**
Number of Credits	**:**	**4 (L: 3, T: 0, P: 1)**

Course Objective

To deepen students' understanding of advanced statistical methods, focusing on nonparametric techniques and the Sequential Probability Ratio Test (SPRT). Throughout the course, students will delve into the intricacies of Bayesian paradigm, nonparametric methods, including hypothesis testing and estimation, particularly suited for data with unknown distributions or small sample sizes. Moreover, students will explore the theoretical underpinnings and practical applications of SPRT, a powerful tool for sequential hypothesis testing. By the end of the course, students will be equipped with the knowledge about Bayesian estimation techniques, and skills to apply nonparametric methods and SPRT effectively in real-world scenarios, enabling them to make informed decisions and contribute to research across various domains

Course Content

Unit	Content	Hours
I	Elements of the Bayesian paradigm, Introduction to prior and posterior distributions, loss functions. Bayes risks, Bayesian paradigm versus classical paradigm. Prior distribution, subjective determination of prior distribution, improper priors, non-informative priors, conjugate prior families, construction of conjugate families using sufficient statistic for fixed dimensions.	**10**
II	Bayesian estimation of parameters of some well-known distributions like binomial, multinomial, Poisson, normal, lognormal, exponential, Rayleigh and Weibull distributions. Credible and highest posterior density (HPD) interval, HPD credible intervals in case of normal, gamma, exponential and Weibull distributions.	**10**
III	Concept of nonparametric and distribution-free methods, probability integral transformation, empirical distribution function, kernel, one-sample and two-sample U-Statistics, test of independence, sign test, rank-order statistics, Wilcoxon signed-Rank test. Wald-Wolfowitz runs test, Kolmogorov-Smirnov two-sample test, median test, Mann-Whitney U test.	**10**
IV	The sequential probability ratio test (SPRT) and its application to binomial, Poisson, geometric, exponential, normal, operating characteristic (OC) function of SPRT, average sample number (ASN) function and their application, Wald's fundamental identity and its uses.	**10**
	Tutorial/Practical	**20**

Suggesting Readings:

11. Berger, J.O. (2013): Statistical Decision Theory and Bayesian Analysis, Springer.
    Hollander, M., Wolfe, D. and Chicken, E. (2013): Nonparametric Statistical Methods, 3rd Edition, Wiley.
12. Gibbons, J.D. and Chakraborti, S. (2010): Nonparametric Statistical Inference, 5th Edition, CRC Press.
13. Rohatgi, V.K. & Saleh, A.K. Md.E. (2015). An Introduction to Probability and Statistics, 3rd Edition. Wiley

Course Outcome: On the completion of the course, student will be able to

- Find posterior distribution of a parameter.
- Identify the nature of the prior.
- Understand various types of loss functions and their nature.
- Use Bayesian theory to draw inferences in simple problems.
- Solve hypothesis testing problems where the conditions for the traditional parametric inferential tools to be applied are not fulfilled.

- Build non-parametric density estimates.
- Critically examine sequential procedures for appropriate statistical analyses
- Apply the sequential techniques for solving real world problems.

Course Code	**:**	STA 121050
Course Title	**:**	**Sampling Methods**
Number of Credits	**:**	**4 (L: 3, T: 0, P: 1)**

Course Objective

To provide students with a comprehensive understanding of various techniques used in sampling and their applications in statistical analysis. Through theoretical lectures, practical exercises, and case studies, students will learn the principles of random sampling, stratified sampling, cluster sampling, and systematic sampling etc. The objectives include enabling students to grasp the importance of representative sampling for making inferences about populations, to evaluate the strengths and limitations of different sampling methods in diverse contexts, and to develop proficiency in designing and implementing sampling plans for research studies. By the end of the course, students will be equipped with the necessary knowledge and skills to conduct sampling procedures effectively, ensuring the validity and reliability of statistical analyses in academic, professional, and research settings.

Course Content

Unit	Content	Hours
I	Introduction to sampling, census and sample surveys, sampling and non-sampling errors. Simple random sampling, sampling from finite populations with and without replacement, unbiased estimation and confidence intervals for population mean and total, simple random sampling of attributes.	**10**
II	Stratified sampling, reasons for stratification, choice of strata, choice of sampling unit, estimation of population mean and its variance, choice of sample sizes in different strata, variances of estimates with different allocation, effects of deviation from optimum allocations, estimation of the gain in precision due to stratification, cost function, construction of strata. Systematic Sampling: merits and demerits of systematic sampling, estimation of sample mean and its variance, comparison of systematic sampling with simple random and stratified sag.	**10**
III	Ratio and regression methods of estimation, variances of the estimates, optimum property of ratio estimates, comparison among ratio, regression and simple random sampling estimates, ratio estimate in stratified sampling, comparison with the ratio and mean per unit. Cluster Sampling, estimates of mean and its variance for equal and unequal clusters, efficiency in terms of intra-class correlation, optimum unit of sampling, sampling with replacement, estimation of mean and its variance.	**10**

IV	Sampling with varying probabilities with and without replacement, sampling with probability proportional to size, Lahiri's method of selection, Horvitz-Thompson estimator, its variance and unbiased estimate of this variance. Introduction of multistage sampling, two stage sampling with equal first stage units, estimation of its mean and variance, introduction of multiphase sampling, double sampling for ratio and regression methods of estimation.	**10**
	Tutorial/Practical	**20**

Suggesting Readings:

1. Hedayat A.S. and Sinha B.K. 1991. Design and Inference in Finite Population Sampling. John Wiley.
1. Kish L. 1965. Survey Sampling. John Wiley.
2. Mukhopadhyay, P. 2008. Theory and Methods of Survey Sampling, John Wiley & Sons
3. Murthy M.N. (1977) Sampling Theory & Methods. Statistical Publ. Society, Calcutta.
4. Sukhatme P.V., Sukhatme B.V., Sukhatme S & Asok C. 1984. Sampling Theory of Surveys with Applications. Iowa State University Press & ISAS, New Delhi.
5. Thompson, S.K. 2000. Sampling. John Wiley.
6. Cochran W.G. 2007. Sampling Techniques. A John Wiley & Sons Publication

Course Outcome: On the completion of the course, student will be able to:

- Understand the distinctive features of sampling schemes and its related estimation problems.
- Learn about various approaches (design based and model-based) to estimate admissible parameters; with and without replacement sampling scheme, sampling with varying probability of selection.
- Learn about the applications of sampling methods; systematic, stratified and cluster sampling.
- Understand the cluster and two stages sampling with varying sizes of clusters/first stage units.

SEMESTER III

Course Code	**:**	STA 211010
Course Title	**:**	**Machine Learning using Python**
Number of Credits	**:**	**4 (L: 3, T: 0, P: 1)**

Course Objective

To equip students with a comprehensive understanding of machine learning concepts and techniques while utilizing the Python programming language. Through a blend of theoretical instruction, practical exercises, and hands-on projects, students will gain proficiency in various machine learning algorithms, including supervised learning, unsupervised learning, and Clustering. The objectives include providing students with the skills to preprocess and manipulate data, select appropriate machine learning algorithms for different tasks, and evaluate model performance using relevant metrics. Additionally, students will learn to implement machine learning models in Python using popular libraries. By the end of the course, students will be capable of applying machine learning techniques to solve real-world problems, analyzing data, making predictions, and contributing to advancements in diverse domains such as finance, healthcare, and marketing.

Course Content

Unit	Content	Hours
I	Basics of Python Type of variables, data types, lists, control statements, functions, classes, files and exceptions. Essential Modules in Python: Jupyter Notebook, Numpy, Scipy, Matplotlib, Pandas, mglearn	**10**
II	Supervised Learning: Classification and Regression, Nearest Neighbors, k-Nearest Neighbors, Decision Trees, Neural Networks	**10**
III	Unsupervised Learning -1: Preprocessing and Scaling, Scaling training, Dimensionality Reduction, Feature Extraction, and Manifold Learning	**10**
IV	Unsupervised Learning -2: hours Clustering: k- Means clustering, Agglomerative Clustering, DBSCAN	**10**
V	Tutorial/Practical	**20**

Suggesting Readings:

1. Haslwanter, T. (2016): An Introduction to Statistics with Python: with Applications in the Life Sciences, Springer.
2. Sheppard, K. (2018): Introduction to Python for Econometrics, Statistics and Data analysis Oxford University press.

Course outcome: On the completion of the course, student will be able to:

- Understand how machine learning works and how to use Python for it.
- Practice using different machine learning methods like supervised and unsupervised learning.
- organize and clean data for machine learning tasks.
- Choose the right machine learning method for different situations and evaluate how well it works.
- Use Python libraries to build machine learning models.
- Use machine learning to solve problems in areas like finance, healthcare, and marketing.

Suggested Readings:

1. Pattern Recognition and Machine Learning. Christopher Bishop.

2. Machine Learning. Tom Mitchell.
3. Pattern Classification. R.O. Duda, P.E. Hart and D.G. Stork.
4. Data Mining: Tools and Techniques. Jiawei Han and Michelline Kamber.
5. Elements of Statistical Learning. Hastie, Tibshirani and Friedman. Springer

Course Code	**:**	STA 211020
Course Title	**:**	**Time Series Analysis & Forecasting**
Number of Credits	**:**	**4 (L: 3, T: 0, P: 1)**

Course Objective

To equip students with the necessary tools and techniques to analyze and forecast time-series data effectively. Students will gain a deep understanding of time-series concepts such as trend, seasonality, and autocorrelation. The objectives include providing students with the skills to model various time-series components using appropriate statistical methods, including ARIMA (AutoRegressive Integrated Moving Average) models, exponential smoothing methods, and seasonal decomposition techniques. Furthermore, students will learn how to assess model adequacy, make reliable forecasts, and interpret forecast results for decision-making purposes. By the end of the course, students will be proficient in applying time-series analysis and forecasting methodologies to real-world data, enabling them to make informed predictions and contribute to decision-making processes across diverse industries and domains.

