

PONDICHERRY UNIVERSITY

DEPARTMENT OF STATISTICS



SYLLABUS FOR M.Sc. STATISTICS

(CBCS Pattern)

Effective from the Academic Year 2025-2026

Syllabus - M.Sc. (Statistics) from AY: 2025-26

Vision of the Department

The Department envisions imparting both core theoretical and applied knowledge in Statistics, aligned with national and international standards. Our aim is to empower students from diverse socio-economic backgrounds to become skilled professional statisticians who contribute meaningfully to society.

Mission of the Department

- To provide an excellent teaching and learning environment for undergraduate and postgraduate programs in Statistics.
- To promote research in both theoretical and applied statistics that addresses societal needs.
- To offer hands-on training in statistical techniques through case studies and real-life data applications.

**DEPARTMENT OF STATISTICS
PONDICHERRY UNIVERSITY**

**M.Sc. STATISTICS CURRICULAM (Programme Code: PG 375)
Choice Based Credit System- Regulations (Semester Pattern)
(Details refer to recent 2019 [PONDICHERRY UNIVERSITY](#) Guidelines)**

1. Aim of the PG Programme:

The Degree of Master of Science in Statistics aims to train the students in the development and applications of Statistical techniques for analyzing data arising in the scientific investigation of problems in various disciplines. It is also proposed to provide first hand practical experience in handling modern statistical software viz., R, Python, Mathematica / MATLAB in the analysis of such data.

2. Eligibility for admission:

Candidates for admission to the first year of the M.Sc. (Statistics) degree programme shall be required to have passed the B.Sc.(Statistics) degree examination of any Indian University recognized by the University Grants Commission with minimum of 55% marks.

3. Duration of the PG Programme:

The course shall be of two years (M.Sc. Statistics) duration spread over four semesters. However, students have the flexibility to complete the PG Programme within a minimum of 3 semesters and maximum of 8 semesters.

4. Eligibility for Attending to Examination:

A candidate shall be permitted to appear for the M.Sc. examination in a subject of study only if he/she secures not less than 70% attendance in the subject concerned.

Medium : The medium of instruction shall be English.

5. Passing Minimum and Weightage of marks:

The weight age of marks for Continuous Internal Assessment (CIA) and end semester examinations shall be 40 and 60 respectively. As per the Choice Based Credit System regulations of the Pondicherry University, a student is declared as pass in a given subject he / she secures:

- (a) A minimum of 40% marks in end-semester exam and
- (b) A minimum of 50% marks in aggregate when Internal assessment and End- Semester marks are added together

5.1 Supplementary Examination

- a. A failed student who meets the attendance requirement shall be permitted to register for the next end-semester examination in the following semester itself and/or in subsequent semesters.

- b. A student who fails in a course due to insufficient attendance should repeat the course as and when it is offered.
- c. A student who gets 'F' or 'FA' grade in a course shall be given an option either to retain the previously awarded Internal Assessment mark or to improve it, and the higher mark out of these two options will be considered for the supplementary exam.

5.2 Continuous Internal Assessment

The internal assessment marks shall be given as per the following breakup:

- a) Internal Assessment Tests /Term Papers/Quizzes (two): 30 marks
- b) Seminars/Assignments /Presentations/ Viva : 10 marks

Internal Total: 40 marks

5.3 Assessment for Statistical Computing Courses:

The students need to work out the practical problems directly on fair workbook and get signed on the same day of practical given. The internal assessment marks shall be given as per the following breakup:

- a) Record submission: 20 marks
- b) Internal Viva Voce: 20 marks

Internal Total: 40 marks

5. Choice Based Credit System (CBCS)

The M.Sc. Statistics program is offered through a unique CBCS. The salient feature of the CBCS is that the program is offered through credit-based courses. Subjects are divided into Hard Core and Soft Core. Hard Core subjects are compulsory. The students have the choice to select from among the list of soft-core subjects. Soft core subjects are similar to elective subjects.

A student is expected to complete a minimum of 72 credits within four semesters. Students are assessed and awarded letter grades based on their performances in the respective courses.

PROGRAMME OUTCOMES

Upon completion of the programme, the students will

- PO1:** acquire knowledge and develop higher-order thinking skills in theoretical statistics.
- PO2:** develop the ability to analyse data derived from real-time studies and practical applications.
- PO3:** comprehend the use of statistical methods across diverse scientific research fields.
- PO4:** attain proficiency in statistical computing through the utilization of specialized software.
- PO5:** gain practical exposure through internships in the analytics and pharmaceutical sectors.
- PO6:** conduct case study analyses and prepare detailed reports.

COURSE STRUCTURE- M.Sc. STATISTICS SYLLABUS
Effective from the Academic Year 2025 – 2026 onwards

Semester	Course Code	Title of the Course	Course Type	No. of Credits	Total Credits
First Semester					
I Semester	STAT-411	Linear Algebra & Matrix Theory	Hard Core	4	19
	STAT-412	Probability Theory	Hard Core	4	
	STAT-413	Distribution Theory	Hard Core	4	
	STAT-414	Sampling Theory	Hard Core	4	
	Refer to List of Softcore courses	Any One Soft Core Course among the list of softcore courses are allowed / Relevant Courses can be opted from SWAYAM /NPTEL-upon approval in PCM)	Soft Core	3	
Second Semester					
II Semester	STAT-421	Theory of Estimation	Hard Core	4	19
	STAT-422	Stochastic Processes	Hard Core	4	
	STAT-423	Regression Analysis	Hard Core	4	
	STAT-424	Statistical Computing with R / Python -I (Based on STAT-414, 421, 423)	Hard Core	4	
	Refer to List of Softcore courses	Any One Soft Core Course among the list of softcore courses are allowed / Relevant Courses can be opted from SWAYAM /NPTEL-upon approval in PCM)	Soft Core	3	
Third Semester					
III Semester	STAT-531	Multivariate Statistical Analysis	Hard Core	4	22
	STAT-532	Testing of Statistical Hypotheses	Hard Core	4	
	STAT-533	Linear Models and Design of Experiments	Hard Core	4	
	STAT-534	Statistical Computing with R / Python -II (Based on STAT-531, 532, 533)	Hard Core	4	
	Refer to List of Softcore courses	Any Two Soft Core Courses among the list of soft core courses are allowed / Relevant Courses can be opted from SWAYAM /NPTEL-upon approval in PCM)	Soft Core 1	3	
		Soft Core 2	3		
Fourth Semester (*)					
IV Semester	STAT-540#	Project Dissertation Work & Comprehensive Viva-Voce (research orientation)	Soft Core	12	12
	STAT-541@	Internship Project Work & Comprehensive Viva-Voce	Soft Core	12	
	Refer to List of Softcore courses	Any FOUR relevant soft-core courses either within or outside the department among the list of softcore courses.	Soft Core 1	3	
			Soft Core 2	3	
			Soft Core 3	3	
		Soft Core 4	3		
Total Credits: 72-(Mandatory)					72

*-Students can choose either STAT-540 or STAT-541 or any FOUR courses from list of soft-core courses in the Final Semester to maintain overall 72 credits.

Top 15% of students who have cleared the courses at first attempt in the preceding semesters with minimum 7.5 CGPA, and have keen research interest and willing to pursue higher studies can opt STAT: 540.

Note: Hardcore courses are mandatory in the respective semesters and Softcore are elective courses that a student can choose the offered courses either from parent department or other departments. (For more details, see, CBCS guidelines.

LIST OF SOFTCORE COURSES

Sr. No.	Course Code	Title of Softcore courses
1	STAT 415:	Statistics with R-Programming (Lab. Based)
2	STAT 416:	Optimization Techniques
3	STAT 417:	Statistical Quality Control
4	STAT 418:	Counting Theory
5	STAT 419:	Econometrics
6	STAT 425:	Biostatistics
7	STAT 426:	Statistical Methods for Reliability
8	STAT 427:	Categorical Data Analysis
9	STAT 428:	Simulation Techniques
10	STAT 429:	Mathematical Modelling
11	STAT 535:	Queueing Theory and Inventory Models
12	STAT 536:	Statistical Data Mining Methods
13	STAT 537:	Survival Analysis
14	STAT 538:	Demographic Techniques
15	STAT 539:	Python for Machine Learning
16	STAT 540:	Project Dissertation Work & Comprehensive Viva-Voce
17	STAT 541:	Internship Project Work & Comprehensive Viva-Voce
18	STAT 542:	Bayesian Inference
19	STAT 543:	Statistical Learning Theory and Neural Networks
20	STAT 544:	Decision Theory
21	STAT 545:	Time Series Analysis
22	STAT 546:	Actuarial Statistics
23	STAT 547:	Statistical Optimizations
24	STAT 548:	Indian Official Statistics

The listed soft-core courses are offered by the Department upon availability of concerned course teacher in the respective semesters.

SEMESTER-I

Syllabus -M.Sc.(Statistics) from AY: 2025-26

Course Objectives: Understand vector spaces, subspaces and change of basis, Understand linear transformations. Need of Generalized inverse and Moore-Penrose inverse of the matrix and to understand bilinear form and quadratic form.

Course Outcomes (COs): On the successful completion of the course, student will acquire:

- CO1:** Gain conceptual knowledge of vector space, subspace, inner product space and their Properties
- CO2:** Attain proficiency in mathematical concepts related to solving system of equations rank and generalized inverse of a matrix
- CO3:** Compute Eigen values and Eigen vectors of a matrix
- CO4:** Understand linear transformation, sum and product of linear transformations, and its Properties
- CO5:** Understand bilinear form and quadratic form

Unit I

Vector Spaces, Sub-spaces, Basis of a vector space – Vector spaces with inner products Gram-Schmidt orthogonalization.

Unit II

Linear transformation (LT) – Properties – Matrix of a linear transformation – Matrix of composite transformation – Matrix of an inverse transformation – Change of basis Orthogonal transformation - Dual space.

Unit III

Linear equations – Solution space and null space – Sylvester’s law of nullity – Generalized inverse of a matrix – Moore – Penrose inverse

Unit IV

Eigen values and Eigen vectors of an LT – left Eigen vectors, right Eigen vectors, Diagonalizable LT – Lambda matrix, Composition of lambda matrices, Operator polynomial, Cayley-Hamilton theorem and minimal polynomial for an LT – Eigen values of matrix polynomials.

Unit V

Bilinear forms Canonical reduction –Definitions of quadratic form, Lagrange’s reduction, Kronecker’s reduction, Reduction involving the Eigen values of the matrix, Generalized Eigen value problem.

CO-PO: MAPPING

COs \ POs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	*					
CO2	*					
CO3			*			
CO4	*					
CO5	*					

Books for Study

1. Biswas S. (2012), Text book of Matrix Algebra, Third Edition, PHI Learning Private Limited, New Delhi.
2. Bhattacharya P.B., Jain S.K., Nagpaul S.K. (2012), First Course in Linear Algebra, New Age International (P) Ltd, New Delhi.
3. Parashar B.P. (1989), Linear Algebra, CBS Publishers and Distributors, Delhi.
4. Rao C.R. (2009), Linear Statistical Inference and its Applications, Second Edition, John Wiley and Sons

Books for Reference

1. Friedberg S.H., Insel A.J. and Spence L.E. (2014), Linear Algebra, Pearson Education.
2. Gilbert J. and Gilbert L. (2005), Linear Algebra and Matrix Theory, Academic Press.
3. Lipschutz S. and Lipson M. (2009), Schaum’s outlines, Linear Algebra, Fourth Edition, McGraw Hill Company.
4. Rao A.R. and Bhimasankaram P. (2000), Linear Algebra, Hindustan.
5. Searle S.R. and Khuri A.I. (2017), Matrix Algebra useful for Statistics, Second Edition, John Wiley and Sons, New Jersey.
6. Searle S.R. and Gruber MHI (2016), Linear Models, Second Edition, John Wiley and Sons, New Jersey.

Course Objectives: The objective for this course is to learn the theory and methods of probability theory, measuring outcomes of sequence of trials and events, mathematical basis for formulating the several probability rules and foundation of probabilistic model for prediction of random events.

Course Outcomes (COs): On the successful completion of the course, student will acquire:

CO1: Understand the concept of sigma algebra and measure of random events and trials

CO2: Able to understand sample space, probability space / measure and random variable

CO3: Capable to gain the knowledge on sequence of random variable, several inequalities and convergence rules on probability.

CO4: Acquire insight of independence class of events (mutual, disjoint, pairwise)

CO5: Attain proficiency in applying weak and strong law of large numbers limits under CLT

Unit I

Algebra of sets - fields and sigma-fields, Inverse function – Measurable function – Probability measure on a sigma field – simple properties - Probability space - Random variables and Random vectors – Induced Probability space – Distribution functions – Decomposition of distribution functions.

Unit II

Expectation and moments – definitions and simple properties – Moment inequalities – Holder, Jensen, Chebyshev, Markov, Minkowski Inequalities– Characteristic function – definition and properties – Inversion formula.

Unit III

Convergence of a sequence of random variables - convergence in distribution, convergence in probability, almost sure convergence and convergence in quadratic mean - Weak convergence of distribution functions – Slutsky theorem - Helly-Bray theorem.

Unit IV

Definition of product space – Fubini's theorem (statement only) - Independence of two events – Independence of classes – Independence of random variables – properties – Borel zero –one law.

Unit V

Law of large numbers - Khintchin's weak law of large numbers, Kolmogorov strong law of large numbers (statement only) – Central Limit Theorem – Lindeberg – Levy theorem, Linderberg – Feller theorem (statement only), Liapounov theorem – Relation between Liapounov and Linderberg – Feller forms – Radon Nikodym theorem and derivative (without proof) – Conditional expectation – definition and simple properties.

CO-PO: MAPPING

COs \ POs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	XXX	X	X	X	X	X
CO2	XXX	X	X	X	X	X
CO3	XXX	X	XXX	X	X	X
CO4	XXX	X	X	X	X	X
CO5	XXX	X	XXX	X	X	X

Books for Study

1. Bhat, B. R. (2007): Modern Probability Theory, 3rd edition, New Age Int. Pvt. Ltd.
2. Ash, R.B. (1972): Real Analysis and Probability, Academic Press.
3. Rohatgi, V.K. and Saleh (2002): An Introduction to Probability Theory and Mathematical Statistics, John Wiley

Books for Reference

1. Athreya K B and Lahiri S N (2005): Measure Theory, Hindustan Book Agency.
2. Tucker, H.G. (1967): A Graduate course in Probability, Academic Press.
3. Burill, C.W. (1972): Measure, Integration and Probability, McGraw Hill.
4. Chow, Y.S. and Teicher, H. (1979): Probability Theory, Springer.
5. Loeve, M. (1985). Probability Theory, 3rd edition, Springer..
6. Resnick S.I. (2001): A Probability Path, Birkauer.
7. Basu A K. and A Bandopadhyay (2012): Measure Theory and Probability, PHI Learning Pvt. Ltd.

Course Objectives: This course is intended to train students in mathematical techniques of constructing various univariate, bivariate and multivariate distributions.

Course Outcomes (COs): On the successful completion of the course, student will acquire:

CO1: Derive the properties of some discrete and continuous probability distributions

CO2: Study the properties of Bivariate, Compound and Truncated probability distributions

CO3: Describe the properties of multivariate normal distribution and non-central sampling distributions

CO4: Define order statistics and obtain their sampling distributions

CO5: Understand empirical distribution and life distributions

Unit I

Discrete Probability distributions - Logarithmic series and Power series distributions - Multinomial distribution – Continuous Probability distributions - Cauchy, Inverse Gaussian, Lognormal, Logistic distribution

Unit II

Bivariate Binomial – Bivariate Poisson – Bivariate Normal- Bivariate Exponential of Marshall and Olkin – Compound distributions – Compound Binomial, Poisson, Negative Exponential (Pareto) distributions - Truncated distributions – Truncated Binomial, Poisson, Geometric, Cauchy distributions - Concept of convolution - Concept of mixture distributions

Unit III

Multivariate normal distribution (Definition and Concept only) - Sampling distributions: Non-central chi-square, t and F distributions and their properties - Distributions of quadratic forms under normality-independence of quadratic form and a linear form- Cochran's theorem

Unit IV

Order statistics, their distributions and properties- Joint and marginal distributions of order statistics - Distribution of range and mid-range – Exact moments of order statistics - Extreme values and their asymptotic distributions (concepts only)

Unit V

Empirical distribution function and its properties - Kolmogorov-Smirnov distributions - Life time distributions – Weibull, Erlang and Rayleigh distributions – Reliability – Reliability function – Hazard Rate function - Mills ratio - Distributions classified by hazard rate – simple problems

CO-PO: Mapping

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	XXX	XX	XX	XX	X	X
CO2	XXX	XX	XX	XX	X	X
CO3	XXX	XX	XX	XX	X	X
CO4	XXX	XX	XX	XX	X	X
CO5	XXX	XX	XX	XX	X	X

Books for Study

1. Dhanvanthan P and Sakthivel K M (2025): Elementary Theory of Probability Distributions, Ane Publishers & Distributors LLP. (Textbook) (Chapter : 5, 6, 8, 9, 11, 12, 14, 15, 16, 17)
2. Johnson, N.L., Kotz, S. and Balakrishnan, N. (1994): Continuous Univariate Distributions, vol.1 &2, Wiley Series in Probability and Statistics.
3. Johnson, N.L., Kemp A.W. & Kotz, S. (1994): Univariate Discrete Distributions, Wiley Series in Probability and Statistics
4. David H. A. and Nagaraja H.N.(2003): Order Statistics, 3/e, John Wiley & Sons.
5. Mood M., Graybill F.A. and Boes D.C.(2001): Introduction to the Theory of Statistics, Tata McGraw-Hill, New Delhi.

Books for Reference

1. Rao C. R.,(1973): Linear Statistical Inference and its Applications, Wiley Eastern Ltd, New Delhi.
2. Dudewicz, E.J and Mishra, S.N(1980): Mathematical Statistics, John Wiley, NY.
3. Kocherlakota S and Kocherlakota K(1992): Bivariate Discrete distributions, M. Dekker.
4. Balakrishnan N and Lai C.D.(2009): Continuous Bivariate Distributions, Springer.
5. Rohatgi, V.K. and Saleh (2002): An Introduction to Probability Theory and Mathematical Statistics, John Wiley.
6. Parimal Mukhopadhyay (2006): Mathematical Statistics, 3/e, Books and Allied (P) Ltd, Kolkata.

Course objectives: The objectives of this course are to teach basic ideas of sampling from an applied perspective and to provide uses in real life problems. To create the knowledge understanding census and sample survey sampling methods and applying them in practice.

Course Outcomes (COs): On the successful completion of the course, student will be able to:

- CO 1:** Understand different random sampling methods including cluster and multistage sampling
- CO 2:** Drawing samples using auxiliary / ancillary information with PPSWR and WOR methods
- CO 3:** Applying these methods to handle for homogeneous and non-homogeneous populations
- CO 4:** Capable to estimation of parameters and analyze properties of estimators
- CO 5:** Develop construct confidence interval estimates for population parameters

Unit I

Preliminaries – Sampling Designs – Simple random sampling– Stratified Random Sampling – Allocation problems – Systematic Sampling Schemes – Linear, Circular, Balanced and Modified systematic sampling methods- Non-random sampling.

Unit II

Probability Proportional to size sampling- Inclusion Probabilities – Horvitz-Thompson estimator – Yates –Grundy Form –Midzuno Sampling design – PPSWOR- Des-Raj’s Ordered estimator – Murty’s unordered estimators

Unit III

Ratio estimators and their properties in Simple Random Sampling – Ratio estimators in Stratified Random sampling – Regression Estimators, Regression estimators in Stratified Random Sampling – Multivariate Ratio estimators and Multivariate Regression Estimators

Unit IV

Cluster Sampling: Equal cluster sampling – Estimators of mean and variance, Determination of optimum cluster size, Unequal cluster sampling – Estimators of mean and variance – Two stage sampling – Estimators of mean and variance – Two-phase Sampling-Double Sampling for stratification and Ratio - Estimators of mean and variance.

Unit V

Randomized response methods – Warner’s, Simmon’s and Two Stage response methods – Sources of errors in Surveys – Mathematical model for the effects of call-backs and the errors of measurement, Concept of Bootstrap sampling.

CO - PO: MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	XXX	XX	XXX	X	XXX	X
CO2	XXX	XXX	XXX	X	XXX	X
CO3	XXX	XX	XX	X	X	XX
CO4	X	X	XXX	X	XXX	X
CO5	X	X	X	X	XXX	X

Books for Study

- Cochran, W.G. (1977): Sampling Techniques, 3/e, Wiley Eastern Ltd.,
- Gupta, A. K. and Kabe D.G, (2011): Theory of Sample Surveys, World Scientific Publishing Co. Pte. Ltd., Singapore
- Singh, D. and Choudhary, F.S (1986): Theory and Analysis of Sample Survey Designs, Wiley Eastern Ltd.,
- Sukhatme PV. et. al. (1984): Sampling Theory of Surveys with Applications, Iowa State University Press and ISARI Publications, New Delhi

Books for Reference

- Desraj and Chandhok P.(1998): Sampling Theory, Narosa Publications, New Delhi
- Kish, L(1995) : Survey Sampling, John Wiley and Sons.
- Murthy, M.N (1979): Sampling Theory and Methods, Statistical Publishing Society, Calcutta.
- Sarjinder Singh (2004): Advanced Sampling – Theory with Applications, Kluwer Publications

SEMESTER-II

Syllabus - M.Sc.(Statistics) from AY: 2025-26

Course objectives: The objective of the course is to learn the basic concepts in estimation theory like consistency, sufficiency, UMVUE and their applications. To study different methods of estimation and their properties.

Course Outcomes (COs): On successful completion of course, students able to

- CO1:** Gain fundamental knowledge related to point estimation, methods of estimation and properties of estimators
- CO2:** Determine lower bound for estimators and obtain uniformly minimum variance unbiased estimators
- CO3:** Understand the concept of minimal sufficiency, completeness and information measure
- CO4:** Compute the estimate of parameters and its standard error related to different statistical distributions based on real data and simulation
- CO5:** Comprehend interval estimation and its computation

Unit I

Parametric point estimation – properties of estimators – Consistency and its different forms Sufficient condition for consistency- Unbiasedness – sufficient statistics – Factorization theorem – Distributions admitting sufficient statistic – Exponential and Pitman families procedure for finding minimal sufficient statistic.

Unit II

The information measure – Cramer – Rao (CR) inequality – Chapman – Robbins (KCR) inequality (single parameter case only) – Bhattacharya inequality (single parameter case only) – minimum variance bound estimator- Invariant (equivariant) estimators (concepts only)

Unit III

Uniformly minimum variance unbiased estimators (UMVUE)- condition for the existence of UMVUE- Completeness and Bounded completeness- Relation between complete statistic and minimal sufficient statistic- Rao – Blackwell Theorem- Lehmann – Scheffe’s theorem.

Unit IV

Methods of estimation – method of moments and its properties – method of maximum likelihood and its properties-Large sample properties of MLE - Method of minimum chi- square and its properties – Methods of least squares

Unit V

Interval estimation – Pivotal method of construction – shortest confidence intervals and their construction (minimum average width) – Construction of shortest confidence intervals in large samples. Decision Theory: Simple problems involving quadratic error loss function – Elementary notions of minimax estimation – Simple illustrations.

Mapping with PO’s

COs\POs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	*		*			
CO2	*	*				
CO3	*					
CO4		*	*	*	*	*
CO5	*	*		*	*	*

Books for Study

1. Rajagopalan M and Dhanavanthan P (2012): Statistical Inference, PHI Learning, New Delhi.
2. Casella, G. and Berger, R.L. (2002):Statistical Inference, Duxubury Process, Belmont, USA.
3. Rohatgi, V.K. (2003): Statistical Inference, Dover Publications, New York.

Books for Reference

1. Lehmann, E.L and Casella G(1998) :Theory of Point Estimation, 2/e, Wiley Eastern Ltd.
2. B.K.Kale and K.Muralidharan (2015), Parametric Inference – An Introduction, Narosa Publishing House
3. Kale, B.K. (1999): A First course on Parametric Inference, Narosa Publishing House.
4. Zacks, S. (1981): Parametric Statistical Inference, John Wiley, NY.
5. Srivastava, Khan and Srivastava (2014), Statistical Inference: Theory of Estimation, PHI, India

Course Objectives: To provide the insights of the Stochastic Processes. To understand the notions and uses of different types of stochastic processes. To have the knowledge of real-time applicability along with the classical theory.

Course Outcomes (COs): After completing the course, the students will be able to

- CO1:** Understand the notion of Markov chains and transition matrices.
- CO2:** Analyze the properties of Poisson processes
- CO3:** Solve problems using Wiener and branching processes
- CO4:** Formulate the renewal models in continuous time
- CO5:** Construct the time series models (MA, AR, ARMA) and assess their stationarity

Unit I

Stochastic processes: Definition and classification – Markov chain– Examples (Random-walk, Gambler’s ruin problem)-Transition Probability Matrices - Higher Transition Probabilities - Bernoulli Trails - classification of states and chains – Markov and Hidden Markov Models.

Unit II

Poisson Process: Overview- postulates- probability mass function -Properties - inter related probability distributions- Generalization- Arrival process, Departure Process, Pure Birth(Yule- Furry) process, Birth and Death Processes, Birth-Death and Migrations processes- Chapman Kolmogorov Equations- Compound Poisson Process - Transition density matrix and Poisson Process.

Unit III

Weiner Process: Brownian motion, Joint probabilities, Wiener process, Differential equations, Kolmogorov equations, First passage time distribution; **Branching Process:** properties of generating functions of branching processes, Probability of Ultimate extinction, Distribution of Total number of Progeny, Age dependent Branching process

Unit IV

Renewal processes: Definition, examples and relationships between terms – renewal interval, delayed recurrent event, Renewal Processes in continuous time, Renewal Function and renewal density, renewal equation, renewal theorems – Study of residual life time process

Unit V

Stationary processes and Time Series: Stationary Processes, second order, stationarity, Gaussian Processes, weakly and strongly stationary process; Time Series- White Noise process, first order Markov process, MA and AR processes, Autoregressive process of order two, ARMA process verification of stationarity.

CO-PO: Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	XXX		XXX			
CO2	XXX			XXX		
CO3					XXX	
CO4		XXX				XXX
CO5			XXX		XXX	XXX

Books for Study

1. Karlin, S and Taylor, H.M(1975): A First Course in Stochastic Processes, Academic Press, New York.
2. Medhi, J (2009): Stochastic Processes, 3/e, New age International.
3. Bhat B.R.(2004): Stochastic Models: Analysis and Applications, New Age Publications

Books for Reference

1. Bhattacharya and Waymire, E.C. (1992): Stochastic Process with Applications John Wiley and sons.
2. Jones,P.W and Smith,P(2001): Stochastic Processes: An Introduction, Arnold Press.
3. Cinlar, E(1975): Introduction to Stochastic Processes, Prentice-Hall Inc., New Jersey.
4. Cox, D.R and Miller, H.D(1983) : Theory of Stochastic Processes – Chapman and Hall, London,3rd Ed/
5. Ross S.M (1983): Stochastic Process, Wiley.
6. G. Grimmett and D. Stirzaker (2001): Probability and Random Processes, 3/e, OUP Oxford.

Course Objectives: This course is intended to train students to get knowledge in theoretical and practical applications of regression techniques.

Course Outcomes (COs):

CO1: Derive and interpret estimators for parameters in regression models using statistical theory.

CO2: Apply hypothesis testing and construct prediction intervals for regression models.

CO3: Conduct residual diagnostics to identify outliers and influential observations.

CO4: Select and validate regression models using appropriate selection criteria and remedial measures.

CO5: Implement and compare non-linear, robust, and non-parametric regression methods using statistical software.