Course Content

Unit	**Content**	**Hours**
I	Basics of Time series: A model Building strategy, Time series and Stochastic process, Stationarity, Auto correlation, meaning and definition–causes of auto correlation-consequence of autocorrelation–test for auto–correlation. Study of Time Series model and their properties using correlogram, ACF and PACF. Yule walker equations.	**10**
II	Time Series Models: White noise Process, Random walk, MA, AR, ARMA and ARIMA models, Box- Jenkins's Methodology fitting of AR(1), AR(2), MA(1), MA(2) and ARIMA(1,1) process. Unit root hypothesis, Co-integration, Dicky Fuller test unit root test, augmented Dickey – Fuller test.	**10**
III	Non-linear time series models, ARCH and GARCH Process, order identification, estimation and diagnostic tests and forecasting. Study of ARCH (1) properties. GARCH (Conception only) process for modelling volatility.	**10**
IV	Multivariate Time series: Introduction, Cross covariance and correlation matrices, testing of zero cross correlation and model representation.	**10**
	Tutorial/Practical	**20**

Suggesting Readings:

1. Box, G.E.P and Jenkins G.M. (1970) Time Series Analysis, Forecasting and Control, Holden- Day.
2. Brockwell, P.J and Davis R.A. (1987) Time Series: Theory and Methods, Springer-Verlag.
3. Abraham, B. and Ledolter, J.C. (1983) Statistical Methods for Forecasting, Wiley
4. Anderson, T.W (1971) Statistical Analysis of Time Series, Wiley.
5. Fuller, W.A. (1978) Introduction to Statistical Time Series, John Wiley.
6. Chatfield, C. (2004) The Analysis of Time Series-An Introduction, 6th edn, Chapman & Hall
7. Montgomery, D.C., Jennings, C.L. & Kulahci, M. (2015). Introduction to Time Series Analysis and Forecasting, 2nd Edition. Wiley.
8. Brockwell, P.J. & Davis R.A. (2016). Introduction to Time Series and Forecasting, 2nd Edition. Springer.

Course outcome: On the completion of the course, the students will be able to

- Understand the components of time series data and interpret their significance in real-world applications.
- Identify and estimate cyclical patterns within time series data to facilitate informed decision-making.
- Explore the temporal dependencies between lagged values of the series to uncover underlying relationships and trends.
- Conduct rigorous stationarity tests to assess the stability and characteristics of time series data.
- Apply ARIMA(p,d,q) modelling techniques to forecast future trends and behaviors within time series data accurately.
- Develop a comprehensive understanding of ARCH and GARCH processes to model and analyze volatility and heteroscedasticity effectively.

Course Code	**:**	STA 211030
Course Title	**:**	**Multivariate Analysis**
Number of Credits	**:**	**4 (L: 3, T: 0, P: 1)**

Course Objective

To provide students with a comprehensive understanding of statistical techniques used to analyze datasets with multiple variables. Students will be provided with the knowledge of principles and methods of multivariate analysis, including multivariate regression, principal component analysis (PCA), factor analysis etc. The objectives include enabling students to grasp the fundamental concepts underlying multivariate analysis, to develop proficiency in using multivariate techniques to explore relationships and patterns among variables, and to apply these methods to solve real-world problems in fields such as finance, marketing, and social sciences. By the end of the course, students will possess the skills necessary to conduct multivariate analyses, interpret results, and communicate findings effectively to stakeholders.

Course Content

Unit	Content	Hours
I	Notion of multivariate distributions, Multivariate normal distribution, Marginal and conditional distributions, Characteristic function, Estimation of mean vector and covariance matrix.	**10**
II	Distribution of rectangular co-ordinates, Wishart distribution and its properties, Distribution of simple, partial and multiple correlations based on samples from normal population	**10**
III	Hotelling's T^2 and Mahalanobis D^2 statistics, Properties of T^2 and D^2 , Multivariate Fisher Behren's problem	**10**
IV	Classification problem, Principal component analysis, Canonical variables, Canonical correlation, Basics of factor analysis.	**10**
	Tutorial/Practical	**20**

Suggesting Readings:

1. Anderson, T.W. (1984) An Introduction to Multivariate Statistical Analysis, John Wiley.
2. Kshirasagar, A.M. (1972) Multivariate Analysis, Marcel-Dekker.
3. Seber, G.A.F. (1977) Multivariate Observations, Wiley.
4. Morrison, D.F. (1976) Multivariate Statistical Methods, John Wiley.
5. Rancher, A.C. (1995) Methods of Multivariate Analysis, John Wiley.
6. Johnson,R.A.& Wichern, D.W.(1990) Applied Multivariate Statistical Analysis, Prentice Hall.

Course Outcome: On the completion of the course, the students will be able to

- Define the multivariate normal distribution and demonstrate a comprehensive understanding of its properties, including its shape, symmetry, and central tendency.
- Apply statistical methods to accurately estimate the mean vector and covariance matrix of multivariate normal populations, facilitating robust data analysis and interpretation.
- Conduct hypothesis tests to determine the significance of a single mean vector and differences between two mean vectors in multivariate populations, enabling informed decision-making in various contexts.
- Utilize principal component analysis (PCA) and factor analysis techniques to extract meaningful patterns and relationships from real datasets, enhancing data exploration and interpretation capabilities.
- Implement classification and discrimination methods to effectively distinguish observations between two populations based on multivariate data, fostering the ability to identify and characterize distinct groups within datasets.

- Perform correlation analysis between two multivariate populations to examine and quantify the relationships between variables across different datasets, facilitating insights into data associations and dependencies.

Course No.	**Elective I**	**Cr. hrs. 4:(3+0+1) / (3+1+0)**
Course No.	**Elective II**	**Cr. hrs. 4:(3+0+1) / (3+1+0)**
Course No.	**Seminar**	**2**

SEMESTER IV

Course Code	:	STA 221010
Course Title	:	**Experimental Designs**
Number of Credits	:	**4 (L: 3, T: 0, P: 1)**

Course Objective

To provide students with a comprehensive understanding of the principles, methods, and applications of experimental design in research. various types of experimental designs, including completely randomized designs, randomized block designs, factorial designs, and Latin square designs, Response surface designs and factorial designs. The objectives include enabling students to comprehend the importance of experimental design in ensuring valid and reliable research outcomes, to develop skills in designing experiments that effectively control for confounding variables and minimize bias, and to analyze experimental data using appropriate statistical techniques. Additionally, students will learn to interpret and communicate results derived from experimental designs, enabling them to make informed decisions and contribute to advancements in their respective fields. By the end of the course, students will be equipped with the knowledge and skills necessary to plan, conduct, and analyze experiments rigorously, enhancing the quality and credibility of their research endeavors.

Course Content

Unit	Content	Hours
I	Randomization, Replication and local control, One way and two way classifications with equal and unequal number of observations per cell with and without interaction, Fixed effects and Random effects model. Model adequacy	10

	checking, CRD, RBD and Latin Square designs, Analysis of co-variance for completely randomized and randomized block designs. Analysis of experiments with missing observations.	
II	Incomplete Block Designs: Balanced Incomplete Block designs, Construction of BIB Designs, Analysis with recovery of inter-block information and intra-block information. Partially balanced incomplete block designs, Analysis of partially balanced incomplete block designs with two associate classes, Lattice designs.	**10**
III	2^n Factorial experiments. Analysis of 2^n factorial experiments. Total confounding of 2^n designs in 2^k blocks. Partial confounding in 2^k blocks. Fractional factorial designs, Resolution of a design, 3^n factorial designs. Split plot and strip plot designs.	**10**
IV	Response surface designs - orthogonality, rotatability blocking and analysis - Method of Steepest accent, Crossover designs, Models properties and Analysis.	**10**
	Tutorial/Practical	**20**

Suggesting Readings:

1. Cochran WG and Cox GM. 1957. Experimental Designs. 2nd Ed. John Wiley.
2. Dean AM and Voss D. 1999. Design and Analysis of Experiments. Springer.
3. Montgomery DC. 2012. Design and Analysis of Experiments, 8th Ed. John Wiley.
4. Federer WT. 1985. Experimental Designs. MacMillan.
5. Fisher RA. 1953. Design and Analysis of Experiments. Oliver & Boyd.
6. Dey, A. (1986). Theory of Block Designs, John Wiley & Sons.
6. Hinkelmann, K. and Kempthorne, O. (2005). Design and Analysis of Experiments, Vol. 2:
7. Advanced Experimental Design, John Wiley & Sons.
8. John, P.W.M.(1971).Statistical Design & Analysis of Experiments, Macmillan Co., New York.

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

- Identify what design was followed and its features, describe whatassumptions are appropriate in modeling the data.
- Analyse the results of a designed experiment in order to conduct theappropriate statistical analysis of the data.
- Interpret statistical results from an experiment and report them innon-technical language.
- Compare efficiency of the experimental designs.

Course Code	**:**	STA 221020
Course Title	**:**	**Statistical Software**
Number of Credits	**:**	**4 (L: 3, T: 0, P: 1)**

Course Objective

To familiarize students with various statistical software packages such as SPSS, R, MATLAB, and others, emphasizing their practical application in problem-solving contexts. Additionally, the course endeavors to equip students with the skills necessary for developing software packages tailored to address specific problems effectively.