Unit I

Review of Linear Models Full rank linear model – least square estimators of the parameters and their properties – Gauss-Markov theorem – Model in centered form – Estimators under normality assumption and their properties – Coefficient of determination – Generalized least squares – misspecification of the error structure and the model.

Unit II

Test for overall regression and for a subset of the parameters – test in terms of R^2 – General Linear Hypothesis testing – special cases – confidence region for the parameters and the mean – prediction intervals – study of the residual outliers and influential observations.

Unit III

Selection of input variables and model selection – Methods of obtaining the best fit – Stepwise regression, Forward selection and backward elimination – Multicollinearity – Collinearity diagnostics – Causes, Consequences and Remedy – Ridge Regression-Principal Component Regression.

Unit IV

Introduction to general non-linear regression – Least squares in non-linear case – Estimating the parameters of a non-linear system, Non-linear growth models – Concept of non-parametric regression-Kernal, Spline, LOWESS Regression.

Unit V

Robust regression – Linear absolute deviation regression – M estimators – least squares approach based on M-estimators – Re-sampling procedures for regression models – Bootstrap and Jackknife methods and its properties (without proof).

Mapping of CO-PO – STAT 423

COs\POs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	XXX	XX	XX	X	X	X
CO2	XXX	XXX	XX	XX	X	X
CO3	XX	XXX	XXX	XX	X	XX
CO4	XX	XXX	XXX	XXX	X	XX
CO5	XX	XXX	XXX	XXX	XX	XXX

Books for Study

1. Alvin C. Rencher (2000): Linear Models in Statistics, John Wiley & Sons, New York (Chapters 7,8 & 9 for Unit I & II)
2. Draper, N and Smith, H (1998): Applied Regression Analysis, 3rd Edition, Wiley-Interscience.
3. Elizabeth C. Peck, Douglas C. Montgomery, G. Geoffrey Vinning (2006): Introduction to Linear Regression Analysis, 3/e, John Wiley & Sons.

Books for Reference

1. Chaterjee, S, Ali S. Hadi (2013): Regression Analysis by Example, 5th edition, John Wiley.
2. Searle, S.R. (1997): Linear Models, John Wiley.
3. Thomas P.Ryan(2006): Modern Regression Methods, John Wiley and Sons, Inc.
4. Seber G.A.F and Wild C.J. (2003): Nonlinear Regression, John Wiley & Sons

STAT 424: Statistical Computing with R / Python -I**CREDITS: 3**

(Based on STAT-414, 421, 423)

Course Objectives: This course is intended to train students to get knowledge in practical applications of Estimation Theory, Sampling Theory and Linear models

Course Outcomes (COs): On completion of course, students able to learn

CO1: Skill in computing point and interval estimates based on real life data

CO2: Skill in selecting samples, determine sample size and compute the estimate of mean and variance of estimators related to different sampling schemes

CO3: Perform simple, multiple linear regression models and identify the significant covariates, outliers and leverage observations

CO4: Gain knowledge in applying the concepts to various scientific experiments and analyse real life data

CO5: Exposure to computation using statistical software

I. Theory of Estimation (20 marks)

1. MLE and Standard error of ML estimators.
2. MLE through the method of successive approximation.
3. MLE for truncated distribution.
4. Method of Moments
5. Method of Minimum Chi-square
6. Method of Least square
7. Interval estimation: Confidence interval for mean,
8. Interval estimation - difference of means,
9. Interval estimation - variance and ratio of variances.

II. Sampling Theory (20 marks)

1. Methods of drawing sample from a population.
2. SRSWR and SRSWOR: Estimation of point and confidence interval estimate of the population total and variance.
3. PPSWR – Drawing sample with CTM and Lahiri’s Method-Estimation of Mean and Variance
4. PPSWOR: Des Raj ordered estimator and Hurwitz Thompson and Murthy’s unordered estimators
5. Linear and circular systematic sampling.
6. Stratified sampling – Estimation of mean and variance and sample size determination
7. Equal Cluster sampling –Estimation of mean and variance.
8. Ratio, Regression and Difference estimation estimators.

III Regression Analysis (20 marks)

1. Fitting of Multiple linear regression model
2. Residual Analysis for model adequacy, detection of outliers and influential observations
3. Variable Selection procedures
4. Collinearity Diagnostics
5. Ridge Regression
6. Principal Component Regression

CO-PO: Mapping

COs\POs	PO1	PO2	PO3	PO4	PO5	PO6
CO1		*	*			
CO2		*	*			
CO3		*	*			
CO4			*		*	*
CO5				*		*

SEMESTER-III

Syllabus -M.Sc.(Statistics) from AY: 2025-26

Course Objectives: To learn about multivariate normal distribution and its characterizations. To study the multivariate tests for mean vectors and covariance matrices. To know the theoretical concepts and applications of multivariate statistical methods like Discriminant Analysis, Principal Component Analysis, Canonical Correlation Analysis and Factor Analysis

Course Outcomes (COs): On the successful completion of the course, student will be able to

- CO1:** Explain the properties and applications of the multivariate normal distribution.
- CO2:** Apply statistical inference to multivariate mean vectors and covariance matrices.
- CO3:** Classify observations using discriminant functions and classification rules.
- CO4:** Reduce dimensionality using principal component and factor analysis techniques.
- CO5:** Apply canonical correlation analysis to study relationships between multivariate datasets.

Unit I

Multivariate normal distribution– Marginal and conditional distributions – characteristic function. Maximum likelihood estimation of the parameters of Multivariate Normal and their sampling distributions – Inference concerning the mean vector when covariance matrix is known

Unit II

Total, Partial, Multiple correlation in the Multivariate setup – MLEs of Total, Partial and Multiple correlation coefficients. Sampling distributions of Total and Multiple Correlation in the null case. Hotelling T^2 statistic, derivation and its distribution –Uses of T^2 statistic - relation between T^2 and D^2 – Mahalanobis D^2 statistic and its distribution.

Unit III

Generalized variance – Wishart distribution (statement only) – Properties of Wishart distribution – Test for covariance matrix – Test for equality of two and several covariance matrices-One -way MANOVA.

Unit IV

Classification problems – Classification into one of two populations (known and unknown dispersion matrix) – Classification in to one of several populations – Fisher’s Linear discriminant function- Variable selection procedures.

Unit V

Principal components –properties, Extraction of Principal components and their variances Canonical correlation – Estimation of canonical correlation and variates. Factor analysis – Mathematical model- Estimation of Factor Loadings — Concept of factor rotation – Varimax criterion

Mapping of CO-PO

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	XXX	XX	XXX	X	X	X
CO2	XXX	XXX	XXX	XX	X	X
CO3	XX	XXX	XXX	XX	X	XX
CO4	XX	XXX	XXX	XXX	X	XX
CO5	XX	XXX	XXX	XXX	XX	XXX

Books for Study

- Anderson, T.W. (2003) : An Introduction to Multivariate Statistical Analysis, Wiley Eastern Ltd.
- Johnson, R. A and. Wichern D.W (2007): Applied Multivariate Statistical Analysis, 6/e, Prentice-Hall of India Private Ltd., New Delhi.
- Giri, N.C(2003): Multivariate Statistical Inference, Academic Press, NY

Books for Reference

- Morrison, F(1985): Multivariate Statistical Methods, Mc Graw Hill Book Company.
- Rao, C.R(1998): Linear Statistical Inference and its Applications, Wiley Eastern Ltd.,
- Alvin C. Rencher(2002): Methods of Multivariate Analysis, 2/e, Wiley Interscience
- Srivastava M.S. and Khatri C.G.(1979):Introduction to Multivariate Analysis, Elsevier

Course Objectives: To emphasize on the theoretical concepts of testing single and composite hypotheses under parametric and non-parametric set up.

Course Outcomes (COs): On the successful completion of the course, student will be able to

CO1: Understand basic testing concepts and apply Neyman-Pearson Lemma to find most powerful tests.

CO2: Learn about unbiased tests and apply them to exponential family using sufficient statistics.

CO3: Understand invariant and consistent tests and use the Likelihood Ratio Test in applications.

CO4: Perform non-parametric tests like Chi-square, Kolmogorov-Smirnov and rank-based tests.

CO5: Learn basics of sequential tests and apply the Sequential Probability Ratio Test (SPRT).

Unit I

Randomized and non-randomized tests, Neyman – Pearson fundamental lemma, most powerful tests, uniformly most powerful test, uniformly most powerful test for distributions with monotone likelihood ratio, Generalization of fundamental lemma and its applications

Unit II

Unbiasedness for hypothesis testing, uniformly most powerful unbiased tests, Unbiased tests for one parameter exponential family, Similar test and complete sufficient statistics, Similar tests with Neyman structure, locally most powerful tests.

Unit III

Invariant tests, maximal invariants, uniformly most powerful invariant tests, Consistent tests, Likelihood ratio test, its properties and its asymptotic distribution, Applications of the LR method.

Unit IV

Non-parametric tests: Goodness of fit test: Chi-square and Kolmogorov Smirnov test - Test for randomness, Wilcoxon Signed rank test – Two sample problem: Kolmogorov-Smirnov test, Wald-Wolfowitz run test, Mann-Whitney U test, Median test, Kruskal Wallis test and Friedman's test

Unit V

Sequential tests: Basic Structure of Sequential tests – Sequential Probability Ratio Test (SPRT) and its applications – Determination of the boundary constants – Operating Characteristic and expected sample size of SPRT – Optimum properties of SPRT.

CO -PO: Mapping

COs\POs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	XXX	XX	XX	X	X	X
CO2	XXX	XX	XX	X	X	X
CO3	XXX	XX	XX	X	X	X
CO4	XX	XXX	XXX	XX	X	X
CO5	XXX	XX	XX	XX	X	X

Books for Study

1. Rajagopalan M and Dhanavanthan P (2012): Statistical Inference, PHI Learning, New Delhi.
2. Lehmann, E.L and Joseph P. Romano (2005): Testing Statistical Hypotheses, 3/e, Springer
3. Rohatgi, V.K.(2003): Statistical Inference, Dover Publications,.
4. Gibbons, J.D. (1985) : Non Parametric Statistical Inference , 2/e , Marckel Decker.

Books for Reference

1. Casella, G & Berger, R.L (1990):Statistical Inference , Duxubury Press, Belmont. USA
2. Ghosh,B.K(1970): Sequential Tests of Statistical Hypotheses, Addison Wesley.
3. Parimal Mukhopadhyay(2006):Mathematical Statistics, 3/e, Books and Allied (P) Ltd, Kolkata.
4. Manoj Kumar Srivastava and Namita Srivastava (2009): Statistical Inference – Testing of Hypotheses, Prentice Hall of India

STAT 533: DESIGN AND ANALYSIS OF EXPERIMENTS CREDITS: 4

Course Objectives: Understand the need of experimental design, understand the link between linear models and design of experiments, Understand the principles of Design of experiments, Understand different design of experiments

Course Outcomes(COs): On the successful completion of the course, student will acquire:

- CO1:** Understand theoretical aspect of design matrix, properties of C matrix and principles of design of experiments
- CO2:** Describe the analysis of the basic designs, missing plot techniques and multiple comparison tests
- CO3:** Discuss in detail various incomplete block designs and their analysis
- CO4:** Study the applications of factorial experiments
- CO5:** Develop the analysis of covariance models

Unit I

Notion of design matrix - C Matrix and its properties - Expected Mean Squares (EMS) and its uses - Algorithm for calculating EMS – Two-way elimination of heterogeneity - Review of principles of scientific experiment: randomization - replication and local control - Experimental error and accuracy of experiments - steps in planning of experiments.

Unit II

Basic Designs: Overview of Completely Randomized Design (CRD), Randomized Block Design (RBD) and Latin Square Design (LSD) – Analysis of RBD (with one observation per cell, more than one but equal number of observations per cell) – Derivation of one and two missing values, Iterative and non-iterative methods – Multiple Comparison Tests(LSD, Tukey, DMR, SNK).

Unit III

Block Designs: Connectedness, balancing, Orthogonality, Efficiency, Resolvable designs - Complete and Incomplete Block Design - Balanced Incomplete Block Design (BIBD)- Types of BIBD - Simple construction methods - Inter and Intra Block analysis of BIBD – Partially Balanced Incomplete Block Design with two associate classes – intra block analysis only

Unit IV

Factorial experiments: 2^2 , 2^3 , 2^4 and 3^2 , 3^3 experiments and their analysis – Complete and Partial Confounding - Balancing in Symmetric factorials - Fractional Replication in Factorial Experiments – Split plot and strip plot designs and their analysis-Mixed Factorial.

Unit V

Youden Square design - Lattice design, simplex lattice design and their analysis - Analysis of covariance in one way and two way classification models.

CO-PO: Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	XXX	XX	XX	XX	X	X
CO2	XXX	XX	XX	XX	X	X
CO3	XXX	XX	XX	XX	X	X
CO4	XXX	XX	XX	XX	X	X
CO5	XXX	XX	XX	XX	X	X

Books for Study

- Das, M.N. and Giri, N.C.(1979): Design and Analysis of Experiments, Wiley Eastern Ltd,
- Montgomery D.C. (2009) : Design and Analysis of Experiments, 7/e, John Wiley and Sons,
- Cochran .W.G. and Cox .G.M. (1995): Experimental designs, 4/e, Wiley.
- Dean, A. and Voss, D. (1999). Design and Analysis of Experiments, Springer.

Books for Reference

- John, P.W.M (1971): Statistical Design and Analysis of Experiments, Mc Graw Hill Book Company.
- Klaus Hinkelmann and Kempthorne, O. (1994): Design and Analysis of Experiments, John Wiley and Sons.
- George W Cobb (2008): Introduction to Design and Analysis of Experiments, Wiley
- Parimal Mukhopadhyay (2005): Applied Statistics, 2/e, Books and Allied (P) Ltd, Kolkata.
- Kabe D. G. and Gupta A. K. (2007): Experimental Designs: Exercises and Solutions, Springer-Verlag, NY.

Course Objectives: This course is intended to train students to get knowledge in practical applications of Hypothesis testing, Multivariate analysis and Design of experiments.

Course Outcomes(COs): On the successful completion of the course, student will be able to:

- CO1:** Perform analysis of data sets using various statistical software.
- CO2:** Apply Hotelling's T² test, discriminant analysis, canonical correlation, Principal Correlation Analysis and Factor analysis in multivariate data.
- CO3:** Construct and interpret MP, UMP, UMPU tests, SPRT and perform non-parametric tests using real data.
- CO4:** Analyze data using various experimental designs including factorial, split-plot and confounding techniques.
- CO5:** Handle missing data in RBD and LSD, apply multiple comparison tests and perform Analysis of Covariance in CRD

I Multivariate Statistical Analysis : (20 marks)

1. Test for equality of mean vectors when covariance matrix is unknown (Hotelling's T² test)
2. Test for Two Covariance matrices
3. Discriminant Analysis
4. Canonical correlation and canonical variables
5. One Way MANOVA with Post hoc tests (DMRT and Tukey's).
6. Principal Component Analysis
7. Factor Analysis

II Testing of Statistical Hypotheses : (20 marks)

1. Construction of randomized and nonrandomized MP, UMP and UMPU tests of hypotheses and drawing the power curves.
2. Construction of SPRT and its OC and ASN curves.
3. Non parametric tests:
Kolmogorov Smirnov test, Mann-Whitney U test, Median test for k-sample problem, Kruskal Wallis test and Friedman's test

III Design and Analysis of Experiments (20 marks) : (20 marks)

1. Multiple Comparison tests (Least Significant Difference (LSD) test, DMR, SNK)
2. Missing Data Analysis- one and two observations in RBD
3. Missing Data Analysis- one and two observations in LSD
4. 2⁴, 3² factorial experiments
5. Complete confounding in 2⁴, 3² factorial experiments
6. Partial confounding in 2⁴, 3² factorial experiments
7. Split plot design
8. BIBD
9. Analysis of Covariance – CRD – One Concomitant Variable

Mapping- CO with PO

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	X	XX	X	XXX	XX	XX
CO2	XX	XX	XX	XX	X	X
CO3	XXX	XX	XXX	XX	X	XX
CO4	XX	XXX	XX	XX	X	XX
CO5	XX	XX	X	XX	X	XX

SOFT CORE COURSES

STAT 415– STATISTICS WITH R-PROGRAMMING (LAB. BASED) CREDITS: 3

Course Objectives: To provide the all the related statistical knowledge and working abilities of making use of the R software for statistical computing as well as Data Analysis. To train the students and enabling them to have software utilization in dealing the topics of Descriptive, Predictive, Prescriptive data analysis through the data analysis training project.

Course Outcomes (COs): After completion of the course, the students will be exposed to

- CO1** Compute and interpret descriptive statistical measures using R
- CO2** Prepare frequency tables and represent data visually using diagrams and plots.
- CO3** Analyze relationships between variables using correlation and regression
- CO4** Conduct hypothesis testing using parametric techniques for various scenarios
- CO5** Carry out a complete applied data analysis project using real time data
- CO6** Synthesize the knowledge of descriptive, predictive, and prescriptive analytics to make decisions

Unit I

Descriptive Data Analysis: Computation of Descriptive Statistics, measures of central tendency, measures of dispersion, measures of Skewness and kurtosis, preparation of univariate, bivariate and multivariate frequency tables, drawing the diagrams such as Bar diagrams, Pie Diagrams, Histogram, Box-Whisker plots, Line diagram, scatter diagram.

Unit II

Predictive Data Analysis: Relational statistics, computation of Correlation coefficients, coefficient of Association, regression coefficient, fitting of regression lines, Estimation of parameters, prediction and forecasting through linear and nonlinear regression.

Unit III

Prescriptive Data Analysis: Inferential statistics, Parametric Testing of hypothesis, large and small sample tests, tests for proportion, means, correlation coefficients, regression coefficients, independence of attributes, Goodness of Fit, Analysis of Variance for one-way and two way classification. Post-hoc tests.

Unit IV

Applied Data Analysis Project: Online real time Data Procurement, Data cleaning, Data Formatting, Data importing and Exporting, Data Processing, Data Analysis by making use of all the above three units, Statistical data analysis Project reporting my using one or two multi variate analysis techniques with the real time data.

CO-PO: Mapping

COs\POs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	XXX			XXX		XXX
CO2				XXX	XXX	
CO3			XXX			
CO4					XXX	XXX
CO5				XXX		
CO6		XXX		XXX		

Books for Study

1. Shailaja R Deshmukh Sudha G Purohit Sharad D Gore (2015), Statistic Using R, Publisher. Alpha Science International Ltd.
2. Peter Dalgaard (2008), Introductory Statistics with R, 2nd edition, Springer.

Lab Exercises:

1. Computation of all types of moments and Pearson's coefficients for the univariate discrete data

2. Computation of all types of moments and Pearson's coefficients for the univariate grouped/frequency data
3. Computation of all types of moments and Pearson's coefficients for the univariate discrete probability distributions
4. Computation of all types of moments and Pearson's coefficients for the univariate Continuous probability distribution
5. Operations on vectors and matrices
6. Preparation Univariate Frequency Table
7. Preparation of Bivariate Table
8. Drawing Pie-diagrams,
9. Drawing Bar Diagrams, Histograms for single and multiple variables
10. Drawing Line diagrams, Scatter diagram
11. Drawing Box Plots for single and multiple variables
12. Finding the descriptive statistics namely Minimum, Maximum, Count, Mode, Range, Variance, CV, for the discrete data
13. Finding the Coefficients of Skewness due to Pearson and Bowley by finding the Mean, Median, Mode, SD, Q1, Q2, Q3 for a discrete data.
14. Checking Normality using Histogram and Q-Q plot.
15. Computation and testing of Correlation coefficient – Pearson's, Spearman, Kendall's Tau.
16. Fitting simple linear and multiple linear regressions.
17. One sample and two sample test for means, t test.
18. Test for goodness of fit, Test for independent of attributes, Chi-square test
19. Finding and testing the regression coefficients
20. One way and two-way ANOVA, F- test.

Course Objectives: To provide the all the related knowledge Mathematical Programming and Post Optimality Sensitivity Analysis. To extend the knowledge of the classical and empirical types on Dynamic programming and Project evaluations Review Techniques. To enable the students in understanding theory and applying it to the real time contexts.

Course Outcomes (COs): After completion of the course, the students will be exposed to

- CO1** Apply knowledge of mathematics, science, and engineering
- CO2** Analyze complex problems to reach substantiated conclusions
- CO3** Design solutions for complex problems considering in different environment
- CO4** Apply appropriate techniques and modern tools for engineering practice
- CO5** Familiar with handling of LPP problems by modeling real time scenarios
- CO6** Perform project management using CPM/PERT techniques

Unit I

Mathematical Programming - Solving of LPP by graphical method - Linear Programming Problem (LPP)– Simplex, Big M and Two Phase methods – Revised simplex method – Solving LPP using Duality - Dual Simplex method

Unit II

Post Optimality and Sensitivity Analysis–Variation in cost vector and requirement vector– Addition and deletion of single variable and single constraint - Integer Programming Problem (IPP) - Gomory’s cutting plane algorithm– Mixed IPP – Branch and Bound technique

Unit III

Dynamic Programming Problem (DPP) - Bellman’s principle of optimality - General formulation - computation methods and application of DPP - Solving LPP through DPP approach

Unit IV

PERT - CPM: Applications, Basic Steps in PERT/CPM techniques; Time estimates and Critical Path in Network Analysis; Optimum and minimum duration cost, PERT, Resource Allocations.

CO-PO: Mapping

COs\POs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	XXX					
CO2		XXX			XXX	
CO3		XXX				
CO4			XXX			
CO5				XXX		
CO6	XXX					XXX

Books for Study

1. Hillier FS and Libermann GJ(2002):Introduction to Operations Research, 7th Edition, McGraw Hill
2. Kanti Swarup, P.K.Gupta and Man Mohan(2004): Operations Research, Sultan Chand and Sons, New Delhi.
3. Gross D, Shortle J.F. , Thompson J.M. and Harris C.M. (2011): Fundamentals Queuing Theory, John Wiley & Sons

Books for Reference

1. Sinha SM(2006):Mathematical Programming: Theory and Methods, Elsevier Publications.
2. Devi Prasad (2015), Operations Research, Narosa Publishing House
3. Kapoor V.K.(2008):Operations Research, 8/e,Sultan Chand & Sons
4. Sharma .S.D(1999): Operation Research , Kedar Nath RamNath & Co., Meerut.
5. Hamdy A.Taha(1987):Operations Research – An Introduction, 4/e, PHI, Private Ltd, New Delhi.
6. Sujit K. Bose (2012), Operations Research Methods, 2/e, Narosa Publishing House
7. K. Chandrasekhara Rao and Shanti Lata Misra (2012), Operations Research, Narosa P House

Course Objectives: To give exposure on the practical implementation of the quality control techniques and acceptance sampling schemes. Students will be able to cater the needs of the industry to resolve the quality issues.

Course Outcomes (COs): On the successful completion of the course, student will be able to:

- CO1:** Construct control charts for large and smaller shifts in the process parameters
- CO2:** Effectively interpreting the results from the various types of control charts
- CO3:** Carry out various types of process capability analysis
- CO4:** Adopt appropriate sampling inspection plans for given conditions
- CO5:** Investigate acceptance sampling variables for process parameters/

Unit I

Modified control charts for mean – CUSUM chart – technique of V-mask – Weighted Moving average charts – multivariate control charts – Hotelling’s T^2 control charts and Economic design of X-bar chart.

Unit II

Process Capability analysis: Meaning, Estimation technique for capability of a process – Capability Indices: Process capability ratios C_p ; C_{pk} , C_{pm} , C_{mk} , C_{pc} – Process capability analysis using a control chart – Process capability analysis using design of experiments.

Unit III

Acceptance sampling – Terminologies – Attribute sampling plan by attributes – Single sampling plan and Double sampling plan – OC, ASN, AOQ, AOQL and ATI curves –MILSTD -105E Tables.

Unit IV

Acceptance sampling variables for process parameter – Sequential plans for process parameter (σ known and unknown) – Sampling variables for proportion non-conforming - \bar{X} method, K method.

CO-PO: Mapping

COs\POs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	XXX	XX	XXX	XX	XX	X
CO2	XXX	XXX	XX	XXX	XXX	X
CO3	XXX	XXX	X	XX	XX	X
CO4	XXX	XX	XX	X	XX	X
CO5	XXX	XX	X	XX	XX	
CO6	XXX	XX	X	X	XX	X

Books for study

1. Douglas C. Montgomery (2009): Introduction to Statistical Quality Control, 6/e, John Wiley and Sons, New York.
2. Edward G. Schilling, Dean V. Neubauer, (2009), Acceptance Sampling in Quality Control, Second Edition, Taylor & Francis
3. Oakland, J.S.(1989): “Total Quality Management”, Butterworth–Heinemann Ltd., Oxford

Books for Reference

1. Mittage, H.J and Rinne, H(1993): Statistical Methods of Quality Assurance, Chapman Hall, London, UK
2. Zeiri (1991): “Total Quality Management for Engineers”, Wood Head Publishers.
3. Juran J.M and Frank M.Gryna Jr .(1982): “Quality Planning and Analysis”, TMH, India.

Course Objectives: To provide the all the related knowledge on counting theory, more focused with classical mathematical approaches. To train the students and enabling them to have conceptual understanding and applications of counting techniques, sequences and series, permutations and Combinotrics.

Course Outcomes(COs): After completion of the course, the students will be exposed to

- CO1** Apply fundamental counting principles
- CO2** Solve problems involving sequences
- CO3** Employ combinatorics and permutations to solve real-life counting problems.
- CO4** Understand the inclusion-exclusion & pigeonhole principle for advanced enumeration.
- CO5** Understanding of tree structures and apply tree algorithms in various contexts.
- CO6** Evaluate properties of trees and their applications in structured problem-solving

Unit I (Fundamentals of Counting Techniques)

Introduction - Fundamental Counting Principles - Additive Counting Principles - Multiplicative Counting Principle - Binomial Theorem – Concept of Binomial Coefficients - Factorial and its Notations.

Unit II (Counting Techniques Through Sequences & Series of Real Numbers)

Definition – Mathematical form – A.P, G.P and H.P Sequences – Bounded and Unbounded Sequence- Monotonic Sequence (Increasing and Decreasing) – Concept of Convergent – Concept of Divergent – Necessary Conditions for Convergence of Series – Properties - Cauchy’s General Principle of Convergence.

Unit III (Counting Techniques through Combinotrics & Permutations)

Definition – Properties of Combinations – Types of Combinations (with and without repetitions) – Concept of Permutations (with and without repetitions) - Circular permutations - Multinomial theorem - Principle of Inclusion and Exclusion - Polya theory of counting - The Pigeonhole Principle for Counting.

Unit IV (Counting Techniques Through Branching Methods)

Definition – Fundamental Terminologies – Binary Tree and their Types – Concept of Bridge – Distance and Eccentricity – Centre and Central Point – Spanning and Searching Trees – Different Types of Algorithms of Trees – Properties of Trees - Some Real – Life Applications on Trees.

CO-PO Mapping

COsPOs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	XXX					
CO2					XXX	
CO3		XXX				
CO4			XXX			
CO5			XXX	XXX		
CO6						XXX

Books for Study:

1. Probability with the Fundamental Counting Principle, Permutations, and Combination Blitzer, R. (2019). Thinking mathematically (7th ed.). Pearson.
2. R.P. Grimaldi, Discrete Mathematics and Combinatorial Mathematics, Pearson Education, 1998
3. Stewart I., Tall D., The Foundations of Mathematics. Oxford University Press, 2015.
4. **M.V. Deshmukh**, Counting Techniques, Himalaya Publishing House, 2023.
5. Rao, G. S., Numerical Analysis. New Age International Publishers, 2003.
6. Discrete Mathematics and its Applications Kenneth H. Rosen 7th Edition -Tata McGraw Hill Publishers - 2007

Books for References:

1. Combinatorics: The Art of Counting by Bruce E. Sagan
2. R. Johnsonbaugh, Discrete Mathematics, 7th Edition, Pearson Prentice Hall, 2009.
3. V.K. Balakrishnan, Combinatorics, Schaum’s Outlines, 1995.
4. Seymour Lipschutz and Marc Lars Lipson, Discrete Mathematics (Schaum’s Outlines), 3rd Edition, 3rd Reprint 2010, Tata McGraw Hill.
5. Shastry S.S., Introductory Methods of Numerical Analysis, PHI, 2012.
6. Kumar A., Kumaresan S., Sarma B.K., A Foundation Course in Mathematics, Narosa publishing house, 2018.