Course Content

Unit	Content	Hours
I	Use of statistical softwares SPSS, R, MATLAB, etc. in solving practical problems.	**20**
II	Development of software packages for solving specific problems.	**20**
	Tutorial/Practical	**20**

Suggesting Readings:

1. Landau, S., and Everitt, B.S. (2004). A Handbook of Statistical Analyses using SPSS, Chapman & Hall/CRC Press, New York
2. Almquist, Y. B., Ashir, S., and Brännström, L. A Guide to SPSS: The Basics, Version 1.0.1, Stockholm University, Sweden.
3. Evans, M. (2009). MINITAB Manual, W.H. Freeman and Company, New York. Related
3. Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]
    (a) https://nptel.ac.in/courses/110/107/110107113/
    (b) https://nptel.ac.in/courses/110/105/110105060/
    (c) https://nptel.ac.in/courses/111/104/111104098/

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

- Gain proficiency in utilizing statistical software packages including SPSS, R, MATLAB, etc.
- Perform data manipulation, visualization, and statistical analysis efficiently.
- Apply statistical software tools to explore, analyze, and interpret data sets, enabling informed decision-making and problem-solving.
- Demonstrate competence in designing, developing, and testing software packages aimed at addressing real-world problems, ensuring accuracy, reliability, and usability.

Course No. **Elective III** **Cr. hrs. 4:(3+0+1) / (3+1+0)**

Course No. **Elective IV** **Cr. hrs. 4:(3+0+1) / (3+1+0)**

Course No. **Project Work** **Cr. hrs. 4**

ELECTIVE COURSES FOR SEMESTER III

Course Code	:	STA 215050
Course Title	:	**Statistical Decision Theory**
Number of Credits	:	**4 (L: 3, T: 1, P: 0)**

Course Objective

To provide students with a comprehensive understanding of the principles and methodologies involved in making optimal decisions under uncertainty. Through this course, students will delve into the fundamental concepts of decision theory including utility theory. The objectives of the course include enabling students to develop skills in formulating decision problems, assessing the trade-offs between risks and rewards, and selecting decision strategies that maximize expected utility or minimize expected loss. Additionally, students will learn to apply decision-theoretic principles to various domains such as business, economics, healthcare, and engineering, gaining the ability to make informed decisions in complex and uncertain environments. By the end of the course, students will be equipped with the knowledge and analytical skills necessary to analyze decision problems rigorously, devise optimal decision strategies, and contribute to advancements in decision-making methodologies.

Course Content

Unit	**Content**	**Hours**
I	Basic elements of a decision problem, Randomized and non-randomized decision rules, Estimation and testing of hypothesis as decision problems, Bayes approach to inference and decision, Loss functions, Prior and posterior distributions, Prior - Posterior analysis for Bernoulli, Poisson and normal processes, Decision principles and Baye's risk.	**10**
II	Utility theory, axioms, construction of utility functions, sufficiency, equivalence of Classical and Bayesian sufficiency, complete and essentially complete classes of decision rules.	**10**
III	Minimax analysis, Basic elements of game theory, General techniques of solving games, Finite games, Supporting and separating hyperplane theorems, Minimax theorem, Minimax estimation for normal and Poisson means.	**10**
IV	Admissibility of Bayes and minimax rules, General theorems on admissibility, Robustness of Bayes rules, Invariant decision rules, Location parameter problems, Confidence and credible sets.	**10**
	Tutorial/Practical	**20**

Suggesting Readings:

1. James O. Berger (1980) Statistical Decision Theory and Bayesian Analysis, Springer Verlag
2. M.H. DeGroot (1970) Optimal Statistical Decisions, John Wiley
3. H. Raiffa and R. Schlaifer (2000) Applied Statistical Decision Theory, Wiley Classics
4. Zellener (1971) An Introduction to Bayesian inference in Econometrics, Wiley
5. Hayes J, G and Winkler R I (1976) Probability, Statistics and Decision, Dower
6. Anthony O' Hagan (1994) Kendall's Advanced theory of Statistics Vol. 2B, Bayesian Inference John Wiley.

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

- Comprehend problems through a decision theoretic lens, assessing utility functions, proposing conjugate families of prior distributions, evaluating various risk functions, and delivering optimal solutions.
- Navigate multilevel decision problems and decision processes incorporating sampling information, demonstrating proficiency in problem-solving within complex decision-making frameworks.

Course Code	**:**	STA 215060
Course Title	**:**	**Demography**
Number of Credits	**:**	**4 (L: 3, T: 1, P: 0)**

Course Objective

To provide students with a comprehensive understanding of population dynamics and the factors influencing population structure, growth, and distribution. Students will explore key concepts in demography such as fertility, mortality, migration, and population projections. The objectives include enabling students to analyze demographic data, interpret demographic trends, and assess the implications of demographic processes on societies, economies, and environments. Additionally, students will develop skills in demographic methods, including data collection, analysis, and modeling, to address real-world demographic challenges and inform policy-making decisions. By the end of the course, students will be equipped with the knowledge and analytical tools necessary to critically evaluate demographic phenomena, understand population dynamics, and contribute to research and policy initiatives aimed at addressing global demographic issues.

Course Content

Unit	Content	Hours
I	Coverage and content errors in demographic data, Chandrasekharan—Deming formula to check completeness of registration data, adjustment of age data- use of	**10**

	Whipple, Myer and UN indices. population transition theory.	
II	Measures of fertility; stochastic models for reproduction, distributions of time of birth, inter-live birth intervals and of number of births (for both homogeneous and homogeneous groups of women), estimation of parameters; estimation of parity progression from open birth interval data.	**10**
III	Measures of Mortality; construction of abridged life tables, infant mortality rate and its adjustments, model life table. Stable and quasi-stable populations, intrinsic growth rate.	**10**
IV	Models of population growth and their filling to population data. Internal migration and its measurement, migration models, concept of international migration. Methods for population projection, component method of population projection, Nuptiality and its measurements.	**10**
	Tutorial/Practical	**20**

Suggesting Readings:

1. Kumar, R. (1986): Technical Demography, Wiley Eastern Ltd.
2. Benjamin, B. (1969): Demographic Analysis, George, Allen and Unwin.
3. Chiang, C.L. (1968): Introduction to Stochastic Progression.
4. Cox, P.R. (1970): Demography, Cambridge University Press.
5. Keyfitz, N. (1977): Introduction to the Mathematics of Population-with Revisions, Addison-Wesley, London.
6. Spiegelman, M. (1969): Introduction to Demographic Analysis, Harvard University Press.
7. Wolfenden, H.H. (1954): Population Statistics and Their Compilation, Am Actuarial Society.

Course Outcome: On completion of the course, students will be able to :

- Identify principle sources of demographic data and assess theirstrengths and weaknesses.
- Evaluate the demographic significance of age and sex structures andthe implications of variations in age & sex structure.
- Construct and interpret life tables.
- Calculate and interpret the principal demographic measures, and standardize these measures for comparison.
- Understand the components of population change, including the effects of changing birth, death and migration rates, and demonstrate their influences on age structure.
- Understand the concept of urbanization on the economic growth of the country.
- Estimate and project the population by different methods.
- Understand the concept of stable and stationary population

Course Code	**:**	STA 215070
Course Title	**:**	**Statistical Quality Control**
Number of Credits	**:**	**4 (L: 3, T: 1, P: 0)**

Course Objective

To equip students with a comprehensive understanding of the principles, techniques, and applications of statistical methods for monitoring and improving the quality of products and processes. The objectives include enabling students to comprehend the principles of statistical quality control, such as variation analysis, control charting, and process capability analysis, and apply them to identify and address quality issues in manufacturing, service, and other industries. Additionally, students will develop skills in interpreting control charts, conducting hypothesis tests for quality improvement, and implementing quality control procedures in organizational settings. By the end of the course, students will be equipped with the knowledge and tools necessary to assess, maintain, and enhance the quality of products and processes, contributing to overall organizational excellence and customer satisfaction.

Course Content

Unit	Content	Hours
I	Introduction to Statistical Quality control, Chance and Assignable causes of variation, Choice of control Limits, Rational Subgroups.	**10**
II	Control Charts for Variables x and R Chart, x and S chart, Control chart for Attributes- control char for Fraction defective, Control chart for Defects. Choice between Variables and Attributes Control Charts.	**10**
III	Shewhart Control Chart –CUSUM Chart , Moving Average Control Chart, x and R Chart for short production Runs, Modified Control Charts , Process Capability Analysis – using Histogram, Probability Plot and Control Chart, Taguchi's Method.	**10**
IV	Acceptance Sampling Plan, Single sampling for Attributes OC Curve Double, Multiple and Sequential Sampling Plans, Dodge Roaming Sampling Plans, Acceptance Sampling By Variables, Designing a Sampling Plan with a Specified OC curve, Sequential Sampling by Variables, Continuous Sampling Plans.	**10**
	Tutorial/Practical	**20**

Suggesting Readings:

1. D.C. Montgomery: Introduction to Statistical Quality Control. Wiley.
2. Wetherill, G.B. Brown, D.W.: Statistical Process Control Theory and Practice, Chapman & Hall.
3. Wetherill, G.B.: Sampling Inspection and Quality control, Halsteed Press.
4. Duncan A.J.: Quality Control and Industrial Statistics, IV Ed., Taraporewala and Sons.
5. Ott, E. R. : Process Quality Control (McGraw Hill)
6. Duncan, A.J. (1986). Quality control and Industrial Statistics.

Course Outcome: On completion of the course, students will be able to:

- Understand the principles and concepts of statistical quality control, including variation analysis, control charting, and process capability analysis.
- Apply statistical methods to monitor and improve the quality of products and processes in various industries, such as manufacturing, healthcare, and services.
- Interpret control charts and other quality control tools to identify trends, patterns, and abnormalities in data.
- Conduct hypothesis tests and analyze statistical results to make informed decisions for quality improvement initiatives.

Course Code	:	STA 225130
Course Title	:	**Non-Linear Regression Models**
Number of Credits	:	**4 (L: 3, T: 1, P: 0)**

Course Objective

To provide students with a comprehensive understanding of advanced regression techniques used to model complex relationships between variables that cannot be adequately captured by linear models. Through theoretical instruction, practical exercises, and real-world applications, students will explore various non-linear regression methods, including polynomial regression, exponential regression, logistic regression, and neural network modeling. The objective of the course is to enable students to develop proficiency in selecting appropriate non-linear regression models, estimating model parameters, and assessing model fit and predictive performance. Additionally, students will learn techniques for model validation, diagnostics, and interpretation to ensure the reliability and validity of non-linear regression analyses. By the end of the course, students will be equipped with the knowledge and skills necessary to apply non-linear regression models effectively in research, data analysis, and decision-making contexts across diverse fields such as economics, engineering, biology, and social sciences.