Course objectives: This course provides insight knowledge about Econometrics, Econometric modeling, its application with real time data and as an outcome it is used for researchers and in areas such as Statistics, Economics and Finance.

Course Outcomes (COs):

CO1: Explain the theoretical foundations of econometric models and estimation techniques.

CO2: Apply regression-based methods to analyze economic and financial data.

CO3: Diagnose econometric issues such as heteroscedasticity, autocorrelation, and multicollinearity, and apply remedial measures.

CO4: Model dynamic relationships using distributed lag and simultaneous equation models.

CO5: Interpret and communicate econometric findings in technical and applied contexts.

Unit I

Nature and Scope of Econometrics - Review of General Linear Model (GLM), Ordinary Least Squares (OLS), Generalized Least Squares (GLS) - Heteroscedasticity - consequences and detection: Graphical methods – Tests: Park test – Glejser’s test – Spearman’s rank Correlation test – Goldfeld-Quandt test – Breusch-Godfrey- Godfrey test and White’s Geenal Heteroscedasticity test – remedial measures for Heteroscedasticity – Weighted Least Squares approach.

Unit II

Linear regression with stochastic regressors - Errors in variables - Instrumental variable estimation - Autocorrelation – consequences and tests: Run’s test –Durbin-Watson test - Autoregressive linear regression - Multicollinearity – Sources, consequences and detection – Principal Component regression and Ridge Regression.

Unit III

Distributed lag models – Finite and Infinite Distributed lag models – Koyck’s approach, Almons’ Model, Cagan’s approach, Arithmetic Lag, Geometric Lag model, Inverted V Lag Model, Pascal’s Lag Model, Nerlove’s Lag Model, Instrumental Variable method.

Unit IV

Simultaneous linear equations model - Identification problem - Restrictions on structural parameters - rank and order conditions - Restrictions on variances and covariances - Estimation in simultaneous equations model

CO-PO: Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	XXX	XX	XX	X	X	X
CO2	XXX	XXX	XX	XX	X	X
CO3	XX	XXX	XXX	XX	X	XX
CO4	XX	XXX	XXX	XXX	X	XX
CO5	XX	XXX	XXX	XXX	XX	XXX

Books for study

1. Gujarati, D.N. (2003): Basic Econometrics, McGraw Hill.
2. Johnston, J. (1984): Econometric methods, Third edition, McGraw Hill.
3. Nachane. D.M. (2006): Econometrics: Theoretical Foundations and Empirical Perspective, Oxford University Press.

Books for Reference:

1. Apte, P.G. (1990): Text book of Econometrics. Tata McGraw Hill.
2. Intrulligator, M.D. (1980): Econometric models - Techniques and Applications, Prentice Hall of India.
3. Kleiber, C. and Zeileis, A. (2008): Applied Econometrics with R, Springer, NY.

Course Objectives: Enable the students to understand the basic preliminaries and advanced modeling techniques applied in biological and medical sciences

Course Outcomes (COs):

- CO1:** Describe and apply statistical designs in clinical trials and epidemiological studies.
CO2: Perform biological assay analysis and interpret dose–response relationships.
CO3: Apply regression models for categorical and count data in biomedical contexts.
CO4: Use ROC curve analysis and related measures for diagnostic test evaluation.
CO5: Integrate biostatistical methods in healthcare and pharmaceutical research projects.

Unit I Note: ICH Guidelines for Unit I (Reference)

Statistical Methods in Clinical Trials: Introduction to clinical trial and its phases - statistical designs - Fixed sample trials: simple randomized design, stratified randomized - crossover design - Sequential design: open and close sequential design. Randomization-Dynamic randomization, Permuted block randomization; Blinding-Single, double and triple – concept of bias – information bias and selection bias- Propensity Score Matching.

Unit II

Biological Assays: Introduction, parallel-line assay, slope- ratio assays and quantile- response assay, Feller's theorem. Dose-response relationships-qualitative and quantitative response, dose response relation- estimation of median effective dose

Unit III

Categorical Data Analysis: Categorical response data, logistic regression-odds ratio, Wald's statistic, logistic regression and its diagnostics, - Poisson regression – Estimation of relative risk and its applications-Negative Binomial Regression. Introduction to sample size determination – one sample and two samples means and proportions

Unit IV

ROC Curve analysis - Estimation of Binomial Model and the Area under the Curve, its applications – Properties of ROC curve - Kullback –Leibler Divergence (KLD)– definition – functional relationship between Kullback –Leibler Divergence and the slope of the ROC curve – derivations of KLD expressions for Bi-normal ROC model. Epidemiological study designs – Cohort study design and its analysis – Case control study design and its analysis – Cross sectional studies.

Mapping of CO-PO – STAT 425

COs-POs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	XXX	XX	XXX	X	X	X
CO2	XXX	XXX	XXX	XX	X	X
CO3	XX	XXX	XXX	XX	X	XX
CO4	XX	XXX	XXX	XXX	X	XX
CO5	XX	XXX	XXX	XXX	XX	XXX

Books for Study

1. Elisa T.Lee & John Wenyu Wang (2003): Statistical methods for Survival Data analysis, 3rd Edition, John Wiley (Chapter 1 and 2)
2. B Antonisamy, Prasanna S. Premkumar, Solomon Christopher (2017): Principles and Practice of Biostatistics, Elsevier Publications

Books for Reference

1. Hosmer and Lemeshow (2000): Applied Logistic Regression, 2/e, Wiley Series
2. Krzanowski, W and Hand, D.J.(2013): ROC Curves for Continuous Data, Chapman and Hall
3. Gareth Hughes and Bhaskar Bhattacharya (2013): Symmetry Properties of Bi-Normal and Bi-Gamma Receiver Operating Characteristic Curves are Described by Kullback-Leibler Divergences, *Entropy*, 15(4), 1342-1356

Course Objectives: To aware about the dealing of life time data in engineering applications, to learn several methods in reliability theory, apply these techniques to assess the failure rates of component / system.

Course Outcomes (COs): On the successful completion of the course, student will be able to:

CO1: Aware the objectives, needs and applications of reliability and ideas of structural reliability.

CO2: Understand the statistical measures and lifetime data and its distributions.

CO3: Modelling of such life time data sets

CO4: Computing expected lifetime and estimation of reliability parameters using frequentist and Bayesian methods.

CO5: Estimating reliability estimates for prediction of different systems and its components.

Unit I

Reliability and its needs; coherent system- types, Structure function and properties, paths and cuts, system reliability and properties, relevant & irrelevant structure, modules of coherent systems, Reliability importance of components, bounds on System Reliability.

Unit II

Life-testing, complete and censoring data, likelihood in these cases, failure function, reliability function, MTTF, MRLF, MTBF, typical bathtub failure rate - Some common Life Distributions – Exponential, Weibull and Gamma and its characterization - Reliability estimation.

Unit III

Notions of Ageing; Classes of life distributions and their duals - preservation of life distribution classes for reliability operation - Formation of coherent systems, convolutions and mixtures. Deshpande tests for exponentiality.

Unit IV

Univariate stock models, cumulative damage model, shock models, bivariate shock models; common bivariate exponential distributions due to shock and their properties. Maintenance- Repair and Redundant system, Probability plotting techniques.

CO-PO: Mapping

COs\POs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	XXX	X	XXX	X	X	XX
CO2	XXX	X	XXX	X	XX	X
CO3	XXX	XXX	XXX	X	X	X
CO4	XXX	X	XXX	XX	X	X
CO5	XXX	X	XXX	XXX	XX	X

Text Books:

1. Barlow, R.E. and Proschan F. (1985): Statistical Theory of Reliability and Life Testing; Rinehart and Winston.
2. Jayant V Deshpande, Sudha G Purohit (2015): Lifetime Data: Statistical Models And Methods (2nd Edition), World Scientific Publishing Company.
3. Lawless, J.F. (2003): Statistical Models and Methods of Life Time Data; John Wiley.

Reference Books:

1. Bain L.J. and Max Engelhardt (1991): Statistical Analysis of Reliability and Life Testing Models; Marcel Dekker.
2. Nelson, W (1982): Applied Life Data Analysis; John Wiley.
3. Zacks, S(1992): Introduction to Reliability Analysis, Springer Verlag.
4. Marshall, A.W. and Olkin I (2007): Life Distributions, Springer

Course Objectives: Students will be able to learn different methods for categorical data analysis using R.

Course Outcomes (COs): On the successful completion of the course, student will able to:

CO1: Understand types of categorical data and analyze two-way contingency tables using measures of association.

CO2: Perform goodness-of-fit and evaluate screening tests using sensitivity, specificity and predictive values.

CO3: Apply and interpret binary response models like logistic, logit and probit models using generalized linear models.

CO4: Fit and analyze advanced categorical models such as conditional logistic regression, loglinear models and perform model diagnostics.

CO5: Use R programming to implement multinomial and ordered logistic regression and apply model selection techniques in real data case studies.

Unit I

Categorical response data, nominal, ordinal and interval categorical data, describing two-way contingency tables, measures of nominal and ordinal association, inference for two-way contingency tables, likelihood functions and maximum likelihood estimates.

Unit II

Testing goodness of fit and testing independence, screening tests, sensitivity, specificity, and Multinomial logistic regression predictive value positive and negative, partitioning chi-squared, large sample confidence intervals, delta method to estimate standard error, exact tests for small samples

Unit III

Models for binary response variables, generalized linear models, 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. Fitting Logit models.

Unit IV

Conditional Logistic regression, Exact trend test. Loglinear models for two dimensions independence model. Strategies in model selection, Analysis of residuals, Cochran-Mantel-Haenszel test. Multinomial logistic regression, ordered logistic regression. Case studies in R programming.

Mapping- CO with PO

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	xxx	xx	Xxx	x		Xx
CO2	xxx	xx	Xx	x		Xx
CO3	xxx	xx	Xxx	xx		Xx
CO4	xxx	xx	Xxx	xx		Xx
CO5	xxx	xxx	Xxx	xxx	xx	Xxx

Books for Study

1. Agresti, Alan (2002): Categorical Data Analysis, 2nd Edition, Wiley Publication.
2. Kleinbaum, David G. (1994) : Logistic Regression, Springer Verlag.

Books for Reference

1. Agresti, A. (2010) : Analysis of ordinal categorical data, Wiley.
2. Hosmer, D.W., Lameshow, S. and Studivant R.X. (2013), Applied Logistic Regression, Wiley.

Course objectives: To expose students to acquire sufficient computational knowledge of generating Monte-Carlo samples using WR and WOR methods of simulation algorithms and applying them to various unsolved analytical problems in theoretical statistics.

Course Outcomes (COs): On the successful completion of the course, students will

CO1: Understand the need for simulation techniques and apply it to real-world problems like inventory and defence.

CO2: Generate random variables using inverse-transform, acceptance-rejection and other standard methods.

CO3: Generate random numbers and vectors using techniques like congruential generators, Metropolis-Hastings and Gibbs sampling.

CO4: Perform Monte Carlo integration and apply variance reduction methods for improving accuracy.

CO5: Use resampling techniques like bootstrap and Jackknife samples for prediction.

Unit I

Introduction, need of simulation, physical versus digital simulation, Bufferies needle problem, Use of simulation in defence, inventory problems and other fields.

Unit II

Random Variate Generation Methods: Inverse transform method, acceptance rejection method, Composition method. Generating random variables from continuous and discrete univariate distributions. Generation of random vectors from multivariate distributions.

Unit III

Random number generation: Congruential generators, Metropolis-Hasting algorithm, Gibbs sampling - Statistical tests for pseudo random numbers. Random number generation from mixture of distributions, compound distributions.

Unit IV

Monte Carlo integration and variance reduction techniques. Hit or Miss Monte Carlo Method, Sample mean Monte Carlo method. Resampling techniques: Bootstrap, Jackknife techniques and their applications.

CO- PO: Mapping

COS\POS	PO1	PO2	PO3	PO4	PO5	PO6
CO1	XX	XXX	XX	X	X	XX
CO2	XXX	XX	XX	XX	X	X
CO3	XX	XX	XX	XXX	X	X
CO4	XX	XX	XX	XX	X	X
CO5	XX	XXX	XXX	XX	XX	XXX

Book for Study

1. Rubinstein, R.Y. (1981): Simulation and Monte Carlo Method, John Wiley and Sons.
2. Gorden, G. (2001): System Simulation, Prentice Hall of India, New Delhi.
3. Fishman, G.S. (1996): Monte Carlo Concepts, Algorithms and Applications, Springer Verlag, New York.

Book for Reference

1. Deo, Narshingh (1991): System simulation with digital computer, Prentice Hall of India Pvt. Ltd, New Delhi.
2. Lewis, P.A.W. and Orav, E.J. (1988): Simulation Methodology for Statisticians, Operations Analysis and Engineering, Wadsworth and Brooks Cole Advanced Books and Software, Vol. 1.
3. Sethi, I.K. and Jain, A.K. (1991): Artificial Neural Networks and Statistical pattern recognition, North-Holland, Amsterdam.
4. McLachlan, G. and Krishnan, T. (2007): The EM Algorithm and Extensions, John Wiley and Sons.

Course Objectives: To provide all the related knowledge formulation, problem solving and real time application. To train the students on the concepts of Mathematical modeling. To extend the knowledge insights of mathematical modeling with Algebra, with differential equations, with stochastic processes, etc.