Course Content

Unit	Content	Hours
I	Review of Simple Linear Regression, Multiple Regression and General Linear Regression Model, Regression models for Quantitative & Qualitative Predictors.	**10**
II	Introduction to non-linear regression. Least squares, Estimation in non-linear regression,	**10**
III	Introduction to neural network modeling, Neural network as generalization of linear regression.	**10**
IV	Logistic regression, Logistic regression diagnostics. Poisson regression and	**10**

	Generalized regression models.	
	Tutorial/Practical	**20**

Suggesting Readings:

1. Bates, D.M. & Watts, D.G.(1988) : Non-linear regression analysis and its applications, Wiley, New York.
2. Gallant, A.R.(1987) : Non-linear Statistical Models, Wikey, New York
3. Kutner, M.H., Nachtsheim, C.J., & Li., W (2013) : Applied Linear Statistical Models 5^{th}
4. Edition.,Mc Graw Hill Education India, Pvt. Ltd.
5. Ratkowsky, D.A. (1983) :Non-linear Regression Modeling, Marcel Dekkar, New York

Course Outcome: On completion of the course, students will be able to:

- Understand the principles and concepts of non-linear regression models, including the assumptions and limitations associated with such models.
- Select non-linear regression models for different types of data and relationships between variables.
- Estimate model parameters using various optimization techniques and interpreting their significance.
- Assess model fit and predictive performance, including measures of goodness-of-fit and validation procedures.
- Apply diagnostic tools to identify and address issues such as multicollinearity, heteroscedasticity, and outliers in non-linear regression analyses.

Course Code	**:**	STA 215090
Course Title	**:**	**Optimization Techniques**
Number of Credits	**:**	**4 (L: 3, T: 1, P: 0)**

Course Objective

To provide students with a comprehensive understanding of optimization fundamentals and algorithms. Students will develop problem-solving skills and proficiency in mathematical modeling, learning to formulate real-world problems and apply appropriate optimization methods. The course aims to equip students with hands-on experience using optimization software tools and to explore applications across diverse fields. Additionally, students will cultivate critical thinking abilities, considering ethical and societal implications, and honing communication skills for presenting optimization solutions effectively.

Course Content

Unit	Content	Hours
I	Linear Programming: Convex sets, Supporting and Separating Hyper-planes,	**10**

	Standard linear Programming Problem, basic feasible solution, simplex algorithm and simplex method, graphical solution, two phase method. Duality in linear programming, duality theorems, dual simplex method with justification, sensitivity.	
II	Transportation and assignment algorithms, Hungarian method of assignment, transshipment problems, duality theory of testing optimality of solution in transportation problem and transshipment problems, transportation problem and transshipment problems as network problems Balance and degeneracy in transportation problem.	**10**
III	Two persons sum game, Integer linear Programming Problem, branch and bound method, Network flows, maximal flow in the network.	**10**
IV	Nonlinear Programming: Kuhn-Tucker conditions, Quadratic programming, Wolfe's, Beale's and Fletcher's algorithms for solving quadratic programming problems.	**10**
	Tutorial/Practical	**20**

Suggesting Readings:

1. Kambo, N.S. (1991) Mathematical Programming Techniques (Affiliated East-west press Pvt. Ltd.)
2. Hadley, G. (1987) Linear Programming.
3. Taha, H.A. (1992) Operations Research 5th ed. (Macmillan)
4. Panneerselvam, R. Operations Research (Prentice hall of India)
5. Medhi J. (1984) Stochastic Processes 2nd ed.(New Age International Pvt. Ltd.

Course Outcome: On completion of the course, students will be able to:

- formulate optimization problems from real-world scenarios, identifying objective functions and constraints, and selecting appropriate optimization techniques to address them.
- implementing and executing a variety of optimization algorithms
- apply optimization techniques to diverse domains such as engineering, economics, logistics, and data science, demonstrating their ability to optimize decision-making processes and resource allocation in practical contexts
- critically analyze optimization solutions, evaluate their effectiveness, and communicate findings clearly and effectively to stakeholders, considering ethical implications and societal impacts

Course Code	:	STA 215100
Course Title	:	**Statistics for Clinical Trials**
Number of Credits	:	**4 (L: 3, T: 1, P: 0)**

Course Objective

To equip participants with comprehensive knowledge and skills essential for designing, conducting, and analyzing clinical trials effectively and ethically. This involves understanding the principles of trial design, randomization, patient selection, data collection methods, and regulatory requirements. Participants also learn to evaluate the risks and benefits associated with clinical interventions, ensuring patient safety and data integrity throughout the trial process. By mastering these concepts, participants can contribute to advancing medical research and improving healthcare outcomes through rigorous and ethical clinical trial practices.

Course Content

Unit	Content	Hours
I	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.	**10**
II	Design of clinical trials: parallel vs. cross-over designs, cross-sectional vs. longitudinal designs, review of factorial designs, objectives and endpoints of clinical trials.	**10**
III	Design of Phase I trials, design of single-stage and multi-stage Phase II trials, design and monitoring of Phase III trials with sequential stopping, design of bioequivalence trials. Reporting and analysis: analysis of categorical outcomes from Phase I-III trials, analysis of survival data from clinical trials.	**10**
IV	Surrogate endpoints: selection and design of trials with surrogate endpoints, analysis of surrogate endpoint data. Meta analysis of clinical trials.	**10**
	Tutorial/Practical	**20**

Suggesting Readings:

1. C. Jennison and B.W. Turnbul (1999). Group Sequential Methods with Applications to Clinical Trials, CRC Press.
2. E. Marubeni and M.G. Valsecchi (1994). Analyzing Survival Data from Clinical Trials and Observational Studies, Wiley and Sons.
3. J. L. Fleiss (1989). The Design and Analysis of Clinical Experiments. Wiley and Sons.
4. L.M. Friedman, C. Furburg and D. L. Demets (1998) :.Fundamentals of Clinical Trials, Springer Verlag.
5. S. Piantadosi (1997). Clinical Trials: A Methodological Perspective. Wiley and Sons

Course Outcome: On completion of the course, students will be able to:

- Understand the basic concepts, statistical principles, and methods forclinical data analysis and reporting.

- Identify and classify different types of trial designs when reading atrial report.
- Understand the essential design issues of randomized clinical trials.
- Detect three possible sources of errors that could lead to erroneous trialresults.
- Understand the relative contributions of clinical judgment and clinicaltrials in evaluating new medical therapies.

Course Code	**:**	STA 215110
Course Title	**:**	**Data Warehousing and Data Mining**
Number of Credits	**:**	**4 (L: 3, T: 1, P: 0)**

Course Objective

To equip students with the foundational knowledge and practical skills necessary to comprehend, design, and implement effective data storage, retrieval, and analysis systems. Through this course, students aim to grasp the principles and techniques behind data warehousing, including the construction of data warehouses, data integration, and the development of dimensional models. Furthermore, they endeavor to understand the methodologies and algorithms central to data mining, enabling them to extract valuable insights and patterns from large datasets efficiently.

Course Content

Unit	Content	Hours
I	Concepts and principles of data warehousing; Project management and requirements. Introduction to Data Mining and its Tasks, Data Pre-processing, Data Discretization Dimensional modeling; Data warehousing architecture; System process and process architecture. Classification and Prediction, Decision Tree, Naive Bayes' Classifier.	**10**
II	Data warehousing design; Database schema; Data staging. Output and Knowledge Representation, Evaluation and Credibility, Association Rule Mining.	**10**
III	Partitioning strategy; Aggregations; Data marts; Meta data management; OLAP Modeling, Query management. Clustering: Similarity measures, Hierarchical Clustering, k-Means Clustering. Data warehouse security; Backup and recovery; Building end-user Applications; Capacity planning; Testing the warehouse. Implementation and maintenance of data warehouse; Case study.	**10**
IV	• Data warehouse design, selection of schema; • Normalization and renormalization; • Query plan strategy; • Performance tuning, backup and recovery of data warehouse; • Dynamic reports and OLAP Reports, • Introduction to Data Mining software,	**10**

	• Data Pre-processing, Discretization, Decision Tree: D3,Naïve Bayes' Classifier, • Association Rule Mining: Apriori Algorithm, • Clustering: Hierarchical Clustering, K-Means.	
	Lab & Practical	**20**

Suggested Reading

1. Gupta, G.K. 2014. Introduction to Data Mining with Case Studies. Prentice Hall of India, New Delhi.
2. Han, J and Kamber, M. 2006. Data Mining: Concepts and Techniques. Morgan Kaufman.
3. Inmon, B. 2005. Building the Data Warehouse. John Wiley.
4. Kelly, S. 1997. Data Warehousing in Action. John Wiley.
5. Kimball, R. 2000. The Data Webhouse Toolkit: Building the Web-Enabled Data Warehouse. John Wiley.

Course Outcome: On completion of the course, students will be able to:

- design, implement, and manage data warehouses
- select and apply appropriate data mining tools and software to analyze large datasets efficiently and effectively.
- Apply data preprocessing techniques to handle missing values, outliers, and noise, ensuring the quality and reliability of mined patterns and insights.
- Visualize tools and techniques to effectively communicate and interpret mined patterns, facilitating informed decision-making and strategic planning processes.

Course Code	**:**	STA 215120
Course Title	**:**	**Statistical Finance**
Number of Credits	**:**	**4 (L: 3, T: 1, P: 0)**

Course Objective

To equip students with the fundamental statistical tools and techniques essential for analyzing financial data and making informed decisions in the realm of finance. Through this course, students will gain a comprehensive understanding of statistical methods and their applications in financial modeling, risk assessment, portfolio management, and investment strategies.