Course Outcomes: After completion of the course, the students will be exposed to

- CO1** Understand the need and applications of mathematical modelling
- CO2** Construct mathematical models using algebraic functions for real-life situations
- CO3** Formulate and solve models using first- and second-order differential equations
- CO4** Understand the differential equations and their application in modelling continuous systems
- CO5** Analyze the stochastic processes using Markov chains

Unit I (Introduction to Mathematical Modelling Concepts)

Introduction – Need and Characteristics of modelling – Model Classifications – Types of Mathematical Modelling – Limitations of Mathematical Modelling – Scope and Applications - Mathematical Modelling Formulation Techniques – Interpretation of Solution - Some Simple Problems.

Unit II (Mathematical Modelling with Algebra Functions)

Introduction – Quadratic Functions with Applications – Projectile Motion – Maxima and Minima Applications – Fitting of Quadratic Models to Data – Polynomial Functions with Higher Degree Applications – Polynomial Interpolation – Fitting Cubic Models to Data.

Unit III (Mathematical Modelling with Differential Equations)

Definition of Differential Equations – Order and Degree of Differential Equations – Formulation of Differential Equations – Ordinary Differential Equations of First Order – Ordinary Differential Equations of Second Order (up to first degree only) – Introduction to Difference Equations - Partial Differential Equations (up to basic level concepts only).

Unit IV (Mathematical Modelling with Stochastic Processes)

Definition and Assumptions - Scope and Applications of Stochastic Processes – Concept of Deterministic and Stochastic Models - Classification of States – Markov Chain – Estimation of Parameters – Markov Processes.

CO-PO: Mapping

COs\POs	PO1	PO2	PO3	PO4	PO5	PO6
CO1		XXX				
CO2			XXX			XXX
CO3						XXX
CO4	XXX	XXX				
CO5				XXX		

Books for Study:

1. Kapur, J. N. (2015). Mathematical Modelling. New Age International.
2. Clive L. Dym, Principles of Mathematical Modelling, Elsevier Press, Second Edition, 2004.
3. Zafar Ahsan. (2004). Differential Equations and Their Applications, PHI Pvt. Ltd.
4. J. Medi. (2023). Stochastic Processes, New Age International.

Books for References:

1. Barnes, B., Fulford, G. R. (2008). Mathematical Modelling with Case Studies, CRC Press.
2. Bender, E. A. (2012). An introduction to mathematical modelling. Courier Corporation.
3. Meerschaert, M. M. Mathematical Modelling. Academic Press, 2013.
4. A.C. Fowler, Mathematical Models in Applied Sciences, Cambridge University Press, 1997.

Learning Objectives: To provide the all the insights of the applications with Queuing Theory and Inventory Modeling. To extend the knowledge of classical concepts, procedures of solving the numerical illustrations.

Course Outcomes (COs): After completion of the course, the students will be exposed to

- CO1 Understand the key characteristics of Poisson queuing models
- CO2 Derive and compute steady-state probabilities and queue lengths for multiple server systems
- CO3 Identify and differentiate between deterministic and probabilistic inventory models
- CO4 Solve deterministic inventory problems involving EOQ models
- CO5 Apply queuing and inventory control models to practical scenarios

Unit I

Poisson Queuing Models with single server: Descriptions of queuing models, Generalized Birth and Death Processes, steady state Birth and death processes- Assumptions, Probability distributions for number of Units (steady state), waiting time distribution, Derivation of characteristics on (M/M/1): (∞ /FIFO) and (M/M/1): (N/FIFO) Models, simple numerical problems

Unit II

Poisson Queuing Models with multiple server: Descriptions of the model, Assumptions, Probability distributions for number of Units (steady state), waiting time distribution, Derivation of characteristics on (M/M/C): (∞ /FIFO), (M/M/C): (N/FIFO) and (M/M/C): (C/FIFO) Models, simple numerical problems.

Unit III

Scope and notion of Inventory, Terminology, overview on probabilistic & Deterministic Models, optimality issues with Inventory; Deterministic Inventory models with shortages and without shortage. Finding EOQ and other characteristics, Simple Problem

Unit IV

Deterministic Inventory models with simultaneous replenishment and stock clearance, with shortages and without shortages, finding EOQ and other parameters, Simple Numerical Problems; Deterministic Inventory models with Single and multiple price Breaks and numerical examples.

CO-PO: Mapping

COs\POs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	XXX					
CO2		XXX				
CO3	XXX		XXX			
CO4					XXX	
CO5		XXX		XXX		XXX

Books for Study:

1. Kanti Swarup et al.: Operations Research, Sultan Chand and Sons, New Delhi
2. S.D Sharma: Operations Research
3. Donald Gross & Carl M Harris (1998): Fundamentals of Queuing theory, John Wiley & Sons
4. Hamdy A. Taha (2006): Operations Research – An Introduction, 8/e , Prentice Hall of India Private Ltd., New Delhi

Books for Reference:

1. Hiller F S and Libermann G J (1995):Introduction to operations Research, 6th Edition, McGraw Hill
2. Prabhu N.U. (1965) Applied Stochastic Processes, Mc.Millan
3. J.Medhi (2009), Stochastic Processes, 3/e, New Age International
4. Bhat. B.R. (2002), Stochastic Processes, 2/e, New Age International

Course Objectives: This course is intended to equip students to get knowledge in clustering and classification techniques.

Course Outcomes (COs) : On successful completion of course, students will be able to:

- CO1:** Gain knowledge in the fundamental concepts of statistical learning and distance computation
- CO2:** Comprehend the working principle of hierarchical, basic k-means and fuzzy c-means clustering algorithms and outcome evaluation
- CO3:** Comprehend the working principle and of decision tree, nearest neighbour classification methods and outcome evaluation
- CO4:** Understand binary logistic regression and ensemble methods
- CO5:** Apply clustering and classification methods to solve real life examples based on case studies

Unit I

Introduction to data mining – data types – Measures of similarity and dissimilarity – Data mining tools – supervised and unsupervised learning – Introduction to Cluster Analysis –Types of clustering – Agglomerative Hierarchical clustering algorithm – Issues – strength and weaknesses.

Unit II

Basic k-means algorithm – Issues – fuzzy clustering – fuzzy c means algorithm – cluster evaluation – unsupervised and supervised measures - Introduction to classification – Decision Trees – Building a decision tree – Tree induction algorithm – model over fitting – Evaluating the performance of a classifier.

Unit III

Nearest Neighbour classifiers – kNN algorithm – Naïve Bayesian classifier – Binary logistic regression – odds ratio – Interpreting logistic regression coefficients – Multiple logistic regression.

Unit IV

Ensemble Methods – Rationale for ensemble methods – Methods for constructing an ensemble classifier – Bagging – Boosting –Adaptive Boosting Algorithm, Random Forests.

CO-PO: Mapping

COs\POs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	*					
CO2	*	*		*	*	
CO3	*	*		*	*	
CO4	*	*		*	*	
CO5		*	*	*	*	*

Books for Study

1. Tan, T., Steinbach, M. and Kumar, V. (2006): Introduction to Data Mining, Pearson Education. (relevant portions of Chapters 1, 2, 4, 5 and 8).
2. Gupta, G.K. (2008): Introduction to Data Mining with case studies, Prentice – Hall of India Pvt. Ltd. (relevant portions of Chapter 2)
3. Daniel T. Larose (2006): Data Mining: Methods and Models, John Wiley and sons.

Books for Reference

1. Han, J. and Kamber, M. (2006): Data Mining: Concepts and Techniques, 2 nd Edition, Morgan Kaufmann Publishers.
2. Paolo Gludici (2003): Applied Data Mining: Statistical Methods for Business and Industry, John Wiley and sons.
3. Rajan Chattamvelli (2009): Data Mining Methods, Narosa Publishing House, New Delhi.

Course Objectives: To aware about the dealing of life time data in medical applications, to learn several statistical methods in survival analysis, apply these techniques to analyze the life time data and to know the likelihood or frequency of failures and causes of failure.

Course Outcomes (COs): On the successful completion of the course, student will be able to:

- CO1:** Aware the fundamental concepts of Life Tables and survival analysis.
- CO2:** Understand the statistical measures and lifetime data and its distributions.
- CO3:** Modelling of such life data (uncensored and random censoring) sets.
- CO4:** Computing expected lifetime and various methods of estimating survival and hazard functions.
- CO5:** Estimating survival estimates and identifying significant factors affecting lifetime for competing risks problems.

Unit I

Survival function, hazard function, CHF, MTTF, Concepts of time, order and random censoring, likelihood in these cases. Some Life distributions and its characterizations - Exponential, Weibull, Gamma, Lognormal, Linear Failure rate- parametric (Point estimation, scores, MLE)

Unit II

Life tables and construction, MRLF and their elementary properties. Ageing, Types of Ageing classes and their properties and relationship between them, Bathtub Failure rate.

Unit III

Estimation of survival function, Actuarial Estimator, Kaplan- Meier Estimator, Greenwood formula, Nelson-Alan Estimator, Estimation under the assumption of IFR / DFR - Tests of exponentiality -Despande test- Total time on test.

Unit IV

Gehan test, Mantel Haenszel test, Tarone Ware tests. Semi- parametric regression for failure rate, Cox’s proportional hazard model with one and several covariates, Partial Likelihood, Competing risks-CIF and CSHF-Estimation-simple problems.

CO - PO: MAPPING

Mapping	PO1	PO2	PO3	PO4	PO5	PO6
CO1	xxx	Xxx	xxx	x	xx	X
CO2	xxx	Xxx	xxx	x	x	X
CO3	xxx	Xxx	xxx	x	xxx	X
CO4	xxx	Xxx	xxx	xxx	xx	X
CO5	xxx	Xxx	xxx	xxx	xx	X

Books for Study

1. Miller, R.G. (1981) : Survival analysis, (John Wiley.
2. Cox, D.R. and Oakes, D. (1984) : Analysis of Survival Data, Chapman and Hall, NewYork.
3. Elisha T Lee, John Wenyu Wang and Timothy Wenyu Patt(2003): Statistical Methods for Survival data Analysis, 3/e, Wiley Inter Science.

Books for Reference

1. Gross, A.J. and Clark, V.A. (1975) : Survival distribution : Reliability applications in the Biomedical Sciences, John Wiley and Sons.
2. Elandt Johnson, R.E. Johnson N.L.: Survival Models and Data Analysis, John Wiley and sons.
3. Kalbfleisch J.D. and Prentice R.L.(1980), The Statistical Analysis of Failure Time Data, JohnWiley.
4. Klelin P. John and Moeschberger(2003): Survival Analysis: Techniques for Censored andTruncated Data, 2/e, Springer.
5. Lawless J.F. (1982) Statistical Models and Methods of Life Time Data; John Wiley & Sons.

Course Objectives: This course is intended to provide basic techniques of analyzing human population characteristics and several life behavior phenomena of population and knowledge of demography techniques. Students will gain knowledge about constructions of life tables and measures of population dynamics.

Course Outcomes (COs): On the successful completion of the course, student will be able to:

- CO 1:** understand the basic terms of the demographic analysis.
- CO 2:** understand the population growth measures (Fertility & Fecundity) in mathematical terminology and applying in various mathematical models.
- CO 3:** understanding the mortality measures and life table construction.
- CO 4:** understanding the Migration and Urbanisation measures.
- CO 5:** understand analysing the nuptiality data.

Unit I

Introduction: History of Demography, Sources, significance and Errors of demographic Data, Concepts and Definitions of terms, fertility, mortality, Nuptiality, Migration; Measures of Age and Sex Composition of the Population. Rates and Ratios, Crude and Specific Rates, Standardization – Direct and Indirect Methods

Unit II

Fertility, Fecundity & Population Growth Measures: Crude and Specific Rates, Standardized Rates, different Fertility Rates, Gross Reproduction Rates, Net Reproduction Rate, Replacement Index. Balancing Equation, Arithmetic, Geometric, Exponential, Logistic. Doubling Time; Structure of Population – Stable, Quasi-stable, Stationary Population, Applications – Population Momentums, Reproductive value; Populations growth models.

Unit III

Mortality & Morbidity Measures: Introduction, Crude, Specific and Standardized mortality Rates; Infant, Neo-natal, Pre and Post neonatal mortality, Life Tables: Concepts, Assumptions, Construction of Life tables, Complete and Abridged Life Tables; Associated Life tables; Morbidity: Prevalence and Incidence Rates, Maternal Mortality

Unit IV

Nuptiality & Migration Measures: Introduction, Sources and Quality of Nuptiality Data, General, Specific, Total and Standardized Marriage rates, Mean Age at Marriage, Measures of Migration: Concept of mobility and migration, sources of data, types of migration, Internal & international migrations; measures of internal migration.

CO with PO: Mapping

Cos\POs	PO1	PO2	PO3	PO4	PO5
CO1	XXX	XXX		XXX	XXX
CO2				XXX	XXX
CO3				XXX	
CO4					XXX
CO5					XXX

Books for study

1. K. Srinivasan (2011), Training Manual on Demographic Techniques, United Nations Population Fund, Institute for Social and Economic Change, Bangalore.
2. Srinivasan, K. (1997). Basic demographic techniques and applications. New Delhi: SAGE.
3. Pathak, K.B. and F.Ram, (1998) Techniques of Demographic Analysis, Mumbai: Himalaya Publishing House
4. Ramakumar. R and Gopal Y S: Technical demography – New Delhi: Wiley Eastern, 1986

Books for Reference

1. Hinde, Andrew (1998) Demographic Methods. London: Arnold
2. Bougue, Donald J: Principles of demography – New York: John Wiley and Sons, 1969
3. Misra.B.D.: An Introduction to the study of population – New Delhi : South Asian, 1981
4. Bhende, Asha and Tara Kanitkar, Principles of Population Studies – 5th Nov. ed. New Delhi, Himalaya, 1992
5. Shryock, Henry S. Jacob S. Siegel and Associate, (1980): The Methods and Materials of Demography Vol.1 & 2, U.S. Bureau of the Census, Washington D.C.
6. Preston, Samuel H, Patrick Heuveline and Michel Guillot: Demography –Measuring and Modeling Population Processes

STAT 539: PYTHON FOR MACHINE LEARNING (Lab Based) CREDITS: 3**Course Objectives:**

1. Introduce foundational concepts and tools for Python programming, covering essential topics for better understanding.
2. Provide hands-on experience in machine learning and data analysis techniques, including data preprocessing, model fitting, evaluation, and tuning etc.,

Course Outcomes (COs): On successful completion, students will be able to:

CO1: Apply Python programming for statistical computing and data analysis.