Course Content

Unit	Content	Hours
I	Basic concepts of financial markets. Forward contracts, futures contracts, options-call and put options, European option and American options. Hedgers, speculators, arbitrageurs. Interest rates, compounding, present value analysis, risk free interest rates. Returns, gross returns and log returns.	**10**
II	Portfolio theory – trading off expected return and risk, one risky asset and one risk	**10**

	free asset. Two risky assets, estimated expected return. Optimal mix of portfolio CAPM, capital market line, betas and security market line. Options, pricing via arbitrage, law of one price.	
III	Risk neutral valuation. Binomial modelsingle and multi-period binomial model, martingale measure. Modeling returns: lognormal model, random walk model, geometric Brownian motion process. Ito lemma (without proof). Arbitrage theorem. The Black-Scholes formula. Properties of the Black-Scholes option cost, the delta hedging arbitrage strategy. Some derivatives, their interpretations and applications.	**10**
IV	Volatility and estimating the volatility parameter. Implied volatility. Pricing American options. Pricing of a European option using Monte-Carlo and pricing an American option using finite difference methods.	**10**
	Tutorial/Practical	**20**

Suggesting Readings:

1. Sheldon M. Ross (2003). "An elementary introduction to Mathematical Finance", Cambridge University Press.
2. David Ruppert (2004). " Statistics and Finance an Introduction" – Springer International Edition.
3. Masaaki Kijima (2003). Stochastic process with applications to finance, Chapman Hall.
4. Ruey S. Tsay (2005). Analysis of Time Series III ed, John Wiley & Sons.
5. John C. Hull (2008). Options, Futures and other derivatives, Pearson Education India.
6. Christian Gourieroux and Joann Jasiak (2005): Financial Econometrics, New Age International (P) Ltd.
7. Cuthbertson K and Nitzsche D (2001). Financial Engineering - Derivatives and Risk Management, John Wiley & Sons Ltd.

Course Outcome: On completion of the course, students will be able to:

- Understand the basic principles of statistics and their relevance to finance.
- Acquire proficiency in various statistical techniques such as probability distributions, hypothesis testing, and regression analysis.
- Apply statistical methods to analyze financial data sets, including stock prices, interest rates, and asset returns.
- Evaluate and interpret statistical measures commonly used in finance, such as volatility, correlation, and covariance.
- Develop skills in quantitative analysis to support investment decisions and risk management strategies.
- Utilize statistical software tools effectively for data manipulation, visualization, and analysis in finance-related contexts.
- Critically assess the assumptions and limitations of statistical models in financial analysis.
- Demonstrate the ability to communicate complex statistical concepts and findings clearly to both technical and non-technical audiences.

Course Code	**:**	STA 215130
Course Title	**:**	**Categorical Data Analysis**
Number of Credits	**:**	**4 (L: 3, T: 1, P: 0)**

Course Objective

To provide students with a comprehensive understanding of statistical methods tailored for analyzing categorical data. Students will delve into various techniques specifically designed for categorical variables, enabling them to interpret, analyze, and draw meaningful conclusions from categorical data sets across diverse fields such as social sciences, market research, and healthcare.

Course Content

Unit	Content	Hours
I	Categorical response variables: Nominal, ordinal, interval. Probability structure for contingency tables: joint, marginal and conditional probabilities, sensitivity and specificity, independence. Comparing proportions in 2 x 2 Tables: difference of proportions, relative risk. Odds Ratio: definitions and properties of odds ratio with examples, inference for odds ratio and log odds ratio, relationship between odds ratio and relative risk. Chi-square tests of independence: Pearson statistic, likelihood ratio statistic, tests of independence, partitioning Chi-squared.	**10**
II	Testing independence for ordinal data: linear trend alternative to independence, extra power with ordinal test, choice of score, trend tests for Ix2 and 2xJ tables, nominal-ordinal tables. Exact inference for small samples: Fisher’s exact test for 2x2 table, p-values and conservatism for actual P(Type I error), small sample confidence interval for odds ratio. Association in three-way table: partial tables, conditional versus marginal associations, Simpson’s paradox, conditional and marginal odds ratios, conditional independence versus marginal independence, homogeneous associations.	**10**
III	Models for binary response variables: logit, log linear, linear probability and logistic regression models. Logit models for categorical data, probit and extreme value models, models with log-log link, model diagnostics.	**10**
IV	Fitting logit models. Conditional logistic regression, exact trend test. Log-linear models for two dimensions - independence model, saturated model and models for cell probabilities.	**10**
	Tutorial/Practical	**20**

Suggesting Readings:

1. Agresti, A. (2013): Categorical Data Analysis, Third Edition, Wiley.
2. Upton, G.J.G. (2017): Categorical Data Analysis by Example, Wiley.

3. Sutradhar, B. C. (2014): Longitudinal Categorical Data Analysis, Springer.
4. Bilder, C. R. And Loughin, T.M. (2013): Analysis of Categorical Data with R, CRC Press.

Course Outcome: On completion of the course, students will be able to:

- Understand the fundamental concepts and principles of categorical data analysis.
- Gain proficiency in analyzing frequency distributions and contingency tables.
- Learn techniques for assessing associations and dependencies between categorical variables, including chi-square tests and measures of association.
- Explore advanced methods for modeling categorical data, such as logistic regression and multinomial regression.
- Develop skills in interpreting and communicating results derived from categorical data analysis effectively.

Course Code	:	STA 215140
Course Title	:	**Reliability Theory**
Number of Credits	:	**4 (L: 3, T: 1, P: 0)**

Course Objective

To provide students with a comprehensive understanding of the principles, models, and methodologies used to analyze the reliability of systems, components, and processes. Through theoretical frameworks and practical applications, students will gain insights into assessing and improving the dependability and performance of engineering systems across various industries.

Course Content

Unit	Content	Hours
I	Basic concepts in reliability: Failure rate, mean, variance and percentile residual life, identities connecting them; Notions of ageing - IFR, IFRA, NBU, NBUE, DMRL, HNBUE, NBUC etc and their mutual implications; TTT transforms and characterization of ageing classes.	**10**
II	Non monotonic failure rates and mean residual life functions, Study of life time models viz. exponential, Weibull, lognormal, generalized Pareto, gamma with reference to basic concepts and ageing characteristics; Bath tub and upside down bath tub failure rate distributions.	**10**
III	Discrete time failure models:- Definition of basic functions and their properties; Ageing classes and their mutual implications, Reliability systems with dependents components:- Parallel and series systems, k out of n systems, ageing properties with dependent and independents components, concepts and measures of dependence in reliability - RCSI, LCSD, PF2, WPQD.	**10**
IV	Reliability estimation using MLE - exponential, Weibull and gamma distributions based on censored and non-censored samples; UMVUE estimation of reliability function; Bayesian reliability estimation of exponential and Weibull models.	**10**

	Tutorial/Practical	**20**

Suggesting Readings:

1. Lai, C.D and Xie, M. (2006) Stochastic ageing and dependence in reliability (Relevant topics) Springer.
2. Sinha S K (1986) Reliability and Life Testing, Wiley Eastern.
3. Barlow, R.E. and Proschan, F. (1975) Statistical Theory of Reliability and Life Testing, Holt, Reinhart and Winston.
4. Marshall, A.W. and Olkin, I. (2007) Life Distributions, Springer
5. Galambos, J. and Kotz, S. (1978) Characterization of Probability distributions, Springer
6. Lawless, J.F. (2003) Statistical Models and Methods for Life Data, Wiley

Course Outcome: On completion of the course, students will be able to:

- Understand the fundamental concepts and principles of reliability theory, including failure rates, reliability functions, and system reliability.
- Explore different types of reliability models such as exponential, Weibull, and bathtub curve models, and their applications in analyzing system reliability over time.
- Learn methods for estimating and evaluating reliability parameters from data, including maximum likelihood estimation and Bayesian inference.
- Gain proficiency in reliability analysis techniques

Course Code	**:**	STA 215150
Course Title	**:**	**Order Statistics**
Number of Credits	**:**	**4 (L: 3, T: 1, P: 0)**

Course Objective

To provide students with a comprehensive understanding of the theory and applications of order statistics in statistical analysis. This course aims to explore the fundamental concepts underlying order statistics, including their probabilistic properties and their significance in various fields such as reliability theory, quality control, and extreme value analysis. Through theoretical discussions and practical exercises, students will develop the necessary skills to analyze and interpret ordered data sets effectively.

Course Content

Unit	Content	Hours
I	Introduction to order statistics, joint, marginal and conditional distributions of order statistics (discrete and continuous cases). Distribution of the range and other systematic statistics, order statistics as a Markov chain. Examples based on discrete and continuous distributions.	**10**
II	Distribution-free confidence intervals for population quantiles and distribution-free tolerance intervals. Distribution-free bounds for moments of order statistics and of	**10**

	the range. Approximations to moments in terms of the quantile function and its derivatives.	
III	Moments of order statistics, recurrence relations and identities for moments of order statistics. Large sample approximations to mean and variance of order statistics. Asymptotic distributions of order statistics.	**10**
IV	Order statistics for independently and not identically distributed (i.ni.d.) variates, Concomitants of order statistics. Random division of an interval and its applications. Order statistics from a sample containing a single outlier. Concepts of record values and generalized order statistics.	**10**
	Tutorial/Practical	**20**

Suggested Readings:

1. Shahbaz, M.Q., Ahsanullah, M., Shahbaz, S.H. & Al-Zahrani, B.M. (2016). Ordered Random Variables: Theory and Applications. Springer.
2. David, H.A. & Nagaraja, H.N. (2005). Order Statistics, 3rd Edition. Wiley.
3. Ahsanullah, M., Nevzorov, V.B. & Shakil, M. (2013). An Introduction to Order Statistics, Atlantis Studies in Probability and Statistics, Vol. III. Atlantis Press.
4. Arnold, B.C., Balakrishnan, N. & Nagaraja, H.N. (2008). A First Course in Order Statistics. SIAM Publisher

Course Outcome: On completion of the course, students will be able to:

- Understand the fundamental concepts of order statistics, including order statistics functions, distributions, and moments.
- Analyze the properties of order statistics, such as distribution functions, density functions, and moments, for different sample sizes and distributions.
- Apply order statistics methods to solve problems in reliability analysis, including determining the distribution of extremes and estimating extreme quantiles.
- Utilize order statistics techniques in quality control to assess the performance of manufacturing processes and detect outliers.
- Explore applications of order statistics in fields such as finance, environmental science, and engineering for analyzing extreme events and assessing risks.
- Develop skills in statistical inference using order statistics, including estimation and hypothesis testing.
- Use statistical software tools to compute and visualize order statistics functions and distributions for practical data analysis.