CO2: Utilize Python libraries such as NumPy, Pandas, and Matplotlib for data processing and visualization.

CO3: Implement supervised machine learning algorithms for classification and regression tasks.

CO4: Evaluate and tune models using validation techniques and hyperparameter optimization.

CO5: Apply advanced concepts such as ensemble learning and deep learning in real-world datasets

Unit I

Introduction to Python – Installation – Basic Object types and Operators: Arithmetic, relational, logical, membership, identity – Control Structure: Selection and iteration – Lists – Tuple – sets – Dictionary – creation, deletion, updation – file I/O operations - Data Analysis Packages: NumPy- creating NumPy array- indexing – slicing- arithmetic operations.

Unit II

Pandas: Creating series and Data frame – reading and writing from csv, text, excel files – summary statistics – merging, join and grouping – pivot tables - Matplotlib: line plots- multiple lines on same axis and different axis, scatter plots, histograms, customize labeling – bar charts: simple, stacked and multiple -Pie charts. perspectives in Data: creating a dummy variables, normalizing and scaling data.

Unit III

Scikit learn – linear and polynomial fit – multivariate regression - supervised learning: logistic regression, support vector machines, decision trees, AdaBoost – case studies on text mining – Support Vector regression.

Unit IV

Model diagnosis and tuning: optimal cutoff point – K-fold cross validation - bagging and boosting – feature importance – hyper tuning parameters - Case studies: Examples for random forest and AdaBoost using validation methods – concept of deep and reinforcement learning.

CO-PO: Mapping

COs\POs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	XX	XXX	XX	XXX	X	X
CO2	XX	XXX	XXX	XXX	X	X
CO3	XX	XXX	XXX	XXX	X	XX
CO4	XX	XXX	XXX	XXX	X	XX
CO5	XX	XXX	XXX	XXX	XX	XXX

Books for Study

1. Manohar Swamynathan (2017), Mastering Machine Learning with Python in Six Steps, A Press
2. William McKinney (2017), Python for Data Analysis: Data Wrangling with Pandas, NumPy, and Ipython, O’Rilley.

Books for Reference

1. Tom M. Mitchell (2017), Machine Learning, Tata McGraw Hill
2. Hastie, Tibshirani and Friedman (2017), The Elements of Statistical Learning: Data Mining, Inference, and Prediction, 2/e, Springer

SOFTCORE COURSES STAT 540 AND STAT 541 OFFERED IN SEMESTER-IV

STAT 540: Project Dissertation Work & Comprehensive Viva Voce

CREDITS: 12

Course Objectives: This course is intended to expose students to apply the methodologies that were covered in the curriculum.

Course Outcomes: Students will gain knowledge on the various steps in research problems handling and learning opportunities for applying statistical techniques to real life problems and motivations towards research contributions.

Course Outcomes (COs):

CO1: Opportunity to learn a literature review study on a topic of interest.

CO2: Explore the research problems and identification of research gap.

CO3: Attempt a research problem or extension research or case studies.

CO4: Analyze real data set application with and interpret the findings.

CO5: Prepare a structured and Dissertation project report.

1. It is an individual project dissertation work offered in IV semester with 12 credits.
2. Top 15% of students who have cleared the courses at first attempt in the preceding semesters with minimum 7.5 CGPA, and have keen research interest and willing to pursue higher studies can opt STAT: 540.
3. Student should be capable to float new thought or idea or research review on a topic with strong computational skills.
4. Students should work a minimum of 12 hrs. per week for the entire semester duration.
5. The Project dissertation work shall be supervised by Department faculty member assigned in the beginning of the semester.
6. The project work should be undertaken in topics are to be selected in such a way that there is enough scope to apply and demonstrate the statistical techniques learned in the preceding semesters.
7. At the end of the semester-IV, bounded hard copy of the project report should be submitted (two copies) to the Department.
8. The project report shall contain the literature review, identified research gap, statement of problem, Methodology adopted, findings, conclusions and references.
9. The project work will be assessed for 12 credits. Students have to give three presentations related to their project work which will be evaluated internally.
10. There will be **viva-voce examination** evaluated by external examiner during the end semester examination of the 4th semester.

The following format may be adopted in preparing the project report:

Certificate from Head of Department, Certificate from Dissertation Project Guided Supervisor,

Acknowledgement from Student, Abstract of work, Abbreviation used

Chapter I : Motivations of a topic, Review of Literature, Research Gap, Objectives of study.

Chapter II : Statistical Methodology and Presentation of Real Data Sets Used.

Chapter III: Statistical Analysis (Problem Statement, Assumption, Derivation, Computation and Result)

Chapter IV: References used for study.

CO-PO: Mapping

COs\POs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	XXX	XXX	XXX	XX	XX	XX
CO2	XX	XXX	XX	XX	XX	XXX
CO3	XX	XXX	XX	XXX	XXX	XX
CO4	XX	XX	XX	XX	XX	XX
CO5	X	XX	XX	X	XX	XXX

Course Objectives: This course is intended to expose students to apply the methodologies that were covered in the curriculum.

Course Outcomes(COs):

- CO1:** Apply statistical methods to address real-world problems in industry or research.
- CO2:** Analyze and interpret data from complex practical case studies.
- CO3:** Utilize appropriate statistical software for project execution.
- CO4:** Prepare a structured and comprehensive project report.
- CO5:** Present and defend project findings in a professional manner.

1. It is an individual project work offered in IV semester with 12 credits.
2. The Project work shall be guided and supervised by a faculty member assigned in the beginning of the semester.
3. The project work should be undertaken in a reputed and relevant organization and topics are to be selected in such a way that there is enough scope to apply and demonstrate the statistical techniques learnt in the course.
4. At the end of the semester, before the last working day, project report should be submitted (two copies) with a certificate from industrial guide.
5. The project report shall contain the statement of problem, Methodology adopted, statistical tools used for analysis, findings, conclusions, suggestions and references.
6. The project work will be assessed for 12 credits. Students have to give a seminar of their project report at the end of the semester and which will be evaluated internally.
7. There will be viva-voce examination by an internal and an external examiner during end semester examination in 4th semester.

The following format may be adopted in preparing the project report:

Certificate from Head of Department, Certificate from Dissertation Project Guided Supervisor, Acknowledgement from Student, Abstract of work, Abbreviation used

Chapter I : Motivations of a topic, Review of Literature, Research Gap, Objectives of study.

Chapter II : Statistical Methodology and Presentation of Real Data Sets Used.

Chapter III: Statistical Analysis (Problem Statement, Assumption, Derivation, Computation and Result)

Chapter IV: References used for study.

CO-PO: Mapping

COs\POs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	XXX	XXX	XXX	XX	XXX	XX
CO2	XX	XXX	XXX	XX	XXX	XXX
CO3	XX	XXX	XXX	XXX	XXX	XXX
CO4	XX	XX	XX	XX	XXX	XXX
CO5	X	XX	XX	X	XXX	XXX

Course Objectives: To learn advance method of estimation. The objectives of the Bayesian inference is that to incorporate the past information with observed data in order to predict the future inferences.

Course Outcomes (COs): On completion of this course, students will be able to:

CO 1: Calculate relative frequencies to *estimate* probabilities and computation of posterior distribution.

CO 2: Incorporate the various types of priors for drawing inference from Posterior distribution.

CO 3: Formulation of Bayes estimator for various types of loss functions.

CO 4: Construction of Bayes credential intervals.

CO 5: Approximation of Bayes estimator for posterior means under MCMC simulation using appropriate sampling algorithms.

Unit I

Introduction about Thomas Bayes - Motivations and Contributions - Evaluation of Subjective probability of an event using a subjectively unbiased coin - Subjective prior distribution of a parameter – Bayes theorem and computation of the posterior distribution.

Unit II

Introduction of Prior Distributions, Types of Prior Distributions, Proper Prior-Enlarging the natural conjugate family by enlarging hyper parameter space - mixtures from conjugate family - choosing an appropriate member of conjugate prior family - Non informative, improper and invariant priors - Jeffrey’s invariant prior

Unit III

Bayesian point estimation: Prediction problem from posterior distribution - Bayes estimators for absolute error loss, squared error loss, linex loss function, Jeffrey’s and 0-1 loss - Generalization to convex loss functions –Evaluation of the estimate in terms of the posterior risk,

Unit IV

Bayesian interval estimation: Credible intervals - Highest posterior density regions - Interpretation of the Credible intervals, Monte-Carlo Integration and Basic Concepts on Markov chain Monte Carlo techniques(MCMC)(without proof)- Introduction to Gibbs Sampling.

CO-PO: Mapping

COs\POs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	XXX	XXX	XXX	X	X	X
CO2	XXX	XX	XX	X	XX	X
CO3	XXX	XX	XX	X	XX	X
CO4	XXX	X	XX	X	XX	X
CO5	XXX	X	X	XXX	XXX	X

Books for Study

1. Bansal A.K.(2007): Bayesian Parametric Inference, Narosa Publications
2. Sinha S K (1998): Bayesian Estimation, New Age International(P) Ltd, New Delhi

Books for Reference

1. Berger, J.O.(1985): Statistical Decision Theory and Bayesian Analysis, 2/e, Springer Verlag.
2. Robert C.P. and Casella, G.(2004): Monte Carlo Statistical Methods, 2/e, Springer Verlag.
3. DeGroot, M.H.(2004): Optimal Statistical Decisions, Wiley-Inter Science.
4. Gamerman, D. and Lobes H.F. (2000): Stochastic Simulation for Bayesian Inference, Taylor and Francis.
5. Box, G.P. and Tiao, G.C.(1973): Bayesian Inference in Statistical Analysis, Addison – Wesley.
6. Hamada, M.S., Wilson, A., Reese, C.S., Martz, H.(2008) :Bayesian Reliability, Springer.

STAT 543: STATISTICAL LEARNING THEORY AND NEURAL NETWORKS CREDITS: 3

Course Objectives: A course in Statistical Learning Theory will provide a rigorous understanding of the theoretical foundations of machine learning, focusing on the properties of learning algorithms and the ability of models to generalize from data. Also this course focusses on the popular machine learning algorithms, support vector machines and neural networks.

Course Outcomes(COs): The students will learn the statistical learning and neural network concepts:

CO1: Gain knowledge of various Regression methods and their real-life applications

CO2: Apply machine learning algorithms in real world scenario

CO3: Explore different Model selection and building methods and its applications

CO4: Introduction to Artificial Neural networks and its fundamental concepts

CO5: Study various neural network models and their applications

Unit I

Statistical Learning – Introduction – Overview of supervised and unsupervised learning – Statistical Decision Theory - Kernel Methods - Bayesian Methods - Linear Methods for Regression - Shrinkage Methods - Ridge Regression - The Lasso - Subset Selection, Ridge Regression - Principal Components Regression - Nonparametric Logistic Regression

Unit II

Piecewise Polynomials and Splines - Natural Cubic Splines - Filtering and Feature Extraction - Smoothing Splines - Multidimensional Splines - Regularization and Reproducing Kernel Hilbert Spaces - Spaces of Functions Generated by Kernels - Wavelet Smoothing - Tree based methods – Basics of Decision Trees – Bagging, Random Forests, Boosting, Bayesian additive Regression trees – Analysis of Random Forests - High-Dimensional Problems – Support Vector Machine

Unit III

Artificial Neural networks – Fundamental concepts on neural networks – Multilayer Feedforward Networks – Radial Basis Function networks – Neural Network and Statistical Model Interfaces – Hopfield Networks

Unit IV

Self-Organizing Maps (SOM) networks - Principal Component Analysis Networks – Factor Analysis Networks - Regression Neural Network Models – Nonparametric Regression and Classification Networks – Probabilistic Neural Network – Recurrent Neural Network

CO-PO: Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	XXX	XX	XXX	XX	X	XX
CO2	XXX	XX	XXX	XX	X	XX
CO3	XXX	XX	XXX	XX	X	XX
CO4	XXX	XX	XXX	XX	X	XX
CO5	XXX	XX	XXX	XX	X	XX

Books for study

1. Basilio de Braganca P, C R Rao and Fabio Norges de Oliveira (2020), Statistical Learning Using Neural Networks – a Guide for Statisticians and Data Scientists, CRC Press.
2. Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani and Jonathan Taylor (2023), An Introduction to Statistical Learning with applications in Python, Springer
3. Robert Schalkoff (1992), Pattern Recognition – Statistical, Structural and Neural Approaches, John Wiley and Sons.
4. Trevor Hastie, Robert Tibshirani and Jerome Freidman (2009), The Elements of Statistical Learning - Data Mining, Inference and Prediction, 2/e, Springer, New York.

Books for reference

1. Christopher M Bishop (2006), Pattern Recognition and Machine Learning, Springer.
2. Ke-Lin Du and M. N. S. Swamy (2019), Neural Networks and Statistical learning, Springer.
3. S Rajasekaran and G A Vijayalakshmi Pai (2009), Neural Networks, Fuzzy Logic and Genetic Algorithms, PHI Learning Private Limited.

Course Objectives: This course intends to get knowledge on inferential based decision problems with theoretical and applications.

Course Outcomes(COs): On the successful completion of the course, Students will learn decision rules with insight inferential mathematical setup for applying in several areas of research viz., Decision and Behavioral Science, Business Management, Commerce and Financial econometrics.

CO1: Understand decision problems and apply Bayesian inference using prior and posterior distributions.

CO2: Learn decision principles, Baye’s risk and utility theory for constructing optimal decision rules.

CO3: Apply minimax analysis and game theory concepts to decision-making and estimation problems.

CO4: Study admissibility and robustness of Baye’s and minimax rules, and understand invariant decision rules.

CO5: Construct and interpret confidence and credible sets in location parameter problems.

Unit I

Basic elements of a decision problem - Randomized and non-randomized decision rules - Estimation and testing of hypothesis as decision problems - Baye's approach to inference and decision -Loss functions - Prior and Posterior distributions and its analysis for Bernoulli, Poisson, and normal processes

Unit II

Decision principles and Baye’s risk–Utility theory - axioms, construction of utility functions, sufficiency, equivalence of classical and Bayesian sufficiency, complete and essentially complete classes of decision rules

Unit III

Minimax analysis - Basic elements of game theory - General techniques of solving games - Finite games - Supporting and separating hyper plane theorems - Minimax theorem - Minimax estimation for normal and Poisson means

UNIT IV

Admissibility of Baye’s and minimax rules, General theorems on admissibility, Robustness of Baye's rules, Invariant decision rules, Location parameter problems, Confidence and credible sets.

CO – PO: Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	XXX	XX	XX	X	X	X
CO2	XXX	XX	XX	X	X	X
CO3	XX	XX	XX	X	X	X
CO4	XXX	XX	XX	X	X	X
CO5	XX	XX	XX	X	X	X

Books for study

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

Books for Reference

1. Zellener (1971): An Introduction to Bayesian Inference in Econometrics, Willey
2. Hayes J. G and Winkler R I (1976): Probability, Statistics and Decision, Dower
3. Anthony O’ Hangan (1994): Kendall’s Advanced theory of Statistics Vol. 2B, John Wiley

Course Objectives: To provide the insights of the time series components. To understand the Irregular Variations of Time series using stochastic processes. To have the conceptual understanding of the individual and combined aspects of AR, MA, ARCG and GARCH methods.

Course Outcomes(COs): After completing the course, the students will be able to

- CO1** Differentiate between deterministic and stochastic time series data
- CO2** Apply the methods to model and interpret real-life time series data.
- CO3** Construct and evaluate discrete stochastic models for time series analysis
- CO4** Formulate AR, MA and ARMA models to understand the behavior of stationary time series
- CO5** Implement ARCH and GARCH models to study volatility and heteroscedasticity
- CO6** Apply ARIMA and SARIMA models to forecast future values

Unit I: Measures of Time Series Data

Stochastic Process, Types of Stochastic Processes, illustrations, – Time Series Vs Stochastic Processes Measurement of Trend: Graphical Method – Method of Semi Averages – Method of Moving Averages – Method of Curve Fitting by Least Squares – Measurement of Seasonal Variations: Simple Average Method – Ratio to Trend Method – Ratio to Moving Average Method – Link Relative Method – Deseasonalisation – Measurement of Cyclical Variations – Measurement of Irregular Variations.

Unit-II: Stochastic Time Series Models:

Types of time series data with reference to its related stochastic processes, Bernoulli - Markov Modeling, Hidden Markov Modeling, Markov-Poisson Modeling, Formulation of probability distributions, Prediction of the model parameters for the discrete time series data. Deriving the explicit mathematical relations for different distributional characteristics and finding such statistical measures for the suitable numerical data

Unit III: Auto Regression Time Series Models

Introduction – Autoregressive (AR) Processes: First Order Autoregressive AR(1) Process – Second Order Autoregressive AR(2) Process – General Order Autoregressive AR(p) Process – Moving Average Processes: First Order Moving Average MA(1) Process – Second Order Moving Average MA(2) Process – General Order Moving Average MA(q) Process – Relationship Between AR and MA Processes

Unit IV: Stationary Time Series Models

Autoregressive Moving Average, ARMA (p,q) models; Autoregressive Integrated Moving Average, ARIMA(p,d,q) models; Seasonal Autoregressive Integrated Moving Average, SARIMA((p,d,q), (P,D,Q,s)) models; Generalized Autoregressive Conditional heteroscedasticity (GARCH) model, Autoregressive Conditional Heteroscedasticity (ARCH), Some Numerical Problems.

CO-PO: Mapping

COs\POs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	XXX					
CO2		XXX				XXX
CO3				XXX		
CO4					XXX	XXX
CO5			XXX			
CO6		XXX				

Books for Study:

- S.C Gupta & V. K. Kapoor (2015): Fundamentals of Applied Statistics 4th Edition, Sultan Chand & Sons Publications.
- William W.S. Wei (2006): Time Series Analysis – Univariate and Multivariate Methods 2nd Edition, Pearson Education Inc.
- Parimal Mukhopadhyay (2005): Applied Statistics, Books & Allied P. Ltd.
- P. N. Arora & Sumeet Arora (2007): Comprehensive Statistical Methods 1st Edition, S Chand and Company Limited.

Books for Reference:

- Walter Enders (2015): Applied Econometric Time Series 4th Edition, Wiley Series.
- Ruey S. Tsay (2005): Analysis of Financial Time Series 2nd Edition, A John Wiley & Sons Inc, Publications.

Course Objectives: The course intends to learn construction of life tables, methods for measuring life assurance and claim, evaluation annuity and premium.

Course Outcomes(COs): After completing the course, the students will be able to

- CO1** gain the knowledge about the methods of computing life tables in the financial and social sector.
- CO2** aware about the financial terminology and calculations in the life insurance designing.
- CO3** capable to evaluate life annuity contracts in financial sector
- CO4** Actuaries often required keen analytical and problem-solving skills using mathematics and statistics.
- CO5** evaluate the life insurance premium and reserve premium in business and commercial fields.

Unit I: The life table

The life table functions. Probabilities of death and survival. Constructing a life table, Lifetime random variables and its distribution and density functions. Complete and curtate expectation of life, Life table functions at non-integer ages-uniform distribution of deaths (UDD)- constant force of mortality (CFM)- Select Mortality. The pattern of human mortality, Gompertz and Makeham laws of mortality.

Unit II: Life assurance contracts

whole life assurance, term assurance, pure endowment, endowment assurance, Deferred assurance. Benefits payable at end of year of death and immediately on death, Mean and Variance of the contracts. Claims acceleration approximation, Variable payments, Payments varying at a constant compound rate and a constant monetary amount. Conventional with-profits contracts

Unit III: Life annuity contracts

Whole life annuity, temporary annuity, Deferred annuities, Guaranteed annuities, payment made in advance, in arrear and continuous cases. Evaluating the means and variances. Evaluation of annuities and Approximation, annuities payable m times each year, Increasing annuities

Unit IV: Premiums & Reserves

The principle of equivalence, the basis, Net Premium, Need for Reserve, Net Premium Reserve, Gross future loss random variable, Calculating gross premiums, Calculating gross premium reserve, prospective and retrospective reserve, Equality of reserves, Recursive formula for reserves.

CO-PO: Mapping

COsPOs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	XXX	XXX	XX	X	X	XX
CO2	XXX	XXX	XX	X	XX	XXX
CO3	XX	XX	XX	XX	X	XX
CO4	XX	XX	XX	X	XXX	XXX
CO5	XX	XX	XXX	X	XX	X
CO6	XXX	XXX	XXX	XX	XX	X

Books for study:

1. Promislow, S.D(2006): Fundamentals of Actuarial Mathematics, John Willey, Chapters 2- 11 & 14.
2. Newton L. Bowers, Jr, Hans U. Gerber, James C. Hickmann, Donald A. Jones and Cecil J. Nesbitt (1997): Actuarial Mathematics, The Society of Actuaries.

Books for Reference:

1. Neill, A. (1977): Life contingencies, Heinemann, London.
2. King, G. Institute of Actuaries Text Book. Part 11, Second edition, Charles and Edwin Layton, London.
3. Donald D.W.A. (1970): Compound Interest and Annuities, Heinemann, London.
4. Jordan, C.W. Jr. (1967): Life Contingencies, Second edition, Chicago Society of Actuaries.
5. Hooker, P.F. and Longley Cook, L.W. (1953): Life and other Contingencies, Volume I and Volume II (1957) Cambridge University Press.
6. Spurgeon, E.T. (1972): Life Contingencies, Third edition, Cambridge University Press.

Learning Objectives: To provide the all the related knowledge on Statistical Optimization through the topics of Mathematical Programming, post sensitivity parametric programming, linear efficiency analysis with DEA, Multi objective decision with Goal Programming problem. To train the students and enabling them to have conceptual understanding and ability of applications in the real time data contexts of the mentioned situations.

Course Outcomes (COs): After completion of the course, the students will be exposed to

- CO1** Formulate and solve Linear Programming Problems (LPPs) integrated with descriptive statistical measures
- CO2** Conduct post-optimal sensitivity analysis and estimate parameters in LPP
- CO3** Apply Data Envelopment Analysis to evaluate relative efficiency of decision-making
- CO4** Formulate multi-objective optimization problems using goal programming
- CO5** Understand the advanced optimization and statistical tools in practical applications.
- CO6** Integrate linear programming with statistical reasoning to address complex problems

UNIT – I: Basic Statistical Optimization - Mathematical Programming

Formulation and solving the Linear Programming Problems with statistical measures, Essentials of Mathematical Programming in Statistics – with Descriptive Statistics (Mean & Variances) – with relational Statistics (Correlation & Regression) - with advanced analysis of variances (MLE, MSE, MAD, MINMAD, Multiple Regression, etc.)

UNIT – II: Post Sensitivity Statistical Optimization - Parametric Programming

Post optimal sensitivity analysis, Parameter estimation of the LPP, Concept of Parametric Linear Programming – Estimation of parameters in the objective function (C- vector), Estimation of the feasible requirements/availabilities (b-vector), estimating the parameters of Data Matrix (A), estimating the optimal number of decision variables (n) and estimating the feasible number of constraints (m),

UNIT -III: Linear Efficiency Analysis - Data Envelopment Analysis

Ratio Estimators, relative efficiency, essentials of efficiency analysis, Introduction to DEA – relevance of LPP and DEA, LPP with deterministic and Probabilistic measures, – Basics of Frontier Analysis – Mathematical Formulation of DEA – BCC & CCR Models - Input/output oriented DEA – slack & surplus analysis, studies of Cost-Efficiency, Technical Efficiency, Cross Efficiency, Allocation Efficiency, Super Efficiency, etc.

UNIT – IV: Multi Criteria Statistical Optimization - Goal Programming

Concept of Goal Programming - Single-Goal Models - Multiple-Goal Model - Multiple-Goals with Priorities - Multiple Goals with Priorities and Weights - Formulation of Goal Programming Models - Graphical Method to GP - Simplex Method to GP (Extended Simplex Method) - Some Problems on GP.

CO-PO: Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6
CO1			XXX			XXX
CO2		XXX				XXX
CO3				XXX		
CO4	XXX					XXX
CO5	XXX		XXX			

Books for Study:

1. T.S. Arthanari & Yadolah Dodge (1980): Mathematical Programming in Statistics, Jhon Wiley & Sons Publications.
2. R. Ramanathan (2003) An Introduction to Data Envelopment Analysis (A Tool for Performance Measurement), Sage Publications.

Books for Reference:

1. S.D. Sharma (1999): Operations Research 16th Edition, Kedar Nath Ram Nath Publications.
2. Gregory F. Lawler (2014) Stochastic Calculus: An Introduction with Applications.

Course Objectives: To learn about the Indian Official Statistical Systems.

Course Outcomes (COs): On successful completion, students will able to

- CO1:** Describe the structure and evolution of the Indian Official Statistical System, including its historical development and present framework.
- CO2:** Understand the role, functions, and organizational structure of key institutions like the MoSPI and the National Statistical Commission (NSC).
- CO3:** Explain the legal provisions supporting official statistics, including the Collection of Statistics Act, 2008, and recognize their importance in governance and policymaking.
- CO4:** Analyse the functioning of the Directorate of Economics and Statistics (DES) and the administrative statistical systems at state and central levels, with emphasis on decentralized data collection and decision-making.
- CO5:** Identify key sector-wise statistical activities (agriculture, health, education, employment) and evaluate the importance of human resource development through institutions like NSSTA and the Indian Statistical Service (ISS).

Unit I

Indian Official Statistical Systems: History of Indian Official Statistical Systems, Present Indian Official Statistical Systems. Flow chart of Indian Official Statistical Systems. Ministry of Statistics and Programme Implementation (MOSPI) and its wings - Vision and Mission, Divisions and important activities

Unit II

National Statistical Commission (NSC) – Need, Composition, Functions of the NSC etc., Legal Acts/Provisions/Support for Official Statistics like Collection of Statistics Act, 2008. Important/Uses of Official Statistics.

Unit III

The States Official Statistical Systems: Directorate of Economics and Statistics (DES): Role of DES – Common Statistical Cadre – Statistical Divisions in Departments – Block Statistical Organization. Administrative Statistical System: Centralised and Decentralised Systems of Collection of Official Statistics. Improving the Administrative Statistical System (AdSS) – Statistics for Decision Making – Operational Aspects – Computerization of Administrative Statistics

Unit IV

Select Sector-Wise Statistics and Human Resource Development: Agriculture, Health, Education Employment. Staffing Pattern at the Centre, Indian Statistical Service and Subordinate Statistical Service. National Statistical Systems Training Academy(NSSTA), MOSPI and its Capacity Building Activities

CO – PO: Mapping

COs\POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	XXX	X	X	X	X	X	XX	X	X
CO2	XXX	XX	X	X	X	X	XX	X	X
CO3	XXX	XX	X	X	X	X	X	X	X
CO4	XXX	XXX	X	X	X	X	X	XX	X
CO5	XXX	XXX	X	X	X	X	X	XX	XX

Book for Study:

1. e-publication of MOSPI <https://mospi.gov.in/documents/213904/0/Ch+14+30.8.2001.pdf/>
2. <https://www.mospi.gov.in/>
3. <https://nssta.gov.in/>
4. Saluja, M.R., (1972), 'Indian Official Statistical Systems', Statistical Pub. Society.

Book for Reference:

1. Government of India (1999), 'Guide to Official Statistics', CSO, MOSPI