ELECTIVE COURSES FOR SEMESTER IV

Course Code	**:**	STA 225050

Course Title	:	Actuarial Statistics
Number of Credits	**:**	**4 (L: 3, T: 1, P: 0)**

Course Objective

To provide students with a solid foundation in statistical methods specifically tailored for actuarial science. Through this course, students will develop the necessary skills and knowledge to analyze and interpret data crucial for assessing and managing risks in insurance, pensions, and other financial sectors. Emphasizing theoretical principles and practical applications, this course prepares students for a career in actuarial science by equipping them with the essential statistical tools and techniques required in the field.

Course Content

Unit	Content	Hours
I	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. Multiple life functions, joint life and last survivor status.	**10**
II	Multiple decrement models, deterministic and random survivorship groups, associated single decrement tables, central rates of multiple decrement. Distribution of aggregate claims, compound Poisson distribution and its applications. Claim Amount distributions, approximating the individual model, Stop-loss insurance.	**10**
III	Principles of compound interest: Nominal and effective rates of interest and discount, force of interest and discount, compound interest, accumulation factor. 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. Life annuities: Single payment, continuous life annuities, discrete life annuities, life annuities with monthly payments, varying annuities.	**10**
IV	Net premiums: Continuous and discrete premiums, true monthly payment premiums. Net premium reserves: Continuous and discrete net premium reserves, reserves on a semi continuous basis, reserves based on true monthly premiums	**10**
	Tutorial/Practical	**20**

Suggesting Readings:

1. Tse, Y. K. and Chan, W. S (2017): Financial Mathematics For Actuaries, World Scientific.
2. Medina, P.K. and Merino, S. (2003): A discrete introduction: Mathematical finance and Probability,Birkhauser.
3. Vecer, J. (2017): Stochastic Finance: A Numeric Approach, CRC Press.

4. Perna, C. and Sibillo, M. (2016): Mathematical and Statistical Methods for Actuarial Sciences And Finance, Springer

Course Outcome: On completion of the course, students will be able to:

- Understand the principles of probability theory and its applications in actuarial science.
- Gain proficiency in statistical modeling techniques relevant to insurance and risk management, such as survival analysis and credibility theory.
- Apply statistical methods to analyze and interpret data sets related to mortality, morbidity, and other actuarial factors.
- Develop skills in assessing and quantifying financial risks associated with insurance products and pension plans.
- Utilize actuarial software tools effectively for data analysis, modeling, and simulation.

Course Code	**:**	STA 225040
Course Title	**:**	**Statistical Simulations**
Number of Credits	**:**	**4 (L: 3, T: 1, P: 0)**

Course Objective

To provide students with a comprehensive understanding of the principles and applications of statistical simulations in various fields, including but not limited to finance, engineering, and natural sciences. Through theoretical foundations and hands-on practice, students will learn how to design, implement, and analyze simulations to model complex systems, make predictions, and solve real-world problems.

Course Content

Unit	Content	Hours
I	Stochastic simulations: generating random variables, simulating normal, gamma and beta random variables. Comparison of algorithms to generate random variables. Generating random variables from failure rates.	**10**
II	Simulating multivariate distributions, MCMC methods and Gibbs sampler, Simulating random fields, simulating stochastic processes.	**10**
III	Variance reduction techniques: importance sampling for integration, control variates and antithetic variables. Simulating a non-homogeneous Poisson process.	**10**
IV	Optimization using Monte Carlo methods, simulated annealing for optimization. Solving differential equations by Monte Carlo methods	**10**
	Tutorial/Practical	**20**

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Suggesting Readings:

1. Fishman, G.S. (1996) Monte Carlo: Concepts, Algorithms, and Applications. (Springer).
2. Rubinstein, R.Y. (1981) Simulation and the Monte Carlo Method. (Wiley).
3. Ripley B.D. (1987) Stochastic Simulations (Wiley)
4. Ross, S.M.(2002) Simulation (Third Edition) (Academic

Course Outcome: On completion of the course, students will be able to:

- Understand the concept of statistical simulations and their importance in modeling complex systems.
- Learn different types of simulation techniques such as Monte Carlo simulation, agent-based modeling, and discrete event simulation.
- Gain proficiency in programming languages or software tools commonly used for simulation, such as Python, R, or MATLAB.
- Apply statistical simulations to solve problems in diverse domains, including finance, engineering, healthcare, and environmental science.
- Develop skills in designing simulation experiments, generating random variables, and validating simulation models.

Course Code	**:**	STA 225060
Course Title	**:**	**Large Scale Data Analysis**
Number of Credits	**:**	**4 (L: 3, T: 1, P: 0)**

Course Objective

To equip students with the theoretical understanding and practical skills necessary to effectively analyze large volumes of data. Through a combination of lectures, hands-on exercises, and real-world case studies, students will gain proficiency in various techniques and tools for processing, managing, and extracting insights from massive datasets.

Course Content

Unit	Content	Hours
I	Generalization of Linear Regression- Ridge Regression, Partial least squares, LASSO and Least angle regression, Principal Components Regression.	**10**
II	Tree based methods- Classification and Regression Trees (CART), Patient rule induction method (PRIM), Multivariate Adaptive Regression Splines (MARS).	**10**
III	Generalization of Linear Discriminant Analysis- Flexible Discriminant Analysis Penalized Discriminant Analysis, Mixture Discriminant Analysis.	**10**
IV	Generalization of Principal Component Analysis- Kernel Principal Components, Sparse Principal Component Analysis, Independent Component Analysis (ICA). Multidimensional Scaling. Applications of above methods in Astronomical Data.	**10**

	Tutorial/Practical	**20**

Suggesting Readings:

1. Myers, R.H, Monetgomery, D.C., Vining, G.G. and Robinson, T.J. (2010): Generalized Linear Models with Applications in Engineering and the Sciences, Second Edition, Wiley.
2. Stroup, W. W. (2013): Generalized Linear Mixed Models: Modern Concepts, Methods and Applications, CRC Press.
3. Agresti, A. (2015): Foundations of Linear and Generalized Linear Models, Wiley.
4. Dobson, A.J. and Barnett, A.G. (2008): Introduction to Generalized Linear Models, Third Edition, CRC Press

Course Outcome: On completion of the course, students will be able to:

- Understand the challenges and opportunities associated with analyzing large-scale datasets.
- Demonstrate proficiency in using distributed computing frameworks such as Hadoop and Spark for data processing.
- Apply statistical techniques and machine learning algorithms to extract meaningful insights from large datasets.
- Design and implement scalable data analysis pipelines for handling terabytes or petabytes of data efficiently.
- Evaluate and select appropriate data storage solutions and database technologies for large-scale data applications.

Course Code	**:**	STA 225070
Course Title	**:**	**Computer Network**
Number of Credits	**:**	**4 (L: 3, T: 1, P: 0)**

Course Objective

To provide students with a comprehensive understanding of the principles, protocols, and technologies that underpin modern networking systems. Through theoretical study, practical exercises, and real-world examples, students will gain the knowledge and skills necessary to design, implement, and manage computer networks effectively. The course aims to equip students with a solid foundation in networking concepts, enabling them to analyze, troubleshoot, and optimize network performance while adhering to industry standards and best practices.

Course Content

Unit	**Content**	**Hours**
I	The importance of Networking, Types of Networking, Network Topology, Transmission Media, Data communication: Concepts of data, signal, channel, bandwidth, bit-rate and baud-rate; Maximum data-rate of channel; Analog and	**10**

	digital communications, asynchronous and synchronous transmission.	
II	Network adapters card, Multiplexer (FDM, TDM, STDM), Hub, Repeater. Network References Models: Layered architecture, protocol hierarchies, interface and services. ISO-OSI references model, TCP/IP reference model; Data link layer function and Protocols: Framing, error-control, flow control; sliding window protocol; HDLC, SLIP and PPP protocol.	**10**
III	Network layer - routing algorithms, congestion control algorithms; Internetworking: bridges and gateway; Transport layer - connection management, addressing; Flow control and buffering, multiplexing. Session layer – RPC; Presentation layer - abstract syntax notation.	**10**
IV	Application layer - File Transfer Protocol (FTP), Telnet, Simple Mail Transfer Protocol (SMTP); World Wide Web(WWW) - Wide Area Indexed Servers (WAIS), WAP; Network Security; Data compression and cryptography.	**10**
	Tutorial/Practical	**20**

Suggested Readings :

1. Arick MR. 1994. The TCP/IP Companion - A Guide for Common User. Shroff Publishers
2. Freer J. 1990. Computer Communication and Networks. Affiliated East West Press.
3. Hayes J. 2001. Modelling and Analysis of Computer Communication Networks. Khanna Publishers.
4. Tanenbaum AS. 2003. Computer Networks. Prentice Hall of India.

Course Outcome: On completion of the course, students will be able to:

- Understand the fundamental concepts and terminology related to computer networks.
- Identify and describe the various components and layers of the OSI and TCP/IP models.
- Explain the principles of data transmission, including modulation, multiplexing, and error detection/correction techniques.
- Demonstrate proficiency in configuring and troubleshooting network devices such as routers, switches, and firewalls.
- Analyze network protocols and their functionalities, including TCP, UDP, IP, ICMP, DHCP, DNS, and HTTP.
- Design and implement LANs and WANs, including addressing schemes, subnetting, and routing protocols.

Course Code	**:**	STA 225080

Course Title	**:**	**Internet Technology**
Number of Credits	**:**	**4 (L: 3, T: 0, P: 1)**

Course Objective

To provide students with a comprehensive understanding of the foundational principles, technologies, and applications that underpin the functioning of the Internet. Through a blend of theoretical concepts and practical examples, students will explore the architecture, protocols, and emerging trends shaping the modern Internet landscape. By the end of the course, students will be equipped with the knowledge and skills necessary to analyze, design, and implement Internet-based solutions and to navigate the dynamic and evolving nature of Internet technologies.

Course Content

Unit	Content	Hours
I	World Wide Web – Web pages, Web Sites, Web Servers; Intranet and Extranet Concepts; Hyper Text Markup Language (HTML); Building static dynamic web pages.	**10**
II	Web application architecture – (ASP.NET/Java) – Web Forms, Server Side Controls, handling events, Validation, JQuery	**10**
III	Database Connectivity, read, write, update databases using web forms; data bound controls, sessions, session handling	**10**
IV	Authentication of users, Personalization, Roles, role based access Using external libraries / controls; Ajax, Jquery; Data Exchange – XML, JSON; Creating web services	**10**
V	**Lab. & Practical** Designing static website with features like tables, hyperlink among pages, pictures, frames and layers; Client side scripting for user interface validation; Server side scripting for database interaction; Designing of information system.	**20**

Suggested Reading:

1. Ayers D, Bergsten H, Bogovich M, Diamond J, Ferris M, Fleury M, Halberstadt A, Houle P,
2. Mohseni P, Patzer A, Philips R, Li S, Vedati K, Wilcox M and Zeiger S. 1999. Professional Java Server Programming. Wrox Press Ltd.
3. Buest C and Allamaraju S. 2007. Professional Java Server Programming: J2EE 3rd Ed.
4. Boudreaux 2005. PHP 5: Your Visual Blueprint for Creating Open Source, Server-side

Content. (Visual Blueprint). Visual.
5. Ellis M.D. 2007. ASP.NET AJAX Programming Tricks. Magma Interactive.
6. Esposito D. 2007. Introducing Microsoft ASP.NET AJAX (Pro-Developer). Microsoft Press.
5. Evjen B, Hanselman S and Rader D. 2008. Professional ASP.NET 3.5: In C# and VB (Programmer to Programmer). Wrox Press Ltd.
7. Haefel-Monson R. 2003. Enterprise Java Beans. O'Reilly & Associates.

Course Outcome: On completion of the course, students will be able to:

- Understand the architecture and infrastructure of the Internet, including its layered model and key components.
- Gain familiarity with Internet protocols such as TCP/IP, DNS, HTTP, and FTP, and their roles in enabling communication and data transfer over the Internet.
- Explore the fundamentals of web development, including HTML, CSS, and JavaScript, and their contributions to building interactive and dynamic web applications.
- Learn about network security principles and techniques to protect against common threats and vulnerabilities in Internet-based systems.
- Examine the concepts of cloud computing and distributed systems, and their implications for Internet-based services and infrastructure.

Course Code	**:**	STA 225090
Course Title	**:**	**Quantitative Epidemiology**
Number of Credits	**:**	**4 (L: 3, T: 1, P: 0)**

Course Objective

To provide students with a comprehensive understanding of the quantitative methods used in epidemiological research and public health analysis. Through this course, students will develop the necessary skills to analyze epidemiological data, assess disease patterns, and evaluate the effectiveness of public health interventions using advanced statistical and mathematical techniques.

Course Content

Unit	Content	Hours
I	Introduction to modern epidemiology, principles of epidemiologic investigation, surveillance and disease monitoring in populations.	**10**
II	Epidemiologic measures: organizing and presenting epidemiologic data, measure disease frequency, measures of effect association, causation and causal inference.	**10**
III	Design and analysis of epidemiologic studies: types of studies, case-control studies, cohort studies, quantitative methods in screening.	**10**
IV	Special Topics: epidemiology of infections and chronic disease, Cancer and cancer prevention, environmental epidemiology.	**10**

	Tutorial/Practical	**20**

Suggesting Readings:

1. Rothman, K. J. & Geenland, S. (ed.) (1988): Modern Epidemiology, Lippincott-Raven.,
2. Selvin, S. (1996). Statistical Analysis of Epidemiologic Data, Oxford University Press.
3. McNeil, D. (1996). Epidemiological Research Methods. Wiley and Sons.
4. Jekel, J.F., Elmore, J. G. & Katz, D.L. (1996). Epidemiology, Biostatistics and Preventive Medicine. WB Saunders Co.

Course Outcome: On completion of the course, students will be able to:

- Understand the basic principles of epidemiology and its role in public health research.
- Gain proficiency in quantitative methods commonly used in epidemiological studies, including study design, data collection, and analysis.
- Apply statistical techniques such as regression analysis, survival analysis, and spatial analysis to investigate disease patterns and risk factors.
- Utilize mathematical models, such as compartmental models and transmission models, to study the spread of infectious diseases and assess the impact of control measures.
- Evaluate epidemiological studies and research findings critically, considering factors such as bias, confounding, and generalizability.

Course Code	:	STA 225100
Course Title	:	**Geographical Information System**
Number of Credits	:	**4 (L: 3, T: 0, P: 01)**

Course Objective

To provide students with a comprehensive understanding of GIS concepts, tools, and applications. This course aims to equip students with the knowledge and skills necessary to effectively analyze, interpret, and visualize spatial data in various fields such as environmental science, urban planning, natural resource management, and public health.

Course Content

Unit	Content	Hours
I	Overview of GIS, Database & Spatial concept related to GIS; Representation & Algorithms; GIS data formats & standard.	**20**
II	Planning & Implementing a GIS; Application of GIS; Case studies on GIS technology trend & Next generation systems; GIS & Remote sensing; GIS & GPS.	**20**
	Tutorial/Practical	**20**

Suggesting Readings:

1. Longley, P. A., Goodchild, M. F., Maguire, D. J., & Rhind, D. W. (2015). *Geographic Information Systems and Science*. John Wiley & Sons.
2. Bolstad, P. (2016). *GIS Fundamentals: A First Text on Geographic Information Systems*. Eider Press.
3. DeMers, M. N. (2014). *Fundamentals of Geographic Information Systems*. John Wiley & Sons.
4. Aronoff, S. (2019). *Remote Sensing for GIS Managers*. Esri Press.
5. Korte, S., & Berger, M. (Eds.). (2019). *Handbook of Position Location: Theory, Practice and Advances*. John Wiley & Sons.
6. Chang, K. T. (2015). *Introduction to Geographic Information Systems*. McGraw-Hill Education.
7. Kang-tsung Chang. (2010). *Introduction to Geographic Information Systems with Data Set CD-ROM*. McGraw-Hill Education.
8. Burrough, P. A., & McDonnell, R. A. (2015). *Principles of Geographical Information Systems*. Oxford University Press.
9. Nyerges, T. L. (2016). *GIS and Public Health*. Guilford Press.
10. Campbell, J. B. (2007). *Introduction to Remote Sensing*. Guilford Press.

Course Outcome: On completion of the course, students will be able to:

- Understand the fundamental principles and components of Geographical Information Systems (GIS).
- Gain proficiency in using GIS software to manipulate, analyze, and visualize spatial data.
- Learn various data input methods including digitizing, GPS data collection, and remote sensing.
- Acquire skills in spatial analysis techniques such as buffering, overlay analysis, and network analysis.
- Explore advanced GIS functionalities including 3D visualization, geospatial modeling, and spatial statistics.
- Apply GIS techniques to solve real-world problems and address spatial challenges in different domains.

Course Code	**:**	STA 225110
Course Title	**:**	**Bayesian Inference**
Number of Credits	**:**	**4 (L: 3, T: 1, P: 0)**

Course Objective

To provide students with a deep understanding of Bayesian statistical methods and their applications across various fields, including but not limited to, data science, machine learning, and decision-making processes. Through theoretical foundations and practical exercises, this course aims to equip students with the necessary skills to apply Bayesian reasoning and inference techniques to complex real-world problems.

Course Content

Unit	Content	Hours
I	Basic elements of Statistical Decision Problem. Expected loss, decision rules (non-randomized and randomized). Overview of Classical and Bayesian Estimation. Advantage of Bayesian inference	**10**
II	Prior distribution, Posterior distribution, Subjective probability and its uses for determination of prior distribution. Importance of non-informative priors, improper priors, invariant priors. Conjugate priors, construction of conjugate families using sufficient statistics, hierarchical priors. Admissible and minimax rules and Bayes rules	**10**
III	Point estimation, Concept of Loss functions, Bayes estimation under symmetric loss functions, Bayes credible intervals, highest posterior density intervals, testing of hypotheses. Comparison with classical procedures. Predictive inference. One- and two-sample predictive problems.	**10**
IV	Bayesian approximation techniques: Normal approximation, T-K approximation, Monte-Carlo Integration, Accept-Reject Method, Idea of Markov chain Monte Carlo technique.	**10**
	Tutorial/Practical	**20**

Suggesting Readings:

1. Berger, J. O. : Statistical Decision Theory and Bayesian Analysis, Springer Verlag.
2. Robert, C.P. and Casella, G. : Monte Carlo Statistical Methods, Springer Verlag.
3. Leonard, T. and Hsu, J.S.J. : Bayesian Methods, Cambridge University Press.
4. Bernando, J.M. and Smith, A.F.M. : Bayesian Theory, John Wiley and Sons.
5. Robert, C.P. : The Bayesian Choice: A Decision Theoretic Motivation, Springer.
6. Gemerman, D. : Markov Chain Monte Carlo: Stochastic Simulation for Bayesian Inference, Chapman Hall.
7. Box, G.P. and Tiao, G. C.: Bayesian Inference in Statistical Analysis, Addison-Wesley

Course Outcome: On completion of the course, students will be able to:

- Understand the principles of Bayesian statistics and the Bayesian interpretation of probability.
- Learn to formulate and interpret Bayesian models for different types of data and problems.
- Gain proficiency in Bayesian computational methods, including Markov chain Monte Carlo (MCMC) techniques.

- Apply Bayesian inference to a variety of domains, such as parameter estimation, hypothesis testing, and predictive modeling.
- Develop the ability to critically evaluate and compare Bayesian models with classical statistical approaches.
- Acquire skills in Bayesian model selection and model averaging for robust inference.
- Utilize Bayesian frameworks for decision-making under uncertainty, incorporating prior knowledge and updating beliefs based on new evidence.

Course Code	**:**	STA 225120
Course Title	**:**	**Non-parametric Inference**
Number of Credits	**:**	**4 (L: 3, T: 1, P: 0)**

Course Objective

To provide students with a thorough understanding of non-parametric statistical methods and their applications in data analysis. This course aims to equip students with the necessary knowledge and skills to analyze data without making strong assumptions about the underlying probability distributions. Students will learn how to employ non-parametric techniques to draw inferences and make decisions in various fields, including economics, biology, engineering, and social sciences.

Course Content

Unit	Content	Hours
I	Concept of nonparametric and distribution-free methods, probability integral transformation, empirical distribution function, kernel, one-sample and two-sample U-Statistics, UMVUE property and asymptotic distribution of U-Statistics. Rank order statistics, treatment of ties in rank tests, linear rank statistics, distribution and properties of linear rank statistics.	**10**
II	Tests of randomness: Tests based on total number of runs, exact null distribution of R, asymptotic null distribution of R, tests based on runs up and down and related applications. The Chi-square goodness-of-fit test, the Kolmogorov-Smirnov one-sample statistic. The Sign test and Wilcoxon Signed Rank test for one-sample and paired sample problems.	**10**
III	Independence in bivariate sample: Kendall's and Spearman's rank correlation. The general two sample problem: median test, Mann-Whitney test, Wilcoxon Rank Sum test, Terry-Hoeffding (Normal Scores) test. Tests for scale problem: Mood test, Klotz Normal-Scores test, and Sukhatme test.	**10**
IV	Tests for k independent samples: Kruskal-Wallis one-way ANOVA test and multiple comparisons, Jonckheere-Terpstra test for ordered alternatives. Friedman's two-way ANOVA by ranks. Asymptotic relative efficiency (ARE): Theoretical basis for calculating the ARE, Examples of the calculation of efficacy and ARE.	**10**

	Tutorial/Practical	**20**

Suggesting Readings:

1. Gibbons, J.D. & Chakraborti, S. (2010). Nonparametric Statistical Inference, 5th Edition. CRC Press.
2. Hollander, M., Wolfe, D. & Chicken, E. (2013). Nonparametric Statistical Methods, 3rd Edition. Wiley.
3. Bonnini, S., Corain, L., Marozzi, M. & Salmaso, L. (2014). Nonparametric Hypothesis
4. Testing Rank and Permutation Methods with Applications in R. Wiley.
5. Sprent, P. & Smeeton, N.C.(2013). Applied Nonparametric Statistical Methods, 4th edn. CRC Press

Course Outcome: On completion of the course, students will be able to:

- Understand the principles and assumptions underlying non-parametric statistical methods.
- Gain proficiency in commonly used non-parametric techniques such as rank-based tests, kernel density estimation, and resampling methods.
- Apply non-parametric methods to analyze data sets with unknown or non-normal distributions.
- Learn how to conduct hypothesis tests and construct confidence intervals using non-parametric approaches.

Course Code	:	STA 215080
Course Title	:	**Survival Analysis**
Number of Credits	:	**4 (L: 3, T: 1, P: 0)**

Course Objective

To provide students with a comprehensive understanding of the principles, methodologies, and applications of survival analysis in various fields such as medicine, sociology, epidemiology, and business. Survival analysis, also known as time-to-event analysis, is a statistical method used to analyze the time until an event of interest occurs. Through this course, students will learn the theoretical foundations of survival analysis and gain practical skills to apply these techniques to real-world data sets, enabling them to make informed decisions and predictions based on time-to-event outcomes.

Course Content

Unit	Content	Hours
I	Basic concepts: Definition and properties, Lifetime models - Continuous and discrete models, General formulation, Different types of censoring, Truncation and other incomplete data, Likelihood inference with censored data, Inference procedures for exponential distributions. Methods based on large sample theory,	**10**

	Inference procedures for gamma and inverse Gaussian distribution.	
II	The Product-Limit Estimate, Nelson Aalan Estimators, Interval estimation of survival probabilities and quantiles, Asymptotic properties of the estimators, Probability plots and hazard plots, Estimation of hazard rate or density functions, Methods for truncated and interval censored data.	**10**
III	Proportional hazards regression models, Methods for continuous multiplicative hazards models, Estimation of β, Comparison of two or more lifetime Distribution, Justification and properties of the likelihood function, Adjustments for tied life times, Estimation of baseline hazard function and baseline survivor function.	**10**
IV	Regression diagnostics techniques: Cox-Snell residual method for assessing the fit, Graphical checks, Deviance residuals, Hypothesis testing: One sample tests for hazard function and survivor function, Two sample tests for comparing hazard rates and survivor functions.	**10**
	Tutorial/Practical	**20**

Suggesting Readings:

1. Lawless J.F (2003) Statistical Models and Methods for Lifetime Data, Second Editon, John Wiley & Sons, Relevant Sections of the Chapters 1, 2, 3, 4, 6,7 and 10.
2. Klein J.P. and Moeschberger M.L. (2003) Survival Analysis - Techniques for censored and truncated data, Second Edition, Springer-Verlag, New York, Chapters 7 and 11.
3. Kalbfleisch J.D and Prentice, R.L. (2002) The Statistical Analysis of Failure Time Data, 2nd Edn, John Wiley & Sons Inc.
4. Hosmer Jr. D.W and Lemeshow S (1999) Applied Survival Analysis - Regression Modeling of Time to event Data, John Wiley & Sons. Inc.
5. Nelson. W (1982) Applied Life Data Analysis.
6. Miller, R.G. (1981) Survival Analysis, John Wiley.

Course Outcome: On completion of the course, students will be able to:

- Understand the fundamental concepts and principles of survival analysis, including censoring, hazard functions, and survival functions.
- Gain proficiency in different survival analysis techniques, such as Kaplan-Meier estimation, Cox proportional hazards regression, and parametric survival models.
- Apply survival analysis methods to analyze various types of data, including clinical trial data, customer churn data, and employee turnover data.
- Interpret and communicate the results of survival analysis effectively, including estimates of survival probabilities, hazard ratios, and time-dependent covariate effects.
- Evaluate the assumptions underlying survival analysis models and apply appropriate diagnostic techniques to assess model adequacy.
- Utilize statistical software packages, such as R or Python, to implement survival analysis techniques and conduct data analysis

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Course Code	**:**	STA 225140
Course Title	**:**	**Generalized Linear Models**
Number of Credits	**:**	**4 (L: 3, T: 1, P: 0)**

Course Objective

To provide students with a comprehensive understanding of the theory and application of generalized linear models (GLMs). GLMs serve as a powerful statistical framework for analyzing a wide range of data types with non-normal distributions and complex relationships. Through this course, students will learn how to utilize GLMs to model and interpret data effectively across various fields, including biology, epidemiology, finance, and social sciences.

Course Content

Unit	**Content**	**Hours**
I	Review of Linear models, least square model fitting, Testing the general linear hypothesis: t-test and F-test. Simple linear regression. Multiple linear regression. Interpretation of the coefficients. Residuals, Leverage and influence. Optimality of least squares and generalized least squares.	**10**
II	Binary data. The binomial distribution. Grouped and ungrouped data. Odds and log-odds. The logit transformation. Logistic regression. Maximum likelihood estimation and testing in logistic regression models. The comparison of two groups. The odds ratio. Comparison of several groups.	**10**
III	Regression models for binary data. Models with two predictors. Main effects and interactions. Multifactor models. Model selection. Alternative links for binary data. Probit analysis. The c-log-log link. Regression diagnostics with binary data. Count data. The Poisson distribution.	**10**
IV	The log link. Maximum likelihood estimation and testing in Poisson regression. The Poisson deviance. Modeling heteroscedastic counts. Models for rates of events. Exposure and the use of an offset in the linear predictor. Extra-Poisson variation. The negative binomial model. Zero-inflated models for counts. Multinomial response models.	**10**
	Tutorial/Practical	**20**

Suggesting Readings:

1. Myers, R.H, Monetgomery, D.C., Vining, G.G. and Robinson, T.J. (2010): Generalized Linear Models with Applications in Engineering and the Sciences, Second Edition, Wiley.
2. Stroup, W. W. (2013): Generalized Linear Mixed Models: Modern Concepts, Methods and Applications, CRC Press.
3. Agresti, A. (2015): Foundations of Linear and Generalized Linear Models, Wiley.
4. Dobson, A.J. and Barnett, A.G. (2008): Introduction to Generalized Linear Models, Third Edition, CRC Press.

Course Outcome: On completion of the course, students will be able to:

- Understand the theoretical foundations of generalized linear models and their extension from linear regression.
- Gain proficiency in selecting appropriate GLMs for different types of data, considering distributions and link functions.
- Develop skills in model estimation techniques, including maximum likelihood estimation and iterative fitting algorithms.
- Apply generalized linear models to analyze real-world datasets and interpret model results accurately.
- Explore techniques for model diagnostics, including residual analysis and goodness-of-fit tests, to assess model adequacy.
- Learn how to handle common challenges in GLM analysis, such as over dispersion and multicollinearity.